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Are Renewable Energy Policies Reducing the Carbon Dioxide Emissions? The Case of Latin American Countries

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Dedicatória

Aos meus pais, pelas oportunidades que me proporcionaram.

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Resumo

Esta dissertação examina o impacto das políticas de energias renováveis nas emissões de dióxido de carbono na região da América Latina. Foram analisados, dez países no período compreendido entre 1991 a 2012, utilizando como metodologia o modelo auto-regressivo, com desfasamentos distribuídos, para decompor o efeito total e as suas repercussões a curto e longo prazo. Foi detetada a presença da dependência transversal, confirmando que estes países compartilham os mesmos padrões espaciais, bem como a presença de heterocedasticidade, correlação contemporânea e autocorrelação de dependência transversal de primeira ordem. Tendo em atenção estas infrações, foi utilizado o estimador dinâmico *Driscoll-Kraay*, com efeitos fixos, que é robusto a estes fenómenos. De igual modo, se observou que o consumo de energia primária *per capita*, contribui, tanto a curto como a longo prazo, para o aumento das emissões de dióxido de carbono. A pesquisa comprovou que o número de políticas e a geração a geração de energias renováveis contribuem para mitigar as emissões de dióxido de carbono.

Palavras-chave

América latina, Dióxido de carbono, Políticas de energias renováveis, Autocorrelação de dependência transversal.

Resumo Alargado

A queima de combustíveis fósseis para a produção de energia tem levado a um aumento nas emissões de dióxido de carbono (CO_2). Esse incremento tem causado uma grande preocupação em todo mundo, tanto no âmbito político como no social. Mais de 80% das emissões de CO_2 são causadas pela ação humana, onde a queima de carvão representa 44% das emissões, o petróleo 36% e o gás natural 20%. Tendo em consideração estes fatores alarmantes, diferentes políticas têm sido aplicadas de forma progressiva para promover o desenvolvimento de fontes de energia renováveis (**RES**), com o objetivo de reduzir as emissões de CO_2. Tendo em atenção as medidas anteriormente referidas, a América Latina assumiu um papel de grande relevância na promoção das energias renováveis devido ao seu rápido crescimento na implementação das RES, bem como pela abundância de recursos naturais, embora esta promoção apenas se tivesse iniciado na década de 1970 com o choque do petróleo e o posterior impulsionamento das primeiras políticas pró-RES. O primeiro país da América Latina a implementar políticas de energias renováveis foi o Brasil, tendo sido estabelecido em 1975 o programa ProÁlcool, destinado à produção de biocombustíveis. Posteriormente, em 1976 na Costa Rica foi criada a lei para produção de energia de origem geotérmica, um recurso abundante naquele país e por último em 1977 a Nicarágua, seguindo os passos da Costa Rica, estabeleceu também diretrizes para a viabilização da produção de energia geotérmica. Entretanto, o aumento das políticas pró-RES na América Latina está relacionado a uma série de desafios energéticos que a região enfrenta como: (**i**) a necessidade de aumentar a quantidade substancial de produção de eletricidade a fim de atender o crescimento da demanda; (**ii**) a falta de diversificação da matriz energética; (**iii**) a grande exposição dos países Latino Americanos a instabilidade dos preços dos combustíveis fósseis uma vez que esta instabilidade poderia afetar fortemente os orçamentos nacionais e os contratos de fornecimento de eletricidade existentes. Outros fatores podem ser destacados como: Variabilidade do clima, incluindo secas, o que afetam países com grande dependência de energia hidráulica, a infraestrutura precária e envelhecida e por último a necessidade de obtenção de recursos financeiros disponibilizados através de negociações internacionais sobre o clima. No entanto, na América Latina existe uma vasta gama de mecanismos a fim de impulsionar o crescimento da RES como: (**i**) Metas nacionais de energias renováveis; (**ii**) *Leilões*; (**iii**) *Feed-in Tariffs* (**FITs**); (**iv**) Sistema de certificação; (**v**) Medição líquida e Auto-

suprimento; (**vi**) Fundos; (**vii**) Incentivos fiscais; (**viii**) Acesso à energia renováveis; (**ix**) Mandos de mistura de biocombustíveis; (**x**) Mandatos solares; e (**xi**) Requisitos de conteúdo local. Contudo, na literatura existem poucas pesquisas que abordam o impacto das políticas de energias renováveis nas emissões de CO_2. No entanto, em pesquisas já existentes as políticas mais usadas são: (**i**) Impostos sobre o carbono; (**ii**) *Feed-in Tariffs*; (**iii**) Pagamentos de prémios; (**iv**) Sistemas de quotas; (**v**) Leilões; (**vi**) Sistemas de capitais, e (vii) Sistemas de comércio. Além disso, há evidências na literatura que estas políticas têm incentivado o aumento das RES e contribuído para a redução das emissões de gases de efeito estufa. Sendo o objetivo desta dissertação, examinar o impacto das políticas de energias renováveis nas emissões de CO_2 na região da América Latina, para atingir tal propósito, na realização desta análise foram abordados dez países Latino Americanos: Argentina, Bolívia, Brasil, Chile, Colômbia, Equador, México, Nicarágua, Peru, e Uruguai, no período compreendido entre 1991 e 2012. Foram utilizadas as seguintes variáveis: (i) Produto Interno Bruto (PIB); (ii) Geração de energias renováveis; (iii) Emissões de dióxido de carbono (CO_2); (iv) Consumo de energia primária; (v) Políticas de energias renováveis. As variáveis escolhidas, seguiram os seguintes critérios: (**i**) as políticas de energias renováveis têm que ser de longo prazo; (**ii**) existir dados disponíveis para todo o período em análise. Todas as variáveis em estudo, foram transformadas em *per capita* exceto as políticas de energia renovável. A opção de utilizar os valores *per capita*, é justificável pois permite controlar as disparidades de crescimento populacional entre os países. De modo a acomodar a dinâmica esperada entre variáveis, foi utilizado o modelo (**ARDL**) permitindo assim gerar estimativas de parâmetros consistentes e eficientes, bem como a inferência de parâmetros com base no padrão de teste. De forma a validar o modelo foram feitos testes preliminares como: (**i**) Dependência Transversal (**CSD**); (**ii**) Teste de Raiz de Unidade de Segunda Geração (**CIPS**); e (**iii**) Teste de Fator de Inflação de Variância (**VIF**), e para a especificação do modelo foram utilizados: (**i**) teste de Wald modificado; (**ii**) teste de Pesaran; (**iii**) teste de multiplicador de Langrarian de Breusch e Pagan; (**iv**) teste de Wooldridge; (**v**) estatística de Durbin-Watson; (**vi**) Teste de Baltagi-Wu LBI. Contudo, ao realizar as análises foi detectada a presença de heterocedasticidade, correlação contemporânea, autocorrelação de dependência transversal de primeira ordem. Tendo em atenção estas violações, foi utilizado o estimador dinâmico *Driscoll-Kraay*, com efeitos fixos, que é robusto a estes fenómenos. De igual modo, se observou que o consumo de energia primária *per capita*, contribui, tanto a curto como a longo prazo, para o aumento das emissões de dióxido de carbono. A pesquisa comprovou que o número de políticas de energias renováveis a longo prazo e a geração de energias renováveis contribuem para mitigar as emissões de dióxido de carbono.

Abstract

This dissertation examines the impact of renewable energy policies on carbon dioxide emissions in Latin America region. Ten countries were analyzed in a period from 1991 to 2012, utilizing the methodology of autoregressive panel with distributed lag to decompose the total effect in their repercussions in the short- and long-run. The presence of cross-sectional dependence confirms that Latin American countries share spatial patterns, as well as, the heteroskedasticity, contemporaneous correlation, and first order autocorrelation cross-sectional dependence were identified. Considering this violations, the robust dynamic Driscoll-Kraay estimator with fixed effects that is robust to these phenomena was used. In the same way, it was observed that the primary energy consumption *per capita* contributes in both the short- and long-run, to increase in carbon dioxide emissions. The research proved that the number of renewable energy policies in the long-run, and renewable electricity generation *per capita* both in the short-and long-run, contribute to mitigate per capita carbon dioxide emissions.

Keywords

Latin America, CO_2 Emissions, Renewable Energy Policies, Panel Autoregressive Distributed Lag.

Contents

List of Figures

List of Tables

List of Acronyms

ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributive Lag
AR	Argentina
BCG	Boston Consulting Group
BRA	Brazil
BTU	British Thermal Unit
BOL	Bolivia
BHU	Banco Hipotecario del Uruguay (Public Mortgage Bank of Uruguay)
BNDES	Banco Nacional de Desenvolvimento Econômico e Social
CCS	Carbon Capture and Storage
CDE	Conta de Desenvolvimento Energético
CDC	Crédito Direto ao Consumidor
CIPS	Second-Generation Unit Root Test
CO2	Carbon Dioxide Emissions
CSD	Cross-Section Dependence
CHL	Chile
COL	Colombia
D	Differences
DFE	Dynamic Fixed Effects
DFE D.-K	Dynamic Fixed Effects with Driscoll and Kraay
ECM	Error Correction Model
ECU	Ecuador
EIA	Energy Information Administration
EViews	Data Analysis and Statistical Software
FE	Fixed Effect
FITs	Feed-in-Tariffs
FENOGE	Fondo de Energías No Convencionales y Gestión Eficiente de la Energía
FAZNI	Fondo de Apoyo Financiero para la Energización de las Zonas No Interconectadas
FEISEH	Fondo Ecuatoriano de Inversión en los Sectores Eléctrico e Hidrocarburífero
FERUM	Programa de Energización Rural y Electrificación Urbano-Marginal

FODIEN	Fondo para el Desarrollo de la Industria Eléctrica Nacional
FONER	Fondo Nacional de Electrificación Rural
GDP	Gross Domestic Product
GWs	Gigawatts
GWh	Gigawatt-hours
GHG	Global Greenhouse Gas
GENREN	Programa de Generación Eléctrica a partir de Fuentes Renovables
IEA	International Energy Agency
IFM	International Monetary Fund
IPPS	Independent Power Producers
IRENA	International Renewable Energy Agency
L	Logarithm
LAC	Latin America and Caribbean
LCU	Local Currency Unity
LM	Lagrangian Multiplier
LLC	Levin, Lin and Chu Test
MG	Mean Group
MWs	Megawatts
MEX	Mexico
NIC	Nicaragua
PER	Peru
PMG	Pooled Mena Group
PROALCOOL	Programa Nacional do Alcool
PROEOLICA	Wind Energy Emergency Program in Brazil
PROINFA	Programme of incentives for Alternative Electricity Sources in Brazil
PRORENOVA	Support for renewal/expansion of sugarcane fields in Brazil
PROESCO	Apoio a projetos de eficiência energética
PPA	Power Purchase Agreement
RE	Random Effects
R&D	Research and Development
RES	Renewable Energy Sources
RES-E	Electricity from Renewable Energy Sources
RPS	Renewable Portfolio Standards
REPC	Renewable Energy Production Credit
RGR	Global Reversion Reserve of Brazil
UK	United Kingdom

URY	Uruguay
SENER	Secretaria de Energía
STATA	Data Analysis and Statistical Software
UECM	Unrestricted Error Correction Model
VIF	Variance Inflation Facto
VAT	Value Added Tax
WBD	World Bank Data

1 INTRODUCTION

The increasing of carbon dioxide emissions (**CO_2**) level have set off an alarm signal worldwide, causing major concern in the political context and in society in general (Arce et al., 2016). The Latin American countries have seen major increases in CO_2 emissions, which have more than doubled during the last three decades (Al-Mulali et al., 2015). In 2010, the region accounted for about 11% of Global Greenhouse Gas (**GHG**) (Vergara et al., 2013). Despite this continuous increase, the Latin America region is a small contributor to the world's GHG (Schipper et al., 2011), but must still be an active player in combating climate change. The policymakers face the dilemma of how to pursue the development of their economies without substantially damaging the environment. Therefore, it is essential that policy makers develop measures to attain economic growth while mitigating climate change (Sakamoto and Managi, 2016). Consequently, several countries have attempted to implement a policy mix of decreasing fossil fuel consumption, while increasing the deployment of renewable energy, with the goal of reducing CO_2 emissions (Sakamoto and Managi, 2016). Europe, as well as in other regions like Latin America has adopted policies to promote renewable energy sources (**RES**). The renewable energy policies began in the Latin America region in the mid-1970s with the establishment of the ProÁlcool biofuels program in Brazil in 1975, the geothermal laws in Costa Rica in 1976 and Nicaragua in 1977 (IRENA, 2015).

The aim of this dissertation is to answer the following question: Are renewable energy policies reducing the carbon dioxide emissions? To answer this question, the impact of renewable energy policies on CO_2, we will analyse emissions in ten Latin American countries, for the period from 1991 to 2012, using a panel Autoregressive Distributed Lag (**ARDL**) approach.

In the literature, the impact of renewable energy policies on CO_2 emissions have been scarcely researched. One example is Arce et al. (2016) who investigated whether renewable energy policies, namely carbon taxes, FITs, premium payments, and quota obligations are efficient in reducing CO_2 emissions. The authors found that carbon taxes are the most cost-effective policy for reducing these emissions. Arce and Sauma (2016) analyzed the efficiency of carbon taxes, FITs, premium payments, and quota systems on CO_2 emissions. They found evidence that FITs and premium payments are more cost-effective to reduce CO_2 emissions than carbon taxes and quota systems. Redondo and Collado (2014) investigated the impact of premium payments in RES consumption in Spain and found that the use of premium payments implies a positive externalities valued at 493 million euros for avoided CO_2 emissions.

Additionally, based on the results it was identified in the literature review, our central hypothesis that renewable energy policies can mitigate CO_2 emissions. The dissertation addresses the impact of renewable energy policies on CO_2 emissions to identify if these policies are efficient, and makes a contribution to expanding the scarce research regarding these impacts on Latin American countries. The choice of Latin American countries have the attraction of being a region that:

(i) Has experienced rapid growth in renewable energy investment and is very interested in developing those resources:

(ii) Has been a pioneer in designing and implementing specific RES promotion mechanisms;

(iii) Has been an important player in the innovation and development of renewable energy policies.

The dissertation is organized as follows. Section 2, presents the main studies that address the impact of renewable energy policies on CO_2 emissions, the framework of renewable energy policies in the Latin America region, the context of CO_2 in the region, and the economic and political shocks in Latin America. Section 3, presents database use, the model specification, and preliminary tests. Section 4, presents the results. Section 5, presents the robustness check. Section 6, the discussions. Finally, Section 7 presents the conclusions.

2 LITERATURE REVIEW

This section is divided into three parts. In the first shows the main studies that address the impact of renewable energy policies on CO_2 emissions. The second shows the framework of renewable energy policies in the Latin America region. The third evidence the context of CO_2 in the Latin America region, addressing the behavior of CO_2 emissions in the region, as well as the sectors and countries that most pollute. Finally, the Fourth shows the economic and political shocks that impacted the Latin America region.

2.1 An Overview of Renewable Energy Policies

The impact of renewable energy policies on CO_2 emissions have been barely researched in the literature. The studies of renewable energy policies have been centred in seven policies (e.g. Arce et al., 2016; Verma and Kumar, 2013) specifically: (**i**) Carbon taxes; (**ii**) Feed-in tariffs; (iii) Premium payments; (**iv**) Quota systems; (**v**) Auctions; (**vi**) Cap systems, and (**vii**) Trade systems. There are evidences in the literature that these policies have paved the way for RES, and helped to restrain CO_2 emissions.

Table 1 presents a summary of the literature review, the namely authors, periods, countries, policies, and main conclusions.

Table 1. Summary of literature review

Author(s)	Period	Country(ies)	Policy(ies)	Conclusion(s)
Arce et al. (2016)	n. a.	n. a.	Carbon taxes; FITs; Premium payments; Quota obligations.	The carbon tax is the most cost-effective policy to reducing CO_2 emissions.
Thapar et al. (2016)	n. a.	India	Grant/subsidies; Accelerated depreciation; Tax concessions/exemptions; Preferential tariffs; Renewable purchase obligations.	Results indicate a high financial impact of these instruments (support of US$ 3-5/MWs over applicable tariff) which becomes neutralized when tax inflow is considered. Lower carbon abatement cost (US$ 3-6/tCO_2eq) indicates higher environmental efficacy.
Arce and Sauma (2016)	n. a.	n. a.	Carbon taxes; FITs; Premium payments and Quota systems.	The FITs and premium payments are more cost effective in reducing CO_2 emissions than Carbon Taxes and Quota systems.

Redondo and Collado (2014)	2011	Spain	Premium payments	The use of premium payments implies positive externalities valued at 493 million euros in terms of avoided CO_2 emissions.
Ortega et al. (2013)	2002-2011	Spain	FITs	The FITs encourage the use of RES and the reduction of CO_2 emissions.
Verma and Kumar (2013)	n. a.	n. a.	Carbon quotas; Cap-and-trade and bilateral IPPs.	All policies contribute to reduction of CO_2 emissions.
Stokes (2013)	1997-2012	Canada	FITs	The FITs can reduce the cost of renewable energy, and speed deployment, supporting much-needed decarbonisation.
Hinrichs-Rahlwes (2013)	1998-2009	Germany	FITs	Mitigate climate change in the best possible way.
Green et al. (2007)	n. a.	n. a.	Carbon Taxes	The carbon tax policies could help to reduce CO_2 emissions associated with conventional energy.
Wüstenhagen and Bilharz (2006)	1973-2003	Germany	FITs	This policy contributes to reduction of greenhouse gases emissions.
Palmer and Burtraw (2005)	n. a.	n. a.	REPC and RPS	The RPS policies appear to be more cost-effective than REPC policies in both promoting renewables and reducing carbon.

Notes: n. a. denotes 'not available'. The abbreviations are as follows: Feed-in tariffs (**FITs**); Renewable Energy Production Credit (**REPC**); Renewables Portfolio Standard (**RPS**); Independent Power Producers (**IPPs**); Carbon Dioxide Emissions (**CO_2**); Renewable Energy Sources (**RES**); Megawatts (**MWs**).

The literature provides evidence that premium payments, quota systems, cap systems and trade systems, i.e. all renewable energy policies have opened the way for renewable energy, and have contributed to the mitigation of greenhouse gas emissions.

The following section will highlight the most common renewable energy policies in Latin American countries, as well as the main findings of the literature.

2.2 Renewable Energy Policies in Latin America

The fast growth of renewable energy policies seen in Latin American countries could be attributed to the interrelated energy challenges they faced. The region will need a substantial amount of new electricity generation to meet growth in demand, and replace aging infrastructure (Jacobs et al., 2013). Currently, several countries in the Latin America region have energy mixes which expose them to fossil fuel price instability. This could significantly affect their national budgets with pass-through provisions in electricity supply contracts or climate variability (including droughts), especially those with heavy hydro-power structures (Jacobs et al., 2013). These energy challenges have led to an increased interest in the development of RES in Latin American countries.

The renewable energy policies in these countries began in the mid-1970s (IRENA, 2015) with the establishment of: (**i**) The ProÁlcool biofuels program in Brazil in 1975; (**ii**) Geothermal laws in Costa Rica in 1976; (**iii**) Assessment of geothermal resources in Nicaragua in 1977, with the "Master Plan for Electrical Development 1977-2000". From this initial period, a range of different mechanisms emerged that drove growth in the renewable energy market. The most common mechanisms on the region according to IRENA (2015) are: (**i**) National renewable energy targets; (**ii**) Auctions;(**iii**) Feed-in Tariffs; (**iv**) Certificate systems; (**v**) Net metering and self-Supply; (**vi**) Direct funds; (**vii**) Fiscal incentives; (**viii**) Renewable energy grind access; (**ix**) Biofuels blending mandates; (**x**) Solar mandates; and (**xi**) Local content requirements.

The next section will show evidence of the most common renewable energy policies and their operations in the Latin America region.

National Renewable Energy Targets

The national renewable energy targets demonstrate the level of RES development and life envisioned by the governments. The RES targets can be applied to electricity, transport sectors and others (Norton Rose Fulbright, 2016). Therefore, many countries in Latin America region have also established their own formal RES targets either by the legislation or decrees (see **Table 2**).

Table 2. The Latin America renewable energy targets

Countries	Renewable Energy Target
Argentina	8% of RES generation by 2016 (i).
Bolivia	549 MWs of RES by 2025, as set by the 2014 Bolivia Electric Plan 2020-25 (ii).
Brazil	42.5% primary energy supply by 2023 and 86.1% of electricity generation matrix by 2023 (iii).
Chile	Target to generate 20% of its electricity from RES by 2025 (iv).
Colombia	6.5% electricity by 2020, excluding large hydro (v).
Ecuador	90% electricity by 2017, 4.2 GWs hydropower by 2022,277 MWs other than hydro by 2022 (vi).
Mexico	13,030 MWs hydropower, 8,922 MWs wind, 1,018 MWs geothermal, 748 MWs bioenergy, and 627 MWs solar (vii).
Nicaragua	91% RES generation target by 2027 (viii).
Peru	6% RES generation by 2018 (excluding hydro) (ix).
Uruguay	50% primary energy by 2015 and 90% electricity by 2015 (x).

Notes: The abbreviations are as follows: Gigawatts (**GWs**); Megawatts (**MWs**). **Sources:** Argentina - Boletín Oficial de la Republica Argentina (2006); Bolivia - Ministerio de Hidrocarburos & Energia (2014); Brazil - Ministerio de Minas e Enegia (2013a); Chile - Ministerio de Energía (2013); Colombia - Mnisterio de Minas e Energia (2010); Ecuador - Consejo National de Electricidad (2013); Mexico - Secretaria de Energía (**SENER**) (2008); Nicaragua - Ministerio de Minas e Energía (2013b); Peru - Congreso de la República de Perú (2010); and Uruguay - Ministerio de Industria, Energía y Minería (2008).

The RE targets have been recognized in all countries in study (see **Table 2**), with the majority designated to the electricity sector. The RE targets can be based on capacity (**MW**) or generation (**MWh**) terms. There are many types of RE targets (e.g. timeline, scope, and technology). For example, Mexico has a targets for RES production of 13,030 MWs hydropower, 8,922 MWs wind, 1,018 MWs geothermal, 748 MWs bioenergy, and 627 MWs solar (Ministerio de Minas e Energía, 2013), while Ecuador has targets of 4.2 GWs hydropower by 2022, 277 MWs other than hydro by 2022 (Consejo National de Electricidad, 2013).

Auctions

The auctions are common policy to the deployment of RES in Latin America region. This policy refers to competitive bidding processes for electricity, where the project developer tale part in the action submit a bid with a price per unit electricity that they are able to realize the project. The government analyses the proposals on the basis of the price and other criteria and signs a contract with winners which offer reliable capacity at efficient prices (Moreno et al., 2010).

In the Latin America region was identified 34 auctions (see **Table A2)**, where the renewable energy-specific (or in that one or more RE technologies were eligible) providing information on the auction year, eligible technologies, amounts auctioned or awarded.

Feed-In Tariffs

The Feed-in Tariffs are policies that provide guaranteed buy at an often above market price (Norton Rose Fulbright, 2016). The FITs are destined to some small RES producers, where it can account among others to capacity installed, technology, overall cost and electricity prices (Jacobs et al., 2013). In some countries, the use of FITs are projected to a reduction in generation costs.

In the Latin America region, the first country to implement the FITs was Argentina, in 1998, for solar power and the wind, and expanded in 2006 to cover bioenergy, ocean energy, small hydro, and geothermal. In 2000 Ecuador established the FITs for solar and hydro-power plants, in 2001 Brazil with PROEOLICA for wind power, and in 2002 with PROINFA, providing FITs for small hydro-power, wind, and biomass. Nicaragua in 2005 established FITs for run-of-the-river and wind power, and Uruguay in 2010 established a limited FITs for biomass (IRENA, 2015).

Certificate Systems

Mexico and Chile are the only countries with certificate systems in the region of Latin America. Mexico has a clean energy certificate system, and Chile has also a RES. In Chile the quota was of 5% in 2010, but until 2025 it will be expanding each year until it reaches 20%. Mexico, on the other hand, introduced a quota system in 2014, where the quota for clean energy included renewable energy sources, low-carbon technologies, nuclear energy and fossil fuels with Carbon Capture and Storage (CCS) (IRENA, 2015).

Net Metering and Self-Supply

This policy allows consumers to generate their own electricity from RES and inject surplus generation on the grid, and taking in consideration their contractual terms, consumers can be remunerated or compensated in a future with some sort of discounts in energy bills (Franz, 2016). This policy has a specific design regarding remuneration terms, transmissions costs, losses, fiscal regime, connection provisions, and off-site generation and balancing periods. In Brazil, Chile, Colombia, Mexico, and Uruguay are the only countries in the Latin America region with this kind of policies (see **Table A3**).

Direct Funds

The direct funds are a key for RES developing as well as to achieve other socio-economic benefits such like poverty reduction, energy access, economic development and job creation. In nine Latin American countries have established and defined public funds to promote the development of RES (see **Table A2**). **Table 3** summarizes the identified funds.

Table 3. Direct funds for renewable energy in Latin America

Country	Sector	Entity/Fund
Argentina	Electricity Biofuels	Misiones (subnational) Renewable Energy Fund
Brazil	Electricity	BNDES;(CDE); *Inova Energia*
	Biofuels	BNDES; PRORENOVA
	Heat	BNDES; PROESCO
	Energy Access	BNDES; RGR; CDC
Chile	Electricity	Support for Non-Conventional Renewable Energy Development
	Energy Access	Energy Access Fund
Colombia	Electricity	FENOGE
	Biofuels	*Fondo Capital Riesgo*
	Energy Access	FAZNI
Ecuador	Electricity	FEISEH (expired)
	Energy Access	FERUM
Mexico	Electricity	Fund for the Energy Transition and Sustainable Electricity Use; Energy Sustainability Fund; Mexican Petroleum Fund
Nicaragua	Electricity	Energy Investment Development Fund
	Energy Access	Electric Development Fund (FODIEN)
Peru	Energy Access	Fund for Rural Electrification (FONER)
Uruguay	Heat	Public Mortgage Bank (BHU)

Notes: IRENA (2015). Information was adapted by author. The abbreviations are as follows: *Banco Nacional de Desenvolvimento Econômico e Social* (***BNDES***); *Conta de Desenvolvimento Energético* (**CDE**); Support for renewal/expansion of sugarcane fields in Brazil (***PRORENOVA***); *Apoio a projetos de eficiência energética* (***PROESCO***); Global Reversion Reserve of Brazil (**RGR**); *Crédito Direto ao Consumidor* (***CDC***); *Fondo de Energías No Convencionales y Gestión Eficiente de la Energía* (***FENOGE***); *Fondo de Apoyo Financiero para la Energización de las Zonas No Interconectadas* (***FAZNI***); *Fondo Ecuatoriano de Inversión en los Sectores Eléctrico e Hidrocarburífero* (***FEISEH***); *Programa de Energización Rural y Electrificación Urbano-Marginal* (***FERUM***); *Fondo para el Desarrollo de la Industria Eléctrica Nacional* (***FODIEN***); *Fondo Nacional de Electrificación Rural* (***FONER***); *Banco Hipotecario del Uruguay* (***BHU***).

The Direct funding would be in the form of grants, direct contract of provisions of equity or debt and subsidies. The direct funding for RES in other Latin American countries have a direct contracting, where RES projects are awarded contracts through direct negotiation or through by PPAs.

Fiscal Incentives

The fiscal incentives for RES have been recognised in nine countries like Argentina, Brazil, Bolivia, Colombia, Ecuador, Mexico, Nicaragua, Peru and finally, Uruguay (see **Table A3**). The fiscal incentives include the following policies: (**i**) National Exemption of Local Taxes; (**ii**) Fuel Tax Exemption; (**iii**) Import or Export Fiscal Benefit; (**iv**) Value Added Tax (**VAT**); (**v**) Income Tax Exemption; (**vi**) Carbon Tax; (**vii**) Accelerated Depreciation; and (**viii**) Other Fiscal Benefits. In Argentina and Peru, fiscal stability incentives have been implemented with the renewable energy technologies being protected from possible changes in their additional fees and fiscal regime. In some cases, new RE specific taxes are created like concession fees for hydro-power in Argentina, Brazil, Bolivia, Colombia, Peru and Uruguay, and geothermal surface tax and vapour tax in Nicaragua (IRENA, 2015).

Renewable Energy Grind Access

The renewable energy grind access policies have been recognised in seven countries in Latin America: Brazil, Colombia, Ecuador, Mexico, Nicaragua, Peru, and Uruguay (see **Table A3**). This policy includes: (**i**) transmission discount or exemption (**ii**) priority or dedicated transmission; (**iii**) grind access; (**iv**) preferential dispatch; and (**v**) other grind benefits.

In some countries (like Colombia), the RES developers under 20 MWs are exempt form a reliability fee to remunerate for reserve power. In Mexico, the development of renewable energy grind access is dedicated to RES transmissions lines through of a coordination process between the energy regulator, the public utility, and RES producers, while in Peru the renewable energy grind access considerate zones with high RES potential in transmission plans (IRENA, 2015).

Biofuels Blending Mandates

In Latin America region, the policies for the promotion of RES in the transport sector is focussed on the use of biofuels and dominated by blending mandates. These mandates establish a percentage of biofuels (e.g. ethanol or biodiesel) that blended with diesel or gasoline (REN21, 2014). In seven countries have blending mandates in their legislation (see **Table 4**).

Table 4. Biofuel blending mandates in Latin America

Countries	Argentina	Brazil	Colombia	Ecuador*	Mexico**	Peru	Uruguay
Ethanol	**10%**	**27%**	**8-10%**	**5%**	**6%**	**7.8%**	**5%**
Biodiesel	**10%**	**7%**	**10%**	**5%**	n. a.	**5%**	**5%**

Notes: n. a. denotes 'not available'. IRENA (2015). Information was adapted by the author. ***** Ethanol blend only in Guayaquil; ***** Only in Guadalajara, Monterrey and Mexico D.F.

The national mandates are applying all territory like Argentina, Brazil, Colombia, Peru and Uruguay or apply only to certain metropolitan areas like in Mexico and Ecuador (see **Table 4**). The fiscal incentives like the fuel taxes, tax exemption are another integral part of biofuels support policies in some countries in Latin America region like Argentina, Brazil, Colombia, and Uruguay.

Solar Mandates

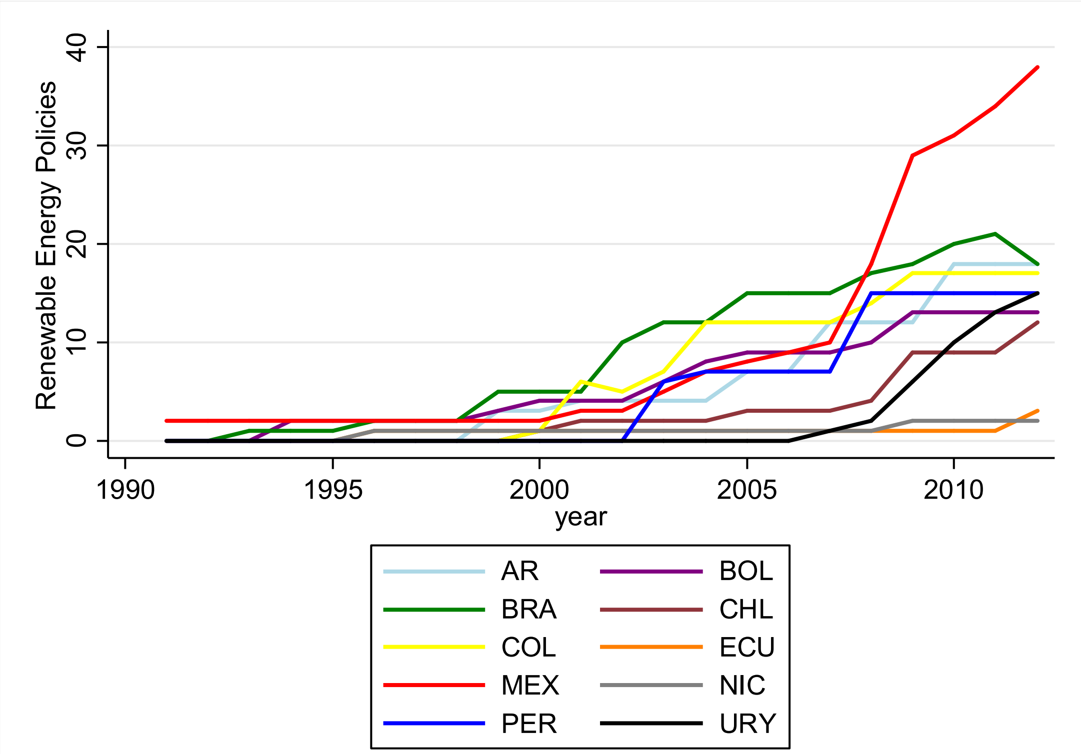
The solar mandates are policies that establish a percentage of their heating needs (e.g. water heating), through solar energy to commercial buildings, industrial and public facilities (REN21, 2014). The Latin America region has a large and unexploited potential for this kind of policy. The solar mandates usually apply to new constructions. In this region, the countries which encourages the use of solar power are: Mexico, Brazil, Uruguay and Nicaragua (IRENA, 2015).

Local Content Requirements

There are others policies and support aspects that contribute to the enabling condition of RES deployment. In some countries in the region of Latin America like Brazil, Ecuador, and Uruguay, all have a local content requirement like policy (see **Table A3**). The local content requirement is imposed in several ways like a percentage of investment, hiring of personnel and use of local materials. For example, both Ecuador and Uruguay impose percentages of local staff to the RES plant control. The local content has been used like a percentage of investment in Uruguay is 20%, Ecuador 40 % and in Brazil is 60% (IRENA, 2015).

Indeed, few authors have focused on the analysis of the impact of RES policies on CO_2 emissions in Latin American countries. For instance, Pereira et al. (2011) analyzed the best strategies for maintaining the high share of RES in Brazil's electric power generation system. Those authors found that the introduction of the energy compensation mechanism had the advantage of being a mechanism that compensated producers to invest in plants emitting less CO_2. Jacobs et al. (2013) studied FITs in 12 Latin America and Caribbean (**LAC**) countries. The results indicated that some LAC countries namely Argentina, Dominican Republic, Ecuador, Honduras, and Nicaragua have used FITs to promote renewable energy to reduce the CO_2 emissions, and that FITs are becoming increasingly popular. If well designed, they can mitigate investor risk in RES. Zwaan et al. (2016) investigated opportunities for energy technology deployment like part of climate change mitigation efforts in Latin American countries. The authors project several renewable energy policy scenarios up to 2050, which could to reduce the CO_2 emissions. **Figure 1** demonstrates the renewable

Figure 1. Renewable energy policies in Latin America



Source: Author compilation based on International Energy Agency (**IEA**) data. **Notes:** The abbreviations are as follow: Argentina (**AR**); Brazil (**BRA**); Chile (**CHL**); Colombia (**COL**); Peru (**PER**); Ecuador (**ECU**); Uruguay (**URY**); Bolivia (**BOL**);Mexico (**MEX**); Nicaragua (**NIC**).

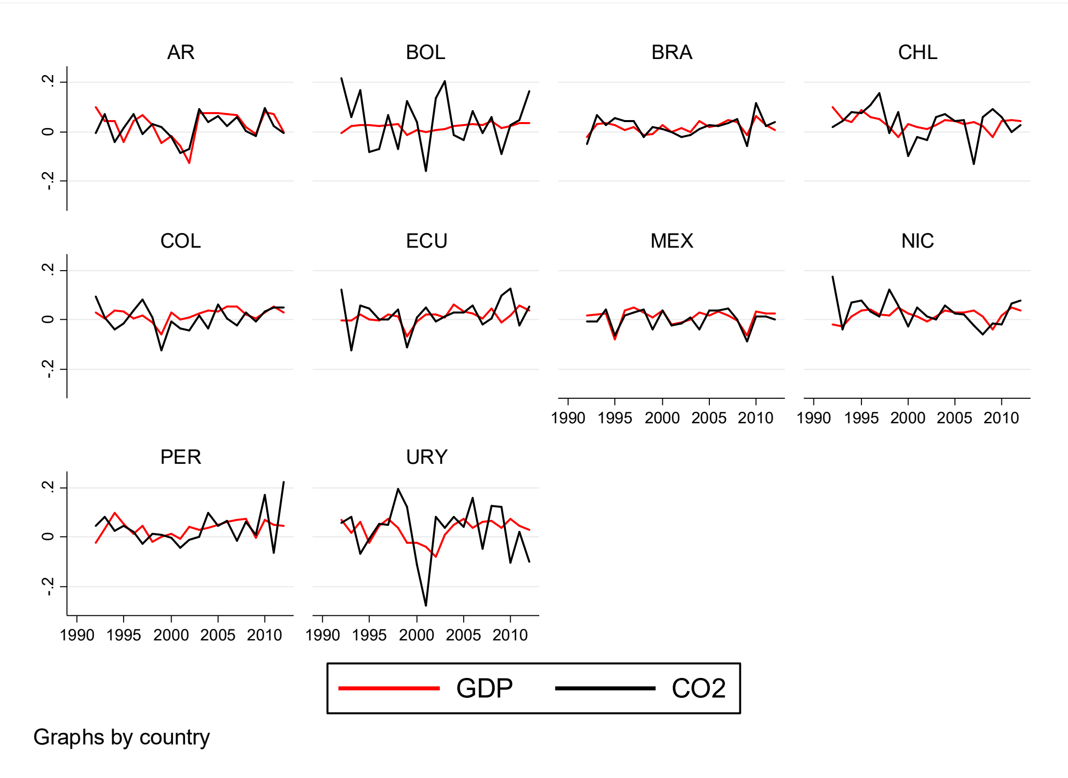
energy policies charted by crosses.

As shown by **Figure 1** the renewable energy policies are constantly growing in Latin American countries, reinforcing the necessity to study. The next section will show the context of the CO_2 emissions in Latin America region.

2.3 The CO_2 Emissions in Latin America

The total CO_2 emissions in Latin America in 2010 were at 4.7 $GtCO_2$ is (10.8% of total global emissions). This index represents a decline of 11 % since the start of the century due to the changes related with the reduction in land-use and the ones related with emissions and energy intensity (Vergara et al., 2013). This decrease occurred during a period of increase in the gross domestic product of countries in the Latin America region, where indicates that economic growth has decoupled from emissions (see **Figure 2**).

Figure 2. GDP vs. CO_2 emissions



Source: Author compilation based on International Energy Agency (**IEA**) and World Bank Data (**WBD**).**Notes:** The abbreviations are as follows: Gross Domestic Product (**GDP**); Carbon Dioxide Emissions (**CO2**); Argentina (**AR**); Brazil (**BRA**); Chile (**CHL**); Colombia (**COL**); Peru (**PER**); Ecuador (**ECU**); Uruguay (**URY**); Bolivia (**BOL**);Mexico (**MEX**); Nicaragua (**NIC**).

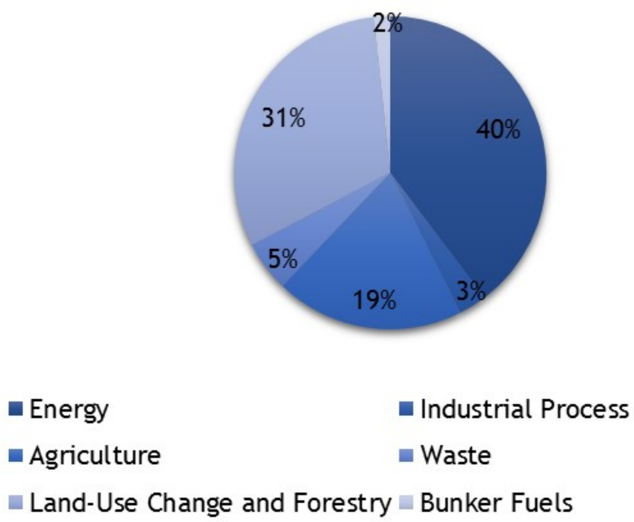
As shown in **Figure 2**, the economic growth has decoupled from CO_2 emissions in countries of Latin America region. The decoupling is due to the introduction of new renewable energy sources in the energy mix as well as the introduction of new technologies that emit less CO_2.

The next subsections will evidence the main sectors that contribute to CO_2 emissions in the analysed region.

The CO_2 Emissions by Sector

The annual emission levels in Latin America region has deteriorated in recent years. The CO_2 emissions intensity in the studied region fell from 1.500 (**tCO_2**) per million dollars of GDP in 1990 to 1.300 (**tCO_2**) per million dollars of GDP in 2005 (Vergara et al., 2013). The mainly composed sectors that contribute to GHG emissions in Latin America are: (**i**) Energy;(**ii**) Industrial Process; (**iii**) Agriculture; (**iv**) Waste; (**v**) Land-Use Change and Forestry, and (**vi**) Bunker Fuels. **Figure 3** shows the sector composition of total CO_2 emissions in Latin America region in 2012.

Figure 3. Sector composition of total CO_2 emissions in 2012



Source: Author compilation based in World Resource Institute (WRI) (2017) data**. Notes:** The above sector contributions refer to percentage shares of total Latin America CO_2 emissions.

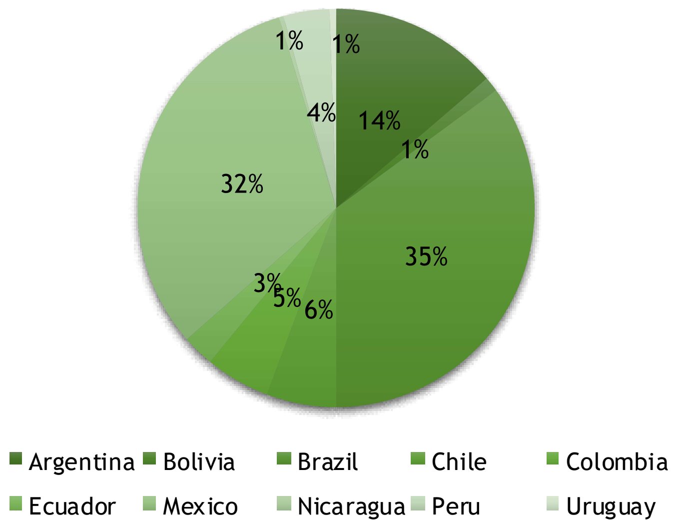
Figure 3 shows that the 40 % CO_2 emissions come from energy consumption, where in Latin America region the energy matrix is mainly composed by fossil fuels (e.g. Oil 46 %, Natural gas 23 % and Coal 5 %). However, at the same time it is incorporated by renewable sources (e.g. Bioenergy and Waster 16 %, Hydro-power 8%, Geothermal 1%, and Solar, Wind and Others <1 %) (IRENA, 2016).

The second and third greatest contributors to CO_2 emissions are land-use Chand and Agriculture. In contrast to the global picture, the emissions in the region are generated not only from energy use, but from land use, agriculture and forestry. As can be seen in **Figure 3**, the Land-Use change contributes to 31 % in CO_2 emissions, while Agriculture 19 %. The Latin America emissions profile is opposite to the world profile, where 50 % of emissions come from agriculture and land use, and only 39% come from energy.

The CO_2 Emissions by Country

Most countries in the region of Latin America are small contributors to the CO_2 emissions, with emissions representing less than 1 % of the global total. This region includes some very large carbon emitters' countries that are in a transition process induced by innumerable structural changes. **Figure 4** illustrates the relative contributions of these principal countries to the regional emissions profile.

Figure 4. The CO_2 emissions by country in 2012



Source: Author compilation based on Energy Information Administration (**EIA**) data. **Notes:** The percentage shares of total Latin America CO_2 emissions.

Brazil was the dominant source of Latin America emissions 35% in 2012 followed by Mexico 32% and Argentina 14 %. The Latin America region is only globally relevant in terms of CO_2 emissions because of Brazil that alone contributes one-third of global land-use emission and Mexico.

The next section will show the economic and political shocks that impacted the Latin America region.

2.4 The Economic and Political Shocks in Latin America

The Latin American countries suffered several economic and political shocks which have impacted the economic growth of the region. However, during the 1990s and the first half of the 2000s and the years 2008-2009, the region suffered several financial crises. The best known of these are the Mexican crisis of 1994-1995, the Brazilian crisis of 1999, the Argentine crisis of 1999-2002, the Uruguayan crisis of 2002 and the Subprime crisis of 2008-2009. These crises are associated with market reforms and the opening of their economies (Edwards, 2008).

The Mexican financial crisis of 1994-1995 refers to the crisis that started after Mexico's devaluation of the peso in 1994, due to the lack of International reserves This crisis was the worst banking crisis in Mexican history (1994-1997), where the depreciation of the currency in December of 1994 was from about 5.3 Pesos per Dollar to over 10 Pesos per Dollar. In November of 1995, Mexico suffered a severe recession which lasted more than a decade, with a decrease of 6 % of GDP (Musacchio, 2012). Mexican's crisis impacted the mainly countries of Latin America region like Argentina and Brazil, where both suffered several financial and cambial crisis. This impact was known as "Tequila Effect" in South American region (Aldrighi and Cardoso, 2009).

The Brazilian currency crisis of 1999 is a result of the crisis of Brazilian Real (BRL) and the devaluation of the exchange rate in January 1999. Moreover, this crisis is directly associated with the structural problems of an anti-inflation plan that was implemented in Brazil. The Brazilian Real plan was successful in controlling the inflation in 1994, but the implementation of deflationary economic policies with an overvalued semi-fixed exchange rate led Brazil into a serious structural economic problem (Averbug and Giambiagi, 2000).

The Argentine financial crisis of 2001-2002 started in 1999 due to several internal and external factors. First, the economic decline, due to a high unemployment and fiscal imbalance. Second, due to the Russian crisis in 1998, the devaluation of the Brazilian currency in 1999, and an enormous aversion to the risk of international financial markets. Taking in consideration the above reasons, the Argentine government established in 2001 that the parity of the Peso should be the same as the Dollar, However, this change brought a severe crisis to the convertibility of the Peso (Fernandes, 2003).

The Uruguayan crisis of 2002, occurred during the severe crisis of Peso convertibility which affected Argentina between 2001 and 2002. Many of the country's customers withdrew their dollar deposits held in Uruguayan banks. This caused a crisis in the financial system in 2002 (Brun and Licandro, 2005).

The subprime crisis of 2008-2009 impacted all countries of Latin America region in different ways, because of the great differences between them. The large and medium-sized countries, already heavily industrialized and urbanized, such like Mexico, Argentina, Colombia, Peru, Venezuela, and Chile, were hit by the crisis in a similar way to Brazil. The principal effects were: foreign exchange flight, exports and external credit, Private banks, which also cut credit and increased interest rates, and as a result the internal market contracted, leading to a fall in production and an increase in unemployment. The small countries like Nicaragua, Bolivia, Ecuador and Uruguay were hit by the international crisis in a more direct way. This impact is due to the fact that these countries are highly dependent of imported products, and have a limited number of primary products to export (Singer, 2009).

The next section will show the used database and specification model while elaborating this dissertation.

3 DATA AND METHODOLOGY

This section is divided into three parts. The first one, shows the variables and the used database. The second shows the model specification. The third shows the preliminary tests.

3.1 Data

In the next lines, the available data in renewable energy policies of the last twenty years (1991-2012) will be analysed, taking in consideration ten countries, namely: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Nicaragua, Peru, and Uruguay. The selection of these countries was based on the available data for RES generation, CO_2 emissions, primary energy consumption, and renewable energy policies. The used variables are: (i) **Carbon dioxide emissions** from energy consumption in million metric tons, and transformed in *per capita;* (**ii**) **Renewable energy consumption** in Kilowatt-hours from hydroelectric, geothermal, wind, solar, tide, wave and biomass and transformed in *per capita;* and (**iii**) **Renewable energy policies** that was constructed as follows form: First, the renewable energy followed selection criteria: (i) **Renewable energy policies** that include following energy sources: Bioenergy, Geothermal, Hydropower, Ocean, and Solar; (ii) **Renewable energy sector** that include: Electricity, Framework Policy, Heating and Cooling, Multi-sectoral Policy, Transport; (iii) **Renewable energy policies jurisdiction** that include: International, National, State/Regional, Municipal; (iv) **Policy status** that include: Just policies with follow status (In Force and Ended), and renewable energy policies that were superseded, under review and planned were excluded from database. Second, were selected the follows policy types availably in IEA for the countries in studies: (i) **Economic Instruments** that include following policies: (a) **Fiscal/financial incentives** with**:** feed-in tariffs/premiums, grants and subsidies loans, tax relief, taxes and User charges; (b) **Market-based instruments** which have the following policies: GHG emissions allowance, green certificates, white certificates; (c) **Direct investments** that include following policies: Funds to sub-national governments, infrastructure investments, Procurement rules, RD&D funding); (ii) **Information and Education** which have the following policies: Advice/Aid in Implementation, Information provision, Comparison label, Endorsement label, Professional training and qualification; (iii) **Policy Support** that include following policies: institutional creation, strategic planning; (iv) **Regulatory**

Instruments which have the following policies: Auditing; codes and standards, monitoring, obligation schemes, other mandatory requirements; (v) **Research, Development and Deployment (RD&D)** which have the following policies: Demonstration project, technology deployment and diffusion, technology development; (vi) **Voluntary Approaches** that include following policies: Negotiated agreements (e.g. Public-private sector), public voluntary schemes, unilateral Commitments (e.g. Private sector). Third, the calculation of variable LPOL is simple and was done as follow: The construction of variable was done by summing of all renewable energy policies types accumulated in the run of their operation, in other words policies (In force and ended), to a better understanding (see, an example in **Table A1**); (**iv**) Primary energy consumption in quadrillion Btu from fossil fuels and other sources and transformed in *per capita*; and (**v**) Gross domestic product (**GDP**) in constant local currency unity (**LCU**) and transformed in *per capita*.

All the variables except the renewable energy policies were transformed in *per capita*. The use of *per capita* values let us control the growth of population disparities among the Latin American countries. Hereafter the prefixes, L, and, D, denote natural logarithm, and first differences of the variables, respectively. **Table 5** shows the name, definition, source of raw data and summary statistics of the variables.

Table 5. Variables description and summary statistics

Variables	Source	Obs	Mean	Std Dev.	Min	Max
LCO2	Energy Information Administration (**EIA**).	220	-13.2156	5.5640	-14.6042	-12.2706
LRE	Energy Information Administration (**EIA**).	220	-14.2404	8.4719	-16.4111	-12.7685
LPOL	International Energy Agency (**IEA**).	220	1.18910	1.0711	0.0000	3.66356
LPE	Energy Information Administration (**EIA**).	220	-17.1651	6.0144	-18.6029	-16.2434
LY	The World Bank Data (**WBD**).	220	10.8001	2.6872	7.7480	16.1225

Given that renewable energy policies are likely to require time to produce their full effect in CO_2, an approach with the ARDL model panel was used. The properties of this estimation method allow the decomposition of the total effect into is short-and long-run dimensions. Accordingly, to achieve the goal of decomposing the global effects in the short-and long-run, we balanced the longest available time span with the maximum possible number of Latin American countries which have renewable energy policies made available. To elaborate the econometric analysis, the **EViews 9.5** and **Stata 14.2** software were used.

3.2 Model Specification

To analyse the impact of renewable energy policies on CO_2 emissions, we used an unrestricted error correction model (**UECM**) form of the ARDL model. This model decomposes the total effect of a variable into its short-and long-run components (e.g. Srinivasan et al., 2012). Moreover, this model generates consistent and efficient parameter estimations as well as the inference of parameters based on the standard test. The general UECM form of the ARDL model used in this empirical analysis follow the specification of **Equation (1)**:

$$\begin{aligned} DLCO2_{it} &= \theta_{it} + \theta_i TREND_t + \sum_{i=1}^{k} \theta_{22i} DLRE_{t-1} + \sum_{i=0}^{k} \theta_{23i} DLPOL_{t-1} + \sum_{i=0}^{k} \theta_{24i} DLPE_{t-1} \\ &+ \sum_{i=0}^{k} \theta_{25i} DLY_{t-1} + \gamma_{21i} LCO2_{t-1} + \gamma_{22i} LRE_{t-1} + \gamma_{23i} LPOL_{t-1} + \gamma_{24i} LPE_{t-1} + \gamma_{25i} LY_{t-i} \\ &+ \varphi_{2i} \end{aligned} \quad (1)$$

where θ_{it} [illegible] the [illegible] θ_i is the [illegible] [illegible] the [illegible] [illegible]

and φ_{2i} is the error term.

3.3 Preliminary Tests

This section shows the preliminary tests in data to check the properties of the variables. Indeed, considering the macro panel, the best econometric practices strongly recommend testing for the presence of heterogeneity, which could arise when a long time span is used. The long-time spans exacerbate the potential occurrence of a panel with parameter slope heterogeneity and the presence of cross-section dependence (**CSD**). In Latin American countries, it is expected the existence of CSD in the model, due to some common characteristics shared by these countries. When the presence of CSD is not controlled, it can produce both biased estimates and a severe identification problem (e.g. Eberhardt and Presbitero, 2013) which require appropriate estimators to handle them. The CSD and the order of integration of the variables are analysed to capture the features of both series and crosses. To check for the presence of multi-collinearity, the variance inflation factor (**VIF**) was applied. This test provides an indication of the impact of multi-collinearity in the accuracy of estimated regression coefficients (e.g. O'Brien, 2007). **Table 6** reveals both results of VIF test and the CSD.

Table 6. VIF test and Pesaran CD test

Variables	VIF	1/VIF	CD-test		Corr.	Abs (corr)
LCO2	n. a.	n. a.	19.13	*	0.608	0.627
LPOL	1.13	0.8884	8.30	**	0.264	0.366
LRE	1.99	0.5015	25.16	*	0.800	0.800
LPE	2.10	0.4761	24.01	*	0.763	0.763
LY	1.19	0.8418	28.63	*	0.910	0.910
Mean VIF	1.60					
DLCO2	n. a.	n. a.	2.75	***	0.089	0.187
DLPOL	1.00	0.9956	-0.52		-0.017	0.214
DLRE	1.11	0.8987	1.43	***	0.047	0.175
DLPE	1.24	0.8060	7.18	**	0.233	0.278
DLY	1.13	0.8857	11.05	*	0.360	0.360
Mean VIF	1.12					

Notes: n. a. denotes 'not available'. ***, **, * denote statistically significant at 1%, 5% and 10% level, respectively. The Stata command xtcd was used to achieve the results for CSD.

The value of mean of VIF was 1.60 in levels, and at the first differences were 1.12. The low VIF statistics than benchmark 10% support the argument that multi-collinearity is of no great concern in the model. The panel data technique allows the heterogeneity control of the crosses. When many individuals are analysed, it provides more information, variability, degrees of freedom and efficiency and thus, less collinearity than is generally present in the time series approach (e.g. Klevmarken, 1989; Hsiao, 2003). The CSD-test points to the presence of cross-section dependence in the variables both in levels and in first differences, except for the RES generation in differences (**DLRE**). A possible answer for this result is that the generation of RES is largely country-specific and conditional in the intermittence that characterizes its generation (e.g. solar and wind sources). The presence of CSD shows evidence of interdependence between the cross-sections, i.e. that the countries share common shocks.

To assess the order of integration of the variables, the first and second-generation unit root tests were used. The first generation unit root tests of LLC (Levin, Lin, and Chu, 2002), ADF-Fisher (Maddala and Wu, 1999), and ADF-Choi (Choi, 2001), were used. The second-generation unit root test CIPS (Pesaran, 2007) was used. Moreover, the null hypothesis of both tests indicate the existence of unit root. **Table 7** shows the results of unit root tests.

Table 7. Unit roots tests

Variables	1st Generation test						2nd Generation unit root test CIPS (Zt-bar)			
	LLC		ADF-Fisher		ADF-Choi					
	Individual intercept and trend						Without trend		With trend	
LCO2	-1.0714		24.3974		-0.6699		-0.776		0.969	
LRE	-4.2044	***	39.3896	***	-2.6446	***	-1.337	***	-1.300	***
LPOL	-0.8576		17.7105		0.1587		-0.404		1.056	
LPE	-0.5597		27.8676		-1.0734		-0.678		1.259	
LY	0.6792		18.9771		1.0888		-1.199		-0.750	
DLCO2	-6.7437	***	83.8301	***	-6.6476	***	-4.976	***	-4.710	***
DLRE	-13.0036	***	139.080	***	-9.6431	***	-6.254	***	-5.157	***
DLPOL	-6.0603	***	65.5947	***	-5.1363	***	-4.038	***	-3.413	***
DLPE	-7.3999	***	113.166	***	-8.0571	***	-3.290	***	-1.868	***
DLY	-6.5306	***	68.1892	***	-5.3035	***	-3.826	***	-2.377	***

Notes: *** denotes statistically significant at 1% level. The null hypotheses are as follow: LLC test the unit root (common unit root process), this unit root test controls for individuals effects, individual linear trends, has a lag length 1, and Newey-West automatic bandwidth selection and Bartlett kernel were used; ADF-FISHER and ADF-Choi test the unit root (individual unit root process), this unit root test controls for individual effects, individual linear trends, has a lag length 1, the first generation test follows the option "individual intercept and trend", which was decided after a visual inspection of the series. The EViews 9.5 was used in the calculus of the first generation tests. The CIPS test has H_0: series are I(**1**). The Stata command *multipurt* was used to compute CIPS test.

The LLC, the ADF and CIPS test (Pesaran, 2007) are consensual, and indicating that all the variables in levels except LRE are integrated of order one I(**1**), i.e. they have one-unit root. The LRE and all the variables in first differences are stationary. The macro panel structure requires a long time span. This has the advantage of allowing panel unit root tests to have a standard asymptotic distribution, which is essential when checking for cointegration (Baltagi, 2008).

The Hausman test of the RE against the FE specification was applied to identify the presence of RE or FE in the model. This test has the null hypothesis that the best model is RE. The results of Hausman test is statistically significant ($X^2_{10} = 70.03$) and indicates the FE model. The presence of FE model in LAM countries were confirmed by the following authors (e.g. Ferreira et al., 2016; Avelino et al., 2015; Gonçalves, 2013).

This model is appropriate for analyzing the influences of variables over time, as well as to remove all time-invariant features from the independent variables. To check the cointegration of results, we used the second-generation cointegration test of Westerlund (2007). This test has as null hypothesis the existence of no-cointegration between the variables. The Westerlund cointegration test is based on an error correction model, where all variables are stationary (Fuinhas et al., 2015).

In the macro panels, the presence of long time spans and many cross-sections, make testing for the slope heterogeneity of parameters highly advisable. This testing could be of two types: (**i**) heterogeneity of parameters in the short-and long-run, and (**ii**) heterogeneity of parameters only in the short-run. To deal with heterogeneity, the Mean Group (**MG**) or Pooled Mean Group (**PMG**) estimators were applied. The MG is a flexible technique that creates regressions for each individual, and computes to all individuals an average coefficient (Pesaran et al., 1999). This estimator is consistent in the long-run average, while when in the presence of slope homogeneity, the model is not efficient (Pesaran et al., 1999). The PMG is an estimator that in long-run parameter makes restrictions among cross-sections and adjustment speed term. Moreover, this estimator is more efficient and consistent in the existence of homogeneity in the long-run than the MG estimator (Fuinhas et al., 2015).

Finally, a battery of diagnostic tests were performed: (**i**) Modified Wald test for groupwise heteroskedasticity. This test has the null hypothesis of homoscedasticity; (**ii**) Pesaran test of cross-section independence, to identify the existence of contemporaneous correlation among cross-sections. The null hypothesis of this test specifies that the residuals are not correlated and it follows a normal distribution; (**iii**) Breusch and Pagan (1980) Langrarian Multiplier test of independence, that follows chi-square distribution, was performed to measure whether the variances across individuals are correlated; (**iv**) Wooldridge (2002) test, to check for the existence of serial correlation; (**v**) Durbin-Watson statistic test, to check the presence of the first-order auto-correlation in the disturbance when all the regressors are strictly exogenous. The null hypothesis of the test is that there is no first-order auto-correlation (Verbeek, 2008, p. 373); and (**vi**) Baltagi-Wu LBI test, to test serial correlation in the disturbance. The null hypothesis of no first-order serial correlation (Baltagi, 2008, pp. 97-98).

The robustness of the model will be tested with the shocks. Indeed, the residual’s model confirms the existence of shocks that need to be controlled in the following countries: Bolivia, Chile and Uruguay. For this reason, were introduced dummy variables that addressed the following years (**BOL2001**, **URY2001**, **CHL2007**, and **URY2009**), with the goal to end these distortions, and correct the shocks in the model. The ARDL model is robust to the inclusion of dummies, where the dummies are statistically significant.

The next section will show the results of the model and the preliminary tests.

4 RESULTS

As stated earlier, the aim of this research is to examine the effect of renewable energy policies on CO_2 emissions in Latin American countries. It is worth nothing that the results are based on *per capita* data. There is evidence of the presence of CSD in the variables (see **Table 6**). The test of unit roots (see **Table 7**) point to the possibility of stationary of LRE. **Table 8** shows the results of the Westerlund cointegration tests.

Table 8. Westerlund cointegration tests

Statistics	**Westerlund cointegration test**								
	None			**Constant**			**Constant & trend**		
	Value	**Z-value**	**P-value robust**	**Value**	**Z-value**	**P-value robust**	**Value**	**Z-value**	**P-value robust**
Gt	-1.777	0.622	0.228	-2.547	-0.337	0.098	-2.484	1.323	0.343
Ga	-5.517	1.940	0.088	-6.916	2.493	0.063	-4.622	4.661	0.466
Pt	-5.445	-0.263	0.116	-5.235	1.439	0.384	-5.957	2.354	0.406
Pt	-5.758	0.154	0.026	-5.856	1.439	0.111	-4.063	3.609	0.429

Notes: Bootstrapping regression with 800 reps. H_0: No cointegration; H_1 Gt and Ga test the cointegration for each country individually, and Pt and Pa test the cointegration of the panel as a whole. The Stata command *xtwest* was used.

The Westerlund cointegration tests rejects the existence of cointegration between variables. The non-detection of cointegration points to the use of econometric techniques that are less stringent, i.e. ARDL models.

The MG and PMG estimators were tested against the dynamic fixed effects (**DFE**). The robust Driscoll and Kraay (1998) estimator was applied, due to the presence of heteroskedasticity, contemporaneous correlation, first orders auto-correlation and cross-sectional dependence. This estimator is a matrix estimator that generates robust standard errors for several phenomena found in the sample errors. The DFE estimator, DFE robust standard errors, and DFE Driscoll and Kraay were computed. Finally, a battery of specification test like (**i**) Modified Wald test; (**ii**) Pesaran test; (**iii**) Breusch and Pagan Langrarian Multiplier test; (**iv**) Wooldridge test; (**v**) Durbin-Watson statistic test; and (**vi**) Baltagi-Wu LBI test were applied.

Table 9 shows the results of the MG, PMG, DFE estimators, and the outcome of the Hausman test, the semi-elasticities and elasticities of the DFE, DFE Robust and DFE D.-K. Models, and the model specification tests. The semi-elasticities were computed by adding the coefficients of variables in the first differences. The elasticities are computed by dividing the coefficient of the variables by the coefficient of (**LCO2**), both lagged once and multiplying the ratio by -1.

Table 9. Estimation results

(Dependent Variable DLCO2)								
	Heterogeneous estimator				Fixed effects			
	MG (I)		PMG (II)		Coefficient	FE (III)	FE Robust (IV)	FE D.-K. (V)
Constant	-2.7910		-4.5068	***	-5.2545	***	***	***
Trend	-0.0013		-0.0027	**	0.0006			
					Short-run (semi-elasticities)			
DLRE	-0.2279	***	-0.1676	***	-0.1854	***	***	***
DLPOL	0.0173		0.0502		0.0061			
DLPE	0.8176	***	0.7630	***	0.5822	***	***	***
DLY	0.5204	***	0.5203	***	0.4276	***	***	***
					Long-run (elasticities)			
LRE(-1)	-1.0157		-0.1163	***	-0.1965	***	***	***
LPOL(-1)	-0.0414		0.0078		-0.0358	***	***	***
LPE(-1)	2.7717		0.6951	***	0.7082	***	***	***
LY(-1)	-1.2185		0.3588	***	0.4776	***	***	***
					Speed of adjustment			
ECM(-1)	-0.9598	***	0.6763	***	-0.5850	***	***	***

	Hausman test		Specification test				
	MG vs PMG	PMG vs DFE	Modified Wald test	Pesaran test	Wooldridge test	Durbin-Watson test	Baltagi-Wu LBI test
	$\chi^2_{11}=20.30$	$\chi^2_{11}=0.00$ ***	$\chi^2_{11}=172.31$ ***	N(0,1) = 4.710 ***	F (1,9) = 111.466***	1.7645	1.8559

Notes: ***, ** denote statistically significant at 1%, and 5% level, respectively; Hausman results for H_0: Difference in coefficients not systematic; ECM denotes error correction mechanism; the long-run parameters are computed elasticities; the Stata commands *xtpmg*, and Hausman (with the sigmamore option) were used; in the fixed effects were used the *xtreg*, and *xtscc* Stata commands; for H_0 of Modified Wald test: sigma(i)^2 = sigma^2 for all I; results for H_0 of Pesaran test: residuals are not correlated; results for H_0 of Wooldridge test: no first-order autocorrelation; The Stata *command xtregar* was used in the Durbin-Watson statistics test and Baltagi-Wu LBI test: The null hypothesis of the Durbin-Watson statistics test is that there is no first-order autocorrelation, and Baltagi-Wu LBI test the null hypothesis of no first order serial correlation.

The elasticities have the expected signs and are highly significant. Additionally, in semi-elasticities, the renewable energy policies (**DPOL**) do not cause any sort of impact over carbon dioxide emissions (**DLCO2**) in the short-run. The elasticities of renewable energy policies (**LPOL**) reduce the carbon dioxide emissions (**LCO2**) to -0.0358 in the long-run. The RES consumption (**DLRE**) in the short-run reduced the carbon dioxide emissions (**LCO2**) to -0.1854, and in the long-run they have decreased -0.1965. Additionally, as expected, the primary energy consumption (**LPE**) and Economic Growth (**LY**) increased the carbon dioxide emissions (**LCO2**) in the short and long-run.

The Hausman test indicates that the DFE is the appropriate estimator, i.e. there is evidence that the panel is 'homogeneous'. The estimations result from the DFE estimator, DFE robust standard errors, and DFE Driscoll and Kraay points to the presence of long memory in the variables. The results are due to the ECM term being statistically significant at 1% level and having a negative sign, where this result confirms the presence of Granger causality (Jouini, 2014).

The battery of specification test, like the modified Wald test, points to a significate presence of heteroskedasticity. The Pesaran test identified the presence of cross-section independence in the model. The Breusch-Pagan LM test has the null hypothesis that the correlated residuals cannot be carried out given that the correlation matrix of the residuals is singular. The Wooldridge test to checks the existence of serial correlation, proved to be highly significant, pointing to the presence of first-order auto-correlation. Finally, modified version of Durbin-Watson test, and Baltagi-Wu LBI test, both of tests reject the null hypothesis, confirming the existence of serial correlation in the disturbance.

To assess the robustness of estimation results, it was introduced dummy variables in order to control shocks of which literature appoints to be disruptive. The next section will show the results of the estimation of semi-elasticities, and the elasticities for the DFE, DFE Robust, and DFE D.-K. models including the dummy variables.

5 ROBUSTNESS CHECK

The results from the previous section, suggest that the renewable energy policies (**LPOL**) reduces the carbon dioxide emission (**LCO2**) in the long-run and the RES consumption (**LRE**), decreases the emissions in both in the short-and long-run. To assess the robustness of estimation results, it was introduced dummy variables (**BOL2001**, **URY2001**, **CHL2007**, and **URY2009**) in DFE, DFE Robust, and DFE D.-K models.

Table 10 shows the results of the estimation of semi-elasticities, and the elasticities for the DFE, DFE Robust, and DFE D.-K. models including the dummy variables.

Table 10. Estimation results with shocks

Models (Dependent Variable DLCO2)				
	Fixed Effects			
	Coefficient	**FE (VI)**	**FE Robust (VII)**	**FE D.-K. (VIII)**
Constant	-4.7448	***	***	***
Trend	0.0006			
	Dummy variables			
BOL2001	-0.1081	***	***	***
URY2001	-0.2054	***	***	***
CHL2007	-0.1573	***	***	***
URY2009	0.1424	***	***	***
	Short-run (semi-elasticities)			
DLRE	-0.1634	***	***	***
DLPOL	-0.0055			
DLPE	0.5822	***	***	***
DLY	0.3733	***	***	***
	Long-run (elasticities)			
LRE(-1)	-0.1433	***	***	***
LPOL(-1)	-0.0415	***	***	***
LPE(-1)	0.6945	***	***	***
LY(-1)	0.4953	***	***	***
	Speed of adjustment			
ECM(-1)	-0.5494	***	***	***

Notes: *** denotes statistically significant at 1% level, respectively. In the fixed effects were used the *xtreg*, and *xtscc* Stata commands.

To select the better model (with or without dummy variables) the likelihood-ratio test was applied. The null hypothesis is that the parameter vector of a statistical model satisfies some mild constraint. The results of the likelihood-ratio test ($\chi^2_4 = $ **56.25**), suggest that the unrestricted model is better and statically significant at 1% level. The shocks proved to be statistically significant at 1% level. Additionally, as can be seen by comparing the **tables 9 and 10**, the results of both models are basically the same, proving the robustness of the approach pursued, even in the presence of shocks.

The next section will show the discussion of the results achieved through this research.

6 DISCUSSION

According to what was mentioned in the previous section, let's proceed to the discussions of the achieved results throughout this research.

The main focus of this dissertation is to study the impact of renewable energy policies on carbon dioxide emissions. The initial test proves the presence of heteroscedasticity, cross-section independence, and first-order auto-correlation. The creation of dummy variables are due to the presence of shocks in the residuals of the model, where the Latin American countries suffered several economic and political shocks that impacted the carbon dioxide emissions in several ways. These shocks were caused by a series of both domestic and external crisis in Latin American countries which began in the 1990s and had impacts on the real economy. The shocks are in conformation with a literary review like the case of Chile (**CHL**), where in 2007 the country saw a reverse trend, mainly driven by the international crisis that affected industry, forestry, steel and further supplemented by reduced diesel generation due to the rearrangement of the matrix of power generation to move away from using this fuel (BCG, 2013). Moreover, Uruguay (**URY**) was also impacted by the international 2008-2009 crisis. However, the impact was very moderate and the country only showed a decline in GDP in the first quarter of 2009, having continued to grow thereafter (IMF, 2010). The shock identified in Bolivia (**BOL**) in 2001 occurred due a social tension that led to the blocking of roads and violent clashes between army troops and peasants who opposed the eradication of coca crops and the Aguas de Ley (**Water Laws**), preventing the operation of networks (Bandeira, 2002). These social tensions, generated many economic and political impacts. Indeed, all of this shocks impacted the CO_2 emissions and proved to be statistically significant at 1% level. Moreover, these shocks have a great importance because they reduce the distortions of model. Additionally, as can be seen in **Tables 9** and **10**, the results of both models are basically the same, proving the robustness of the approach pursued, even in the presence of shocks.

Our analysis is focused on the results in short-and long-run of the variable (**LPOL**). The semi-elasticities of renewable energy policies (**DPOL**) does not exert a reduction in carbon dioxide emissions (**DLCO2**) in short-run, and elasticities the renewable energy policies (**LPOL**) to reduce the carbon dioxide emissions (**LCO2**) in -0.0358 in long-run. The capacity of renewable energy policies to reduce CO_2 emissions in the long-run is probably also related to the efficiency gains associated with these policies. For example, in Latin American countries, the most efficient policies are the national renewable energy targets, which provide a clear indication of the intended level of renewable energy development and the timeline envisioned by governments. For this reason, several countries in Latin America have established their own formal renewable energy targets by the legislations or decrees. Another extremely effective and very popular policy in Latin American countries is that of auctions. The renewable energy auctions refer to competitive bidding procurement processes for electricity from renewable energy sources, or where renewable energy technologies are eligible. The RES auctions in Latin American countries usually offer a long-term power PPA, with durations ranging from 10 to 30 years to successful bidders. By others words, State participation, through laws, decrees, and auctions to incentivize investments in RES, and spread incorporation of RES in the energy matrix of the region, is very large. However, the vast State participation is because the region faces a series of interrelated energy challenges. On the one hand, the Latin American region will need a substantial amount of new electricity generation to meet growth in demand and to replace aging infrastructure as well as many Latin American countries have undiversified energy portfolios and are very exposed to fossil fuel price instability that could seriously affect their national budgets. In addition, they have a strong incentive to implement low-carbon generation into their energy systems to reduce CO_2 emissions and take advantage of the financial resources available throughout the international climate negotiations. It is worthwhile to note that renewable energy policies, when implemented even if inactive continues producing stimuli over time. The capacity of renewable energy policies in decrease the CO_2 emissions could be due to the implementation of renewable energy policies that increase the introduction of RES into the energy mix.

The RES consumption decreases CO_2 emissions in the short-and long-run. This result is possible, due the existence of policies which substitute the use of fossil fuels by production and use of RES in Latin American countries, where, in 2014 the region consumed 94% of RES generated and received US$ 244 billion in investments in alternative renewable technologies (e.g. Solar, wind, geothermal, ocean, small-scale hydroelectric and bioenergy).Finally, the primary energy consumption (**LPE**), and economic growth (**LY**) increase CO_2 emissions in both the short- and long-run could result from evidence that the Latin American economies are still highly dependent in fossil fuels to growth. This dependence is due to many of these countries being major fossil fuels producers like Argentina, Brazil, Colombia, Ecuador, Mexico, Peru, and Venezuela, or because they depend of imports, like the Central American countries and Chile. During the next section, the conclusions of this dissertation will be developed.

7 CONCLUSIONS

The impact of renewable energy policies on CO_2 emissions was analyzed in ten Latin American countries, for the period from 1991 to 2012, using a panel auto-regressive distributed lag approach. The pre-testing proved the presence of cross-sectional dependence, confirming that these countries share spatial patterns, heteroskedasticity, contemporaneous correlation, and first order auto-correlation. The results show that the semi-elasticities of renewable energy policies does not exerts a reduction in carbon dioxide emissions in short-run, and elasticities the renewable energy policies reduce the carbon dioxide emissions in -0.0358 in long-run. The capacity of renewable energy policies to reduce CO_2 emissions in long-run is probable also related to the efficiency gains associated with these policies. The renewable consumption decrease the CO_2 emissions in -0.1854 in short-run and -0.1965 in long-run, respectively. This result is possible, due the existence of policies which substitute the use of fossil fuels by production and use of RES in Latin American countries. The primary energy consumption increases the CO_2 emissions in 0.5822 in short-run and 0.7082 in long-run, respectively. This result is possible due the presence of fossil fuels on energy matrix in some countries in Latin America like Mexico, Chile, Colombia, and Bolivia. Finally, the economic growth increases the CO_2 emissions in 0.4276 in short-run and 0.4776 in long-run. This result, evidence that the Latin American economies are still highly dependent of fossil fuels to growth. This dependence is due to many of these countries being major fossil fuels producers like Argentina, Brazil, Colombia, Ecuador, Mexico, Peru, and Venezuela, or because they depend of imports like the Central American countries and Chile. These evidences points to the necessity to create new renewable energy policies to promote the production and consumption, because the impact of renewable energy policies in CO_2 emissions is very small. Moreover, these evidences are an opportunity to alert the policy makers to the necessity to change the current energy mix to a more sustainable one as well as the creation of new renewable policies designed to promote economic growth and social development. Additionally, the renewable energy policies have capacity to bring new investments in RES and foster the economy of a country or region as well as the social aspect.

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APPENDIX

Table A1. An example of the calculating the variable LPOL (Argentina)

Year	Economic Instruments—Fiscal/financial incentives						Total of Policies
	Feed-in tariffs/premiums	grants and subsidies	loans	tax relief	taxes	User charges	
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	0	1 (i)	0	0	0	0	1
2000	0	1	0	0	0	0	1
2001	0	1	0	1	0	0	2
2002	0	1	0	1	0	0	2
2004	0	1	0	1	0	0	2
2004	0	1	0	1	0	0	2
2005	0	2 (ii)	0	1	0	0	3
2006	0	2	0	1	0	0	3
2007	1	3(iii)	0	1	0	0	5
2008	1	2	0	2	1	0	6
2009	1	2	0	2	1	0	6
2010	1	3 (iv)	0	3	1	0	8
2011	1	3	0	3	1	0	8
2012	1	3	0	3	1	0	8

Notes: (i) A first RE policy was created in 1999 and in Force ; (ii) A second RE policy was created in 2005 and in Force;(iii) A third RE policy was created in 2007 and ended in 2007; (iv) A forth RE policy was created in 2010 and in Force. This calculation was applied in all RE policy types and in the end was summed. This Table were created by authors.

ANNEX

Table A2. Renewable energy auctions in Latin America

Country		Year	Wind(MW)	Solar(MW)	Hydro(MW)	Biomass(MW)	Reference
Argentina	2009	**	(500)*	(20)*	(60)*	(390)*	GENREN
Brazil	2015	**	*	*	n. a.	n. a.	Rule MME 070/2015
Brazil	2015	**	*	*	n. a.	n. a.	Rule MME 069/2015
Brazil	2015	**	*	n. a.	n. a.	*	Rule MME 672/2014
Brazil	2015	**	n. a.	n. a.	*	*	Rule MME 653/2014
Brazil	2015	**	*	n. a.	n. a.	*	Rule MME 563/2014
Brazil	2014	n. a.	n. a.	n. a.	n. a.	*	010/2014
Brazil	2014	n. a.	769.1*	889.6*	n. a.	n. a.	008/2014
Brazil	2014	n. a.	926*	0*	43.88*	611*	006/2014
Brazil	2014	n. a.	n. a.	n. a.	1,471 MW*	1 MW*	005/2014
Brazil	2014	n. a.	551*	n. a.	417*	n. a.	003/2014
Brazil	2013	n. a.	2,337.8*	n. a.	1,007.7*	161.8*	010/2013
Brazil	2013	n. a.	867.6*	0*	0*	0*	009/2013
Brazil	2013	n. a.	n. a.	n. a.	618.5*	647*	006/2013
Brazil	2013	n. a.	1,505*	n. a.	n. a.	n. a.	005/2013
Brazil	2012	n. a.	281.9*	n. a.	292.4*	0*	006/2012
Brazil	2011	n. a.	976*	n. a.	135*	100*	007/2011
Brazil	2011	n. a.	861*	n. a.	n. a.	357*	003/2011
Brazil	2011	n. a.	1,067.6*	n. a.	450*	197.8*	002/2011
Brazil	2010	n. a.	2,047.8*	n. a.	131.5*	712.9*	007/2010
Brazil	2010	n. a.		n. a.			005/2010
Brazil	2009	n. a.	1,805.7	n. a.	n. a.	n. a.	003/2009
Brazil	2008	n. a.	n. a.	n. a.	n. a.	2,379.4*	001/2008
Brazil	2007	n. a.	0*	n. a.	96.7*	541.9*	003/2007
Peru	2015	**	*	1,300 GWh/yr*	450 GWh/yr*	*	4th RE auction
Peru	2014	n. a.	n. a.	*	n. a.	n. a.	1st off-grid RE auction
Peru	2013	n. a.	n. a.	n. a.	1,278 GWh/yr*	*	3rd RE auction
Peru	2011	n. a.	416 GWh/yr*	43 GWh/yr*	680 GWh/yr*	14 GWh/yr*	2nd RE auction
Peru	2010	n. a.	n. a.	0*	92 GWh/yr*	11.7 GWh/yr*	1 st Auction, 2nd call
Peru	2009	n. a.	571 GWh/yr*	173 GWh/yr*	161*	143 GWh/yr*	1st Auction, 1st Call
Uruguay	2013	n. a.	n. a.	(207)*	n. a.	n. a.	Decree 133/013
Uruguay	2011	n. a.	(150)*	n. a.	n. a.	n. a.	Decree 159/011
Uruguay	2009	n. a.	(150)*	n. a.	n. a.	n. a.	Decree 403/009
Uruguay	2006	n. a.	(20)*	n. a.	(20)*	(20)*	Decree 77

Notes: IRENA (2015). n. a. denotes 'not available'. Information was adapted by the author. ***** Technology eligible; ** Planned; Number indicates amount contracted if known, number in brackets **()** indicates amount auctioned; all figures in MW unless otherwise noted.

Table A3. Renewable energy policies in Latin America

Country	National Policy								Fiscal Incentives								Grid Access				
	Renewable Energy Target	Renewable Energy Law / Strategy	Solar Heating Law / Programme	Solar Power Law / Programme	Wind Power Law / Programme	Geothermal Law / Programme	Biomass Law / Programme	Biofuels Law / Programme	VAT Exemption	Fuel Tax Exemption	Income Tax Exemption	Import / Export Fiscal Benefit	National Exemption of Local Taxes	Carbon Tax	Accelerated Depreciation	Other Fiscal Benefits	Transmission Discount / Exemption	Priority / Dedicated Transmission	Grid Access	Preferential Dispatch	Other Grid Benefits
Argentina	*	*			*			*	*	*	*	*	*		*	*					
Bolivia	*								**			**	**								
Brazil	*				**			*		*		*	*			*	*				
Chile	*	*	*	*		*	*														
Colombia	*	*							*	*	*	*			*	*					*
Ecuador	*					*	*	*			*	*							*	*	
Mexico	*	*	*			*	*	*					*	*	*	*	*	*	*		*
Nicaragua	*	*				*	*	*	*		*	*	*			*				*	*
Peru	*	*		*		*		*	*							*		*	*	*	*
Uruguay	*	*	*				*	*	*	*	*					*	*			*	*

Notes: IRENA (2015). Information was adapted by the author. (*) Active, (**) Expired, superseded or inactive, (***) Subnational level, (****) Under development.

Table A3 (Contd.). Renewable energy policies in Latin America

	Regulatory Instruments											Finance						Other						
Country	Auctions	Feed-in Tariff	Premium	Quota	Certificate System	Hybrid	Net Metering	Ethanol Blending Mandate	Biodiesel Blending Mandate	Solar Mandate	Registry	Currency Hedging	Dedicated Fund	Eligible Fund	Guarantees	Pre-investment Support	Direct Funding	Renewable Energy in Social Housing	Renewable Energy in Rural Access Programmes	Renewable Energy Cookstove Programme	Local Content	Special Environmental Regulations	Food / Bioenergy Nexus	Social Requirements
Argentina	*	**						*	*			*	***			*	***		*					
Bolivia		*** *														*			*					
Brazil	*	**				**	*	*	*	***	*		*	*		*	*	*	*		*	*		
Chile	*			*	*		*						*			*	*		*					
Colombia							*	*	*				*	*					*			*** *		*
Ecuador		**						***	*			*	*	*		*	*		*		*		*	*
Mexico	**			*	*		*	***		***			*	*		*	*	*	*				*	*
Nicaragua	*	*		*		*						*	*		*	*	*		*	*		*		
Peru	*	*	*	*		*		*	*			*		*			*	*** *			*	*	*	
Uruguay	*	*				*	*	*	*	*		*		*			*	*** *			*	*	*	

Notes: IRENA (2015). Information was adapted by the author. (*) Active, (**) Expired, superseded or inactive, (***) Subnational level, (****) Under development.