Ibero-Amerika Institut für Wirtschaftsforschung
Instituto Ibero-Americano de Investigaciones Económicas
Ibero-America Institute for Economic Research
(IAI)

Georg-August-Universität Göttingen
(founded in 1737)

Diskussionsbeiträge · Documentos de Trabajo · Discussion Papers

Nr. 229

Green Growth in Mexico, Brazil and Chile: Policy strategies and future prospects

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November 2014

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Abstract

This research focuses on identifying the main policy strategies that could potentially contribute to the advance of three Latin American economies, namely Brazil, Chile and Mexico towards a green growth model that is social and inclusive, given the actual patterns of development of those economies. With this aim, we first identify and describe past and current policies in each country in terms of economic, social and environmental indicators. A detailed analysis follows for Brazil, Chile and Mexico, in which we propose a series of green growth indicators and choose a definition and classification of green growth sectors. We estimate an empirical model to explain the determinants of green house gas emissions and deforestation in Latin American countries. We broadly identify the sectors that contribute to its increase and describe the main green policies applied in each country. In turn we identify the sectors with higher potential for the future. Finally, we present policy recommendations and reflections for the future.

Introduction

There is a vast interest for countries in achieving green growth not only as it is related to lower energy intensities but also as it is related to a higher quality of life. This interest has also led to a growing proliferation of studies and scientific research, whose main objective has been to identify the factors that contribute to green growth and the policies that should be implemented in different countries to enter the path of green growth. The main objective of this research is to analyze from a socio-economic and environmental perspective recent developments in three Latin American countries, namely Brazil, Chile and Mexico, concerning green growth and social inclusion. Past and current environmental as well as social policies are compared between the countries and are related to a selection of indicators. We analyze in particular developments of green house gas emissions, deforestation and social indicators.

According to The United Nations Environment Program (UNEP), a green economy should aim at improving human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Green growth in income and employment should in turn be driven by investments that reduce carbon emissions and pollution, improve resources and energy efficiency and avoid the lost of biodiversity (UNEP 2013). The main green house gas is carbon dioxide (CO_2) and therefore CO_2 will be used as the main global environmental-degradation indicator. Other green house gases considered are CH_4 and N_2O. In order to account for biodiversity losses we rely on the measure of forest area in each country.

This research has four complementary objectives. First, a detailed description of the most relevant economic and socio-economic indicators in the three countries under study is presented in order to identify the main environmental challenges. As economic indicators we present the sectoral distribution of GDP (agriculture, services, manufactures) as well as GDP and trade growth figures. The socio-economic indicators considered are GDP per capita, population, life expectancy and education (World Bank 2013; World Economic Forum 2013; FOASTAT 2013), poverty and social inequality (poverty rate, Gini coefficient, gender inequality), as well as the different dimensions of the Human Development Index and the Human Opportunity Index, both developed by the World Bank and the Global Gender Gap Index, published by the World Economic Forum since 2006. We further study what are the main industries/sub-sectors in each country in terms of production and employment and identify how much each sector contributes to pollution in terms of greenhouse gas emissions in order to describe and analyze the impacts these sectors have on green growth. Second, we analyze a number of green growth indicators classified according to international criteria for Brazil, Chile and Mexico and select four of them, namely CO_2, CH_4 and N_2O and deforestation to analyze how sectoral changes have contributed to the development of the four green growth indicators. Third, a detailed description of the institutional structure and the measures and strategies related to environmental policy and its impact on poverty, social and gender inequality is outlined. Based on the results obtained, the most successful economic activities in terms of green growth and inclusion are identified for each country, and are studied in comparative terms using an economic model. Finally, the study provides policy recommendations concerning social, economic and sectoral issues to draw specific action lines for each country to improve the results in terms of social inclusion and green growth.

The methodology is based on secondary data collection, graphical and descriptive analysis of the data and specification and estimation of an economic model to draw policy implication based on the results. A comparative analysis of country data in terms of polluting effects of the most important sectors and industries in each country is presented. We also analyze the data collected for LA countries by specifying and estimating an economic model, which explains the determinants of three green house gases and deforestation. The model, which is used to identify the contribution of each economic sector to green growth, is derived from the identity IPAT identity: $Impact = Population * Affluence * Technology$. This identity states that the level of pollution, impact (I), depends on three factors: population (P), gross domestic product (A) and the state of technology (T) in a country. Marin & Mazzanti (2009) apply this model at the aggregated level; this paper proposes to apply the model to sectoral-level data of CO_2, CH_4 and N_2O emissions, gases that significantly contribute to the greenhouse effect. Grunewald & Martínez-Zarzoso (2012) have applied the IPAT model to estimate the effect of country participation in the Kyoto Protocol on carbon emissions.

The paper is structured as follows. Section 1 presents a brief review of the economic, social and environmental patterns in the three selected countries. Section 2 outlines the methodology. First, several green growth indicators are presented and compared between the three countries and second, four green growth indicators are chosen to analyze how sectoral changes affected green growth in Latin America. Section 3 presents the main results of the model estimation and of the comparative study. Section 4 describes the main green policies implemented in each country in the last decade to improve environmental quality and to encourage clean development, their limitations and their expected outcomes. Finally, section 5 outlines policy recommendations regarding the subsectors with a greater growth potential.

1 Current Economic Policies

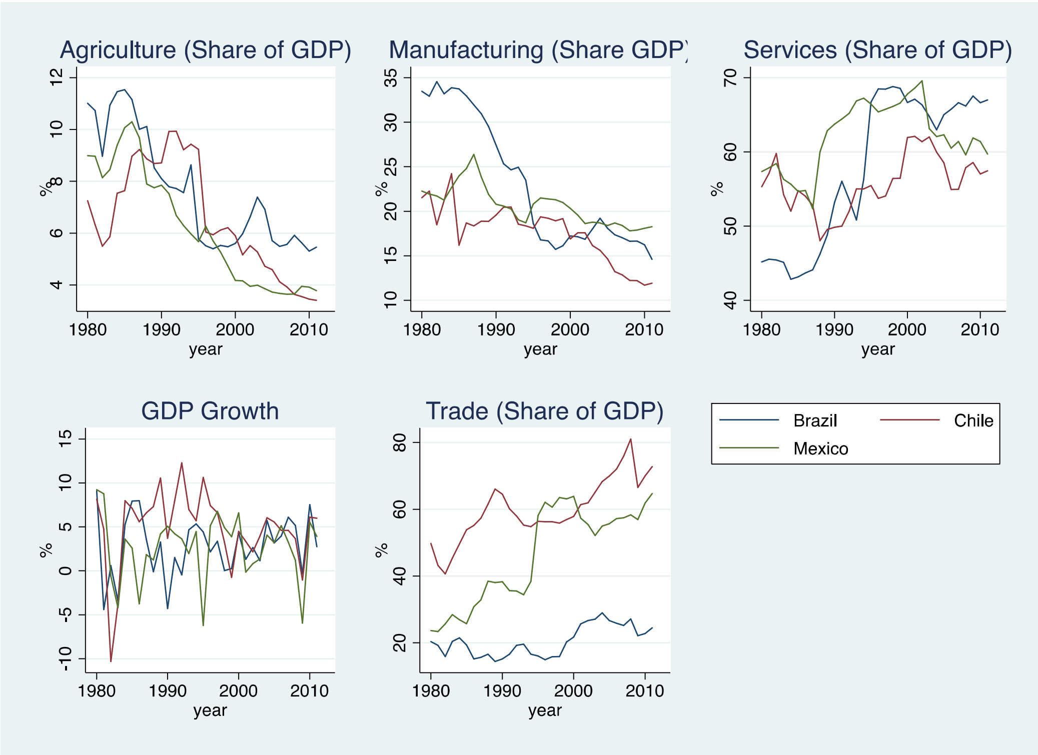
In this section we first present current and historic economic and social indicators. We describe the main economic sectors and their economic and social weight in order to identify the key environmental issues that are relevant for each sector and country.

1.1 Model of economic development and growth patterns

After a period in which import substitution and trade limitation had been the main foreign policies in most Latin American countries, these policies were replaced in the 1980s by trade liberalization and export promotion strategies. Brazil, Chile and Mexico tried to increase economic competitiveness by supporting the creation and intensification of specific clusters of economic activity. Brazil and Mexico focused on the manufacturing sector, and in particular on the automobile industry, whereas Chile focused on the refining and extraction of natural resources, such as copper. The free trade strategies in the three countries were further strengthened with the creation of Mercosur and with Mexico entering the NAFTA free trade agreement in 1995. Meanwhile, out of the three countries Chile has been the most active signing free trade agreements outside the American continent. At the same time, a number of economic reforms have aimed at creating the legal basis to attract foreign direct investment (Peres 2011).

Figure 1 shows the evolution of a number of economic indicators over the last 30 years. Each of the countries shows relatively volatile GDP growth rates that fluctuate around 5 percent. Chile is outperforming Mexico and Brazil in terms of growth rates, in particular during the 1990s. This performance is mainly due to the revenues from the mining sector. This picture is similar concerning the share of trade in GDP. In Chile, total trade accounts for 65 percent of GDP in 2012, followed by Mexico with about 62 percent, whereas the figure is considerably lower for Brazil (around 20-25 percent). Since the early nineties Mexico's trade in goods and services has been steadily increasing, fact which can be attributed to the above-mentioned policies. The strong rise in Mexican trade has been mainly based on exports of manufacturing goods. The expansion of Brazil's agricultural sector, especially in soy and bio ethanol, explains the more modest decline in the share of value added of the agricultural sector in comparison with the other countries. Also the share of value added in manufacturing goods has been declining for all three countries especially for Brazil. In Mexico it declined just slightly over the period analyzed.

Figure 1. Sectoral Development and Trade



Source: World Bank (2013).

Turning to the specific policies in each of the three countries, Brazil's policy reforms between 2003 and 2008 focused on the development of international well-established industries such as high tech and pharmaceutics, in which the country however did not have a comparative advantage. At the same time, one of its core industries, namely the car industry, was protected with a 30 percent import tax on cars imports with more than 65 percent foreign content (Ban 2013). Currently, Brazil is promoting the biofuel sector as part of its low carbon development plan. The Brazilian National Plan on Climate Change aims at providing low carbon growth in line with social development and poverty reduction. In particular, the applied policies try to identify the most vulnerable groups and provide climate change adaption, education and development assistance (Fujita et al. 2013).

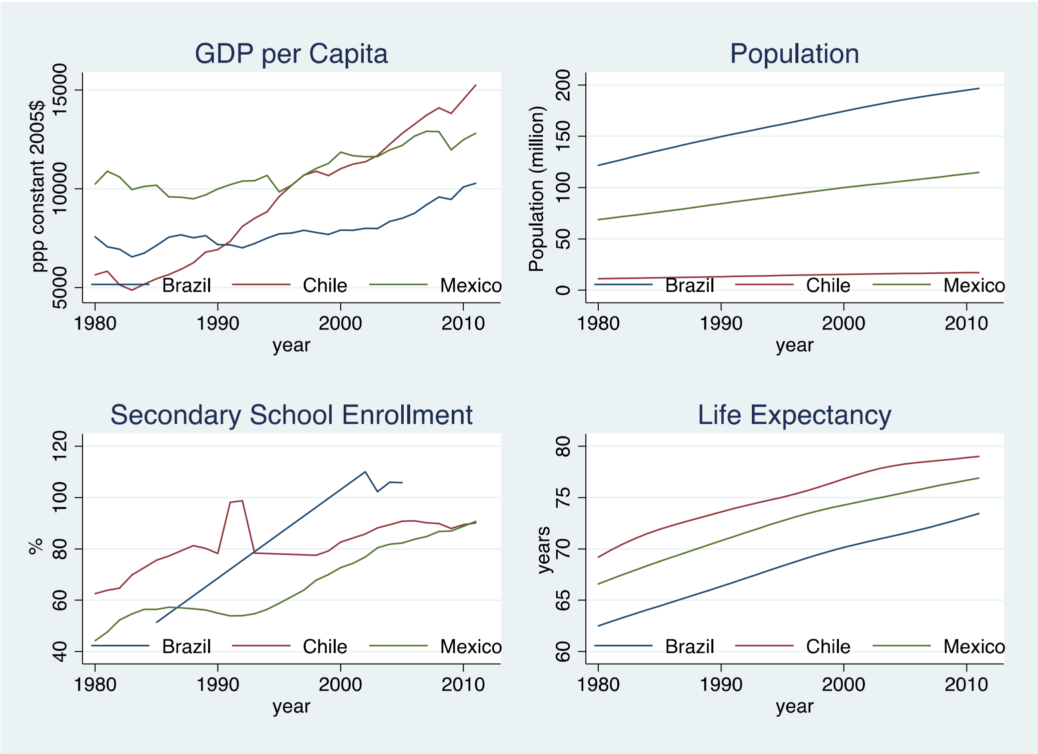
The golden age of growth in Chile, from 1978 to 1997, was mostly achieved through export led growth driven by the mining sector. Since 1990 Chile started to apply and enforce the implementation of environmental policies focusing on a few key sectors, namely mining, energy, agriculture, transport and tourism. The mining sector contributed up to 18 percent of total GDP and around 50 percent of total exports between 2004 and 2008. It is the most capital as well as water and energy intensive sector. Since 1970 Chile has been determined to treat wastewater from the mining industry before discharging it surface waters. Chile is leading in water management and introduced tradable water rights already in 1981. Nevertheless, the total revenues from environmental taxes are still low compared to other OECD countries (OECD 2011).

Mexico turned to a marked driven industrial policy after the crisis in 1982. State preferences for specific industries, as well as subsidies and other distortions, were reduced or eliminated. As a result, Mexico started to diversify its economy and moved from exporting mainly primary products to also focusing on export of manufacturing goods. Since the mid-1980s, the steady increase in trade and foreign direct investment has also generated technological spillovers, especially in the maquiladora industry located on the US border. Car manufactures and electronics are among the main industrial sectors, the latter sector in particular was growing very fast in the 2000s. However, Gallagher & Shafaeddin (2010) find that these technological spillovers are minor and that US firms producing in the Maquiladoras achieve their technological developments mainly outside of Mexico. They further point out that foreign direct investment partially crowded out local investments in research and development. Although the first National Climate Change Strategy was only launched in 2007, Mexico was the first of the three countries to implement policies that promoted the use of renewable energies. It started in 1975 with the Public Electricity Service Law, which main aim was to provide electricity more efficiently and to incorporate the electricity from renewable energies.

1.2 Human Development Indicators

A green economy should contribute to reducing poverty and social inequality. Hence, to achieve sustainable growth human and social progress should also be achieved. Figure 2 shows how the above-mentioned economic policies have influenced socio-economic development. We use four indicators, namely GDP per capita in international dollars, secondary school enrolment rates, life expectancy at birth and population. The first three indicators are commonly known as the basis of the Human Development Indicator (HDI) computed by the United Nations, which define development as progress in the three dimensions of the index: income, education and health.

Figure 2. Socioeconomic Development Indicators



Source: World Bank (2013).

Regarding Figure 2, Chile clearly shows the highest GDP per capita figures with a strong rise since the early 1990s. Mexico and Brazil show instead a moderate growth in GDP per capita. Concerning education, Brazil reached full secondary school enrolment already in 2000; meanwhile Mexico and Chile still show values below full enrolment in 2012.[1] Life expectancy, which is closely correlated with GDP per capita, is the highest in Chile with almost 80 years in 2010 followed by Mexico (77) and Brazil (74). Therewith, we conclude that the progress in human development in the three countries has not only been driven by higher GDP per capita rates, but also by improved educational as well as health standards. Population has been growing steadily in Brazil as well as in Mexico, and at a lower path in Chile. The HDI as a composite index ranges between 0 and 1, with higher values indicating higher levels of development. During the period from 980 to 2012, Brazil improved its HDI by 21 percentage points (from 0.52 to 0.73), Chile's HDI gained instead18 percentage points (from 0.64 to 0.82) and Mexico 17 percentage points (from 0.6 to 0.77). Chile and Mexico's scores are in the range attributed to high human development countries, meanwhile Brazil is still considered to have medium human development.[2]

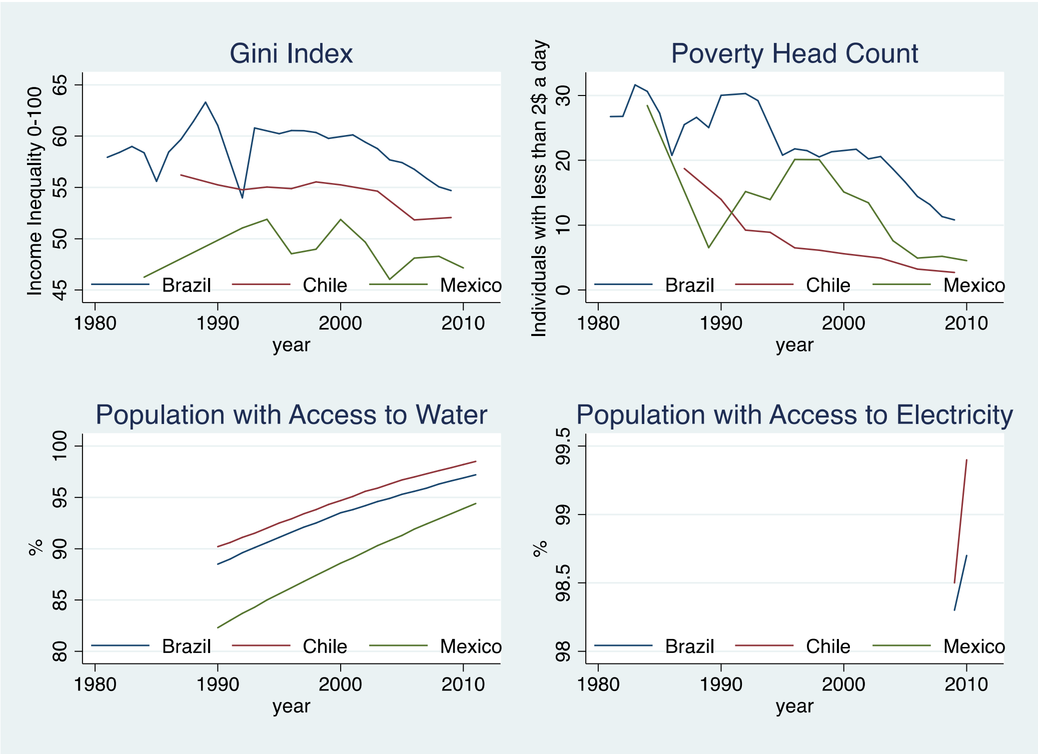
The second important aspect of social development is related to equity and poverty reduction. The upper part of Figure 3 shows the evolution over time of income inequality and poverty rates in the three countries. The Gini index is used as a measure of inequality in levels of income among individuals within a country. A value of 100 indicates total inequality (one individual earns all the income) and a value of 1 indicates total equality (every individual earns the same). As shown in Figure 3, the Gini index of Brazil is the highest among the three countries, with a value of 54 in 2010. Mexico, on the other hand, with an income inequality of 47 is much closer to the OECD average, which is 46. Those differences reflect historic distributions of assets among the population and are a consequence of past policies, which failed to give equal opportunities to the population. Figure 3 also shows that the levels of income inequality have been declining over time in the three countries and that the number of people living with less than 2 international dollars a day also declined drastically since the mid-nineties. This indicates that the social policies from the last two decades also seem to have had an effect on income inequality and poverty levels. Therefore, we can conclude that some of the GDP per capita growth as indicated in Figure 2 has reached poor households. Other important indicators of

[1] The gross enrolment rates can be above 100% since they account for students of all ages. If there is late enrolment or repeaters the number of students can exceed the number of children in that age group in the population.

[2] The data on the human development index is from the United Nations Development Program (UNDP 2013).

socioeconomic development are the access to water and electricity. Figure 3 shows that the access to water has increased substantially since 1990 with Chile reaching almost 100 percent access and Mexico 94 percent. Access to drinking water in the household goes usually in line with access to sanitation and shows large health and environmental benefits. The data on electrification of households is scarce and indicates that almost all households in Brazil and Chile have access to electricity. However, the related literature indicates that remote areas in the three countries still do not have access to electricity.

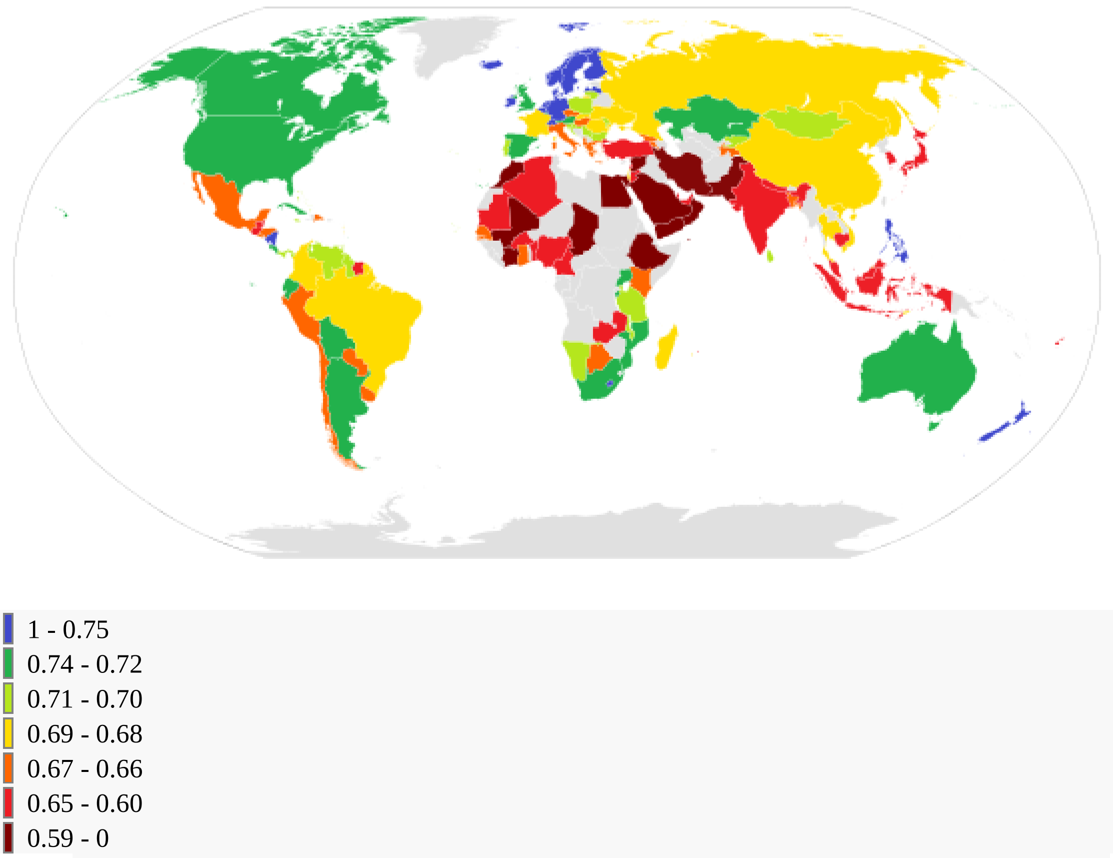
Figure 3. Poverty and Capability Measures



Source: World Bank (2013).

In terms of the Human Opportunity Index (HOI, World Bank), which measures how personals circumstances impact children's probability of accessing the necessary services to success in life, Chile (95 percent) and Mexico (90 percent) have the highest overall HOI in Latin America, being first and third in the LA ranking, whereas Brazil lyes behind (78 percent). In all three countries there have been moderate improvements over the last decade. Finally, the Global Gender Gap Index (Figure 4), which measures the percentage of the inequality between women and men that has been closed in access to resources and opportunities, indicates that the three countries have made some progress in closing this gap in the last seven years, with Brazil been slightly better positioned (0.69 in 2012, place 62 in the ranking of 135 countries) than Mexico (0.67) and Chile (0.66).

Figure 4. **Global Gender Gap**



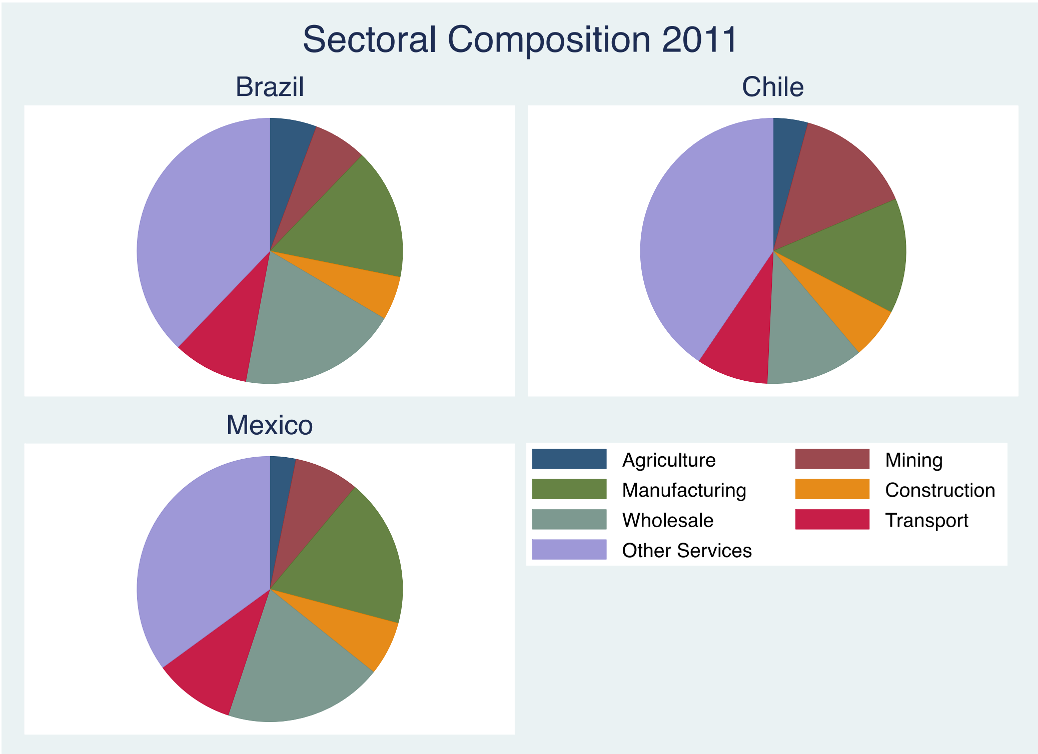
Note: The highest possible score is 1 (equality) and the lowest possible score is 0 (inequality). Source: World Economic Forum (2013).

Summarizing, in terms of human development the situation of the three countries is as follows. Whereas Chile is the country with the best performance, Mexico has also performed well and both countries are classified as highly human-developed countries. On the other hand Brazil, which has also improved in several aspects, especially in decreasing poverty and inequality rates and in closing the gender gap, is still classified as medium human-developed country in terms of its HDI rating.

1.3 Main Economic Sectors and Environmental Concerns

Generally during the development process a country passes through a stage in which the agricultural sector is prevailing, followed by industrialization with a growing manufacturing sector and reaching later on a post-industrialization stage with a strong service sector. We present a more disaggregated look into the composition of the sectoral value added for each country in Figure 5. More specifically, the mining sector is shown separately and the service sector is decomposed into wholesale, construction, transport and other services. The wholesale sector includes retail trade, restaurants and hotels. The main difference between the three countries is the larger share of the mining sector and smaller share of the wholesale and manufacturing sectors in Chile in comparison to Brazil and Mexico.

Figure 5. Sectoral Value Added to GDP in 2011



Source: UNSTAT (2013).

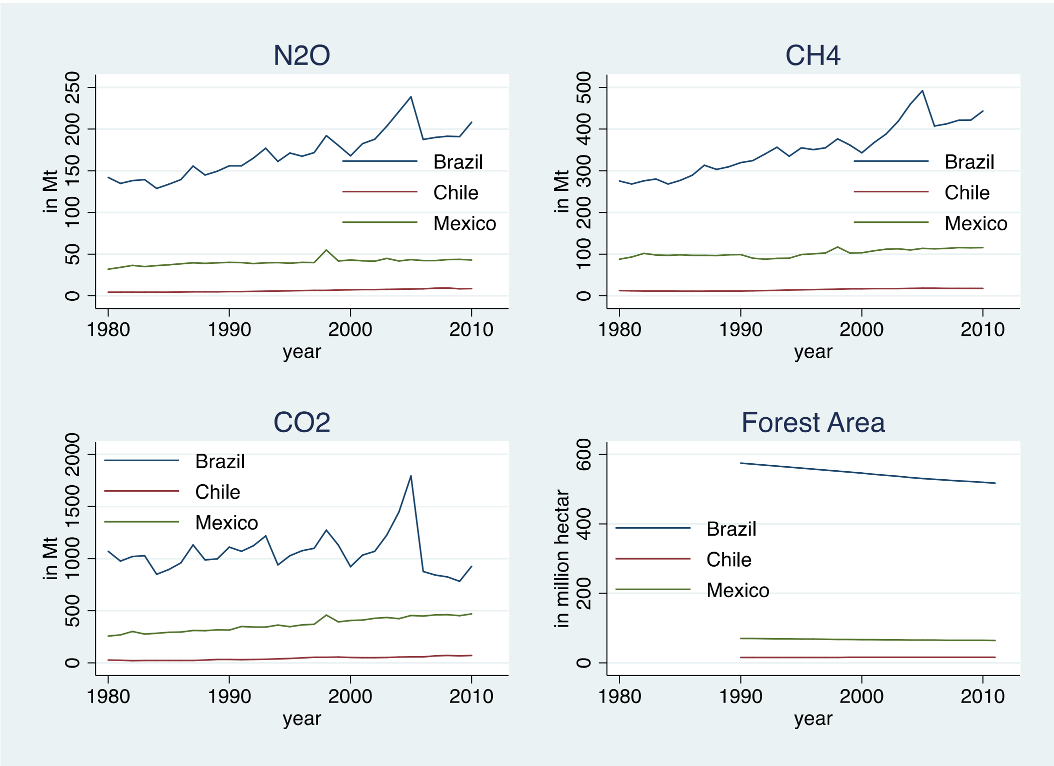
The socio-economic importance of each specific sector could be measured with the number of people employed. In Brazil the largest sector is “other services[3]”, which accounted for around 30.3 million formal jobs (33 percent) in 2007, followed by the wholesale sector, which accounted for almost 20 million employees (22 percent), agriculture with 16.6 million jobs (18 percent) and manufacturing with 13.1 million jobs (14 percent). Mining, which creates about 10 percent of value added, occupies 379000 (0.4 percent) employees. Also in Chile, the largest employer is “other services” with almost 2.5 million employees (37 percent of total employment) in 2008

[3] Other services main categories are: Financing, insurance, real state, education, information and communication and business services.

followed by wholesale with 1.3 million employees (20 percent), manufacturing with 865000 employees (12 percent) and agriculture with 790000 employees (12 percent). Only 1.5 percent of the employees work in the mining sector. Finally, in Mexico the picture is slightly different, with the wholesale sector accounting for 12.8 million employees (30 percent), followed by other services with 12 million jobs (27 percent), manufacturing with 7.2 million jobs (17 percent) and agriculture with 7.6 million jobs (13 percent).

Figure 6 shows the development of three major green house gases and forest area in the three countries. Brazil the biggest economy of the three countries has the highest emissions from N_2O, CH_4 and CO_2. The data on CO_2 emissions is the most volatile in comparison with other greenhouse gases, mainly because CO_2 emissions are highly correlated with GDP. CH_4 and N_2O are mainly omitted by agricultural activities such as the use of fertilizers.

Figure 6. Sectoral Composition of the three Economies



Source: (EDGAR 2013; FOASTAT 2013).

Figure 6 shows that over time green house gas emissions have been steadily rising over time, fact that should raise environmental concerns. Also an alarming signal comes from the forest area measure for Brazil and Mexico, where loses in forest area of 10 and 8 percent, respectively are shown in the last two decades, whereas in Chile an increase in 7 percent has been observed.

2 Methodology

The methodology section is structured as follows. First, section 2.1 presents a more detailed selection of green growth indicators that will be used to identify the sectors with greater potential for green growth by country. Second, section 2.2 presents the model specification for the regression analysis including all Latin American countries, whose results will be presented in section 3.

2.1 Green Growth Indicators: Measurement and Analysis

Until very recently green growth publications have mainly dealt with specific issues related to climate change and with assessing the efficiency of environmental policy instruments. Currently, the related discussion goes beyond the above-mentioned aspects and covers taxation, eco-innovations, public infrastructure, and access to clean water as well as resource efficiency. Therefore, new analytical tools are needed to integrate the use of natural resources into productivity measurement and growth models in order to develop new methods to assess environmental impacts. This evolution is also reflected in the “green models” followed by Brazil, Chile and Mexico in recent years.

2.1.1 Selection of indicators

In this section we present a number of indicators to measure progress in green growth in each country and analyze their evolution over time. We partly follow the framework proposed by the Green Growth Knowledge Platform (GGKP) in 2013. GGKP is a global network created with the main aim of identifying and addressing the major knowledge gaps concerning green growth in theory and practice. It was launched in Mexico in 2012 by the OECD, United Nations Environment Program (UNEP), the World Bank and the Global Green Growth Institute (GGGI). Its Green Growth Knowledge Platform Scoping Paper (GGKPSP 2013) proposes a common approach on green growth indicators based on the knowledge already accumulated by the GGKP members since 2009, when the UNEP took a leading role in the promotion of “green growth” with its Policy Brief “Global New Deal”.

The main characteristics that green growth indicators have to fulfill according to the GGKP are: to be dynamic and flexible; to cover the main areas of concern at the country level but also at a global level; and to allow for the evolution or addition of new indicators. Furthermore, indicators should be selected based on transparent criteria and should be available from reliable sources. The set of categories covered can be classified into 5 categories, namely: *natural asset base*; *environmental life quality*; *environmental and resource productivity indicators*; *economic opportunities* and policies; and *social (well-being) indicators*. We compare a number of indicators from each category across the selected countries. Some of them will be selected for our IPAT analysis in the next section. The selection criteria are availability and relevance.

First, as indicators of the *natural asset base* we present forest resources, land resources and water resources, as well as the percentage of threatened species, as a measure of diversity. Table 1 shows the average values of a list of available indicators. Brazil has the highest percentage of forest area (61 percent in 2011, equivalent to 5.17 million km^2) with a decline of 10 percent over the period 1990 to 2011, followed by Mexico (646 thousand km^2), which also experienced a decline of the forest area of about 8 percent. Whereas, Chile’s forest area (around 20 percent, 163 thousand km^2), has increased over the period (7 percent). In Mexico pasture and cropland represent more than 50 percent of the total land, with other land showing the highest percentage in Chile (58 percent). In Brazil pasture, cropland and arable land represent around 30 percent of all available land.

Table 1. Natural Assets, Environmental Life Quality and Biodiversity

Period: 1990-2011	**Average**			**Change**		
Indicator	**Brazil**	**Chile**	**Mexico**	**Brazil**	**Chile**	**Mexico**
GG_C12: Renewable freshwater, thousand m3 per capita	-	62.8	4.1	-	-24%	-26%
GG_C13: Total freshwater abstraction, thousand m3 per capita	0.3	2.0	0.6	-	-	-
GG_C41: Arable and cropland, % total land area	8.1	3.0	14.1	38%	-42%	7%
GG_C42: Pasture, % total land area	22.8	18.0	39.8	6%	9%	-3%
GG_C43: Forest, % total land area	64.6	21.2	34.6	-10%	7%	-8%
GG_C44: Other land, % total land area	4.5	57.8	11.6	81%	-2%	31%

GG_C51: % Threatened species – Mammals	-	25.1	35.0	-	-	-
GG_C52: % Threatened species – Birds	-	10.9	21.9	-	-	-

Source: OECD Statistics (2013)

Concerning *environmental life quality*, Chile is relatively rich in fresh water resources in comparison to Mexico; whereas this indicator is not available for Brazil. Regarding biodiversity the percentage of threatened species is considerably higher in Mexico than in Chile, and unfortunately, the data from the OECD is only available for a single year and is missing for Brazil. In addition, according to World Bank data, the number of threatened fish (mammals) species is 83 (81) in Brazil, 20 (20) in Chile and 152 (100) in Mexico. The World Bank also provides data on the benefits index for biodiversity (from 0= no biodiversity potential to 100=maximum). Brazil's rating is 100, with the maximum potential, followed by Mexico with a value of 69 and Chile with 15. Out of the first two categories we will use forest area as an indicator for the economic model estimated in the next sub-section.

Table 2 shows *environmental and resource productivity and intensity indicators* (category 2). We mainly focus on emissions productivity/intensity, energy and non-energy material productivity as well as the supply of renewable energy. The first indicator, production-based CO_2 emissions show a decrease in Brazil, but an increase in Chile (25 percent) and Mexico (5 percent). Concerning intensity indicators, emissions intensity has almost doubled in Brazil and Chile and increased by 17 percent in Mexico. At the same time, energy intensity has increased in the three countries. Regarding productivity, production based indicators measure the total amount of CO_2 emitted during production processes relative to GDP,demand-based indicators measure instead the CO_2 embedded in final domestic demand (CO_2 footprint) and therefore also consider the effect of international trade. Production-based CO_2 productivity shows a slight decrease in Brazil and a slight increase in Chile and Mexico. In contrast, demand-based CO_2 productivity has remained stable and at similar levels in the three countries. Material productivity is the highest in Mexico and the lowest in Chile and it has sharply increased over time in Brazil and moderately in Mexico but decreased in Chile. In contrast, energy productivity has slightly decreased in Brazil and increased in Chile and Mexico, but stays at similar levels in the three countries. In terms of renewable energy supply, it represents more than 40 percent of total energy supply in Brazil, but only around 22 and 10 percent respectively in Chile and Mexico. Renewable electricity represents more than 80 percent of total electricity generation in Brazil in contrast to 40 and 18 percent in Chile and Mexico. Hence, in the later two countries there is potential to increase these percentages to higher levels.

From this category, production based CO_2 emissions, will be used in the empirical analysis, since it is available for all LA countries and over time.

Table 2. Environmental and Resource Productivity

Period 1990-2010	**Brazil**		**Chile**		**Mexico**	
Indicator	Aver.	change	Aver.	change	Aver.	change
GG_B11: Production-based CO2 emissions, index 1990=100	91.37	-8.17	118.12	25.63	102.55	4.94
GG_B12: Production-based CO2 productivity, US$ per kg of CO2	5.05	-8.14	3.32	26.52	3.30	4.97
GG_B13: Production-based CO2 intensity, tonnes per capita	1.68	51.13	3.23	72.88	3.47	17.78
GG_B14: Demand-based CO2 productivity, real net national income per unit of CO2	2.37	-2.41	2.69	-	2.72	1.87
GG_B21: Energy productivity, US$ per ktoe	7.51	-3.26	7.11	28.59	7.58	13.49
GG_B22: Energy intensity, toe per capita	1.12	42.71	1.50	70.75	1.52	8.90
GG_B26: Renewable energy supply, % TPES	43.09	-6.14	25.99	-21.01	11.29	-19.85
GG_B27: Renewable electricity, % total electricity generation	90.00	-10.35	53.81	-24.98	20.30	-28.72
GG_B32: Non-energy material consumption - DMC, 1990=100	117.23	39.23	205.69	212.94	116.03	37.06
GG_B33: Non-energy material productivity, US$ per kg	0.62	5.08	0.39	-26.67	1.32	10.57

Source: OECD Statistics (2013)

As *economic opportunities* and *policy responses*, a number of proxies for innovation and environmental policies are shown in Table 3. Brazil is the leader in terms of green patents, showing an impressive increase in 2005 and 2010. Unfortunately this indicator is not available for Chile and Mexico, for which only the percentage of green patents as a share of total patents is shown. Patents in renewable energy represent around 2 percent of total number of patents in Brazil and 1.75 in Mexico, but less than 1 percent in Chile, a country which has been more active with innovations in the water pollution sector since 2010. It is worth noting that expenditure on R&D was only 1.1 percent in Brazil in 2010 (compared with only 0.37 in Chile in 2008 and 0.40 in Mexico in 2010), significantly below the OECD average. As regards environmental policies, total environmental taxes as a percentage of GDP shows the highest value in Brazil (more than 3 percent) and the lowest in Mexico, with Chile collecting around 1 percent of its GDP in environmental taxes. The values in Brazil are the closest to the OECD average of 3 percent. In comparison to labor taxes, environmental taxes account for a similar percentage of GDP in Chile. In Mexico labor taxes represent only 0.25 percent of GDP and are higher than environmental taxes (which show negative values in 2006-2008 and 2010-2011). This negative revenue is due to the structure of the existent fuel tax, which is levied inversely to oil prices and therefore turns into expenditures above a certain level. We will not be able to use indicators in this section in the economic model because they are only available for a limited number of years and their incidence (e.g. patents) is still very low.

Table 3. Innovation and Environmental Policy Indicators

Average 1990-2010			
Indicator	**Brazil**	**Chile**	**Mexico**
GG_E13: Public spending in environmentally related RD, % total public spending	-	-	1.366
GG_E17: Green Patents, Index 1990=100	720.5	-	-
GG_E19: Patents - Electric and hybrid vehicles, % total PCT patents	0.072	0	0.106
GG_E110: Patents - Energy efficiency in buildings and lightning, % total PCT patents	0.114	0	0.116
GG_E111: Patents - Renewable energy, % total PCT patents	0.998	0.196	0.65
GG_E112: Patents - Air pollution, % total PCT patents	0.962	0.244	0.522
GG_E113: Patents - Water pollution, % total PCT patents	0.874	0.782	1.374
GG_E114: Patents - Waste management, % total PCT patents	1.904	0.516	1.254
GG_E41: Total environmentally related taxes, % GDP	2.264	1.038	-
GG_E42: Labour taxes, % GDP	-	1.362	-

Source: OECD Statistics (2013)

Finally, we present a number of *socio-economic or well-being indicators* that depart from the use of GDP per capita as the only indicator and move towards measures related to sustainability and the quality of growth. The better life index is part of the

Better Life Initiative (LBI). This index has been constructed following the approach proposed by Stiglitz et al. (2009), which distinguishes between current wellbeing and its sustainability over time and includes environmental related aspects. It is planed that future work will also include inequality indicators. The ranking of OECD countries indicates that Chile and Mexico have very low scores (0.37), and are only better placed than Turkey (0.23). Although Brazil is not included in the overall score, it is ranked according to a single indicator.

Table 4 present the values of the different categories used to compute the index for the three countries under study, as well as the average score for OECD countries. A total of 11 categories are listed, which refer to different aspects related to the quality of life. In recent years the quality of life of its citizens has improved in Brazil, which reflected by the value of the “life satisfaction” indicator. Indeed, Brazilian life satisfaction is slightly above the average OECD value and the value for Chile is slightly below, with Mexico showing a higher value. However, in terms of net adjusted disposable income Brazil is far below the OECD average and also Chile’s and Mexico’s values are half than the OECD average. In terms of housing facilities, the percentage of dwellings without basic facilities (access to an indoor flushing toilet) is very high in Chile and Brazil. Mexico’s value is still twice as high as the OECD average, hence there is potential for improvement. Concerning jobs, 68 percent of the population in Brazil have a paid job (80 percent for men compared to 56 percent for women), whereas in Mexico’s and Chile’s the employment rate is lower and below the OECD average. Long-term unemployment rates are lower in the three countries than the OECD average and personal earnings are close to the bottom of the earning distribution in OECD countries, especially in Mexico. The quality of the support network measures the percentage of people that believe to know someone they could rely on in time of need. A weak social network is reported for Mexico, whereas Brazil shows the highest percentage close also to the OECD average.

In terms of education attainment, which measures the percentage of adults with a high-school degree, Mexico and Brazil present very low numbers, whereas Chile is close to the OECD average, hence room is left to improve education in the first two countries. Indeed, in Mexico around 60 percent of the population aged 25 to 64 have not completed upper secondary education.

The quality of local living environment is measured with two indicators. First, using PM_{10} concentrations as a proxy for local air pollution, which are highly above 20 micrograms per cubic meter (annual guideline limit set by the World Health Organization) in Chile and Mexico, with Brazil showing a lower level (19). Second, the indicator "access to clean water", which is basic for human well-being, measures the percentage of people that are satisfied with water quality in each country, with Brazil showing the lowest percentage and Chile and Mexico also with values below OECD average.

Civil engagement is the highest in Mexico when measured by the consultation on rule-making indicator, which is based on a composite index that comprises information on the openness and transparency of a consultation process. However, Chile shows the lowest score in the sample of countries and also Brazil shows a low score. In contrast, in terms of voter turnout Mexico shows a value of 63 percent, well below the values observed for Chile (88) and Brazil (78), both above the OECD average (72).

Table 4. Socio-economic Indicators: Better Life Index Indicators

Measure	**Indicator**	**Country**			
		Chile	**Mexico**	**Brazil**	**OECD**
Housing	Dwellings without basic facilities	9.4	4.2	6.7	2.2[a]
	Housing expenditure	18	18	21[a]	21[a]
	Rooms per person	1.3	1	1.4[a]	1.6[a]
Income (USD)	Household net adjusted disposable income	11039	12732	10225[a]	23047[a]
	Household net financial wealth	16972	9946	5861[a]	40516[a]
Jobs	Employment rate	61	60	68	66
	Job security (% of temporary contracts)	10.5 [a]	21.4	14	10.5
	Long-term unemployment rate	2.94 [a]	0.11	3.02[a]	3.14
	Personal earnings (USD)	15820	9885	10905[a]	34466
Education	Educational attainment (% with High-school)	71	36	41	74
	Student skills	439	420	401	497
	Years in education	16.2	14.9	16.3	16.5

Environment	Air pollution (PM10 concentrations)	53	33	19	21
	Water quality (% of people satisfied)	77	78	75	84
Civic engagement	Consultation on rule-making (index)	2	9	4	7.3
	Voter turnout (%)	88	63	78	72
Community	Quality of support network	82	76	88	90

Note: * denotes estimated values. Source: OECD Statistics (2013).

Table 4. Socio-economic Indicators: Better Life Index Indicators Continued

Measure	**Indicator**	**Country**			
		Chile	**Mexico**	**Brazil**	**OECD**
Health	Life expectancy	78.3	74.2	73.5	79.8
	Self-reported health	59	66	69[a]	69
Life Satisfaction	Life satisfaction	6.5	7.3	6.7	6.6
Safety	Assault rate (% of people assaulted, last 12 months from Gallup World Poll)	8.3	13.1	7.9	4
	Homicide rate (murders per 100,000 inhabitants)	3.7	23.7	21	2.2
Work-Life Balance	Employees working very long hours (% of employees working more than 50 hours per week)	16.32	28.63	12.5	8.76
	Time devoted to leisure and personal care (hours per day)	13.66[a]	12.66 [a]	14.84 [a]	14.87 [a]

Note: * denotes estimated values. Source: OECD Statistics (2013).

Aslo health indicators are considered to construct the better life index. Among them are life expectancy and self-reported health, the later indicating that about 59 percent of adults in Chile say their health is good or very good. Values closer to the OECD average are reported in Mexico and Brazil. Safety is a great matter of concern in Mexico with extremely high rates of assault (more than 3 times the OECD average) and homicide (more than 10 times the OECD average), the later being also very high in Brazil. Finally, regarding work-life balance indicators, nearly 29 percent of the employees work very long hours in Mexico, in contrast to only 16 and 12 in Chile and

Brazil and and 8 on average in OECD countries. In terms of time devoted on other activities, the three countries are closer to the OECD average. Although we are fully aware of the importance of well-being indicators that depart from the use of GDP per capita, we are constrained to use GDP per capita in our empirical analysis as a proxy for wellbeing due to insufficient data across countries and over time in the abovementioned “new proposed” socio-economic indicators.

2.2 Determinants of Environmental Indicators in LA Countries

Before looking at each country separately we use data on 19 Latin American countries between 1980 and 2012 to estimate the abovementioned IPAT model that explains the determinants of a number of environmental indicators (see Table A. 1 in the appendix for a list of countries). The data on GDP, and sectoral composition of the countries is taken from the World Development Indicators (World Bank 2013). Green house gas emissions CO_2, NO_2, and CH_4 and forest area from the Edgar Database and FAO (FOASTAT 2013; EDGAR 2013). Value added for each sector (Agriculture, Forestation and Land Use; Construction; Energy; Industry and Transport sector) comes from UNSTAT (United Nations Statistics Division 2013). Summary statistics of the data are shown in Table A. 2 in the appendix.

2.2.1 Model specification and estimation technique

We estimate a model based on the IPAT equation and apply a regression analysis to determine the relative importance of the drivers of environmental impacts. Green house gases namely CO_2, N_2O, CH_4 are taken as indicators of environmental pollution and forest area is taken as an indicator of sustainability. The choice of the three green house gases was made in the light of global warming and the preparation of the NAMAs. Since the share of renewable energy is still considerably low, the three countries could be considered as fossil fuel based economies. The goal in the next years is to reduce emission intensity in order to mitigate climate change and in order move towards a more efficient economy by promoting green growth.

The regression model builds on the IPAT equation by York et al. (2003), which attributes an environmental impact to its major sources of origin, namely changes in the size of the population, changes in affluence, which is referred to as GDP or as value added of the specific sector, and changes in the technology. Originally, the model was formulated as an identity and later it was reformulated in stochastic terms

(STIRPAT) to be able to test hypothesis. The main model specified in natural logs is given by:

$$\ln EnvInd_{ikt} = \alpha_i + \lambda_t + \beta_1 \ln POP_{it} + \beta_2 \ln VA_{ijt} + \beta_3 \ln \mathrm{EE}_{\mathrm{it}} + \beta_4 \ln \mathrm{X}_{\mathrm{it}} + \varepsilon_{ikt} \quad (1)$$

where $lnEnvInd_{it}$ is the natural logarithm of a given environmental indicator k. Here k denotes $CO_{2,}$, CH_4, N_2O emissions in kilo tons or forest area in hectares of country *i* in year *t*. α_i and λ_t are country and year-specific effects that control for unobservable country heterogeneity and common time-varying effects that could affect emissions. The population variable POP_{it} is measured by the number of inhabitants. VA_{ijt} represent the value added of sector j, where j=1,…4 (AFOLU=Agriculture, Forestation and Land Use; Construction; Industry and Transport sector) measured in constant 2005 US$ respectively. EE denotes energy efficiency measured as GDP per unit of energy use (GDP ppp constant 2005 per kg). X denotes other control variables, namely the level of urbanization and level of openness ((exports+imports)/GDP), which could influence in particular CH_4, N_2O and deforestation. Finally, ε_{ikt} is the error term that is assumed to be independent and identically distributed.

3 Main results

Table 5 presents the results from the regression analysis. In column 1 the dependent variable is total CO_2 emissions in the classic IPAT approach. While changes in population do not affect CO_2 emissions from fossil fuels in LA countries, changes in the affluence variable and in energy efficiency do significantly influence a the impact variable. More specifically, a rise of GDP by 10 percent contributes on average to an increase of CO_2 emissions by 11 percent. The average effect of a rise in energy efficiency of 10 percent is related to a decrease in emissions by 3.9 percent, which is only below the increase of CO_2 caused by increasing GDP. In column (2) the results for CH_4 are presented, showing that increasing population is associated to lower levels of CH_4 emissions and that changes in GDP are not associated to changes emissions. Whereas increases in energy efficiency are related to lower emissions, given that an increase of 10 percent in energy efficiency reduces emissions by 2.4 percent, emissions of CH_4 increase with urbanization and decrease with openness. When the model is estimated for N_2O, the results in column (3) indicate that whereas affluence is contributing less than proportionally to higher N_2O emissions, higher urbanization decreases these types of emissions. Finally, concerning deforestation, the model indicates that the level of forest area decreases with urbanization and with openness and is positively associated to population increases.

Table 5. Aggregate Results for Environmental Indicators

VARIABLES	(1) Ln CO_2	(2) Ln CH_4	(3) Ln N_2O	(4) Ln FOREST
Ln POP	-0.544	-1.148***	0.356	0.260**
	[0.492]	[0.337]	[0.241]	[0.118]
Ln GDP	1.101***	0.135	0.280***	0.00964
	[0.187]	[0.129]	[0.102]	[0.00628]
Ln EE	-0.387***	-0.241**	-0.0274	-0.00537
	[0.146]	[0.0992]	[0.0866]	[0.00335]
Ln Urban		0.799**	-0.619**	-0.538***
		[0.379]	[0.270]	[0.109]
Ln Open		-0.0842*	-0.0227	-0.00476**
		[0.0476]	[0.0462]	[0.00208]
Constant	-7.757**	24.84***	3.156	6.873***
	[3.085]	[2.164]	[2.493]	[0.0320]
R-squared	0.586	0.483	0.388	0.422
Observations	566	566	566	378
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets).

In a next step we estimate similar equations for sectoral emissions and sectoral value added. Table 6 shows the results for CO_2 emissions coming from each sector of economic activity. Results in Table 6 indicate that an increase in value added in the Agriculture, Forestation and Land Use sector reduces emissions of CO_2, whereas population and energy efficiency are not significantly affecting CO_2 emissions. As regards the construction sector, an increase of 10 percent in its value added increases emissions of this pollutant by 3.4 percent, whereas for industry and transport sectors the corresponding increase is 8.3 and 4.2 percent respectively. Increases in energy efficiency only appear to reduce emissions from the industry sector more than proportionally.

Table 6. Determinants of Sectoral Emissions (CO_2)

	(1)	(2)	(3)	(4)
		Ln CO_2 by Sector		
VARIABLES	AFOLU	Construction	Industry	Transport
Ln POP	2.110	0.224	-0.0883	1.372***
	(1.572)	(0.774)	(0.586)	(0.447)
Ln VA	-0.501**	0.339**	0.833***	0.425***
	(0.237)	(0.154)	(0.113)	(0.0850)
Ln EE	0.129	-0.262	-1.037***	-0.0774
	(0.389)	(0.305)	(0.277)	(0.174)
Constant	-15.00	-3.625	-7.324	-22.27***
	(23.58)	(12.40)	(9.751)	(7.298)
Observations	585	585	585	585
R-squared	0.115	0.590	0.755	0.885
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets).

Table 7 shows the sectoral results for CH_4, which indicate that energy efficiency mainly reduces emissions of this gas in the construction and industry sectors, whereas population increases only foster emissions in the transport sector and indeed, more than proportionally. As before, an increase in value added of the industry sector is associated to higher emissions, although the elasticity is lower than for CO_2.

Table 7. Determinants of Sectoral Emissions (CH_4)

	(1)	(2)	(3)	(4)
	Ln CH_4 by Sector			
VARIABLES	AFOLU	Construction	Industry	Transport
Ln POP	0.175	0.0520	-0.0661	2.044***
	(0.539)	(0.863)	(0.365)	(0.654)
Ln VA	0.119	0.0286	0.278**	0.259
	(0.111)	(0.129)	(0.107)	(0.180)
Ln EE	0.216	-0.542*	-0.441***	0.197
	(0.190)	(0.307)	(0.152)	(0.307)
Constant	5.619	5.871	3.333	-30.96**
	(8.868)	(14.31)	(5.613)	(10.81)
Observations	585	585	585	585
R-squared	0.114	0.081	0.913	0.617
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets). Other control variables, urban, open where not statistically significant in any regressions and are therefore not included in the model explaining sectoral emissions.

Finally, Table 8 show the sectoral results for N_2O emissions, for which increases in value added in the industry and transport sectors are associated with higher N_2O emissions on the industry and transport sectors, but not in construction and agriculture and population increases are also associated to higher emissions, but only in the transport sector.

Table 8. Determinants of Sectoral Emissions (N_2O)

	(1)	(2)	(3)	(4)
	Ln N_2O by Sector			
VARIABLES	AFOLU	Construction	Industry	Transport
lnPOP	-0.218	0.210	-0.0345	1.935***
	(0.475)	(0.733)	(0.358)	(0.350)
lnVA	0.148	0.0699	0.506**	0.461***
	(0.117)	(0.119)	(0.190)	(0.115)
lnEE	-0.0956	-0.485	-0.0731	0.269
	(0.118)	(0.288)	(0.152)	(0.212)
Constant	12.17	1.706	-5.291	-27.44***
	(7.571)	(12.15)	(3.693)	(5.884)
Observations	585	585	585	585
R-squared	0.285	0.087	0.469	0.792
Number of cid	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets). Other control variables, urban, open where not statistically significant in any regressions and are therefore not included in the model explaining sectoral emissions.

To summarize, on the one hand we find that population growth mainly contributes to the increase in green house gases in the transport sector, whereas a rise in sectoral value added contributes to increasing emissions of N_2O and CO_2 not only from the transport sector from but also from the industrial sector.. On the other hand, increases in energy efficiency are associated with reductions of CO_2 and CH_4 in the industry sector.

The analysis shows that policies regarding energy efficiency can have different effects depending on the sector and on the pollutant they are targeting. The industrial sector can contribute most to GHG reductions when policies target energy efficiency. Nevertheless, strengthening value added from the agricultural sector relative to the other sectors does also contribute to lower CO_2 emissions. The analysis further shows that it is not straightforward to quantify the green growth potential of a specific policy measure as the ones listed in the following chapter. The effects can be manifold. Policies enforcing the use of renewable energy such as biofuel can have a positive impact on a countries overall CO_2 emissions due to the use of alternative fuels rather than fossil fuels. Still, the production of biofuels goes in line with other pollutants and an intensified use of fertilizers, which again are the source of GHGs. In the analysis at hand energy efficiency policies show the highest potential for green growth in terms of reducing different GHGs. Nevertheless, policies have to be evaluated in case by case studies taking into account the specific prerequisites of the countries.

After examining the effect of different activities on the four indicators, we outline in the next section the current policies in each country. Later we discuss their strengths and weaknesses before pointing to options to improve those policies.

4 Diagnosis of the Green Growth Sectors by Country

In this Section we first present national-level green policies that have been pursued in each country under study in the recent past and also make an attempt to relate the results obtained in the previous section to evaluate the effectiveness of these policies.

4.1 Brazil

4.1.1 Identification of Green Policies

The corner stone of Brazil's green policies is its 2008 National Climate Change Plan, which aims to promote sustainable development through mitigation and adaption, the reduction of vulnerability and impact, research and development as well as human capital development. Table 9 summarizes the main green policies in Brazil since

1996. One of the main mitigation options is a high use of renewable energy in the energy production and the use of bio diesel in the transportation sector. Brazil has implemented several market-based mechanisms, starting with electric power auctions for biomass in 2008 and for wind in 2009. Brazil was one of the first countries to demand the addition of biodiesel in vehicle fuel.

Currently, Brazil has a total primary energy consumption of 10,055.1 PJ, of which renewable energy amount to 4,606.7 PJ. Due to large hydro power plants such as Iguaçu, Brazil has a very high share of renewable energies (45.8 percent). The country has a target of 16 percent of electricity generation from renewables by 2020, without taking large hydro power plants into account. Furthermore, Brazil aims to extend its wind energy capacity to 11.5 GW, its biomass-fired energy capacity to 9.2 GW and its small hydro capacity to 6.4 GW by 2020 (IRENA 2013).

Table 9. Green Policies in Brazil

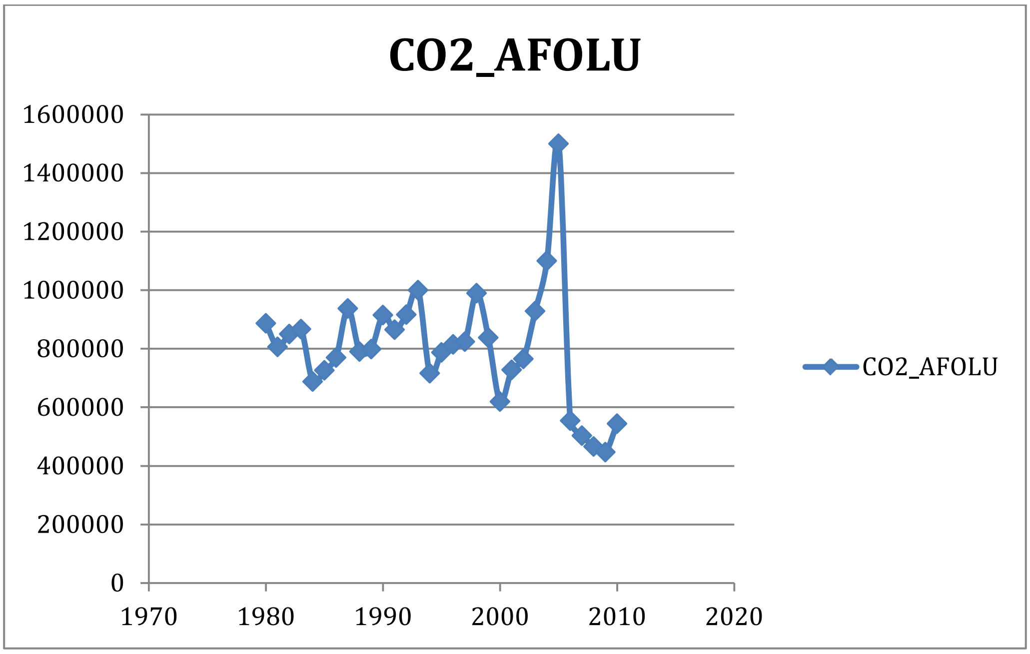
Title	Year	Policy Type	Policy Target
Agriculture and Livestock Plan	2010	Policy Support, Strategic planning,	Reduce CO_2 for agriculture by 4.9 to 6.1 % by 2020
2010-2019 Plan for Energy Expansion	2010	Economic Instruments, Direct investment, Infrastructure investments, Policy Support, Strategic planning	Multiple RE Sources
Electric power auctions - Wind	2009	Regulatory Instruments	Wind, Onshore
Climate Change Policy	2009	Green House Gas Reduction Policy	Green House Gas reduction of 36.1 to 38.9 of projected emissions by 2020
Mandatory Biodiesel Requirement	2008	Regulatory Instruments, Other mandatory requirements, Regulatory Instruments	Bioenergy, Biofuels for transport
Brazil National Climate Change Plan	2008	Policy Support, Strategic planning	Wind, Solar Thermal, Solar, Solar photovoltaic, Multiple RE Sources, Hydropower, Bioenergy, Bioenergy, Biofuels for transport
Electric power auctions - Biomass	2008	Regulatory Instruments	Bioenergy, Biomass for power
India-Brazil-South Africa Declaration on Clean Energy	2007	Public Voluntary Schemes	Multiple RE Sources
Luz para Todos (Light for All) electrification program	2003	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Loans, Policy Support	Multiple RE Sources, Power, Multiple RE Sources

Program of Incentives for Alternative Electricity Sources - PROINFA	2002	Economic Instruments, Market-based instruments, Green certificates, Fiscal/financial incentives, Loans, Economic Instruments, Fiscal/financial incentives, Grants and subsidies, Regulatory Instruments, Other mandatory requirements, Regulatory Instruments, Obligation schemes	Wind, Bioenergy, Biomass for power, Hydropower
Integrating Environmental Strategies	2000	Policy Support, Research, Development and Deployment (RD&D)	
National Rural Electrification Program	1999	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Loans	Multiple RE Sources, Power, Multiple RE Sources, CHP
Interministerial Commission on Climate Change (CIMGC)	1999	Information and Education, Advice/Aid in Implementation, Policy Support, Institutional creation, Policy Support, Strategic planning, Research, Development and Deployment (RD&D)	Multiple RE Sources, All
National Program for Energy Development of States and Municipalities - PRODEEM	1996	Policy Support, Economic Instruments, Fiscal/financial incentives, Grants and subsidies	Solar, Solar photovoltaic

Source: IRENA (2013) and (Fujita et al.2013).

A large share of Brazil's green house gas emissions originates from its agricultural sector and from deforestation. The Agriculture and Livestock Plan from 2010 aims at reducing CO_2 emissions from agriculture by 4.9 to 6.1 percent by 2020. Our analysis from section 3 shows that CO_2 emissions from Brazil's agricultural sector are actually declining with rising value added from this respective sector. All the other sectors in the analysis show a positive relationship between value added and the respective emissions. According to the results of our model, higher share in value added from the agricultural sector is associated to lower CO_2 emissions. This result shall not indicate that to de-industrialize is desired. It should rather indicate that, when countries are industrializing more, they should take advantage of the leapfrogging options they might have with modern technology. This result only holds for CO_2 emissions. For CH_4 emissions, which are mainly originated from the agricultural sector we do not find a significant relation between value added in agriculture and these emissions, the same is true for N_2O. To validate this result, the next figure shows the evolution of CO_2 emissions from the agricultural sector in Brazil. The graph clearly shows a reduction in emissions around 2010, which could be associated to the Agricultural and Live Stock Plan of 2010.

Figure 7. Evolution over time of CO_2 emissions from the agricultural sector in Brazil

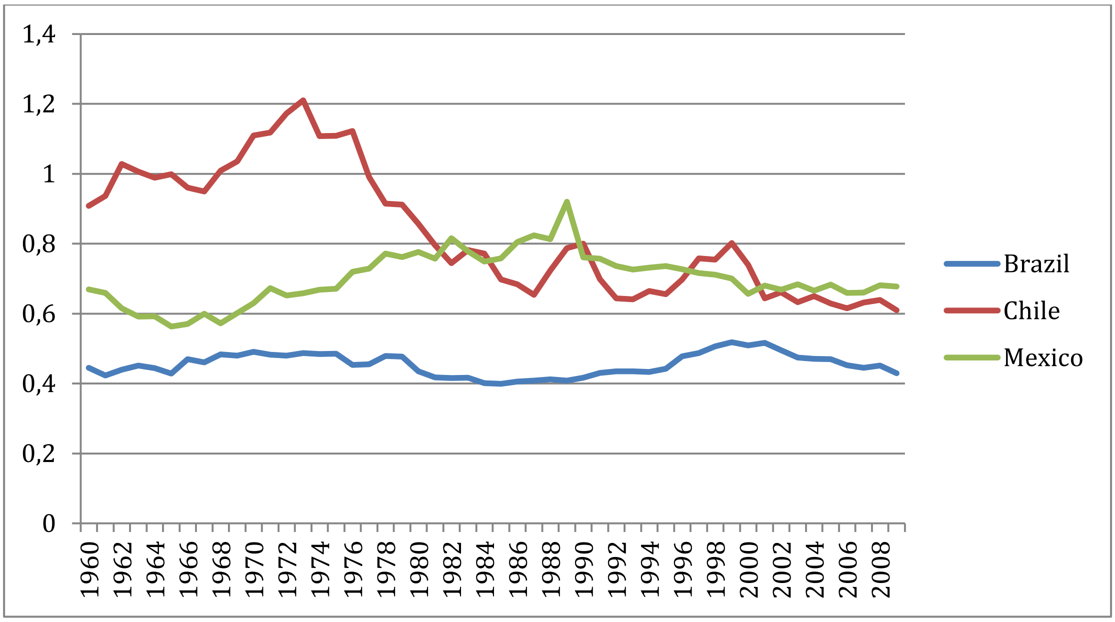


The strength of Brazil's green growth policies such as the National Climate Change Plan is that it aims to harness green growth with economic growth and poverty reduction simultaneously. Promoting the use of renewable energy in remote un-electrified regions does contribute human capital development. The size and the distribution of the population make it reasonable to apply a more decentralized energy grid (Fujita et al. n.d.).

4.1.2 Strengths and Weaknesses of the Policies

Brazil is a resource abundant country and can afford a large biofuel industry. Nevertheless, if the production of biofuel leads to further deforestation in the country then it does not contribute to the mitigation of green house gases and does not help to prevent dangerous climate change. The use of cultivated land for biofuel production is also under critique as it may lead to higher prices for other agricultural goods such as wheat or corn. Gibbs et al. (2008) and Field et al. (2008) find that the use of biofuels can contribute to the reduction of green house gases, but this reduction is rather small. This makes the use of biofuels controversial as on the one hand there shall be no new croplands cultivated, and on the other hand the cropland available for food production becomes smaller and food prices may rise. For the poverty reduction the provision of energy access is a basic requirement, but the current rise in energy demand cannot yet be met with renewable energy sources.

Concerning the policies aimed at control climate change and at reducing emissions from the agricultural sector, it is not straightforward to evaluate their effects, because those coincided with the economic crisis and started to be implemented in very recent years. However, it is clear that CO_2 intensity figures show a decreasing trend in Brazil, as shown in Figure 8 below, after 2002, when a number of initiatives to support alternative energy sources stated been suported.Figure 8. CO_2 emissions intensities in three countries



Note: Calculated as CO_2 emissions/GPD.

4.1.3 Policy Recommendations

Brazil has a great potential in relation to its resource abundance. It can literally increase the production of all sorts of renewable energies and it has its own resources from fossil fuels. The current phase of strong economic growth has come along with higher inflation and rising prices as well as rising inequality. The goal of Brazil's green growth strategies have to focus on reducing inequality and increasing the access to resources such education and health care meanwhile further increasing the quality of those public goods.

According to the recent economic developments, the sectors targeted should be the transport sector with a great potential to improve energy-efficiency and the renewable-energy sector. Switching to more fuel-efficient vehicles in public transport is an option. Given that this option is costly and public transport is in most cities undersupplied, new vehicle would not replace old ones but should be added to the fleet. The implementation of forest protection management practices also should play an important role in preserving deforestation, which according to our analysis in Section 3 is affected by population growth, by urbanization and openness.

4.2 Chile

4.2.1 Identification of green policies

Chile has a long history of market based policy instruments regarding green growth. Table 10 gives an overview of the relevant policies, which already have been implemented. It is among the first country that launched a system of nationwide water rights (in 1981) to use this scarce resource more efficiently. The National Strategy of River Basin Management from 2007 aims at improving the public-sector coordination on water rights. In 1992 the country launched a system of tradable emission permits for particulate matter in Santiago de Chile to solve the severe health problems caused by local air pollution. In the same year transferable fishing quotas were established to protect the country's natural resources. Later on, Chile provided governmental support for aquaculture fish industry, which turned the country into a global player in fish exports. Further policies to protect biodiversity, the country richest resources, were launched in 2003 with the National Biodiversity Strategy and the follow up specific policies on the protection of endangered species as well as areas and wetlands from 2005 (OECD 2011). Chile is in a favorable position compared to the other two countries due to its currently high share of renewable energy. CO2 intensity considerably decreased in the 1970s and in the 1980s (see Figure 8) and has been maintained since then below Mexico's levels. Since Chile is a rather resource abundant country, which had managed its resources well in the recent past, the topic of energy efficiency is not any longer high on the agenda. Still investing in energy efficiency provides a double dividend since it goes in line with technological improvements, which make the countries industries more competitive.

Table 10. Green Policies in Chile

Title	Year	Policy Type	Policy Target
National Strategy for the Energy Sector	2012	Policy Support, Strategic planning	Multiple RE Sources
Support for Non-Conventional Renewable Energy Development Program	2012	Economic Instruments, Direct investment, Infrastructure investments, Economic Instruments, Direct investment, RD&D funding	Bioenergy, Geothermal, Hydropower, Multiple RE Sources, Ocean, Solar, Solar Thermal, Wind
Creation of the Ministry of Environment	2010	Legal Act	Environmental Protection, Efficient Resource Use
Regulatory Framework for Solar Water Thermal (Law 20,365)	2009	Regulatory Instruments, Codes and standards, Economic Instruments, Fiscal/financial incentives	Solar Thermal, Solar heat
Program for Rural and Social Energy (PERYS)	2009	Policy Support, Economic Instruments, Regulatory Instruments	Solar, Solar Thermal, Multiple RE Sources, Bioenergy, Wind
National Policy on Chemical Safety	2008	Regulatory Instruments, Regulatory Instruments, Obligation schemes	Reduce Risks from Handling of Chemicals
Non-conventional renewable energy law (Law 20.257)	2008	Regulatory Instruments, Regulatory Instruments, Obligation schemes	Bioenergy, Biomass for power, Geothermal, Multiple RE Sources, Ocean, Solar, Solar Thermal, Wind
National Strategy of Integrated River Basin Management	2007	Policy Support, Strategic planning	Improve Public Sector Coordination
Invest Chile Project	2005	Economic Instruments, Direct investment, RD&D funding	Wind, Bioenergy, Biomass for power, Geothermal, Power, Hydropower, Multiple RE Sources, Power
Specific Policies on Endangered Species, Areas and Wetlands	2005	Regulatory Instruments	Multiple Species and Areas
Access for Small and Non-Conventional Power Producers: Short Law I and II	2004		Multiple RE Sources, Power, Multiple RE Sources
National Biodiversity Strategy	2003	Policy Support, Strategic planning	Multiple Natural Resources
Rural Electrification with Renewable Energy Program	2001	Economic Instruments, Direct investment, Infrastructure investments	Wind, Onshore, Hydropower, Solar, Solar photovoltaic
Law 19,657 on Geothermal Energy Concessions	2000	Regulatory Instruments, Codes and standards	Geothermal, Power
Transferable Quotas for Several Fish Species	1992	Regulatory Instruments, Quota	Fish Resources
Tradable Particulate Mater Emission Permit in Santiago de Chile	1992	Regulatory Instruments, Quota	Air Pollution
Nationwide Trading of Water Rights	1981	Regulatory Instruments, Quota	Water

Source: IRENA (2013) and OECD (2011).

The currently strongest green growth potential is located in Chile's energy sector and the use of renewable energy. Currently, Chile has a total primary energy supply of 1,205.1 PJ of which are renewable 302.9 PJ. This amounts 25.1 percent energy use from renewables, which is mostly addressed to hydropower, one of the country's natural advantages. The country set a target of 8 percent of electricity generation from renewables excluding large hydropower plants by 2020. The policies to pave the way for this target go back to 2000 when Chile promoted the use geothermal power plants. The nature of renewable energy plants such as geothermal or photovoltaic allows the decentralized energy supply of remote urban regions such in the Rural Electrification Program in 2001. Several policies to promote the investment into renewable energies especially in the rural area, such as the Rural Electrification with Renewable Energy Program in 2001 and the Program for Rural and Social Energy (PERYS), have had been following since 2001 and amount into the National Strategy for the Energy Sector from 2012 (IRENA 2013).

4.2.2 Strengths and Weaknesses of the Policies

The strength of Chile's green growth policies is in the renewable energy sector, currently dominated by hydropower. However, Chile placed instead ambitious targets on the use of energy from photo voltaic, geothermal and wind. Especially, the electrification of rural areas has been a key target in this renewable energy plan. If the target of a higher use of renewable energies in remote areas is reached, then there would be not only a higher use of renewable energies, but also a higher quality of life in remote areas, which are mostly populated by indigenous people. Considering that the first policies in this field were passed in 2001 the progress has been rather slow compared to countries, which implemented those policies later. Nevertheless, the ministry of environment was just recently established in 2010. Therefore, future coordination and implementation of policies might be faster (OECD 2011).

Within the international effort to prevent dangerous climate change, Chile proposed currently 16 national appropriate mitigation actions (NAMAs) in order to mitigate green house emissions. Six of those actions are in the field of energy supply. Within this field green house gas emissions are mostly reduced through the implementation of renewable energy projects. There are two mitigation actions in the area of waste management such as the flaring of methane gas. Another four mitigation actions are in the transport sectors and are based on efficiency improvements and the electrification of transport (NAMA Database 2013).

The report on Chile going green by the OECD (2011) identifies Chile's fresh water management as still being inefficient. The issuance of water rights has been too generous, which leads farmers, energy generators and speculators to stock up on water rights, which have not yet been used. There is only a limited amount of trade in water rights as too many have been issued. The National Strategy on River Basin Management could potentially help to coordinate the public sector in this area. Apart from the agricultural sector the mining sector is one of main water consumers. Mining is crucial part Chile's economy and the environmental regulations dealing with the negative side effects from this industry are not yet established. There is a National Policy on Chemical Safety, which aims to regulate poisonous hazards to human health and the environment from the industries, which apply chemicals. Still the mining sector has not been targeted.

4.2.3 Policy Recommendations

Green growth policies need to be further integrated in sectoral policies. The use of renewable energy in specific sectors such as transport should be promoted and the protection of biodiversity and water rights play a major role for two crucial industries in Chile namely, the mining sector and the aquaculture. Public policies are not coordinated well enough to protect the environment from the negative side effects from those industries.

Revenues from the strongest sector in the Chilean economy, the mining sector, could be transferred to increase human, environmental and social capital. The National Climate Action Plan from 2008 focuses solely on green house gas mitigation in the energy sector other sectors have been given less attention in order estimate the countries' mitigation potential (OECD 2011). As our findings in chapter 3 show, there is potential to reduce CO_2 emissions in the industrial sector through improved energy efficiency. Nevertheless, activities with high potential to reduce other GHGs such as CH_4 are waste management activities (also in the mining sector), and or recycling.

4.3 Mexico

4.3.1 Identification of green policies

Mexico was the first of the three countries to implement policies promoting the use of renewable energies. Table 11 describes the main environmental policies launched in Mexico since 1975. In this year the Public Electricity Service Law was implemented to provide electricity more efficiently and incorporate the electricity from renewable energy. Twenty six years later, the grid interconnection contract for renewable energy was passed, which improved the integration of renewable energy into the energy grid. From 2008 onwards, several policies have been applied in order provide financial resources for investments into renewable energy projects. Nevertheless, the share of renewable energy in the Mexican energy supply is only 9.5 percent. This is considerably low given the natural potential that the country has to generate electricity from renewable sources. The target is to reach a share of renewable energy of 25 percent by 2012 and 34 percent by 2024.

Table 11. Green Policies in Mexico

Title	Year	Policy Type	Policy Target
Large-scale renewable energy development project (PERGE)	2013	Economic Instruments, Direct investment	Multiple RE Sources, Wind
National renewable energy inventory	2013	Information and Education, Information provision	Multiple RE Sources,
General Law of Climate Change	2012	Policy Support, Institutional creation	Multiple RE Sources, Power
National Energy Strategy 2012-2026	2012	Policy Support, Strategic planning	Multiple RE Sources, Power
National Ecological Land Use Plan	2012	Policy Support, Strategic planning	Sustainable use of Natural Resources
Special Program on Climate Change	2009	Policy Support, Strategic planning	Measures and Objectives for Mitigation and Adaption
Fund for the Energy Transition and Sustainable Electricity Use	2009	Economic Instruments, Direct investment, Research, Development and Deployment (RD&D), Research program	Multiple RE Sources
Special Program for the Use of Renewable Energy 2008-2012	2009	Regulatory Instruments, Codes and standards, Information and Education, Information provision, Advice/Aid in Implementation, Economic Instruments, Fiscal/financial incentives, Tax relief, Grants and subsidies, Loans, Policy Support, Strategic planning, Direct investment, Infrastructure investments	Multiple RE Sources
Methodology to value the externalities associated with the Electricity Generation in Mexico	2009	Policy Support, Strategic planning	Multiple RE Sources, Power
Law for the Development of Renewable Energy and Energy Transition Financing (LAFAERTE)	2008	Regulatory Instruments, Economic Instruments, Fiscal/financial incentives, Policy Support, Strategic planning, Institutional creation	Wind, Geothermal, Solar, Hydropower
Integrated Energy Services Project (2007-2014)	2008	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Policy Support	Solar, Solar, Solar photovoltaic

Table 11. Green Policies in Mexico (continued)

Title	Year	Policy Type	Policy Target
Energy Sustainability Fund	2008	Research, Development and Deployment (RD&D), Research program	Multiple RE Sources
National Climate Change Strategy	2007	Policy Support, Strategic planning	Medium and Long Term Goals for Mitigation
National Development Plan	2007	Policy Support, Strategic planning	Framework of Sustainable Development
National Environmental Policy for the Sustainable Development of Mexico’s Coastlines and Oceans	2007	Policy Support, Strategic planning	Sustainable use of Natural Resources
Strategy of Environmental Education for Sustainability	2006	Policy Support, Strategic planning	Adding Sustainability in the curriculum at school, green schools program
Accelerated Depreciation for Environmental Investment	2005	Economic Instruments, Fiscal/financial incentives, Tax relief	Multiple RE Sources, Power
Project of Ecological Norm for Wind Farms	2005	Policy Support	Multiple RE Sources
Wheeling Service Agreement for electricity from renewable energy sources	2004	Regulatory Instruments	Multiple RE Sources, Power
Federal umbrella program that promotes sustainable forestry	2004	Policy Support, Strategic planning	Sustainable use of Natural Resources, Support of Indigenous People
National Program of Payments for Ecosystem Services	2003	Regulatory Instruments	
Methodology to establish service charges for transmission of renewable electricity	2003	Regulatory Instruments	Multiple RE Sources, Power
Grid interconnection contract for renewable energy	2001	Regulatory Instruments	Wind, Hydropower, Multiple RE Sources, Power, Solar
National Biodiversity Strategy	2000	Regulatory Instruments	
Policies against Air Pollution - Pro Aire	1990	Regulatory Instruments	Local Pollutants
Public Electricity Service Law	1975	Regulatory Instruments, Other mandatory requirements	Multiple RE Sources, Power

Source: IRENA (2013) and (OECD 2013).

Mexico, like Chile, faces high levels of air pollution in its urban areas (See Table 4, air pollution indicator, according to which PM_{10} concentrations are well above the average OECD level). In 1990, the first Pro Aire project, among many which followed, was launched in order to find a way to reduce traffic and therewith pollution. There are a number of policies which aim to encourage sustainable resource use, such as the National Ecological Land Use Plan from 2012, the Federal umbrella program that promotes sustainable forestry from 2004, National Program of Payments for Ecosystem Services from 2003 and the National Biodiversity Strategy from 2000. Those policies are regulatory instruments to improve the efficiency of the resource use and protect environmental areas (OECD 2013).

4.3.2 Strengths and weaknesses of the policies

The National Development Plan is at the core of Mexico’s environmental policies. It aims to cover sustainable development in the area of water and waste management, climate change mitigation and adaption, the preservation of biodiversity and the efficient use of natural resources and last but not least the creation of human capital and awareness for the environment. The sub-targets in each of those categories are not clearly defined and an evaluation of the success of the single policies is missing so far (OECD 2013).

One of the most pressing issues is the energy subsidies, which Mexico applies to fossil fuels. The subsidized fossil fuels do encourage people to buy and use cars. Therefore the subsidies in the energy sector do not only undermine the efforts from policies such as the Pro Aire clean air project but also make it harder for alternative energy sources such as renewable to enter the market.

Mexico does engage in the mitigation of dangerous climate change. The National Climate Strategy from 2007 targets a green house gas reduction of 50 percent by 2050 with 2000 as the base year. The General Law on Climate Change from 2012 allows producers of renewable energy sources to access the grid and feed in renewable energy. The targets are very ambitious and are not jet broken down into specific sectors. There is the idea of launching an emission trading system but it has not been implemented yet. Therefore, it seems unclear if the targets will be met especially since there is no monitoring of the progress made (OECD 2013).

4.3.3 Policy Recommendations

The green house gas reduction targets from the General Law on Climate Change have to be substantiated and defined among sectors. An intra-industry emission trading system could lead to substantial green house gas reductions at lowest cost. Removing the energy subsidies would not only encourage efficient resource use but also make the use of renewable energy sources more attractive. Decentralized energy systems from renewable should also be applied in remote areas. Vehicle fuel efficiency standards and an efficient low carbon public transportation could further curb green house gas emissions (OECD 2013). Therefore, based on the above analysis of green growth indicators and policies, Mexico should focus on the renewable-energy sector and the transport sector. In line with our results from Section 3 CO_2 emissions from the transport sector are highly sensitive to increasing demand due to rising population and income. Therefore the transport sector should be as energy efficient as possible to reduce CO_2 emissions. Again our results indicate the need of an efficient resource use. The Mexican policies aim on an efficient resource use. The success of these policies is hard to be evaluated without a baseline from the time before the implementation of the relevant policies.

5 Reflections

This study presents a comparative analysis of the green growth strategies and achievements in three Latin American countries, namely Brazil, Chile and Mexico. These three countries have made important progress in some of the areas under study, in particular in setting the necessary institutional and regulatory framework to protect the environment and to preserve its natural resources. As regards the implementation of green policies, all three countries have launched regulatory instruments and policy instruments and have given economic support to renewable energy sources. Brazil has also established green house gas reduction plans, whereas Chile and Mexico have launched regulatory instruments to control local air pollution. However, many important challenges remain.

Also an important progress has been made in some social aspects as reducing poverty and increasing education and opportunities for women, but more effort is needed. More specifically, poverty and inequality levels are still very high, despite the important progress made in the past decade. In particular, income indicators (household net disposable income and financial wealth) are well below the OECD average, inequality levels are very high in Brazil. Secondly, air pollution levels in big cities are still very high and life expectancy is below average OECD levels. Thirdly, resources dedicated to R&D, especially in green good sectors, are still at very low levels in comparison to OECD standards and more public effort has to be made in this area. Finally, there is room to improve the regulatory framework and to delimit competences between central, regional and local authorities. It is worth to emphasize the need to address distributional issues. Hence, green policies should be identified favoring the poor and middle class, instead of only benefiting the upper social class and elites. Also the burden of the most vulnerable and disadvantaged communities that could be most affected by climate change should be alleviated with appropriate mitigation policies and direct payments to the poor and disadvantaged.

Our empirical analysis has shown that there is the potential to reduce green house gas emissions especially CO_2 through improvements in energy efficiency in Latin America. Those improvements in energy efficiency can also be achieved through the use of renewable resources. CO_2 emissions from the agricultural sector are not sensitive to an increase in value added from the respective sector. Green house gas emissions from the industrial sector (manufacturing and mining) are especially sensitive to a rise in value added from the respective sector. Nevertheless, an increase in value added rises emissions less than proportionally.

Since each country has also its particularities, some specific activities have a higher potential to be developed successfully in each country. First, Brazil started to implement green policies only in 1996, whereas Chile started already in 1981 and Mexico in 1975. Brazil is the richest in terms of resource abundance and has therefore the greatest potential in bioenergy, biomass and forest conservation. Although most of the regulations launched since the late 1990s have been supporting investments in renewable energies, the share of Geothermal together with solar and wind energy production is still below 1 percent, hence there is room for improvement, otherwise, the share of biofuel and waste has steadily increase since the 1970s, as well as the share of hydropower. However, oil still represents 40 percent of total primary energy supply and hence there is room for increasing the share of renewables. As regards electricity generation, Brazil has a very clean energy matrix, however emissions from agriculture, steel and transportation are expected to growth with its development process. Hence, to launch low carbon options for these sectors is recommended.

Concerning other regulation initiatives, it has only been in the late 2000s that the Climate Change Policy and the Agriculture and Livestock Plan aimed at reducing greenhouse gas emissions have been launched and as a consequence, it is still too early to evaluate its effects. It is also worth noting that deforestation has been observed in the last 2 decades, with a decrease of 10 percent of forest land, hence more efforts have to be done to conserve the forest and to protect the Amazonia region. The country has already moved in this direction and deforestation has been already reduced in recent years.

In terms of social policies, Brazil should continue dedicating resources to reduce inequality and to support education of poor children. Initiative aimed at training and employing low income workers in reforestation and renewable energy firms are recommended.

Secondly, Chile started already in the early 1980s to set green policies related to water management, air pollution and resources conservation, as well as supporting investments in renewable energy. As we mentioned in previous sections, Chile's production structure is biased towards the mining sector, which is more pollutant intensive than other industrial activities. Hence, according to our analysis Chile's activities with high growth potential are waste management activities in the mining sector (copper in particular), and aquaculture. Aquaculture is a very important activity in Chile, in particular salmon and trout aquaculture, with salmon volumes just behind Norway in its contribution to the world production. However the appearance of an infectious disease in 2007 led to a crisis and an important drop in production that is now recovering. To control the disease new density regulations will be put in place in 2014 that involve density limits in each neighborhood based in its sanitary risk. This could also have a positive impact on prices, benefiting therefore the producers.

It is also worth mentioning that the forest area in Chile increased by 7 percent in the last two decades, in part as an outcome from the reforestation policies that have been in place. For instance, Chile and Uruguay are the only two South American countries where woodland has increased; it has indeed doubled in Chile in the last three decades. Since almost 90 percent of new forest is situated on grounds with erosion, reforestation generates not only environmental benefits, but also economic and social gains, including employment creation. Chile could also benefit from improving the levels of secondary school enrolment, which according to our analysis lay below the desirable levels.

Finally, among Mexico's main GG initiatives are the Special Climate Change Program launched in 2009 aimed at cutting gas emissions by 50 percent by 2050 and the National Development Plan 2007-2012 aimed at strengthening and consolidating adaptation capacities among the most vulnerable. Both initiatives are ambitious and have already accomplished some achievements, with an increasing share of renewable energies in electricity production. However, the country still presents the highest share of total primary energy supply coming from oil (54 percent) and hence subsidies supporting fuel consumption should be phased out and replaced by cash-transfer programs to help poor consumers to overcome its energy needs.

According to our analysis car manufactures and electronics are among the main industrial sectors in the country, the latter sector in particular was growing very fast in the 2000s. Since the growth in value added in both sectors will contribute to increasing emissions according to our model in Section 3, the country should make an effort in diversifying more its economic activities, focusing in tourism and other services as well as continue to support free trade initiatives and to profit from technological spillovers by investing more in R&D in order to increase the quality of its products, also by making them “cleaner”. The privileged location of Mexico, sharing border with a huge market, the US, should be also taken as an advantage to exploit its comparative advantage in producing part and components of final goods.

Mexico has therefore a high potential to improving the efficiency of the transport sector with the subsequent reduction in emissions and also to increase the share of renewable energy supply and electricity generation from renewable sources. In addition, the country should greatly benefit from implementing social programs to improve security in big cities and to reduce assault and homicide rates, which are among the highest in the world and clearly have a negative impact on wellbeing.

Summarizing, this study indicates that the three countries under study have made a remarkable progress by setting the necessary institutions and regulations to pave the road towards GG. However, it is still early to evaluate whether the initiatives have been fully implemented and whether the progress has been translated to an increase in wellbeing that is respectful with the environment. Surely, some tensions and complementarities between the model of economic growth and the proposed environmental and socio-economic policies will have to be solved in the near future and, in specific ways in each economy.

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Appendix

Table A. 1. List of Countries

Argentina	Honduras
Bolivia	Mexico
Brazil	Nicaragua
Chile	Panama
Colombia	Paraguay
Costa Rica	Peru
Dominican Republic	Trinidad and Tobago
Ecuador	Uruguay
El Salvador	Venezuela, RB
Guatemala	

Source: World Bank (2013).

Table A. 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	589	1.16E+05	2.44E+05	1.90E+03	1.79E+06
CH_4	589	4.15E+04	8.03E+04	2.17E+03	4.92E+05
N_2O	589	1.82E+04	3.83E+04	1.83E+02	2.39E+05
Forest Area	418	5.02E+04	1.19E+05	2.26E+02	5.75E+05
Pop	608	2.40E+07	3.91E+07	1.08E+06	1.97E+08
GDP	603	1.97E+11	3.62E+11	1.01E+10	2.02E+12
EE	587	7.39E+00	2.35E+00	1.46E+00	1.51E+01
N_2O_Transport	589	4.60E+02	8.33E+02	2.30E+01	3.98E+03
N_2O_Industry	589	9.13E+02	2.13E+03	2.34E+01	1.25E+04
N_2O_Energy	589	1.80E+02	3.58E+02	1.98E+00	2.44E+03
N_2O_Buildings	589	1.23E+02	1.62E+02	3.32E+00	1.07E+03
N_2O_AFOLU	589	1.66E+04	3.52E+04	7.62E+01	2.25E+05
CH_4_Transport	589	7.49E+01	1.24E+02	2.06E+00	5.33E+02
CH_4_Industry	589	5.32E+03	1.11E+04	2.84E+02	6.41E+04
CH_4_Energy	589	6.00E+03	9.49E+03	5.85E+00	3.88E+04
CH_4_Buildings	589	5.34E+02	7.28E+02	1.15E+01	5.05E+03
CH_4_AFOLU	589	2.96E+04	6.22E+04	6.64E+01	3.95E+05
CO_2_Transport	589	1.82E+04	3.19E+04	6.10E+02	1.66E+05
CO_2_Industry	589	1.42E+04	2.45E+04	1.61E+02	1.24E+05
CO_2_Energy	589	1.71E+04	3.21E+04	1.21E-05	1.87E+05
CO_2_Buildings	589	4.26E+03	6.90E+03	5.00E+01	2.62E+04
CO_2_AFOLU	589	6.20E+04	1.85E+05	3.20E+00	1.48E+06
VA Agriculture	608	5.53E+09	8.98E+09	6.45E+07	5.40E+10
VA Construction	608	6.63E+09	1.25E+10	7.09E+07	6.48E+10
VA Services	608	3.57E+10	7.11E+10	9.08E+08	3.59E+11
VA Industry	608	2.84E+10	5.13E+10	5.43E+08	2.46E+11
VA Transport	608	8.11E+09	1.67E+10	1.41E+08	9.33E+10

Source: World Bank (2013).