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DETERMINANTS OF CO_2 EMISSION IN MERCOSUR: THE RULE OF INVESTMENT IN EDUCATION

DETERMINANTES DA EMISSÃO DE CO_2 NO MERCOSUL: A REGRA DO INVESTIMENTO EM EDUCAÇÃO

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Abstract

The aim of this research was to assess the impact of the governmental expenses with Education on CO_2 emission in countries from Mercosur and other associate ones. It included annual data related from 1990 to 2014, obtained from World Bank (*world development Indicators)*, through an online database (http://data.worldbank.org). As proxy for pollutant emissions, we used the variable CO_2, which represents the emission of carbon dioxide in metric tons per capita. Final sample comprised eight countries, four from Mercosur itself (Argentina, Brazil Paraguay and Uruguay) and four associate countries (Chile, Peru, Colombia and Ecuador) in a 25-years consecutive period. According to data, it wasn't possible to infer that government's outlays on Education does not impact on CO_2 emission neither in Mercosur nor in associate countries, what also does not support our first hypothesis. On the other hand, segregation on Education outlays showed there is a negative and significant relation between governmental expenses in Education per student (from secondary and tertiary teaching) and the CO_2 emission in the previously mentioned countries, supporting both second and third hypotheses of this research.

Keywords: CO_2 emission. Governmental outlays in Education. Renewable Energy

Resumo

O objetivo desta pesquisa foi avaliar o impacto dos gastos governamentais com Educação na emissão de CO2 em países do Mercosul e outros associados. Incluiu dados anuais referentes ao período de 1990 a 2014, obtidos do Banco Mundial (indicadores de desenvolvimento mundial), por meio de um banco de dados online (http://data.worldbank.org). Como proxy de emissão de poluentes, utilizou-se a variável CO2, que representa a emissão de dióxido de carbono em toneladas per capita. A amostra

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final compreendeu oito países, sendo quatro do próprio Mercosul (Argentina, Brasil, Paraguai e Uruguai) e quatro países associados (Chile, Peru, Colômbia e Equador) em um período de 25 anos consecutivos. De acordo com os dados, não foi possível inferir que os gastos do governo com Educação não impactam na emissão de CO2 nem no Mercosul nem nos países associados, o que também não corrobora nossa primeira hipótese. Por outro lado, a segregação dos gastos com Educação mostrou que há uma relação negativa e significativa entre os gastos governamentais em Educação por aluno (do ensino médio e superior) e a emissão de CO2 nos países mencionados anteriormente, apoiando tanto a segunda quanto a terceira hipóteses desta pesquisa.

Palavras-chave: Emissão de CO2. Gastos Governamentais em Educação. Energia renovável

Introduction

Earth has been deeply modified by human actions over last centuries. In few generations, humanity exhausted fossil fuel formed throughout several million years, resulting in big emissions of atmospheric pollutants (DOGAN, 2015). Combustion of fossil fuels, along with deforestation, soil erosion and livestock, have substantially increased atmospheric concentrations of various greenhouse gases (GHG) - such as carbon dioxide (CO2) and methane (CH4), contributing to global warming (BENÍTEZ et al., 2019).

Capitalism has transformed the geography of ecosystems worldwide, resulting in pollution, climate change, ozone depletion and exhaustion of non-renewable resources (BENÍTEZ et al., 2019) so that environmental pollution has become one of the major global issues over recent years, due to the increase in greenhouse gas (GHG) emissions, thus, several researches have been conducted in an attempt to identify the main variables that impact this increase.

Researches have been carried out to identify the relationship between pollution (e.g. CO2 emission) and renewable and non-renewable energy consumption (AL-MULALI et al., 2014; APERGIS; PAYNE, 2012; BHATTACHARYA et al., 2016; DOGAN, 2015; FANG, 2011; INGLESI-LOTZ, 2015; JEBLI; YOUSSEF; OZTURK, 2016; KULA, 2014; SHAHBAZ et al., 2015).

Other researches have related economic growth (measured by Gross Domestic Product (GDP)) and aggregate energy consumption as variables that impact CO_2 emissions (AJMI et al., 2015; ALSHEHRY; BELLOUMI, 2015; BAEK, 2015; JEBLI; YOUSSEF, 2015; COWAN et al., 2014; DOGAN; SEKER, 2016; KASMAN; DUMAN, 2015; SHAHBAZ et al., 2015; YAVUZ, 2014); others also highlight the existence of the environmental Kuznets curve (EKC) structure, known as the Kuznets Curve (or U-Inverted Hypothesis), which establishes a U-inverted relationship between inequality in income distribution and economic growth (KUZNETS, 1955), as shown in Dogan (2015), Farhani and Shahbaz (2014), Kasman and Duman (2015) and Tang and Tan (2015).

These researches have been conducted mainly in countries like US (DOGAN; TURKEKUL, 2015; MENYAH; WOLDE-RUFAEL, 2010; SOYTAS et al., 2007), França (ANG, 2007), Malasya (ANG, 2008), Albania, Bulgaria, Hungary and Romania (OZTURK; ACARAVCI, 2010b), Brazil, Russia, India and China (COWAN et al., 2014; PAO; TSAI, 2011), China (DU et al., 2012; FANG , 2011; JALIL; FERIDUN, 2011), Russia (PAO et al., 2011), South Korea (PARK; HONG, 2013), Turkey (BÖLÜK; MERT, 2015; DOGAN, 2015; SEKER et al., 2015; YAUZ, 2014), Saudi Arabia (ALSHEHRY; BELLOUMI, 2015), European Union Countries (BENGOCHEA; FAET, 2012; KASMAN; DUMAN, 2015; LÓPEZ-MENÉNDEZ et al., 2014), Canada, Denmark, Iceland, Finland, Norway, Sweden, USA (BAEK, 2015), France (IWATA et al., 2010), USA, Japan, France, Korea, Spain, and Canada (BAEK; PRIDE, 2014), North Africa (JEBLI; YOUSSEF, 2015), South America (APERGIS; PAYNE, 2015), among other countries.

According to Benítez et al. (2019), environmental speech began to take root in institutional spheres in 1972 with the United Nations Conference on the Human Environment, held in Stockholm. In 1977, UNESCO and UNEP organized the Intergovernmental Conference on Environmental Education in Tbilisi (Georgia, USSR) to broaden their political and educational outreach. In addition to these events, some countries, including the European Union (EU) Member States, have signed the Kyoto Protocol, which entails binding obligations (DOGAN; SEKER, 2016) proposing the reduction of GHG emissions. If on the one hand, developed countries made a commitment to reduction targets, on the other hand, developing countries were encouraged to reduce their emissions voluntarily (UN,

1998). For Bento and Moutinho (2016) the EU has adopted stricter environmental targets with the 2020 climate energy package, - regardless of its commitment to the Kyoto Protocol - which aims to make Europe a highly energy efficient low carbon economy, targeting the reduction of greenhouse gas emissions to 20% and the increase of renewable energy consumption (and consequently reduction of non-renewable energy consumption) to 20% by 2020.

However, a few researches aimed the determinants of CO_2 emission in Mercosur countries. This economic block exists since 1991 and Argentina, Brazil, Paraguay, Uruguay and Venezuela, together, correspond to more than one third of all the South America's GDP. Moreover, we found no researches related to the impact of environmental education – especially about the efforts made by environmental education promoters in schools, since primary education. In a few words, there is a gap when it comes to evidence the investments on Education about CO_2 emission (COSTA; LOUREIRO, 2015; PEDRINI et al., 2016), mainly because such investments might make people more conscious and mitigate pollutant gases emission.

Under this perspective, also based on the listed reasons, the problem of this research may be addressed through this following question: what is the relation between government expenses in Education and CO_2 emission in countries of Mercosur and associate ones? In order to answer this request, this research was to assess the impact of the governmental expenses with Education on CO2 emission in countries from Mercosur and other associate ones.

Considering that "environmental education must help raising awareness of the economic, political and ecological interdependence of the modern world while aiming to enhance the spirit of responsibility and solidarity among nations" (UNESCO, 1978), it is expected that, over the years, the various investments in education, from basic education, can result in positive effects in people in relation to environmental issues, if there is an intrinsic environmental education at its various levels, enabling sustainable development, meeting the needs of the present without compromising the needs of future generations.

This study may contribute to the literature related to environmental problems, once previous researches did not seek to demonstrate the relationship between government expenses on education and CO_2 emissions. This perspective aims to demonstrate whether expenses on education have enabled people to be aware of environmental problems and, if so, they have produced positive results in mitigating CO_2 emissions.

Literature review and development of hypotheses

CO_2 emission has been the target of several researches over the last years at both national and international levels. Such researches seek to show the main variables that impact over increase and decrease of CO_2 levels, like economic growth, aggregate energy consumption, renewable and non-renewable energy consumption, trade openness, financial development, urbanization, *inter alia* (AJMI ET AL., 2015; ALSHEHRY; BELLOUMI, 2015; ANG, 2007; APERGIS; PAYNE, 2015; APERGIS; PAYNE, 2009; ATICI, 2009; BAEK, 2015; JEBLI; YOUSSEF, 2015; CHANDRAN; TANG, 2013; COWAN et al., 2014; DOGAN; SEKER, 2016; DOGAN; TURKEKUL, 2015; DU et al., 2012; FARHANI; OZTURK, 2015; HALICIOGLU, 2009; JALIL; FERIDUN, 2011; KASMAN; DUMAN, 2015; NASIR; REHMAN, 2011; OMRI, 2013; OZTURK; ACARAVCI, 2010a, 2010b; PAO et al., 2011a; PAO; TSAI, 2011b; PARK; HONG, 2013; SAY; YÜCEL, 2006; SEKER et al., 2015; SHAHBAZ et al., 2014, 2013; SHAHBAZ et al., 2015; HOSSAIN, 2011; SOYTAS; SARI, 2009; SOYTAS et al., 2007; TANG; TAN, 2015; YAVUZ, 2014).

With regard to aggregate energy consumption, previous researches are conclusive and converge to the view this kind of consumption contributes to CO_2 emissions, although they highlight the existence of different causal directions between carbon emissions, trade openness, income and energy consumption (AJMI et al., 2015; ALSHEHRY; BELLOUMI, 2015; APERGIS; PAYNE, 2015; BAEK, 2015; JEBLI; YOUSSEF, 2015; CHANDRAN; TANG, 2013; COWAN et al., 2014; DOGAN; SEKER, 2016; DOGAN; TURKEKUL, 2015; FARHANI; OZTURK, 2015; JALIL; FERIDUN, 2011; KASMAN; DUMAN, 2015; NASIR; UR REHMAN, 2011; OMRI, 2013; OZTURK; ACARAVCI, 2010a, 2010b; PAO et al., 2011; PAO; TSAI, 2011; PARK; HONG, 2013; SEKER et al., 2015; SHAHBAZ et al., 2014, 2013; SHAHBAZ et al., 2015; HOSSAIN, 2011; TANG; TAN, 2015; YAVUZ, 2014).

With the breakdown of aggregate energy consumption by sources and, i.e., segregation between non-renewable and renewable energy consumption, previous literature data have shown the existence of a positive relationship between non-renewable energy consumption and CO_2 emissions (ALSHEHRY; BELLOUMI, 2015; APERGIS; PAYNE, 2015; DOGAN; SEKER, 2016;

SOUZA et al., 2018). On the other hand, the research results demonstrate the existence of an inverse relationship between renewable energy consumption and CO_2 emission (ALSHEHRY; BELLOUMI, 2015; APERGIS; PAYNE, 2015; DOGAN; SEKER, 2016; SOUZA et al., 2018).

Many studies are based on the Kuznets curve (EKC) environmental structure hypothesis (AJMI et al., 2015; APERGIS; PAYNE, 2009; ATICI, 2009; BAEK, 2015; CHANDRAN; TANG, 2013; SOUZA et al., 2018), while several researches do not investigate the presence of the EKC hypothesis. Among those which assessed the validity of the EKC hypothesis, the results found are divergent even for the same countries and regions, as in the case of Turkey, there are some that point to the validity of the EKC (SEKER et al., 2015; YAVUZ , 2014) and, on the other hand, other which don't (HALICIOGLU, 2009; OZTURK; ACARAVCI, 2010a). For Brazil, EKC hypothesis was supported (SOUZA et al., 2018), unlike the United Kingdom, Italy, and Japan, where no support was found (AJMI et al., 2015). In turn, little evidence has been found for Arctic countries (Canada, Finland, Denmark (Greenland), Iceland, Norway, Russia, Sweden, and the United States (Alaska)) (BAEK, 2015).

When it comes to trade liberalization, previous researches such as Dogan and Turkekul (2015), Dogan and Seker (2016) and Hossain (2011), showed that it mitigates pollution. On the other hand, other researchers showed the opposite, since trade openness contributes to the increase of pollution level (JALIL; FERIDUN, 2011; NASIR; REHMAN, 2011).

CO_2 emissions and renewable energy consumption have a statistically significant positive impact on GDP, evidencing the need of renewable (rather than non-renewable) energy because it increases CO_2 production, reduces the energy dependence on fossil energy and can reduce CO_2emissions (JEBLI; YOUSSEF, 2015). According to AJMI et al. (2015), there is a bidirectional causality between energy consumption and CO_2 emissions for United States and France; as for GDP and energy consumption in Japan. In turn, there is a unidirectional causality from GDP to energy consumption for Italy and United Kingdom; as for energy consumption to GDP in Canada.

In Saudi Arabia, there is unidirectional short-term causality that results from CO_2 emissions for energy consumption and GDP, as for in the long term, between energy consumption for economic growth and CO_2 emission (ALSHEHRY; BELLOUMI, 2015). There is also the two-way causality between economic growth and CO2 emissions in Indonesia and Thailand, as well as the unidirectional causality of GDP for emissions in Malaysia (CHANDRAN; TANG, 2013).

Ang (2007) shows that economic growth causally influences the energy consumption, and both positively impact CO_2 emissions in France (ANG, 2007; APERGIS; PAYNE, 2009) and in the Arctic countries (Canada, Finland, Denmark (Greenland), Iceland, Norway, Russia, Sweden, and the United States (Alaska)) (BAEK, 2015). For Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Suriname, Uruguay and Venezuela, there is a positive relationship among real GDP per capita, CO_2 emissions per capita and real prices of oil (APERGIS; PAYNE, 2015). For Bulgary, Hungary, Romania and Turkey, the results confirm the existence of EKC, so that per capita emissions decrease over time as per capita GDP increases (ATICI, 2009).

Environmental Education

The Brazilian Federal Constitution (1988) considers that education is a right of all, and aims at the full development of people, their preparation for the exercise of citizenship and their qualification for work, are a priority field of public policies to ensure equity and social inclusion. In turn, Article 1 of Law 9.795 / 1999, when disposing of Environmental Education (EE) and instituting the National Policy of EE, highlights:

> Environmental education means the processes by which the individual and the community build social values, knowledge, skills, attitudes and competences turned to the conservation of the environment, a common good of the people, essential to the healthy quality and sustainability of life (BRAZIL, 1999).

According to Collado (2017), EE combines the internal and external dimensions of human training. By addressing trans-disciplinarily the fundamentals of environmental education, the teaching-learning process is significantly enriched, as its formative dimensions become fertilized and lead to new ways of feeling-thinking-acting. According to Costa and Loureiro (2015) and Pedrini, Brotto, Santos, Lima and Nunes (2016), EE is essential because it has the potential to provide a

collective understanding of the systemic nature of environmental crises and to transform the way urban and rural dwellers relate to the environment.

The field of EE has been developed and incorporated into the discussion of sustainability since the 1970s, when environmental problems were shown in global scale and impacted society as a whole, thus, their importance and modes of implementation at major conferences and meetings were discussed. education and environmental organizations (Mesquita et al., 2019).

More recently, Education on Climate Changes (ECC), based on environmental education, emerges as a new proposal, with guidelines aiming at improving the population's climate literacy; also with consumerism mitigation goals for climate mitigation and adaptation. Obtaining knowledge and skills related to climate change, and changing patterns of human activity in search of more sustainable behavior are parallel and simultaneous paths proposed for this approach (FERNANDES et al., 2016 *apud* Mesquista et al., 2019).

Following this conception, Education, especially EE, when combining the internal and external dimensions of human training, emphasizes the development of competences aimed at the conservation of the environment and, therefore, the survival of future generations. By promoting the development of education, particularly through government investment, the effects of climate change are expected to be mitigated.

Considering that several countries around the world have highlighted the importance of EE and the reduction of greenhouse gases, especially CO_2, the awareness among people, especially students of basic education, is fundamental. Thus, it is expected that government investments in education, in a multivariate context, can promote sustainable practices and, consequently, the reduction of CO_2 levels.

From these evidences, regarding education, especially EE, consumption of renewable and non-renewable energy, income and CO_2 emission, some hypotheses were elaborated. Thus, considering that spending on education makes citizens more aware, and therefore more aware of environmental issues, this research enabled the following assumptions:

H_1= There is a negative and significant relationship between government expenses on education and emission of pollutants in Mercosur and associated countries.

H_2= There is a negative and significant relationship between government expenses per primary student, with education and emission of pollutants in Mercosur and associated countries.

H_3 = There is a negative and significant relationship between government spending per tertiary student, education and emission of pollutants in Mercosur and associated countries.

Methodology

This survey used the annual data panel for the period 1990 to 2014. As a proxy for pollutant emissions (dependent variable), we used the CO_2 variable, which represents carbon dioxide emissions in metric tons per capita. Online data were obtained from the World Bank (world development Indicators) available on the website (http://data.worldbank.org). The sample comprises eight countries representing Mercosur (Argentina, Brazil, Paraguay and Uruguay) and associated countries (Chile, Peru, Colombia and Ecuador), covering a period of 25 consecutive years. The countries Bolivia (associate) and Venezuela (representative) were not considered in the research due to the lack of information in the research database.

In order to analyze the influence of education investments on carbon dioxide (CO2) emissions as a proxy for Greenhouse Gases (GHG), this study is based on global investments as a percentage of GDP. And data like both primary, secondary and tertiary education, as a percentage of GDP were likewise considered.

In addition to the variable 'expenses on education' as a percentage of GDP, were included as control variables as well: non-renewable energy consumption, renewable energy consumption, population growth and the real value of gross domestic product (GDP) per capita, whereas some researches emphasized the importance of these variables in determining CO_2 emissions (APERGIS; PAYNE, 2015; BAEK, 2015; DOGAN, 2015; DOGAN; SEKER, 2016; JEBLI et al., 2016; SHAHBAZ et al., 2015).

To test the association between GHG emissions and education spending, the following model, Equation 1, was used:

$$CO_{2_{it}} = \beta_0 + \beta_1 GEE_{it} + \beta_2 NREN_{it} + \beta_3 REN_{it} + \beta_4 GROWTH_{it} + \beta_5 GDP_{it} + \varepsilon_{it} \quad (1)$$

where

$CO_{2_{it}}$ = Carbon dioxide emissions in metric tons per capita from country i in year t;
GEE_{it} = governmental expenses with education in terms of percentuals in relation to GDP;
$NREC_{it}$ = it is the non-renewable energy consumption such as thermal, oil and natural gas, as a percentage of the country's total energy consumption;
REC_{it} = is renewable energy consumption including hydro, wind, solar and biomass measured as a percentage of total energy consumption in country i in year t;
$GROWTH_{it}$ = is the percentage of population growth in country i in year t;
GDP_{it} = Real Value of Gross Domestic Product (GDP) per capita, constant in US $ for 2010, from country i, in year t.

In addition to the variables: expenses on education, energy from renewable sources, non-renewable sources and population growth and GDP, two variables related to governmental tastes in education were also inserted, aiming at the segregation of such expenditures, ie, government expenses on primary education per student and government expenses on tertiary education per student. In other words, checking the specific effect of spending on education, as shown in Equation 2:

$$CO_{2_{it}} = \beta_0 + \beta_1 GEE_{it} + \beta_2 NREN_{it} + \beta_3 REN_{it} + \beta_4 GROWTH_{it} + \beta_5 GDP_{it} + \beta_6 GEEP_{it} + \beta_7 GEET_{it} + \varepsilon_{it} \quad (2)$$

where

$GEEP_{it}$ = government expenses on primary education per student, as a percentage of GDP;
$GEET_{it}$ = government expenses on tertiary education per student, as a percentage of GDP.

Specifically, GEEP is expenditures per student in primary education calculated by dividing total government expenditures in primary education by the number of students in primary education, expressed as a percentage of GDP per capita. In turn, GEET is the overall expenditures per student in higher education and is calculated by dividing total government expenditures in higher education by the number of students in higher education, expressed as a percentage of GDP per capita. The variables and their measurements are summarized and justified in Table 1.

Table 1: Summary of variables

Variables	Expected Signal	Justification
Explanatory variables		
Government expenses with Education as percentage of GDP (GEE).	Negative	Climate Change Education (EMC) emerges as a new proposal, with guidelines aimed at the improvement of the population's sustainable and climatic literacy and with consumption mitigation goals for climate mitigation and adaptation. Obtaining knowledge and skills related to climate change, and the change of patterns of human activity in search of more sustainable behavior are parallel and simultaneous paths proposed for this approach (SILVA et al., 2016 apud Mesquista et al. 2019). If EE is intrinsic at the most diverse levels of education, in an interdisciplinary way, the higher the investments, the lower the pollutant emission levels.
Government expenses with Primary Education per student as percentage of GDP (GEEP).	Negative	
Government expenses withTerciary Education per student as percentage of GDP (GEET).	Negative	
Control Variables		
consumption of energy from non-renewable sources ($NREC$)	Positive	The combustion of fossil fuels substantially increased the atmospheric concentrations of various greenhouse gases (GHG) - such as carbon dioxide (CO2) and methane (CH4) (BENÍTEZ et al., 2019) so that Dogan and Seker (2016)) point to a direct relationship between non-renewable energy consumption and CO2 emissions.
Energy Consumption from Renewable Sources (REC)	Negative	Bölük and Mert (2014) point out that renewable energy consumption contributes about 1/2 less per unit of energy consumed than fossil energy consumption in terms of GHG emissions, implying that a change in the mix of energy consumption to alternative renewable energy technologies can reduce emissions of these gases. Thus, the major use of energy from renewable sources results in reduced energy use from non-renewable sources, resulting in CO2 emissions reduction (Al-Mulali et al., 2015; APERGIS; PAYNE, 2014; BÖLÜK; MERT, 2015; DOGAN, 2015; DOGAN; SEKER, 2016; JEBLI et al., 2016; SOUZA et al., 2018).
Populational Growth (GROWTH)	Positive	In a few generations mankind has run out of fossil fuels that have been generated over several billion years, resulting in large emissions of air pollutants. Combustion of fossil fuels, together with deforestation, soil erosion and livestock, have substantially increased atmospheric concentrations of various greenhouse gases (GHG) - such as carbon dioxide (CO2) and methane (CH4), contributing to global warming (BENÍTEZ et al., 2019). Urban population growth results in the increase of industrial production, transportation, energy consumption and, consequently, gas emissions (MARTÍNEZ-ZARZOSO; MARUOTTI, 2011; KASMAN; DUMAN, 2015).
Gross Domestic Product (GDP)	Positive	Combustion of fossil fuels, together with deforestation, soil erosion and livestock, have substantially increased the atmospheric concentrations of various greenhouse gases. Capitalism has transformed the geography of ecosystems around the world, resulting in pollution, climate change, ozone depletion, desertification, higher temperatures, depletion of non-renewable resources, accumulation of radioactive waste, food shortages, disease proliferation, water pollution etc. (MARTÍNEZ-ZARZOSO; MARUOTTI, 2011; KASMAN; DUMAN, 2015), so that the higher the economic growth, measured by GDP, is expected, the higher pollutant emissions, especially CO2, implying a positive relationship between economic growth and CO2 emissions (ANG, 2007; APERGIS; PAYNE, 2015;APERGIS; PAYNE, 2009; BAEK, 2015).

Source: written by the authors.

Results and discussion

This study assessed the relation between governmental expenses in Education on CO_2 emission of Mercosur and associate countries from 1990 to 2014. The descriptive statistics of the variables presented in Table 2 show that: a) Brazil emits, on average, 1.86 metric tons per capita of CO_2, consumption higher than other countries, like Paraguay and Uruguay; b) Paraguay stands out as a country with a renewable energy matrix, since of its total energy consumption, on average, 0.68 comes from renewable sources, followed by Brazil with 0.45; and c) in terms of GEEP, Uruguay presented the lowest indicator.

Descriptive statistics strengthen country classified information, facilitating local verification. Argentina with the highest CO2 emission, more than double the Brazilian. Thus, Argentina with more than 87% of its non-renewable energy matrix.

Table 2: Descriptive Statistics by Country

Country	Variable	Mean	Median	St Deviation	Min.	Max.
Argentina	CO2	4.00	3.85	0.45	3.29	4.74
	GROWTH	1.12	1.09	0.13	1.43	0.96
	NREC	88.18	88.65	1.23	85.80	90.65
	REC	10.17	10.15	1.37	7.60	13.28
	GDP	3.01	3.95	5.58	-10.89	10.12
	GEE	4.49	4.58	1.03	1.06	5.77
	GEEP	12.97	13.68	1.78	9.88	15.70
	GEET	15.47	16.25	2.50	10.42	20.29
Brasil	CO2	1.86	1.84	0.30	1.39	2.59
	GROWTH	1.26	1.25	0.31	0.78	1.79
	NREC	54.96	54.60	2.36	51.21	59.10
	REC	45.60	45.42	2.39	49.86	41.47
	GDP	2.28	2.60	2.78	-3.54	7.52
	GEE	4.94	4.92	0.81	3.75	6.24
	GEEP	16.30	18.22	4.12	9.83	20.61
	GEET	38.05	31.25	14.20	27.15	78.74
Bolívia	CO2	1.33	1.30	0.27	0.83	1.93
	GROWTH	1.77	1.78	0.17	1.49	1.97
	NREC	78.60	80.95	5.69	66.51	85.95
	REC	26.93	26.73	7.02	16.81	38.28
	GDP	4.17	4.49	1.38	0.42	6.79
	GEE	6.24	6.25	0.90	4.65	8.08
	GEEP	17.50	16.59	3.62	12.64	23.48
	GEET	-	-	-	-	-
Chile	CO2	3.67	3.83	0.74	2.32	4.76
	GROWTH	1.16	1.10	0.25	0.80	1.64
	NREC	73.02	73.74	2.98	66.35	77.60
	REC	31.58	31.47	3.05	24.88	38.61
	GDP	4.68	4.96	2.73	-1.56	11.16
	GEE	3.61	3.72	0.81	2.25	5.35
	GEEP	14.03	14.28	1.98	10.44	18.01
	GEET	15.49	15.56	3.05	10.77	20.21
Colômbia	CO2	1.57	1.59	0.16	1.28	1.89
	GROWTH	1.34	1.36	0.31	0.84	1.90
	NREC	73.92	74.97	3.06	67.37	77.30
	REC	29.52	28.96	3.70	23.56	38.25
	GDP	3.54	3.91	2.28	-4.20	7.36
	GEE	4.27	4.35	0.37	3.51	4.90
	GEEP	15.29	15.48	1.15	12.47	16.91
	GEET	25.03	23.06	5.95	16.29	38.41
Equador	CO2	2.06	2.07	0.37	1.21	2.76
	GROWTH	1.82	1.68	0.28	1.45	2.38

	NREC	84.16	84.94	2.56	78.20	87.84
	REC	16.96	17.25	3.83	12.10	24.19
	GDP	3.18	3.60	2.59	8.21	-4.73
	GEE	3.67	4.50	1.51	1.15	5.26
	GEEP	9.06	10.29	2.95	2.84	11.73
	GEET	46.23	43.12	4.39	43.11	52.45
Paraguai	CO2	0.73	0.73	0.10	0.49	0.88
	GROWTH	1.80	1.74	0.46	1.27	2.64
	NREC	29.52	30.10	3.45	20.14	33.81
	REC	68.27	67.35	4.42	61.67	79.15
	GDP	3.40	4.18	3.04	-2.31	11.14
	GEE	3.97	4.25	0.96	1.06	4.96
	GEEP	11.27	10.60	1.88	9.13	15.09
	GEET	29.15	24.00	10.86	19.25	50.40
Peru	CO2	1.28	1.14	0.35	0.89	1.99
	GROWTH	1.46	1.32	0.28	1.21	2.11
	NREC	69.85	69.50	4.22	62.65	79.55
	REC	32.20	32.48	3.95	25.50	39.91
	GDP	4.33	4.56	3.50	-4.98	12.30
	GEE	3.14	3.03	0.40	2.62	3.96
	GEEP	8.95	8.37	1.99	6.49	12.92
	GEET	11.21	11.21	1.11	9.27	12.50
Uruguai	CO2	1.78	1.69	0.36	1.27	2.55
	GROWTH	0.40	0.35	0.24	-0.06	0.73
	NREC	60.30	60.72	5.40	46.27	70.24
	REC	43.30	42.90	5.86	33.29	58.02
	GDP	3.13	3.81	3.87	-7.73	8.54
	GEE	2.63	2.48	0.53	2.06	4.35
	GEEP	7.64	7.31	1.08	5.85	9.63
	GEET	19.52	18.46	3.60	16.48	29.31
Venezuela	CO2	6.25	6.15	0.59	5.09	7.60
	GROWTH	1.78	1.77	0.32	1.28	2.41
	NREC	88.69	88.87	1.02	86.42	90.48
	REC	13.50	13.45	1.04	11.43	16.51
	GDP	2.80	3.68	6.19	-8.85	18.28
	GEE	4.32	3.94	1.28	2.52	6.87
	GEEP	13.39	13.49	4.85	8.03	18.54
	GEET	19.92	19.92	0.00	19.92	19.92

Source: written by the authors.

The basic assumptions like multicollinearity, normality of residues, homoscedasticity and autocorrelation were analyzed. Regarding the normality of the residues, the Jarque-Bera test was performed, and indicated that the residues did not follow a normal distribution. However, the Central Limit Theorem, based on Gujarati and Porter (2011), was used as support for samples larger than 100 observations, assuming a normal distribution.

With regard to the autocorrelation of the residues, the Durbin-Watson test was used, demonstrating the no existence of autocorrelation of the residues. For the assumption of homoscedasticity of the residues, the Breusch-Pagan-Godfrey test was used, and demonstrated the existence of heteroscedasticity. Hereroscedasticity was corrected by the Coef Covariance Method Period Weights (PCSE) during coefficient estimation.

Additionally, the Breusch-Pagan-Godfrey, Hausman and F (Chow) tests were performed to detect the best model and the results showed the existence of the group effect. Thus, fixed effect regression was performed and the results are described in Table 1 below.

Columns A and B of Table 3 show the results of the estimated OLS regression of equation (1) as follows: column A, excluding GEEP and GEET variables; and column B, with all the variables of the model.

Column A shows that the variable GEE (government expenditure on education) is negatively related to CO_2, but not significant at a 5% level. This result demonstrates that government expenses

on education have impacted CO_2 emissions in Mercosur and associated countries. Thus, this result does not support the first hypothesis of the research.

In relation to the control variables, REN is negatively related to CO_2 emission, as highlighted in the previous literature (ALSHEHRY; BELLOUMI, 2015; APERGIS; PAYNE, 2015; DOGAN; SEKER, 2016; SOUZA et al., 2018), confirming the existence of the inverse relation between renewable energy consumption and CO_2 emissions for Mercosur and associated countries. In turn, GDP is positively related to CO_2 emissions, corroborating to with Dogan and Seker (2016) and, for Mercosur, Souza et al. (2018). The other variables did not present significant coefficients at a 5% level, not enabling larger inferences.

Table 3: Analysis of Regression of variables

VARIÁVEIS	A	B
	t-value	t-value
	(sig)	(sig)
INTERCEPTO	-0,3141	-0,2319
	0,7534	0,8166
GROWTH	-1,2219	-1,2865
	0,2220	0,1985
NREN	1,2059	1,0514
	0,2281	0,2932
REN	-3,0875	-2,9429
	0,0021	0,0033
GDP	10,3428	10,3320
	0,0000	0,0000
GEE	-1,2046	1,2082
	0,2286	0,2272
GEEP		-1,9673
		0,0494
GEET		-2,0322
		0,0423
Efeitos	Pooled	Fixed
R^2	0,18681	0,19180
R^2 ajustado	0,15012	0,15395
F	5,09161	5,06724
(sig)	0,00000	0,00000

Source: written by the authors.

With the estimation of the model with all variables, column B, the variable GEE presented non-significant coefficients. In turn, GEEP and GEET presented significant coefficients, inversely related to the CO_2 variable, in accord with the expected result (SILVA et al.,, 2016 *apud* MESQUITA et al. 2019; COSTA; LOUREIRO, 2015; PEDRINI et al., 2016). This result shows that the higher the expenses on both primary and tertiary education, the lower the CO_2 emission of the Mercosur and associated countries. In a segregated way, it is possible to verify the impact of education on pollution. Emphasizing that investment in education is fundamental in the search for pollution reduction, specifically in CO2 emission research.

Thus, the second and third hypotheses were confirmed. It is worth mentioning that the acquisition of knowledge related to climate change, along with the change in human activity patterns in a search of a more sustainable behavior, as shown by Mesquista et al. (2019), can promote the development of education through investment, if combining both internal and external dimensions of human training and developing competencies for the conservation of the environment and the survival of future generations.

Finally, the results of the other variables remained unchanged, picturing in the control variables that REN is negatively related to CO_2 emissions, since the use of renewable energy

mitigates CO_2 emissions and, in turn, GDP is positively related to CO_2 emissions. Results also show that economic development increases CO_2 emissions, what corroborates with previous literature data. Also, the other variables did not present significant coefficients at a 5% level.

Conclusions

The aim of this research was to investigate the relationship between government expenditure on aggregate education from primary and tertiary sectors, related to CO_2 emissions. The initial results indicated the rejection of the first hypothesis, since it was not possible to confirm that aggregate government expenditure in Education negatively impacts on CO_2 emissions. These results must be carefully interpreted, once they can only be inferred for this specific sample and not generalized to other countries or other historical contexts.

The second hypothesis was confirmed, in other words, there is a negative and significant relationship between government expenditure per student from primary education and emission of pollutants in Mercosur and associated countries. Similarly, the third hypothesis was confirmed, since it is possible to infer that there is a negative and significant relationship between governmental expenses per tertiary education student and emission of pollutants in Mercosur and associated countries. These results corroborate the idea that spending on education can make people more aware, enabling the reduction of greenhouse gases.

As a suggestion for future researches, we include: (i) sample containing developed and developing countries; (ii) inclusion of other research hypotheses, e.g., relationship of CO_2 emission to the HDI and (iii) adoption of a larger sample period.

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