TESTING THE STRONG DECOUPLING HYPOTHESES IN LATIN AMERICA: EXPLORING THE GDP-ENERGY-CO 2 EMISSIONS NEXUS

Conference Paper · March 2019

3 authors:

Carlos Germán Meza González
University of São Paulo

Nilton Bispo Amado
University of São Paulo

Ildo Luís Sauer
University of São Paulo

TESTING THE STRONG DECOUPLING HYPOTHESES IN LATIN AMERICA: EXPLORING THE GDP-ENERGY-CO_2 EMISSIONS NEXUS

Carlos Germán Meza[a*], Nilton Bispo Amado[b] and Ildo Luís Sauer[b].

[a] Graduate program on Energy, University of Sao Paulo, Brazil.

[c] Institute of Energy and Environment, University of Sao Paulo, Brazil.

Presented at: *7th Latin America Conference on Energy Economics. Decarbonization, efficiency and affordability: New Energy Markets in Latin America. Buenos Aires, Argentina - March 10-12, 2019.* **Available at:** <*https://www.iaee.org/proceedings/article/16016*>.

Abstract

Decoupling economic growth from energy use and/or from CO_2 emissions is a central element in the climate change and environmental debates. It is important –especially for underdeveloped economies- that reductions in the energy use and/or CO_2 emissions could be achieved maintaining or even accelerating economic growth. The possibility of this negative correlation between these variables (↑GDP - ↓energy use and/or ↓CO_2 emissions) is typically called strong decoupling. This paper aims to test for the strong decoupling hypotheses in 21 Latin American economies during the period of 1971-2013 using the Spearman rank correlation coefficient. The results of the tests indicate that -except for the Cuban economy- there are no empirical evidences to support the GDP-energy strong decoupling hypothesis. In addition, there are no empirical evidences in Latin America (not even in Cuban economy) to support the GDP-CO_2 emissions strong decoupling hypothesis. Three economies with no real long-term economic growth in the region (Nicaragua, Venezuela and Peru) are not reducing energy use per capita or the CO_2 emissions per capita. Our findings suggest that deep national and regional decarbonization initiatives combining renewable sources to produce electricity and electric mobility are required to reverse the current trend in CO_2 emissions. More reflections on assumptions tacitly assumed in the environmental and energy discourses -as well as a deepening in the empirical research- are required.

Keywords: energy use, CO_2 emissions, decoupling, Latin America

1. Introduction

For decades the scientific community has been warning about climate change and the need to reduce the socioeconomic metabolism and greenhouse gases emissions. Two fundamental pillars have supported the narrative and the actions to face the global ecological crisis (a) 'dematerialization' of the economy using more efficient technologies and processes [1,2] (b) decarbonization of the economy using renewable sources [3]. Latin America is not the exception when it comes to the promotion of energy efficiency and integration of renewable energy sources [4]. In fact, as a region but also for the majority of the economies in the world, the energy intensity (MJ/US$) and the carbon intensity (emissions/US$) has been reduced in the last

*Corresponding author at: Av Professor Luciano Gualberto, 1289, Institute of Energy and Environment, University of Sao Paulo, Sao Paulo-SP, Zip code: 05508-010, Brazil. Tel.: +55 11 968640932; fax: +55 11 30912500.
E-mail address: mezagonzalez@usp.br ; cgmgcimp@gmail.com (C.G. Meza).

decades indicating a relative dematerialization and decarbonization of the economies (Figure 1 and Figure 2).

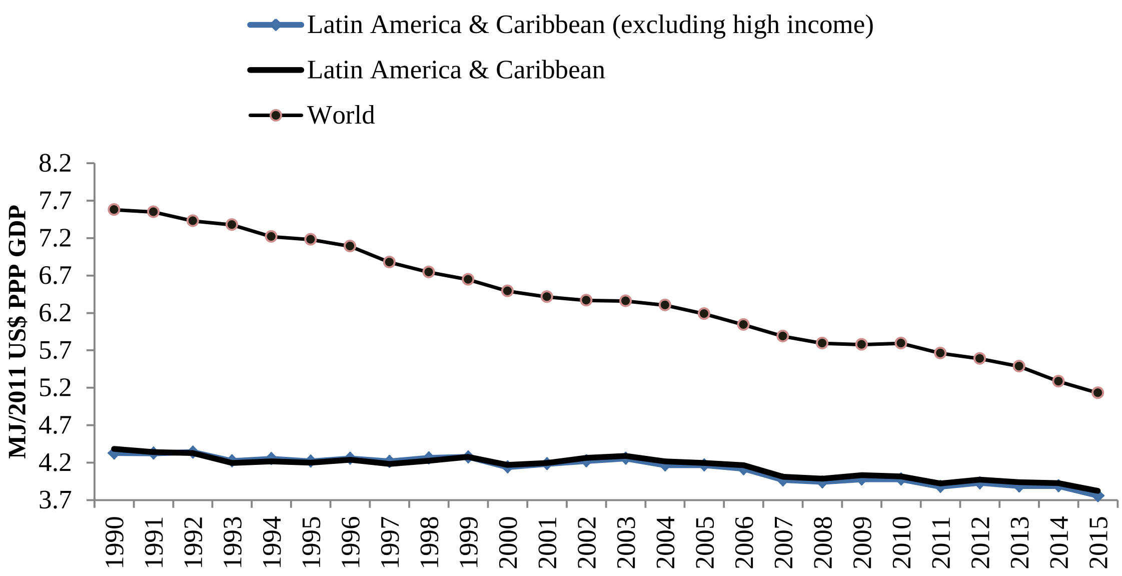

Figure 1. Energy intensity level of primary energy in Latin America & Caribbean and the World. Period 1990-2015. **Source**: [5].

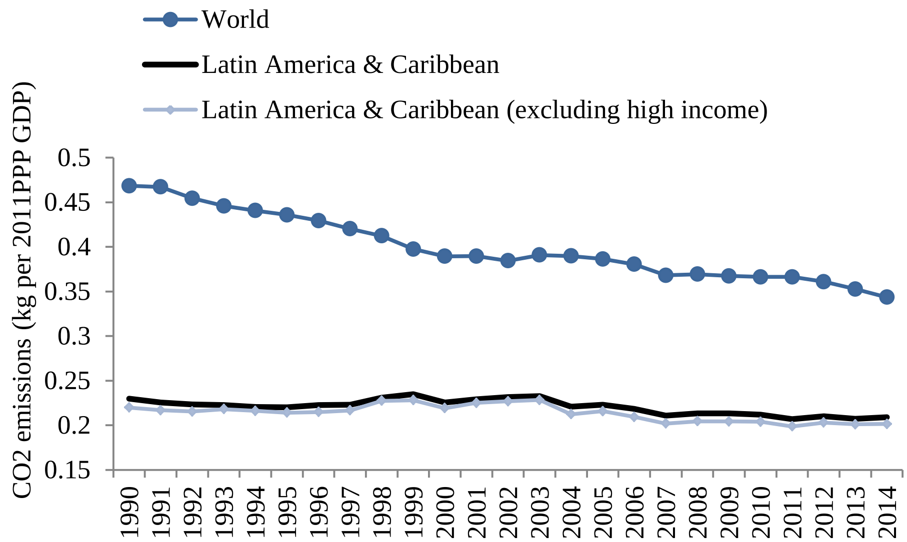

Figure 2. Carbon intensity of GDP in Latin America & Caribbean and the World. Period 1990-2015. **Source**: [5].

However, from environmental and climate perspectives, the important issues are the absolute reduction in energy use and CO_2 emissions. In these cases, the contrary is occurring in the world: primary energy use and CO_2 emissions are increasing (Figures 3 and 4). In fact, renewable energy sources (excluding hydro) accounted for only 3.2% of the total world primary energy consumption in 2016 (3.6% in Latin America) [6]. Thus, the long-term reductions of the energy intensity level and carbon intensity of the economy are not sufficient conditions to reduce the aggregate use of energy and/or emissions of CO_2.

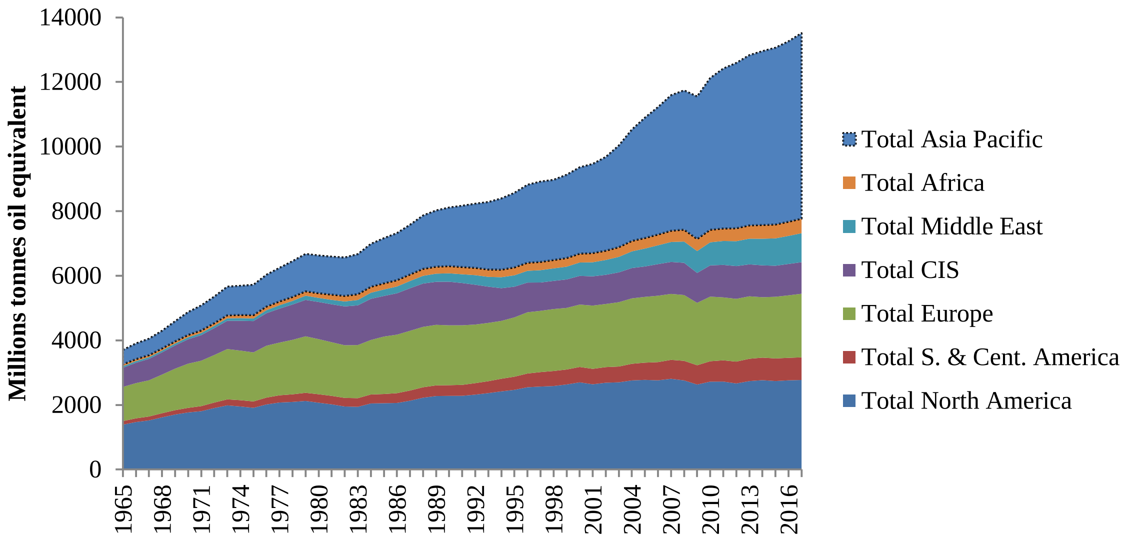

Figure 3. Primary energy consumption by regions. Period 1965-2017. **Source**: [6].

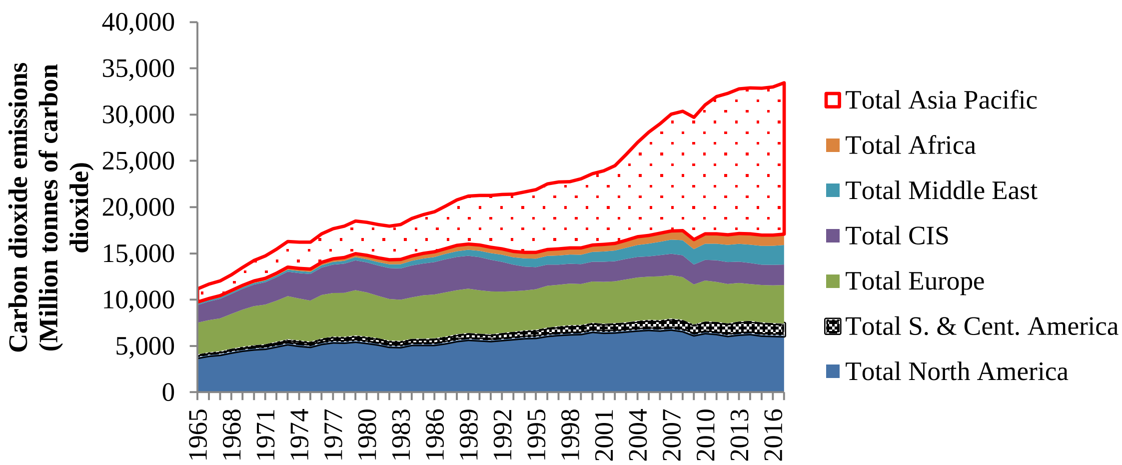

Figure 4. Carbon dioxide emissions by regions. Period 1965-2017. **Source**: [6].

In capitalist economies -especially for underdeveloped economies- it is crucial that the reduction in the energy use and CO_2 emissions could be achieved maintaining or even accelerating economic growth. The possibility of this negative correlation between these variables (↑GDP - ↓energy use and/or ↓CO_2 emissions) is typically called strong decoupling. In simple terms, technological, behavioral and regulatory adjustments in the economic and societal patterns could guarantee the absolute reduction in energy use and CO_2 emissions without compromising the economic growth trajectories. The International Energy Agency announced in 2015 that OECD economies are decoupling economic growth from greenhouse emissions [8] and expanded this optimism on a global scale in 2016 [9]. Nevertheless, the increasing in global CO_2 emissions in 2017 and the cumulative evidence that CO_2 emissions and energy use continue to growth correlated with economic growth [10–13] are a cold shower amid the premature excitement.

These historical and prevailing trends motivates some authors to affirm the 'impossibility' of absolute decoupling of economic growth from environmental impacts and biophysical materiality [14–17].

This paper aims to contribute with this debate by testing for the strong decoupling hypotheses in 21 Latin American economies during the period of 1971-2013. Although there are several studies exploring causal relationships between energy demand, CO_2 emissions and economic growth, the problem approached in this paper is from an earlier, more general stage, because it considers the existence or not of Latin American economies in decoupling. However, for our knowledge, these are the first empirical results using trend tests based on Spearman rank coefficient to test for the strong decoupling hypotheses in Latin America and showing the significant complexity between GDP stagnation and GDP contraction, energy use and CO_2 emissions in the region. This work is divided into the following sections. In Section 2, a description of the methodology and Data is provided. Section 3 presents the tests results and discussion and section 4 presents the conclusions of this study and policy implications.

2. Methodology

The analyses were conducted in three steps. Step one: the existence of an upward trend on GDP per capita was tested using the Spearman's rank correlation test with a level of confidence = 97.5%. The Spearman's ρ test is a rank-based non-parametric statistical test that can be used to detect monotonic trend in a time series. The idea behind the test is the following: each variable is ranked separately from the lowest to highest (e.g. 1, 2, 3, etc.) and the difference between ranks for each data pair is recorded. If the data are correlated, the sum of the square ranks will be small. The magnitude of the sum is related to the significance of the correlation [18]. The Spearman´s rank correlation is calculated according the following equation

$$\rho = (1-6*\sum d_i^2)/n^3-n \qquad \text{Eq.(1)}$$

In which d_i is the difference between ranks for each data pair and n is the number of data pairs. Given a sample data set of real GDP per capita by year X= {1971, 1972,…, X_i}, i.e, the null hypothesis H_0 of the Spearman's rank correlation test against the trend test is that all the X_i are independent and identically distributed. The alternative hypothesis is that X_i increases or decreases with i, that is, there is a trend. The pth quantile of ρ is approximated by the following:

$$Wp = Zp/\sqrt{n-1} \qquad \text{Eq.(2)}$$

Where Zp is the standard normal quantile found in Table A1, p. 506 in Ref. [19].

Step two: for those countries with a long-term economic growth trend detected, the same test (with the same level of confidence) was applied for the time series of energy use per capita and CO_2 emissions per capita. Step three: The strong decoupling hypotheses would be supported if the time series of real GDP per capita has a positive trend over time Δ(PIB/Pop)> 0) while energy use per capita and/or CO_2 emissions per capita decrease over time, that is, Δ(Energy/Pop) <0 and/or Δ(CO_2 emissions/Pop) <0. Step four: in order to expand the analyses, we preliminary explore the nexus GDP-energy-CO_2 emissions in countries with no real long-term economic growth.

2.1. Data

A total of 21 Latin American countries available in the World Bank data base were analyzed. For each country, 3 times series were explored (1) GDP per capita (US$ 2010) (2) energy use per capita (kg of equivalent oil) (3) CO_2 emissions per capita (metric tons). The objective of using per capita variables was to eliminate the effect of the population. The period of analysis was 43 years (1971-2013) according with the availability of the World Bank data base in December, 2017. Small countries with less than 1 million inhabitants were excluded from the analyses.

3. Results and discussion

Table 1 shows the results of the Spearman´s rank correlation tests for the GDP per capita (U$S 2010), energy use per capita and CO_2 emissions per capita. Long-term real GDP per capita growth was detected for 18 countries of the 21 Latin American analyzed between 1971 and 2013 (Spearman´s $\rho_{GDP} > W_{0.975}$). Of these 18 economies, only the Cuban economy has an upward trend during that period and, simultaneously, has a downward trend in the energy use per capita (Spearman´s $\rho_{GDP} = 0.67 > W_{0.975} = 0.35$ and Spearman´s $\rho_{energy} = -0.67 < -W_{0.975} = -0.35$)[1]. Thus, empirical evidence supporting that the Cuban economy decoupled energy use from economic growth in the last decades was founded. Nonetheless, the GDP-CO_2 emissions strong decoupling tests indicate that none of the 21 economies (not even Cuban economy) are reducing the CO_2 emissions per capita in Latin America. In addition, the three economies with no real long-term economic growth in the region (Nicaragua, Venezuela and Peru)[2] did not reduce neither the energy use per capita nor the CO_2 emissions per capita.

Table 1. Spearman´s rank correlation tests for 21 Latin American countries. Period 1971-2013.

Number	Countries	n (43 years)	ρ (GDP)	ρ (energy)	ρ (CO_2 emissions)	$W_{0.975}$*	Strong decoupling?
1	Argentina	1971-2013	0.62	0.92	0.48	0.35	No sign
2	Bolivia	1971-2013	0.49	0.91	0.82	0.35	No sign
3	Brazil	1971-2013	0.96	0.97	0.89	0.35	No sign
4	Chile	1971-2013	0.97	0.92	0.78	0.35	No sign
5	Colombia	1971-2013	0.98	0.38	0.16	0.35	No sign
6	Costa Rica	1971-2013	0.94	0.92	0.86	0.35	No sign
7	Cuba	1971-2013	0.67	-0.67	-0.15	0.35	Decoupling GDP-energy but not GDP-CO_2 emissions.
8	Dominican Republic	1971-2013	0.98	0.72	0.87	0.35	No sign
9	Ecuador	1971-2013	0.92	0.89	0.71	0.35	No sign
10	El Salvador	1971-2013	0.65	0.73	0.85	0.35	No sign
11	Guatemala	1971-2013	0.76	0.64	0.79	0.35	No sign
12	Honduras	1971-2013	0.88	0.51	0.83	0.35	No sign
13	Jamaica	1971-2013	0.53	0.21	-0.05	0.35	No sign
14	Mexico	1971-2013	0.93	0.91	0.62	0.35	No sign
15	Nicaragua	1971-2013	-0.44	0.31	0.44	0.35	GDP contraction
16	Panama	1971-2013	0.94	0.07	0.53	0.35	No sign
17	Paraguay	1971-2013	0.90	0.74	0.87	0.35	No sign
18	Peru	1971-2013	0.23	-0.41	0.05	0.35	GDP stagnation
19	Trinidad and Tobago	1971-2013	0.58	0.99	0.85	0.35	No sign
20	Uruguay	1971-2013	0.93	0.45	0.06	0.35	No sign
21	Venezuela	1971-2013	-0.25	0.73	0.74	0.35	GDP stagnation

*Confidence level = 97.5%.

4. Conclusions and policy implications

The GDP-energy use-CO_2 emissions nexus was analyzed in 21 Latin American economies and the strong decoupling hypotheses (GDP-energy and GDP-CO_2 emissions) were tested. It is

[1] The negative value of $W_{0.975}$ is used to test the downward trend. In the Cuban case, column 5, ρ (energy) = -0.67 is lower than -0.35, the negative value of $W_{0.975}$. Thus, the downward trend in energy use per capita was accepted.
[2] Due to the lack of data, Haiti and Puerto Rico were excluded of the analyses.

observable that the economic growth in Latin America is strongly associated with an increase in the use of natural resources (specifically fossil fuels) and with CO_2 emissions. Yet, the Cuban economy is the only detected case in Latin America where the strong decoupling hypothesis between GDP and energy use is supported by the tests. This result may reflect the influence of the deindustrialization and fuel shortages in the Cuban economy during the 'special period' after the dissolution of the Soviet Union. In addition, it could be associated to some degree to the particular characteristics of a blockaded, socialist and tourism-oriented economy or even to energy-efficiency programs [20]. However, CO_2 emissions are increasing in all Latin America, including the Cuban economy. Thus, the Cuban case shows that GDP-energy decoupling is not a sufficient condition to induce GDP-CO_2 emissions decoupling. On the other hand, the 3 countries that experienced long-term economic crises or stagnation in Latin America (Nicaragua, Venezuela and Peru) did not diminish their energy use per capita and/or decarbonize their economies. Thus, reduction and stagnation of the real GDP per capita are not sufficient conditions to reduce the energy use and/or decarbonize the economy.

Renewable sources of energy are gradually replacing conventional ones and energy efficiency becomes more important, but our results suggest that deep national and regional decarbonization initiatives combining renewable sources to produce electricity and electric mobility [21–23] are required to revert the current trends in CO_2 emissions in Latin America. Furthermore, it is important to analyze the influence of structural transformations of the Latin American economies on the energy use and CO_2 emissions. According to Ref. [24], the observed decoupling in European economies is mainly because of the structural effect of deindustrialization. However, Latin American countries have also been experiencing rapid and premature deindustrialization in recent decades [25]. Yet, this process has not meant a reversal in the growing trends in the use of energy and in CO_2 emissions. Further causal research and case studies are required on these topics to improve our understanding of the factors involved and to enhance the energy, climate and socioeconomic policies.

These findings warrant further research on the roles, possibilities and limits of energy-efficiency, energy-intensity, 'green growth' and 'degrowth' proposals in the global climate and environmental goals. These results could also be used to explore theoretical implications on sustainability economics [26,27], political economy, political ecology and (sustainable) development economics. Finally, it is also important to recognize the geopolitical, social and economic importance of the fossil fuel industries in Latin American. Hence, the decarbonization of Latin America should incorporate elements related to energy, climate and social justice [28–30].

Acknowledgements

This work was supported by the Brazilian National Council for Scientific and Technological Development (CNPq 161007/2015-5) and by the R&D-00061-0054/2016.

References

[1] K. Bithas, P. Kalimeris, Unmasking decoupling: Redefining the Resource Intensity of the Economy, Sci. Total Environ. 619–620 (2018) 338–351. doi:10.1016/J.SCITOTENV.2017.11.061.

[2] J. Goldemberg, L.T. Siqueira Prado, The decline of sectorial components of the world's energy intensity, Energy Policy. 54 (2013) 62–65. doi:10.1016/J.ENPOL.2012.11.023.

[3] P.J. Loftus, A.M. Cohen, J.C.S. Long, J.D. Jenkins, A critical review of global decarbonization scenarios: What do they tell us about feasibility?, Wiley Interdiscip. Rev. Clim. Chang. 6 (2015) 93–112. doi:10.1002/wcc.324.

[4] IRENA, Latin America’s Renewable Energy Market Analysis, Articles. (2016). http://irena.org/newsroom/articles/2016/Nov/Latin-Americas-Renewable-Energy-Market-Analysis (accessed February 24, 2018).

[5] The World Bank, World Development Indicators, 2017. https://data.worldbank.org/indicator (accessed January 15, 2018).

[6] BP, Statistical Review of World Energy, 2017. https://www.bp.com/content/dam/bp/en/corporate/excel/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-underpinning-data.xlsx (accessed January 25, 2018).

[7] The World Bank, Inclusive Green Growth: the pathway to sustainable resource management, World Bank. (2012) 171. doi:10.1205/psep.05009.

[8] IEA, Global energy-related emissions of carbon dioxide stalled in 2014, Newsroom. (2015). https://www.iea.org/newsroom/news/2015/march/global-energy-related-emissions-of-carbon-dioxide-stalled-in-2014.html.

[9] IEA, Decoupling of global emissions and economic growth confirmed, Int. Energy Agency. (2016). https://www.iea.org/newsroom/news/2016/march/decoupling-of-global-emissions-and-economic-growth-confirmed.html (accessed January 25, 2018).

[10] D.I. Stern, R. Gerlagh, P.J. Burke, Modeling the emissions–income relationship using long-run growth rates, Environ. Dev. Econ. (2017) 1–26. doi:10.1017/S1355770X17000109.

[11] P.J. Burke, M. Shahiduzzaman, D.I. Stern, Carbon dioxide emissions in the short run: The rate and sources of economic growth matter, Glob. Environ. Chang. 33 (2015) 109–121. doi:10.1016/j.gloenvcha.2015.04.012.

[12] Z. Csereklyei, D.I. Stern, Global energy use: Decoupling or convergence?, Energy Econ. 51 (2015). doi:10.1016/j.eneco.2015.08.029.

[13] P.J. Burke, Z. Csereklyei, Understanding the energy-GDP elasticity: A sectoral approach, Energy Econ. 58 (2016) 199–210. doi:10.1016/j.eneco.2016.07.004.

[14] H.E. Daly, K.N. Townsend, Sustainable Growth: An Impossibility Theorem, in: Valuing Earth Econ. Ecol. Ethics, 2nd ed., The MIT Press, 1993: pp. 267–271. http://dieoff.org/page37.htm.

[15] H.N.S. Earp, A.R. Romeiro, The Entropy Law and the Impossibility of Perpetual Economic Growth, Open J. Appl. Sci. 5 (2015) 641–650. doi:10.4236/ojapps.2015.510063.

[16] J.D. Ward, P.C. Sutton, A.D. Werner, R. Costanza, S.H. Mohr, C.T. Simmons, Is Decoupling GDP Growth from Environmental Impact Possible?, PLoS One. (2016). doi:10.1371/journal.pone.0164733.

[17] N.B. Amado, I.L. Sauer, An ecological economic interpretation of the Jevons effect, Ecol. Complex. 9 (2012) 2–9. doi:10.1016/j.ecocom.2011.10.003.

[18] T. Gauthier, Detecting Trends Using Spearman’s Rank Correlation Coefficient, Environ. Forensics. 2 (2001) 359–362. doi:10.1006/enfo.2001.0061.

[19] W.J. Conover, Practical Nonparametric Statistics, Third Edit, John Wiley & Sons, Ltd,

1999.

[20] J.A. Suárez, P.A. Beatón, R.F. Escalona, O.P. Montero, Energy, environment and development in Cuba, Renew. Sustain. Energy Rev. 16 (2012) 2724–2731. doi:10.1016/j.rser.2012.02.023.

[21] I.L. Sauer, J.F. Escobar, M.F.P. da Silva, C.G. Meza, C. Centurion, J. Goldemberg, Bolivia and Paraguay: A beacon for sustainable electric mobility?, Renew. Sustain. Energy Rev. 51 (2015) 910–925. doi:10.1016/j.rser.2015.06.038.

[22] C.G. Meza, C. Zuluaga Rodríguez, C.A. D'Aquino, N.B. Amado, A. Rodrigues, I.L. Sauer, Toward a 100% renewable island: A case study of Ometepe's energy mix, Renew. Energy. 132 (2019) 628–648. doi:10.1016/j.renene.2018.07.124.

[23] C.G. Meza, N.B. Amado, I.L. Sauer, Transforming the Nicaraguan energy mix towards 100% renewable, Energy Procedia. 138 (2017) 494–499. doi:10.1016/j.egypro.2017.10.234.

[24] V. Moreau, C.A.D.O. Neves, F. Vuille, Is decoupling a red herring? The role of structural effects and energy policies in Europe, Energy Policy. 128 (2019) 243–252. doi:10.1016/j.enpol.2018.12.028.

[25] D. Rodrik, Premature deindustrialization, J. Econ. Growth. 21 (2016) 1–33. doi:10.1007/s10887-015-9122-3.

[26] N.B. Amado, C.G. Meza, I.L. Sauer, Testing Alternative Models in Sustainability Economics: Baumol versus Georgescu-Roegen, Desenvolv. E Meio Ambient. 42 (2017) 9–21. doi:10.5380/dma.v42i0.48764.

[27] N.B. Amado, C.G. Meza, I.L. Sauer, Análise Teórica e Empírica do Indicador Elasticidade de Substituição na Avaliação da Sustentabilidade Forte e Fraca, in: X Congr. Bras. Planej. Energético, Gramado, 2016. http://dedalus.usp.br/F/F64UT3LRV4XP794CK6NYME55LEVP5NEC7YDS8PJ6GKTXJYLJ1K-00940?func=full-set-set&set_number=001467&set_entry=000001&format=999.

[28] B.K. Sovacool, M.H. Dworkin, Global energy justice: Problems, principles, and practices, (2014) 391. doi:10.1017/CBO9781107323605.

[29] B.K. Sovacool, J. Scarpaci, Energy justice and the contested petroleum politics of stranded assets: Policy insights from the Yasuní-ITT Initiative in Ecuador, Energy Policy. 95 (2016) 158–171. doi:10.1016/j.enpol.2016.04.045.

[30] G.A. Lenferna, Can we equitably manage the end of the fossil fuel era?, Energy Res. Soc. Sci. (2017) 0–1. doi:10.1016/j.erss.2017.11.007.