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Renewable Energy’s Effect On the Economy

Bachelor’s Thesis

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Abstract

Climate change mitigation and dealing with ecological catastrophes is one of the hottest topics in modern global politics. There's a wide acceptance that these problems are man-made, but a lingering political stalemate and expectations for economic growth, have not helped the cause to reduce greenhouse gas' (GHG) emissions. Since the energy sector is the biggest emitter, states and international organisations are increasingly investing in renewable energy sources (RES) with an expectation that it will soon replace fossil-fuel origin sources from economies' energy portfolios. Consequently, renewables, with their pros and cons, have started to get the attention of critics, who blame the RES sector for being no different to any other capitalistic industry, thus always looking to expand without achieving any of the ambitious global sustainability standards.

The main aim of this paper is not only to refute such criticism, but to reveal that a share of renewable energy in a states' total primary energy supply (TPES), is not only helping to fight against the climate change, but also brings additional value to the economy. To prove the thesis is correct, the author conducted a series of Pearson's r and Spearman's ρ correlation tests between the independent variable (RES/TPES) and the dependent economic variables of GDP, energy intensity (EI) and adjusted net worth (ANS).

The results revealed that an increase in renewables in the energy sector mostly does not affect the GDP, but when correlated against an economic indicator that on some scale makes distinctions between environmentally harmful and harmless economic activities, e.g. ANS, then the test results proved, that increases in renewables add value to the economy without unsustainably expanding it. The results of this thesis also highlight how the developed and developing countries are differently affected by RES implementation.

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Introduction

With the number of UN's COP (Conference of the Parties) climate mitigation talks now counting 25, and environmental catastrophes all across the globe becoming a normality, climate change has become the biggest and the most covered global issue of the 21st century. Despite all of that, the gulf between scientists' warnings of an impending global catastrophe and the political and economic will to avoid such a fate, remains large (Harris, 2013). Although there's high diplomatic activity around the topic, the real situation resembles more of the 'tragedy of the commons' – actions, that benefit an individual, but harm the community -, than a solution to the continuous increase of greenhouse gas' (GHG) emissions, which is the main cause of global warming.

The main contributors of the GHGs emissions are the energy and transport sectors, which have traditionally relied on energy extracted from fossil-fuels (IRENA, 2017b). Considering the facts that (a) the dependency of fossil fuels is even higher amongst the developing economies, which energy needs are growing faster than in the developed world; (b) we have not reached 'peak oil', yet, which would force humanity to consume less; and (c) the capitalistic economy by its nature always seeks to expand (Antolick, 2002), then it appears that humanity's only remaining option is to seek for a cleaner and more effective way to generate energy. In other words, in order to decrease energy intensity, which measures how much energy is consumed to produce a unit of economic output (OECD, 2019), or to invest more in renewable energy sources (RES) (EC, 2012).

Renewable energy sources are the main subject of this paper. Its technology has developed exponentially, making it today affordable, even to the least developed economies (IRENA, 2019b) and proving to be efficient enough, in the example of Scotland, Sweden and Denmark, to take over the majority of those countries energy portfolios from the domineering conventional energy sources, like coal-fired power plants and oil etc. The main aim of this thesis is to go a step further, and observe, if renewable energy sources' increase in a country's energy portfolio also adds value to modern economies.

The theoretical background of this thesis is covered between chapters 1.1 to 1.5, which were divided into two parts: RES and the economy. The first three chapters will offer an overview of all the factors to be considered about renewable energy sources (RES). Chapter 1.1 is an introduction to RES. It gives background information on the increasing influence the RES' industry has on modern policy and explains shortly, how renewables can be used regarding climate change mitigation. The same chapter will also introduce the advantages and disadvantages of the major renewable energy sources. Chapter 1.2 supports the thesis of this paper by introducing theories of how an increased share of renewables could be beneficial for the economy. On the contrary, chapter 1.3 adds value to the thesis by offering critical perspective on the RES industry.

The second half of the theoretical part brings the subject of this thesis, economic growth, to a modern context. Chapter 1.4 introduces Peter Victor's (2010) theory of green growth economy, where greenhouse gas emissions (GHGs) become an important indicator in measuring the success of the modern economies that have to deal with climate change mitigation. Finishing the theoretical part, chapter 1.5 is a short criticism of GDP. The chapter focuses on ideas supporting the modification of the GDP indicator, so that it would reflect more on present environmental requirements (Harris, 2010).

To support the main aim of this thesis, the method that the author chose for this research, focuses on correlation tests based on Pearson's r and Spearman's ρ coefficients between an independent variable representing the share of renewables in the total energy supply (RES/TPES) from one, and multiple economic aggregates, including GDP, on the other side. These correlation tests were conducted on sample frames consisting of both, the developed and the developing economies of the World, with a purpose to discover how does renewable industry's effect variate between economies from different development stages. Chapters 2.1 and 2.2 will explain in depth the choice of indicators and the overall methodology of this research.

The thesis commences with empirical analysis. Chapter 3.1 offers an opportunity to study the selected sample frame of countries with the aid of Victor's (2010) green growth economy theory. The purpose of this part is to offer analytical perspective for the following chapters.

Chapters 3.2 to 3.4 will reveal the results of the 96 different correlation tests conducted between the variables. These paragraphs explain, with multiple graphs, how and in what manner renewable energy could be affecting different dependent variables, like gross domestic product (GDP), energy intensity (EI) and adjusted net savings (ANS). This part of the thesis will be brought together by a conclusion, which highlights the main findings of the empirical analysis and offers a critical review on the completed research.

1. Theoretical context

1.1 Renewable Energy Sources (RES) & the Policy

In order to limit the temperature increase on Earth below 1.5-2°C compared to pre-industrial levels, the global community has partially agreed, in the form of agreements like the Kyoto Protocol (2005) and the Paris agreement (2015) etc., on mutual emission(s) reduction commitments and other similar action plans. European Union, a frontrunner in that matter, has set a target to reduce greenhouse gas emission by 85% by 2050. The main motivation for the union has not only been the environment, but also its economic sustainability. The EU is rather convinced that a low carbon future under any scenario is cheaper for Europe than continuing a fossil-fuel dependent system (European Union, 2010).

Other major international organisations like the United Nation and the OECD are also involved, where, for example the latter provides its member states a transparent arena for discussions and exchanging knowledge, helps governments with policy alignment and mitigation strategies, provides governments expertise to prepare for prognosticated climate change related issues, etc. (OECD, 2016).

The target to reduce greenhouse gas emissions and the global enforcement of the green economy, defined as "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011), are believed to be accomplished via green investments in multiple ways. Options can range from energy efficiency, technology of renewable energy, pollution abatement and materials recycling, natural-resources conservation and ecological restoration to environmental compliance, education, training, and also public awareness (Barbier, 2016).

Since the wider global acceptance of man-made climate change, renewable energy sources (RES) have received most of the publicity amongst all the other options. RES are generally believed to satisfy our increasing demand for energy and solve the biggest piece (in EU 29.2% of GHG are created by the energy sector (EEA, 2019)) in the fight with reducing CO^2 emissions and maintaining environmental quality.

To break RES down, the European Commission is using the following classification based on type of consumption/usage:

(1) RES-Electricity (E) - electricity produced by RES;

(2) RES-Heat (H) - heat generated from burning RES (eg. wood etc.), and utilizing technologies like solar thermal, geothermal;

(3) RES-Transport (T): RES-based transportation fuels like biodiesel etc.

(European Commission, 2014)

Main RES are hydro, wind and solar energy, every one of them a coin with two sides. They have proved to be technologies with high potential to satisfy World's future energy need, but they also bring with them, one more than another, high costs, limits and sacrificies.

The oldest and the most cost-effective of RES technologies is hydropower. It is mainly harnessed by turning rivers into large water reservoirs that generate electricity with the help of gravity forcing the water flow downstream through a turbine. Hydropower can be produced everywhere across the world where there is water moving, and because of the simplicity of the solution, water dams today decorate states' infrastructure everywhere we go, limiting the potential of that part of the RES sector to grow. Due to the maturity of the technology, the potential of growth for hydroenergy has proven to be limited: only 2.96% annual growth between 2010-2016 and an estimated decrease in total global share of RES-E from 18% in 2016 down to 11% by 2050 (IRENA, 2020). Another downside of hydroenergy is that since its source is unmovable, it can not be used for RES-H and RES-T.

Wind energy, in contrast to hydroenergy, can be produced in many more locations – a wind turbine can basically be set up wherever there is wind. Since 2000, with the help of technological progress and government incentive programmes, wind turbine electricity generation has increased by more than 30 times (IRENA, 2019). In 2018, all wind turbines installed across the world covered up to 6% of RES-E and growing (WWEA, 2019). On the down side, there are challenges with the technology. First of all, wind is renewable, but the turbines are not, because they are mainly produced in fossil-fuel-dominated Asia. More radical environmentalists do even argue that wind power is merely a fossil-fuel hybrid (Zehner, 2012). Secondly, wind power is very intermittent – it often supplies electricity when there is no demand, creating surplus that is exported for a bargain price (Zehner, 2012). Finally, similarly to hydro, wind power can be utilised only to produce electricity, it does not help directly with providing energy to RES-T and RES-H sectors.

Solar photovoltaics (PV) is the youngest of the three main RES technologies, but is the one with the highest potential**.** 2010-2016 solar PVs capacity increased annually by 47.5% and its share in total electricity supply is estimated to grow from 1% in 2016 to 14-25% by 2050 (IRENA, 2019). Solar PV panels are not affordable for everybody, but the technology's high potential comes from the possibility to convert sunlight into direct current electricity everywhere on the planet. Due to this kind of a flexibility and mobility, the technology is also already used for RES-H and has the potential to be directly used for RES-T. From the other hand, solar power, similar to wind power, is also intermittent – without storage option, the energy generated can be used only during the daylight. Furthermore, the fast growth of solar PV was artificially caused by government subsidies. Without supporting funds, the technology has proved to be too expensive to sell alone. This is illustrated well by the fact that in 2015 cloudy Germany generated three times more solar electricity than sunny Spain (Smil, 2017).

Other RES technologies are biomass, hydrogen, ethanol/biodiesel and more.

The most effective renewable-energy infrastructure would combine solar and wind, along with geothermal, hydro and clean bioenergy as supplemental sources. (Pollin, 2018)

1.2 Renewable Energy's positive effect on the economy

Increased global awareness of man-made climate change has altered the way of thinking about the continuation of societies' welfare and economic growth. This is fertile ground for the rise of new ideas and ideologies on how to run the economic system. For example, there's a spread of ecologism, which prioritises nature and the planet over humans, viewing the latter as a servant of the former. Also, wide popularity has gathered ecosocialism that sees the destruction of the natural environment as a characteristic trait of capitalism, and like socialism, it forecasts a revolution for the capitalistic regime. On the other hand, there are aspirations that occurring global environmental problems can be solved with a 'green' addition or a modification of the capitalistic economy – establishing a "green economy". That means a low-carbon economy or a sector of the economy that "produces goods and services with an environmental benefit" (Muro et. al., 2011).

Renewable energy is expected to have a major part in the proposed green economy. As a matter of fact, the European Commission has seen RES as "a major player in the European energy market" for some time. EC does not only view RES as a way to diversify their energy supply and decrease GHG emissions, but they see it also as a solution to create new industries, jobs and export opportunities, thus providing economic growth. (EC, 2012)

Following is a list of means on how RES benefits the economy. Firstly, recent reports reveal that the average costs of generating electricity with RES is now roughly equal with fossil fuels (IRENA, 2019b, Pollin, 2018). And when the environmental costs of burning fossil-fuels are also taken into consideration, then renewables have already become cheaper (Pollin, 2018), giving the economies an opportunity to fulfill their energy requirements at a reduced price.

Secondly, and also related to energy, it has been widely claimed that RES' technologies help to decrease energy intensity (EI), which is an indicator showing how much energy is spent to produce one unit of economic output. To simplify, the lower the EI, the less energy is spent for value creation in the economy. A positive correlation between a decreasing EI and growth of GDP has been the outcome of numerous studies (Smil, 2017; Bartoletto, 2012). Furthermore, conducted researches have also highlighted that RES, by increasing energy efficiency, is having a positive effect on EI (IRENA, 2017). This carries out in two simultaneous ways. On one hand, EI's value lowers because the efficiency of final conversions of RES is superior to conventional power sources (Smil, 2017; IRENA, 2017). This is because RES has no fuel input, which removes the need for thermal conversion that would have amounted to a loss of energy.

On the other hand, since energy generation from RES is more efficient than burning fossil-fuels, it does reduce the amount of TPES (Total Primary Energy Supply). That is because RES replaces non-renewable sources with lower efficiency in EI's equation. Overall IRENA (International Renewable Energy Agency, 2017) claims that RES accounts for 20-30% of total present day EI improvements. (IRENA, 2017)

Thirdly, RES sector provides new employment opportunities, with numbers of people employed in the RES sector increasingly rising, even in coal-friendly major economies like the USA and China (IRENA, 2019c). It has been also claimed that jobs in the RES sector provide a better working environment (e.g. working outdoors) and require a higher skillset than conventional energy sectors (Muro et. al., 2011). These are qualities that normally go hand-in-hand with higher salaries, which translate into an increase in total GDP.

RES contributes significant amounts of funds in total new investments. By a recent report by UNEP (2019), global investements in renewable industry (excl. hydro energy) amounted to $2.6 trillion USD during the last decade (2010-2019), which is three times more compared to 2000-2009. The reasons behind these investments is the continuous technological race which, as has been historically proven (Heaton et. al., 1991), contributes to the expansion of wealth and productivity of the economy. This kind of a competition will not be harmful to a green economy's perspectives, if it parallelly, with economic growth, also brings merits to sustainability targets (Heaton et. al., 1991).

A good example to conclude this section and bring together the economic factors highlighted above, is the analysis done by A. Blinder (2010) and M. Zandi, who compared the US's and the EU's fiscal policy actions during the 2007-2008 financial crisis. They discovered that US's aggressive fiscal policy, which also included large portions of green investments, most likely held off a much gloomier outcome and returned it to economic growth relatively quickly. But its peer, the EU, chose a much stringent fiscal policy for RES and other segments, which could be one of the main causes of ongoing economic slowdown in many of its member countries.

1.3 Criticism of RES policies

During the first couple of decades of RES implementation, production and consumption has revealed to us the technologies' deficiences and subsequent shortcomings. With criticisms from both sides - from environmentalists and obviously from the stakeholders who would prefer the status quo. Criticism from stakeholders, that is people and companies who own shares and have interests for the the continuation and success of fossil burning industries, does not come to many as a surprise. However, criticism from environmentalists and such towards an emerging alternative energy industry that is supposed to help tackle the same ecological issues that they advocate, is a growing trend that should not be left aside when researching how these new technologies affect the socio-economic space in our societies.

Firstly, environmentalists argue that RES will be insufficient to produce all the energy humanity needs. They point out that the data from the past decades about RES technologies' speedy improvement can't be extrapolated forecasting the future, which has often been optimistically done for different reasons. Since the gradual improvement of these technologies has largely plateaued, it's false to suppose and promote that the technology will improve with the same tempo it has for the last few decades. The Moore's Law, outcome doubles while costs decrease, does not apply here. (Zehner, 2012)

Furthermore, just producing more alternative energy will expand energy supplies, which decreases the price of energy, encourages people to consume more, and finally brings us right back to where we started – lack of supply and increasing demand of energy. A phenomen termed the rebound-effect (Aydin-Kok-Brounen, 2017; Khazzoom, 1980). The United States example shows how the same scenario played out with subsidized nuclear power: More nuclear power plants were supposed to satisfy country's electricity demand forever, but to the contrary, it increased demand, which translated into the building of more coal-fired power plants (Zehner, 2012). Overall, environmentalists argue that cleaner energy means less energy.

Secondly, ecologists argue that a RES economy is no different from a fossil burning economy. Since economic systems worldwide reward the commoditization of knowledge and resources for profit, there's no need to presume it to be any different with energy produced from RES (Zehner, 2012). The standard operating procedure that has worked like a well-oiled machine for the main stakeholders in the energy sector will continue to run with no big differences, with productivist's leanings to push through legislation that suits them and expand production and profits (Zehner, 2012)

Thirdly, environmentalists feel that the presented 'pit fights' between RES and fossil fuel energy in the media, in the public and private sector have blinded the society by taking attention away from the real issues and other alternative solutions available to deal with ecological crisis and social welfare. These fights have delivered an illusion that an increase in renewable energy production will correspondingly diminish the need for fossil-fuel resources. The main criticism they have is that the decision makers of society and society itself compares production against production and believe that increasing amount of ecological and economical problems waiting us ahead can be beaten with upgraded technology and growing production of energy. (Zehner, 2012)

And finally, environmentalists find that the real fundamental weakness of the RES projects is that they do not deal with the real sources of our problems such as consumerism, capitalism, walkable neighbourhoods, energy conservation and more. Energy production is preferred over energy reduction and conservation, because constructing better insulation for buildings, creating walkable neighbourhoods and living a more minimalistic life is not exciting and will not create jobs. (Zehner, 2012) In other words, these solutions bring less profitable opportunities for the capitalistic system.

Taking all of the claims above into consideration, when researching how RES affects the economy, a couple things must be taken into account:

1. Increasing the share of RES in a country's energy portfolio could have a negative effect on GDP and indicators similar because of the artificial nature of how the sector is subsidised and the continuing damage the sector does to the environment.
2. Since there's a hinted cap on GDP – economies can't grow exponentionally in an isolated system like our planet -, alternative indicators to measure the well-being of our economies and societies should be considered when looking for a more precise result on what kind of effect RES' sector truly brings.

1.4 Economic Growth, Degrowth & "Green Growth"

A general economical forecast is that growth-obsessed industrialisation will intensify. Even most of the economists have been too long attached to an unrealistic view that perpetual growth is necessary and also possible to achieve. Neo liberal economies have an inbuilt cycle of lending and printing money and drilling holes into earth, in order to keep the elite and the voters satisfied. This is a necessity to maintain order and power in such states. Resulting in the notion that the economy must always expand and reducing the environment to a 'standing reserve' for unending economic growth (Antolick, 2002).

As most of the scientists and ecologists have by now discovered, societies' ambitious endeavours have reached physical fundamental barriers to ongoing economic expansion. Proofs of ecological crises, diminution of finite resources is met on every continent. Realization has arrived that economic growth as we have known is over (Heinberg, 2011). And since it's not realistic to grow our economy forever, we can't rely on growth to pay down our debt, both to banks and the environment.

It is advised to reconceptualize economic growth. "Either a different type of growth, or an adaptation to a lower or no-growth economy, is necessary" (Harris, 2013). Because, as Robert Solow explained 50 years ago, there is nothing that says that economic growth is a natural and unremovable particle of a capitalistic system (Solow, 1970).

Ecological economists have developed new strategies of economical growth with less impact on the environment. Peter A. Victor divides states into categories based on their track record in GDP growth and its relation to total greenhouse gas emissions (GHG) emitted, where the growth rate of GDP of a state is compared to the growth rate of GHG intensity (GHG/GDP). In short, these categories are ’green growth’, ‘brown growth’, ‘black growth’ and ‘green degrowth’ (Victor, 2010).

Victor labels countries with the term ’green growth’, where there is improvement in both GDP and GHG intensity, but the rate of reduction in the latter is bigger than the rate of growth in the former. In this category a few of the present day well-developed European countries may belong. A country is in a ‘brown growth’ category when the rate of reduction in GHG intensity is less than the rate of its increase in GDP. Opposite to ‘green growth’, the environmental impact in ‘brown growth’ increases with every dollar made in the economy. As the analyses in this paper will disclose later, most of the modern age developed and developing countries fall into this category. Going down the ladder, there’s ‘black growth’, which consists of countries with economical growth and a rise in GHG intensity. And finally, there’s also a possibility for a ‘green degrowth’ economy, where the size of GDP shrinks together with GHG emissions. (Victor, 2010).

With the importance of environmental politics sharply rising in the European Union (EU) and a large part of the continent struggling to find economical growth after the 2007-2008 financial crisis, it is becoming increasingly realistic to find examples of ‘green degrowth’ economies. Many developed Western European countries have struggled to bounce their economies back towards growth, while at the same time exemplarily legislating new environmental laws and conducting subsidy programs for RES technology investment and implementation. Differently to the opinion of the leaders of some of the developed countries, who have involuntarily found themselves in the cluster of ‘green degrowth’, ecologists suggest that the situation is anticipated and justify their thesis of degrowth: “growth is uneconomic and unjust…it is ecologically unsustainable and that it will never be enough” (D’Alisa, Demaria, Kallis, 2015).

Political campaign slogans and a small number of seats in an average contemporary parliament (Grant-Tilley, 2019) show that green parties are not very popular amongst its people. In fact, what is popular, is the thought that ecologism as an ideology proves to be democratically impossible, since an anti-growth message is unattractive to voters (Heywood, 2007). The people want employment, social security, prosperity amongst many things and generally they prioritize short-term needs over long-term ones, with ecological reasoning lagging behind or getting more attention only once mundane needs are satisfied (Grant-Tilley, 2019). Add in increasing international pressure and competition that degrowth politics would bring to a government of any state, and it looks like the ideology of degrowth is better to be shelved, waiting for a time of complete ecological catastrophe or similar.

Fortunately, there are less radical, and at the same time more viable and ecologically sustainable economic growth solutions available. In a paper written in 1993 by H.Daly, defining the economy as an open subsystem in a closed ecosystem (total system), the idea of a steady-state macroeconomics was introduced into the modern economics conversation. He states that since the earth grows qualitatively, but there’s no new material entering the total system, the modern economy, being an inseparable part of the system, needs to move away from quantitative growth to qualitative, achieving equilibrium with its environment. Beyond an optimal point ecological costs will start growing faster than profit and instead of promised prosperity will make humanity poorer. Therefore, economy must find a steady state in a closed system. A state that satisfies the needs of a society, but doesn't pollute beyond the environment's absorptive capacity. (Daly, 1993)

In RES context, a move towards steady-state could be made with 'green growth' via a strategy called 'decoupling' – in other words, removing energy use (fossil-fuel consumption) from the economic growth process (and its' indicators) (Harris, 2017 & Pollin, 2018). Decoupling can theoretically be achieved through greater energy efficiency and RES supply systems, which decreases the emitted amount of GHG, while still benefitting from economic growth. The goal is to use less energy to achieve the same results. Further case is made that when the composition of GDP, which most governments trust as the main measure for economic success, "changes in favor of services and away from goods, GDP can rise with the same or even less impact on the environment" (Victor, 2010).

1.5 Alternatives to Measure the Economy

Political and economical solutions for manifestation of the ideas discussed could be found from the works of John Maynard Keynes, who, in an effort to understand and solve the Great Depression in 1930s, became well known for his works on economic reforms. Without going into historic details, it is widely agreed that the capitalistic economy owes much to Keynes for bringing it out from its collapse and for its continuing growth up until to present day. One of the central ideas of Keynesian economics is 'Keynesian Compromise' – right degree and nature of state intervention within an overall system of open markets (Balaam, 1996). Although Keynes did believe in the positive force of the market, he saw the need for state involvement where numerous rational individual choices could most likely produce irrational collective outcomes. A tenet being that government intervention can stabilize the economy.

What a true Keynesian view shares in common with ecological perspective is the refusal of market optimality assumed in classical economic models. Mainstream economic theories' assumption of a self-regulating economic system makes it essentially impossible to deal with issues like the need for a major energy transition, environmental sustainability etc. On the contrary, true Keynesian ideology does not depend on growth, therefore, if followed, it gives governments 'freedom' to transform problems like unemployment, pollution, infrastructure, deforestation etc. into specific solutions and massive investments. (Harris, 2013)

Persisting economical and ecological problems in the World have urged many environmentalists to compose a toolkit of political views and techniques under the name of Green Keynesianism – that is, Keynesian fiscal policies combined with environmental objectives. The hope is that a revised and 'greened' Keynesian thinking can offer a solution to both economic stagnation and a guidance away from a GHG-intensive direction. (Harris, 2013; Pollin, 2018)

The critics of Green Keynesianism dispute that it is not possible to achieve both economical growth and environmental sustainability. It's a paradox – If one is achieved, it likely fails in the other. In their opinion, "Keynesianism is not the answer, because it (the ideology) is all about expanding demand". (Blackwater, 2012)

But green Keynesians assure us that there would not be any serious obstacles to economic growth. Instead, they see the issue in how economic growth is defined (Harris, 2010). Does it depend on mining, consumption import, etc. or should it focus more on energy-efficient service-oriented activities? For example, there are certain parts of GDP formula (like investments in RES) that are ecologically favorable or neutral, thus economical prosperity could also be achieved with a shift from consumption-focused economy to one that is highly investment-focused (Jackson-Senker, 2009). In other words, moving towards an economy that prioritizes investments in energy efficiency, environmental conservation and RES technology installations. Consequently, it can be claimed that the obstacles to achieve equilibrium between ecology and economy are institutional and political, not economic (Harris, 2013).

Jonathan M. Harris proposes to replace or reform the GDP as a form of economic measurement, so that it would be easier to distinguish between those macroeconomic aggregates that should be strictly limited and those that can grow over time without negative environmental consequences (Harris, 2010). In other words, "angelising" the GDP, as Herman Daly (1973) framed it. Shortly, the goal of "angelisation" is to limit or remove the factor of resource- and energy-intensive sectors, which have negative effect on the environment, in the calculations for the value of the economy. It is believed that there are enough opportunities for economic growth in resource-conserving and service-oriented sectors, like healthcare, education, RES and others. Obviously, this kind of new direction will not happen through market mechanisms alone, thus it depends upon strong government leadership (Harris, 2010).

From one angle, advanced simultaneous reforms are advised to move countries from consumption-based economies to one focused on sufficiency (Zehner, 2012), but from another, fiscal policy is seen as an essential tool achieving full employment, social equity and environmental sustainability which all are considered highly important fields in a sustainable economy (Harris, 2010).

Fiscal policy is where the (green) Keynesian policy toolkit is viewed as most useful – both, its contractionary and expansionary methods are able to reduce ecological deficits by placing taxes on environmentally unfriendly and subsidising environmentally friendly sectors of the economy (Harris, 2013). In regards to RES and the energy sector, to effectively solve economical stagnation and environmental problems, two targets are recommended to government offices to be set:

1. To reduce overall energy use (or TPES - Total Primary Energy Supply) by 1% of energy consumption per year,
2. To raise the share of RES in energy consumption (or in TPES) by 1% per year. (Harris, 2019)

In conclusion, a combination of Keynesian and environmental principles with strong government leadership is advised to make the transition to a more sustainable economy, which is able to take care of both the environment and the society. The bad news is that required investments in infrastructure, RES, energy efficiency, etc. to maintain our environment are colossal. But the good news is that these expenditures would offer economies many opportunities to expand (GCEC, 2018). And for measuring the expanse of that kind of an economy an "angelised" version of GDP is recommended.

The task of this work is to prove that an increase of in renewable energy sources in a state's energy portfolio brings economical success. The confirmation or refutation to the statement is potentially achieved via a series of quantitative correlation tests conducted between different economic indicators, like GDP, and a value representing renewable technologies' share in TPES. If the correlation results return as positive, then they will confirm the hypothesis that by increasing energy efficiency, employment opportunities, investments, and by decreasing environmental costs etc. with the help of RES, implementation of its technology is beneficial to a modern states' economies. The research also investigates if RES implementation impacts the World's green, brown and black growth economies differently.

2. Methodology

2.1 Indicators

The goal of this research is to see if renewable energy brings benefits to the economy. The success of the modern economy can be measured in multiple ways, starting with indicators that sum up gross revenues, savings or investments, all the way up to aggregates that consist of non-financial measures, where value is measured with questionnaires about overall happiness in life. The following list of economic indicators are believed to be the best fit to measure what kind of effect renewable energy sources have had on modern economies.

<u>Indicator 1. RES/TPES</u>

RES/TPES is a share of renewable energy sources (RES) contribution to total primary energy supply (TPES). What RES/TPES specifically shows is what percentage of share renewable energy sources have in total energy supplied in the economy. The higher the value, the more likely that the economy is moving towards a green growth economy. Renewables included in the aggregate include "hydro (excluding pumped storage), geothermal, solar, wind, tide and wave sources. Energy derived from solid biofuels, biogasoline, biodiesels, other liquid biofuels, biogases and the renewable fraction of municipal waste are also included" (OECD, 2019).

RES/TPES is the independent variable used throughout this work to conduct correlation tests against dependent economic variables, because it resembles accurately half of the hypothesis of this work. Its value is used by calculating the difference between two different periods or years. For example, if the value in 2005 was 5.4% and in 2010 it was 8.1%, then a total growth between these periods were calculated – 2.7%. It resembles the increase of share of renewable in TPES, not an increase of total RES capacity.

Modern economies are recommended to increase RES share in TPES by 1% per year to avoid economic stagnation and environmental catastrophe (Harris, 2019). Finding out with the help of empirical analysis if this progress is actualizing, is a central part of this thesis.

Indicator 2. Gross Domestic Product (GDP)

GDP is the most widely used indicator to measure (in USD) the size of an economy. According to OECD (2019) it "is the standard measure of the value added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production, or the total amount spent on final goods and services (less imports)." The indicator was picked for this research because it is globally the most recognized and most widely reported economic aggregate, thanks to this, the tests can be conducted on a very ample sample frame, representing states from different geographies and development stages.

It includes under one variable all major sectors in the country that have a relationship with money.

GDP value was (1) always used in per capita basis to standardise the value between economies of different sizes; (2) similar to RES/TPES measured as growth throughout a period of five or six years; (3) not standardised (e.g. Real GDP, Nominal GDP etc.) between sample frames, just as long identical type of GDP indicator was used on one sample case.

Going back to chapter 1.2, since RES has influence on many economic sectors, like investments, taxes, salaries, business expenses government spending, and GDP indicators include all of the stated in its equation, then in theory, growth in RES/TPES should be reflected in GDP figures.

The criticism of GDP is that it does not distinguish between those macroeconomic aggregates that were produced with negative environmental consequences and those that weren't (Harris, 2010). Since RES could deliver for a country reaching further than just only finance, more economic indicators were included in this research.

Indicator 3. Energy Intensity (EI)

Energy Intensity is an alternative option for measuring RES' share effect on the economy on a GDP basis. While total primary energy supply (TPES) is already part of the RES share indicator as the denominator, then EI makes it also part of GDP's indicator. Only in this case it's the numerator: TPES divided by GDP of a country. According to the World Bank (2019) EI "is an indication of how much energy is used to produce one unit of economic output." The smaller the value of the indicator, the more efficient and mature is the economy (Smil, 2017).

EI fits well with the goal of this research to discover if RES implementation has been beneficial to economies, because both, its denominator and the numerator, are being impacted by the renewable energy industry. Since RES in theory (IRENA, 2017) via increased efficiency, lessens the value of the numerator (TPES) and certainly via increased economic activity increases the value of the denominator (GDP), then overall, the value of EI would be expected to decrease.

EI was included in the correlation calculations in the form of its difference between two points of time, receiving the total improvement or progress. For example, if the United Kingdom's EI's score in 1999 was 4.98 and in 2015 3.01, then the total improvement for the country was 1.97. This number would be inserted in correlation coefficients' formulas to observe if there's correlation with RES share increase.

The downside of using EI in this research was that the values available had been reported by states only till 2015. Considering that RES industry improves almost exponentially, EI does not help researching the most recent years where, potentially, energy efficiency improvement around the globe have been the biggest.

Indicator 4. ANS –Adjusted net savings, including particulate emission damage.

The utilisation of adjusted net savings (ANS), including particulate emission damage, in this research represents the idea of 'angelising' the GDP (Daly, 1973). It is far from being similar to GDP, but it resembles the ideas (Harris, 2010) covered in the theoretical part because it, in some extent, distinguishes environmentally beneficial economic activities from the harmful ones. Compared to more suitable indicators, like GPI (Genuine Progress Indicator), ANS is globally reported, which simplified the process of this research. According to The World Bank (2019) ANS is net national savings, "plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, and carbon dioxide and particulate emissions damage." While GDP measures all the revenue produced in a state, ANS sums up how much the state has saved on its bank account, arguably being more adequate at valuating how wealthy a country is.

The value of ANS was, before calculations, standardised to a per capita value to better represent the welfare of the population and eliminate differences between total size of economies. The value that was correlated against RES/TPES, was the total amount of savings per capita the state accumulated throughout the period. In RES context, ANS does not count the investments and profits made by the industry, but it includes, for example, the amount of profit's saved, reservation of natural resources and pollution damage caused by the energy sector.

Indicator 5. Total GHGs emissions

The first indicator that will be used in the empirical part of this paper is the total greenhouse gas' (GHG) emissions. By United Nations' (2019) database GHG excludes emissions related to land use and forestry, but includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), hydrofluorocarbons (HFCs) etc. The indicator is measured in kilotonne CO2 equivalent.

The indicator was included in the analysis when Peter Victor's theory (2010) of green, brown and black growth economies was tested with GHG Intensity (GHG/GDP). Truth to be told, since his work had not specified which GDP indicator precisely to use, and because different versions of GDPs delivered country-basis different overall results, then this research decided to not follow his theory word-for-word and replaced GHG intensity with only GHG. Nevertheless, it was discovered that the variance in results differences was not very different than it was between different GDP indicators.

Total GHG emissions indicator is important for this research because it helps to understand better the researched sample frames, but since the theory needs more research, the results of green growth economies in this paper are advised to be approached as illustrative, not factual.

2.2 Method

This research was carried out using a quantitative method on the basis of two different correlation coefficients: Pearson's r and Spearman's rho (ρ). The first one, Pearson's r was selected not because it is one of the most widely used correlation evaluaters, but because it shows the strength and direction of the correlation. Therefore, if the researched variable, RES/TPES, increases, then, hypothetically, an economic indicator's value should also increase, giving the Pearson's r value above 0. The same, but in a negative direction, applies in the case of RES decrease in a country's energy porftolio.

Initially, it was planned to use only Pearson's r coefficient to conduct the tests, but since empirical observations discovered that Pearson's equation was, in many occasions, leaving out of the selection very influential outliers, then a Spearman's ρ was introduced to the research in order to offer an alternative result for each conducted test. Spearman's ρ input was valuable because of its simplicity. Compared to Pearson's r, it does not require us to distinguish outliers from the selection, therefore it offered actual results on the sample frame. On the other hand, since some of the sample frames, especially the ones that included the developing world, where disparate – standard deviation (ST DEV) values ranging between 6-9 – a Pearson's r coefficient was trusted over Spearman's ρ.

The data to conduct the tests was gathered from public databases released by international organisations like the World Bank (2019), the OECD (2019) and the EU (Eurostat, 2019), who have collected the data in cooperation with their member states. In order to categorize the data, to standardise indicators' value and to calculate correlation, Microsoft Excel 2013 software with its functions, like 'PEARSON' for Pearson's r and 'CORREL' for Spearman's ρ, were used. In addition, MS Excel assisted also with identifying and removing outliers for Pearson's r equation with 'QUARTILE, 1' and 'QUARTILE, 3' functions. The use of these functions also helped to succesfully discover data that might be false.

The data analysis was focused on a concept of dividing the total researched timeline (2000-2017) into 3 different periods of time (e.g. 2000-2005, 2006-2010, 2011-2017), and the values for the indicators, that were going to be inserted in correlations' formulas, were derived by calculating the total difference between the two ends of the time period or by summing up all the values reported throughout the period. The reason to use predominantly five-year periods for observations was because the RES industry has still remained premature in many countries. Thus, annual statistical view would have produced inadequate information.

The selection of sample sizes was based on an understanding that present environmental problems are a global issue – thus, sample sizes had to involve countries from different geographical positions and economical development levels. Moving forward, the selection of countries were roughly divided into two groups: the developed and the developing World, which where further divided, making up in total, four sample frames:

1. **OECD**. This sample frame consists of all the 36 member states of the OECD (2020). The OECD was selected to be one of the sample frames because of it's very high availability of data and similar development stages of member states' economies, despite their geographical position.
2. **EU**. The EU's sample frame's selection consisted of all the current 28-member states' data, with ~95% information available. The EU's sample frame covers in large part the same selection of countries as the OECD does, giving the two an opportunity to confirm or decline the correlation present in the test results based on different databases (e.g. Eurostat (2019) versus OECD (2020)).
3. **BRIICSZ**. The name 'BRIICSZ' is the author's creation to 'squeeze' together in one sample frame all of the world's major economies (based on G20 membership) that are not members of the OECD. These countries are Brazil, Russia, India, Indonesia, China, Saudi Arabia, South Africa and Argentina. The last one of the list did not receive 'a spot' in the abbreviation because then the name would have lost its meaningful resemblance to the informal international economic development group of BRICS, where more than half of the countries from this sample frame are members of (BRICS, 2020). BRIICSZ by any means is not a group of countries with meaningful central policy or cooperation, but it represents the developing part of the World that because of the sizes of their respective economies, might have had more financial capacity to implement renewable energy technologies.
4. **LDCs**. Represent the least developed countries. These 51 countries were selected based on the World Bank's 2015 year GDP per capita (Appendix 1) statistics, drawing the line at $5000 USD per year. All the countries below this number, were selected, incl. Indonesia and India that are also part of BRIICSZ. The abundance of countries in the sample frame gave the necessary flexibility to manage statistical problems like gaps in data, which for this group of countries was a recurring issue.

A separate section in this research has been devoted to Victor's (2010) theory of green, brown and black growth economies, a classification made based on a states' GHG emission and GDP growth rates. His theory does not directly correspond to the main thesis, but a test trial conducted covering a part of the centre core of Victor's vision, which are tightly connected to the renewable energy industry's ideology, gave a valuable overview of the created sample frames' climate change mitigation track record. Thus, the main goal of paragraph 3.1 is to offer adequate perspective and support for the research of the main thesis in the following chapters.

3. Results and Empirical Analysis

3.1 Green, Brown or Black Growth

The first goal of this empirical analyse is to become familiar with the sample case by figuring out with the aid of A. Victor's ecological economics theory (Victor, 2010) how many countries in each sample case could be classified as black, brown, green growth or even green degrowth economies. The results are expected to (1) show if modern states are moving towards the green economy; and (2) offer a bigger overview on current global progress in climate mitigation, as well a better perspective when analysing each sample frame on RES implementation's role on the direction of economies.

Starting with OECD, the trial results on figure 3.1 show that based on average GDP and GHG growth, majority (80%) of the members between 2000-2017 have been brown growth economies - there's been an average annual decrease of GHG emissions by 0.6% while the GDP grew by 7.5%/year. The rest of the sample frame during the same period qualified as black growth economies.

Figure 3.1 - GDP & GHG emissions growth directions in OECD member countries.

OECD % of countries	2000-2017	2000-2005	2006-2010	2011-2017
Black Growth	20%	53%	25%	18%
Brown Growth	80%	47%	53%	59%
Green Growth	0%	0%	14%	12%
In Transition		0%	8%	12%
GDP AVE annual growth	7.5%	7.5%	4.6%	5.4%
GHG AVE annual growth	-0.6%	0.5%	-1.0%	-1.9%
Difference	6.9%	8.0%	3.6%	3.5%

Author's created *Source: OECD*

Breaking the timeline down to five-to-six-year periods, figure 3.1 examplifies a trend moving towards brown and green growth economies. In 2011-2017 there were only 18% of the countries left under the black growth economy classification compared to 53% during the years between 2000-2005. The rest were 62% in brown growth, 12% in green growth (GHG emissions decrease faster than GDP grows) and 9% labelled as “in transition”. The category “in transition” was created throughout the course of this research to reveal the amount of countries in process of becoming a green growth economy – that is, countries with a decreasing GHG emissions rate which is not more than 0.66% slower than annual GDP growth. Based on this research OECD’s green growth members during the most recent period (2011-2017) were Finland, Greece, Norway and United Kingdom. Countries which are still reporting increase in GHG emissions (black growth) are Lithuania, Turkey, Portugal, Poland, South Korea and Hungary. Overall OECD members make together up a brown growth economy.

Figure 3.2 reveals that in the EU there’s also been a trend away from black growth economies: 61% of the members in 2000-2005 versus 4% remaining in 2011-2016. Being partially related to OECD’s sample frame, the EU is today dominated by brown growth economies (82%) and the union as the whole can be categorized as “in transition”: average annual GHG decrease in 2011-2016 was only 0.6% slower than annual GDP increase.

Figure 3.2 - GDP & GHG emissions growth directions in EU member countries.

% of EU members	2000-2016	2000-2005	2006-2010	2011-2016
Black Growth	14%	61%	18%	4%
Brown Growth	86%	39%	75%	82%
Green Growth	0%	0%	4%	7%
In Transition	N/A	0%	4%	7%
GDP AVE annual growth	8.4%	7.6%	5.7%	4.8%
GHG AVE annual growth	-0.7%	0.9%	-1.2%	-1.8%
GDP-GHG*-1	7.7%	8.5%	4.4%	2.9%

Author’s created *Source: UNDP & OECD*

EU’s green growth economies are Greece and Finland, with Ireland being the sole black growth economy.

Based on the data available for the period of 2000-2012, BRIICSZ have as individual entities and as a whole remained in the black growth category. Despite that, the groups’ average GHG emissions growth has slowed down: 11% of total growth throughout 2006-2010 compared to 30% between the years of 2000-2005, while GDP growth in the same periods fell from 44% down to just 39%. ‘The blackest’ of all the economies in this group belongs to Saudi Arabia, whose GHG emissions in total increased by 25% more than its GDP. The country which is closest to a transition to a brown growth economy is Argentina (2% GHG growth versus 32% GDP growth in 2006-2010). (World Bank, 2019; OECD, 2019)

Figure 3.3 implies that there is a similar movement towards green growth economy amongst the World’s LDCs, but there’s been a noticeable turnaround in 2011-2012, when every one of the countries in the sample frame were categorized as black growth economies, instead of 64% in 2006-2010. What is more, comparing 2000-05 & 2011-12, the GDP's average annual growth had decreased by 0.5% and GHG emissions growth had slowed down by 0.5%.

Figure 3.3 - GDP & GHG emissions growth directions in LDCs

% of LDCs	2000-2012	2000-2005	2006-2010	2011-2012
Black Growth	78%	78%	64%	100%
Brown Growth	22%	20%	22%	0%
Green Growth	0%	0%	14%	0%
In Transition	0%	2%	0%	0%
GDP AVE annual Growth	7.3%	5.8%	5.8%	5.3%
GHG AVE annual Growth	2.2%	3.2%	0.7%	2.7%
Difference	9.5%	9.0%	6.5%	8.0%

Author's created *Source: World Bank*

Conclusion

As a result of this trial, there is a stark contrast in comparison between the developed (OECD & EU) and the developing (BRIICZ & LDCs) countries' sample frames. While the LDCs make up 100% (note: a more recent data might reveal a smaller share) a black growth economy, the developed countries are today mainly brown economies with fairly small, but equal share divided between green and black growth economies. This balance of unbalances is illustrated well by the opposing positions at the ongoing UN's COP (Conference of the Parties) climate talks: decreasing GHG emissions is much more expensive for the developing countries than it is for the developed states, therefore bigger financial, technical and institutional support from the latter has been required and requested (UNFCCC, 2008). While large parts of the developed World are close to becoming green growth economies, there is still a long way to go for the rest of the World.

The biggest leap towards the green growth economy was made during the period of 2006-2010 when the the difference between GHG emissions decrease and GDP growth rate shrank by 2-4% in different sample frames. Without trying to take the credit away from environmental lobbyists, the two dependant indicators were surely affected by the 2007-2008 financial crises, when GDP decreased worldwide, resulting in smaller economies that emitted less GHG. This might also explain the sudden turnaround to black growth economy in 2011-2012 by the LDCs – their regained confidence in the global economy could have ignited local economies, therefore, also sped up the emittance of GHGs.

In conclusion, the developed part of the modern World is moving towards a system of green growth economy, but the World as a whole is not. The count of black growth economies, although succeeding at slowing down the rate of increase of their GHG emissions, outweighs the number of current green economies, thus making the total global economy a black growth one. What is even more important, these outnumbering black growth economies outweigh its counterparts also in GDP and population growth rates, making the mutual aspiration of reducing

GHG total emissions even harder. The supporting analysis of the thesis in the following chapters will examine what kind of role renewable energy plays in the direction of these economies.

3.2 Renewable Energy's Effect on the Economy – GDP

To discover if renewable energy implementation has had any effect on states' economies, this research carried out numerous tests on multiple time periods to find a correlation between RES/TPES share increase and GDP growth. The goal is to confirm if the stated thesis that 'RES politics improve economies and societies welfare' is true or not. This is observed separately on developed and developing countries' sample frames.

We start with the group of developed states, OECD and EU members that during the period of 2000-2017 were predominantly brown growth economies (Figure 3.1 & 3.2). Despite the improvements made with GHG emittance reduction, this research revealed (Figure 3.4) adversarial results for the complete observed time period (2000-2017): half of the data correlation trials returned a weak positive correlation while the other half showed a weak positive correlation between RES/TPES and GDP growths. What's worth to highlight is the reason behind the polarising difference between EU and EU RES-E (share of renewable electricity) – the difference is most likely created because of a missing dataset about EU's RES-E for the period of 2000-2005.

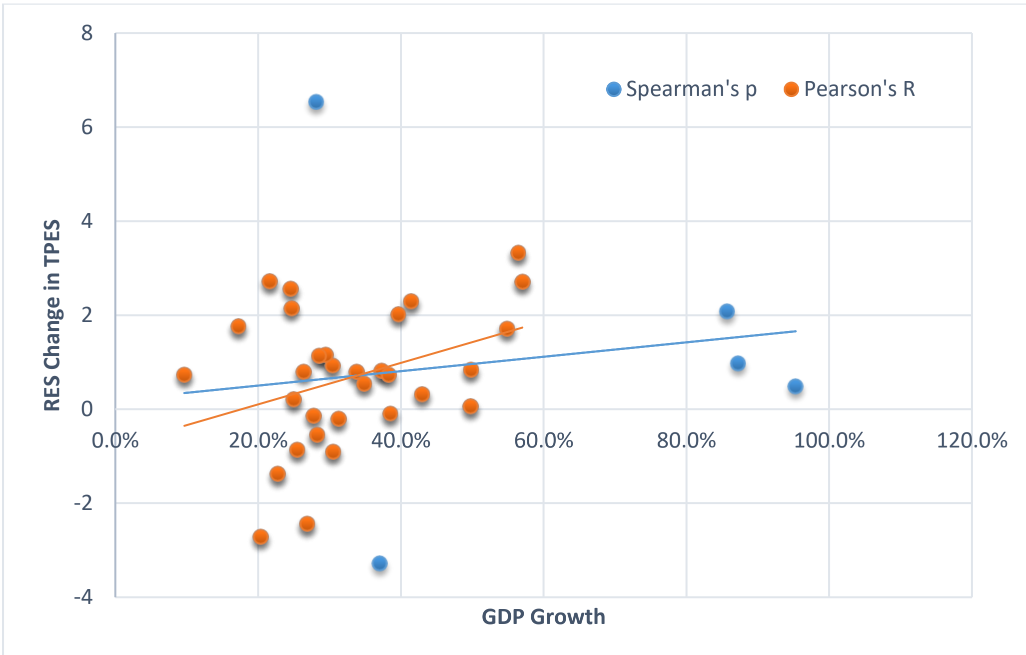
<u>Figure 3.4 - Developed countries RES/TPES & GDP Growth Correalation</u>

Pearson's R (r) / Spearman's (ρ)	Period	TOTAL	I 2000-05	II 2006-10	III 2011-17	RES STDEV	Source	Comment
OECD	2000-2017	-0.134	0.356	-0.058	-0.324	-	OECD	
		0.196	0.184	-0.069	-0.061	5.878		
EU	2000-2017	0.177	0.199	-0.020	0.066	-	OECD ja WB	
		0.111	0.047	-0.035	0.043	4.476		
EU (RES-E)	2005-2018	-0.170	-	-0.250	0.180	-	Eurostat	RES-E only
		-0.206	-	-0.369	-0.014	8.396		

Author's created

Pearson's r value for OECD in period I, 2000-2005, shows a moderate positive correlation (0.356) between the two variables (figure 3.4). Although, when the test was run through once more with Spearman's ρ, the correlation changed to a weak positive, proving the existence of influential outliers (revealed in blue on figure 3.5) in OECD's sample frame. The tests for EU returned one weak correlation with Pearson's r, but when outliers were included with Spearman's ρ, then countries with very high GDP growth, but no RES improvements to report (e.g. Estonia, Latvia), changed the result to disassociation.

Figure 3.5 - OECD 2000-2005 RES/TPES & GDP Correlation



Author's created *Source: OECD*

Tests conducted on period II, 2006-2010, revealed for the EU two results of weak negative and two instances without correlation. Disassociation applied also to both of the tests carried out on OECD (figure 3.4). Throughout this period the most significant value that can be brought out are of EU's RES Electricity (RES-E), where both coefficients revealed that increasing the share of renewable electricity in the total electricity portfolio decreased chances of economic growth. Figure 6 reveals that many states, especially the outliers, with the highest GDP growth had a limited amount of RES-E increase, while the states that by the reported TPES share data were the biggest RES-E investors, experienced in many cases an economic halt throughout the period.

Figure 3.6 - EU 2005-2010 RES-E & GDP correlation.

Author's created *Source: Eurostat*

The overall picture of tests conducted on period III (2011-17,-18) showed no correlation between the two variables, with one instance of weak positive (EU RES-E, r=+0.180) and one instance of moderate negative (OECD, r=-0.324) correlation. Both of the results were retested with Spearman's ρ, which showed disassociation. (Figure 3.4)

Developing countries

The biggest takeaway from Victor's (2010) green growth tests conducted on developing countries was, that all together they make up a black growth economy – meaning that both growths are present, growth in GHG emittance and in GDP. As the correlation tests' results on figure 3.7 show, BRIICSZ and LDCs differ on how RES has affected their economies. Throughout 2000-2017 BRIICSZ's statistics prove that an average RES decrease of -3.9% in TPES did not harm their economies: 186% GDP growth in average (OECD, 2019). While Pearson's r gives a moderate negative correlation (-0.392), then Spearman's ρ includes China, the outlier, and shows that there's a strong (-0.714) negative correlation between RES and GDP increases.

<u>Figure 3.7 - Developing countries RES/TPES & GDP Growth Correalation</u>

Pearson's R (r) / Spearman's (ρ)	Period	TOTAL	I 2000-05	II 2006-10	III 2011-	RES STDEV	Source	Comment
BRIICSZ	2000-2017	-0.392	-0.420	-0.418	0.303	-	OECD, WB	
		-0.714	-0.619	-0.405	-0.024	5.461		
LDCs	2000-2015	0.049	0.133	-0.070	0.044	-	WB	RES (excl. Hydro)
		-0.220	0.104	-0.128	-0.018	8.132		

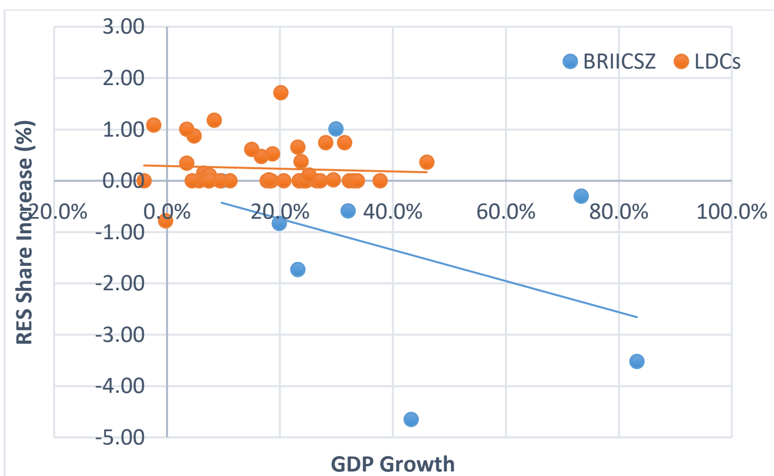
Author's created

In comparison, LDCs overall experienced a very weak negative correlation in 2000-2017. The difference here is probably the global status and opportunities countries have in different groups. Despite strong correlation, the affecting variable in BRIICSZ case might not even be RES, but the amount of revenue few of the states in the group receive from oil exports and the 'upper hand' bigger states normally have in international trade negotiations.

Period I (2000-2005) results are for BRIICSZ an exemplary of the total measured timeline, but for LDCs the correlation results this time show a very weak positive correlation. These outcomes should not be taken very seriously since about half of the countries in the sample frame didn't add any non-hydro RES electricity in their energy portfolio.

Period II was a continuation to period I, although there were many more countries amongst the LDCs who had started to invest in non-hydro RES technologies. Figure 8 shows that while BRIICSZ black growth market scenario was business as usual – with Brazil solely increasing RES share, then LDCs positioning on the graph is very much scattered: there's been trials with the new technology in economies that have vastly different GDP growth outcomes. In 2006-2010 period, Pearson's and Spearman's coefficients returned very similar outcomes on both sample frames.

Figure 3.8 - Developing countries' Pearson's r correlation of RES & GDP in 2006-2010



Author's created *Source: OECD & World Bank*

Period III (2011-2017) was for the BRIICSZ group of countries much different than the previous ones. For the first time the tests were not only without negative correlation, but this period Pearson's r returned also a moderate positive correlation of 0.300. The outlier on this instance was India, who, when included to the formula, with its 62.1% GDP growth and -4.82% RES share (OECD, 2019) decrease, gives Spearman's ρ value of -0.024. On the other hand, because during this period there's no correlation between the two variables in both sample frames, the BRIICSZ and the LDCs, an improvement can be stated: RES implementation no longer backpedals their economies.

Conclusion

To bring together all the correlation tests ran on the four sample frames, the results show that RES implementation does have some kind of an effect on GDP growth, but the effect is different for developed and developing countries. If the tests on developing countries overall did return a negative correlation, then for the developed countries the observed periods were all different, with negative, positive and disassociation all represented.

2000-2005 showed a low positive correlation for OECD members, but a moderate negative one for BRIICSZ. OECD results could be overestimated, since 2000-2005 represented decent economic growth for developed countries and it was the time when early adopters, that is wealthy nations, could afford expensive RES technologies' implementation. The risks to change their energy policy were manageable. On the other hand, for BRIICSZ, the World's largest developing economies, investing in RES deployment was not the decision that was made, due to the fact that their growing energy demands and socio-economic needs urged them to invest in quicker solutions, like coal-fired power plants, oil exports etc.

The II period, 2006-2010, was characterised by the 2007-08 global financial crises. While it was the period where most of the developing countries started investing in RES, for the EU investments in RES-E (figure 3.4) proved to have a negative effect on its economy.

The III researched period, when outliers, like India, were included in the results, delivered similar results between the developed and developing countries sample frames - they both showed no correlation between RES and GDP growths. In comparison to previous periods, this result was not expected from developed states sample cases. Would the post financial-crisis period not have been a smart time to invest in RES technology that has gotten only cheaper over time? Perhaps developed states capacities to install more RES achieved a certain level of maturity, having waited for technological improvements in RES (e.g. battery technology) to catch up. Or there might not be correlation because Europe's economy continued to struggle during 2011-2017.

For developing countries no correlation throughout the III period might not be what the number really shows, but a turning point (1) away from the tendency of RES's negative effect on GDP growth and (2) towards a brown growth economy as the previous chapter's results implied.

To conclude this part, RES share increase in TPES historically tends to have a negative influence on GDP growth, but the scale of effect is not strong enough to come to any final conclusions. What is more, GDP as an indicator has a couple weaknesses to be considered. Firstly, as it came out during the correlation tests, GDP is very strongly affected by global economic crisis, but a financial crisis does not equally affect the welfare of the society, as it affects the financial sector. Secondly, GDP's formula includes sectors of the economy, like oil export etc., which arguably do not benefit the welfare of everyone in the society. A good example on this are the BRIICSZ countries that include big oil exporters like Russia and Saudi Arabia, whose GDP growth (304,8% & 63%; OECD, 2019) was throughout 2000-2017 relying on oil export, while making minimum investments in RES share (respectively -0.53% & +0.01 change in TPES; OECD, 2019). Examples of this kind suffice to change the results of the correlation, therefore raising the need to use other indicators to discover what manner of effect RES share increase does have on modern economies.

3.3 Renewable Energy's Effect on the Economy – Energy Intensity (EI)

The idea behind measuring Energy Intensity's (EI) improvement's correlation in comparison to RES share increase is an indirect way to see RES's effect on GDP. Since (1) EI is an indicator, showing how much energy is used to produce one unit of economic output (eg. GDP); (2) energy efficiency is a major part of EI's formula; and (3) RES is one of the most influential energy efficiency increasing variables in the 21st century, it gives enough reasons to observe if tests can confirm the theory that there is an association between the two. Thus, RES share increase could benefit the economy via increase in energy efficiency which results in lower energy intensity and higher growth in GDP.

Test results conducted for the total period (2000-2015) represent a stark contrast between developed and developing countries. While the developed World showed no significant correlation (except EU RES-E, which was measured only between 2005-2015), then the developing countries, especially BRIICSZ, revealed a negative correlation between RES share and EI developments. (Figure 3.9)

Figure 3.9 - RES & EI Correlation Results.

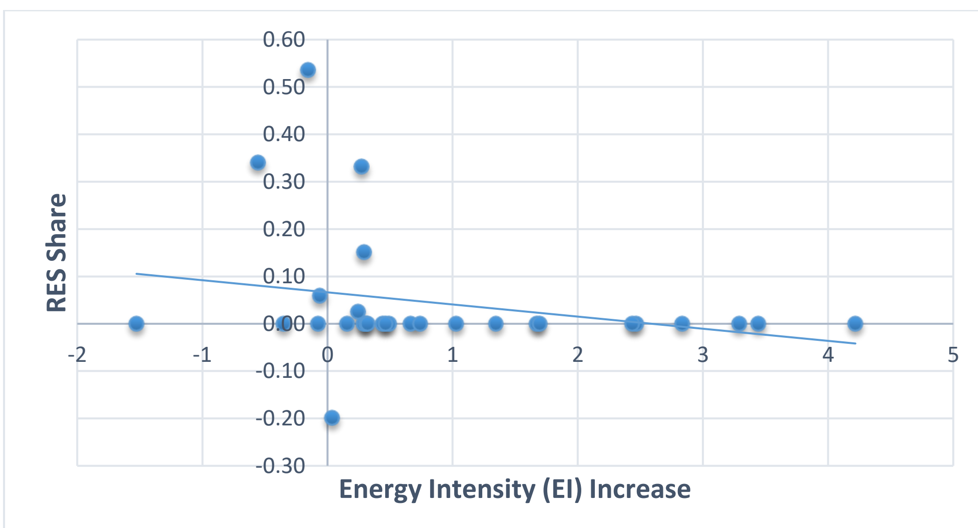
Pearson's R (r) / Spearman's (ρ)	Period	TOTAL	I 2000-05	II 2006-10	III 2011-15	RES STDEV	Source	Comment
OECD	2000-2015	0.110	0.347	0.062	0.015	-	OECD	
		0.047	0.346	0.160	0.128	5.1		
EU	2000-2015	0.097	0.322	0.126	0.073	-	OECD	
		0.025	0.354	0.182	0.161	4.1		
EU (RES-E)		-0.200	-	-0.337	-0.115	-	Eurostat	

	2005-2015	-0.178	-	-0.322	-0.062	6.6		RES-E only
BRIICSZ	2000-2015	-0.457	-0.481	-0.201	-0.256	-	OECD, WB	
		-0.667	-0.500	-0.690	0.310	5.2		
LDCs	2000-2015	-0.114	-0.249	-0.192	-0.101		WB	RES (excl. Hydro)
		-0.244	-0.228	-0.071	-0.046	7.6		

Author's created.

In closer observation, the biggest contrast between the two opposite sides was in the period of 2000-2005: developed countries were showing a weak positive correlation, opposed to developing countries' moderate or weak negative correlations. Figure 3.10 of the LDCs' in 2000-2005 shows well, how the few LDCs that invested in RES experienced no improvement in EI. Even the biggest outliers, Kenya (RES +7.65%) and Nicaragua (RES +4.27%), experienced no improvement in energy intensity (World Bank, 2019). Figure 3.10 also shows that the LDCs that decided to hold off from RES implementing policies during the time span, and perhaps invested their funds in other energy efficiency solutions, did show developments of EI in half of the cases.

<u>Figure 3.10 - LDCs Pearson's r Correlation of RES & EI in 2000-2005</u>

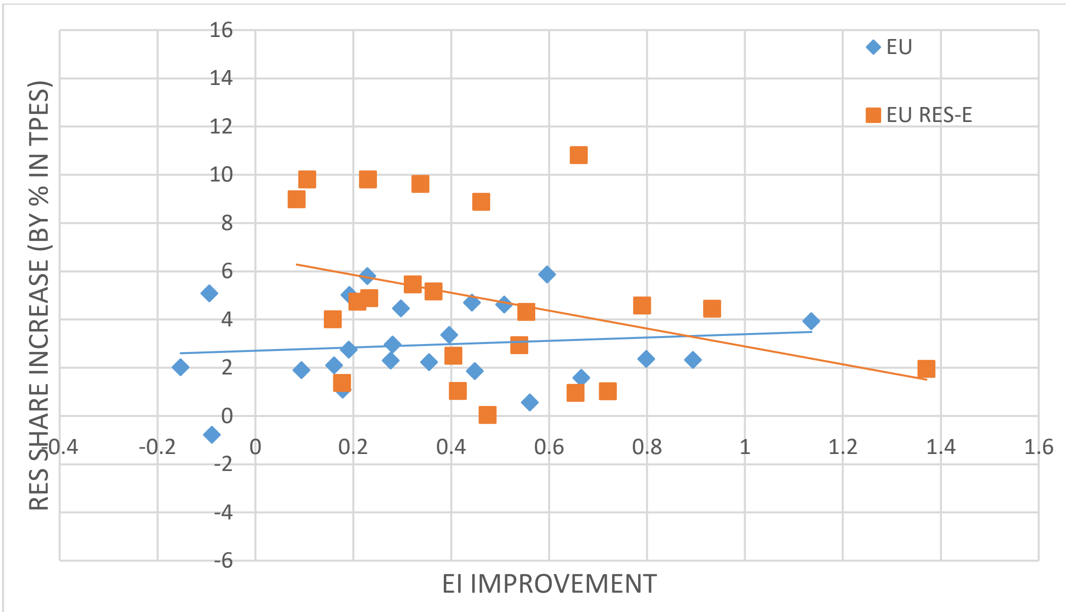


Author's created *Data source: World Bank*

In period II (2006-10) the vast distance between the developed and the developing countries somewhat lessened. If RES did continue to have a slightly positive effect on the former's EI, then it had a weak/moderate negative correlation in the latter's sample frame.

What does look like an anomaly, is the difference between EU's 'RES-E' and 'EU' results. To remind, RES-E represents the share of renewables in total produced electricity and the latter is total share of renewable energy in total primary energy supply. Figure 3.11 reveals, RES-E increase in electricity's sector worked counter effectively towards EI. The difference is too big compared to RES TPES to blame it for a slightly different timeline (EU RES-E's results are from 2005-10 vs. EU is 2006-10). On the other hand, the difference could be caused by (1) different databases: Eurostat versus OECD, (2) technological improvements in respective sectors or (3) it is a comparison of natural (EU) versus aggressive (EU RES-E) policies.

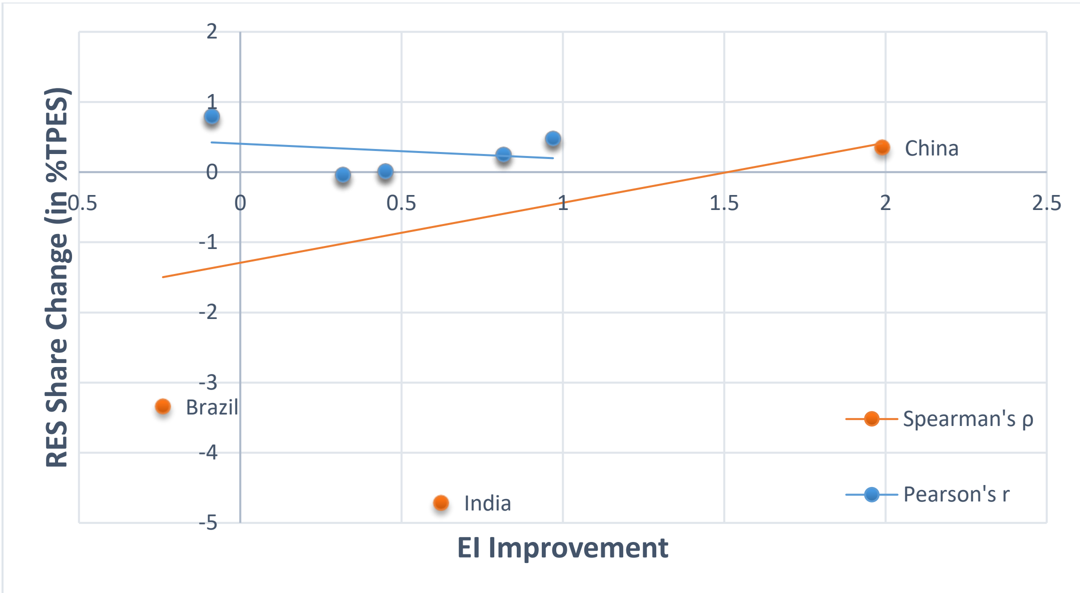
Figure 3.11 - EU versus EU RES-E Pearson's r Correlation of RES & EI in 2006-2010



Author's created *Source: OECD, Eurostat.*

RES's effect on EI, positive or negative, had waned on all of the sample frames by 2011-2017 (figure 3.9). The only remaining one with significant strength in correlation was BRIICSZ. In comparison to previous periods, where the correlation for the group between RES and EI was mostly moderate negative, then in this period the Spearman's ρ coefficient shows a weak positive correlation of 0.310 (figure 3.12).

Figure 3.12 - BRIICSZ' 2011-2015 RES & EI Pearson's r versus Spearman's ρ



Author's created *Source: OECD & the World Bank*

Spearman's ρ value on figure 3.12 reveals the outliers (in orange) that Pearson's r leaves out of the equation. Firstly, China, positioning far right on the graph, statistically has made a big leap while increasing its RES' share in TPES. This is an improvement compared to 2000-2005 when the country's RES share decreased by 8.5% in TPES (OECD, 2019) and EI was quiescent – 0.48 point improvement (WB, 2019). Secondly, Brazil and India at the bottom of the graph, represent a direction away from RES solutions: the former with 3.34% and the latter with 4.71% RES share decrease in TPES (OECD, 2019). The graph suggests that these developments also have affected their EI results, especially for Brazil whose EI score decreased by 0.24 points throughout 2011-15.

It could be argued that BRIICSZ is a very small sample frame from which to draw any big conclusions, but the results show some kind of a direction to the World's biggest developing economies to consider - investing in energy efficient RES solutions. BRIICSZ results also confirm LDCs correlation results in 2011-15 (r=0.101; ρ= -0.046 (figure 3.9)), which suggest that RES implementation has stopped to have a countereffect on developing countries EI.

<u>Conclusion</u>

In conclusion, the RES versus EI correlation tests conducted on the sample frames showed a connection between the variables. For EU & OECD, increase of RES share in TPES has proved to have a positive effect on EI, but EU RES-E results revealed that an aggressive movement (e.g. subsidies) towards a RES dominant electricity portfolio, might leave out other important solutions achieving the green growth economy, thus harming EI. The small difference between the results of Spearman's ρ and Pearson's r also revealed a small number of outliers. Member states of the EU and OECD delivered fairly homogenous results, therefore, from this one could claim that a strong and effective presence of central policies in the respective fields in these international organisations are not only existent, but also effective.

The outcome of correlation tests conducted on the developing World show that historically RES implementation has proved to have a negative effect on improving their energy intensity, but recent times (2011-15) show that this statement is no longer true. The factor here might be expenses related to RES technology. The possible turnaround in the results could be caused by (1) a developing country, like China, who throughout the researched period has grown to become increasingly analogous to a developed state; (2) or because of the rapidly decreasing costs of RES technology (IRENA, 2019b). Overall progress with the strength of correlation between EI and RES shows that while amongst the developed states RES is losing its positive effect on EI, the developing countries are lagging 15 years behind, having the RES momentum possibly just building up.

3.4 Renewable Energy's Effect on the Economy - Adjusted Net Savings (ANS), including particulate emission damage.

Adjusted net savings (ANS), including particulate emission damage, is an aggregate that, considering its ingredients, should aid this research to find a more accurate correlation between RES on one hand and economic or welfare success on the other. Compared to GDP, ANS differs by summing up savings instead of revenue, but because it also treats the environment as an asset and excludes from its formula all financially profitable activities that are environmentally unsustainable (e.g. mining of mineral resources), then it might be a better indicator to discover if RES share increases in TPES benefits states' economies.

In summary, out of the 32 correlation tests conducted for the period 2000-2017, 19 of them returned a positive correlation value between ANS and RES' increases, with three moderate and 16 weak positive correlations. Important to note is, that there was only one negative result in total – LDCs in 2000-2005. Overall 2000-2017 showed a positive weak correlation between RES share and ANS increased on three out of four sample frames (figure 3.13).

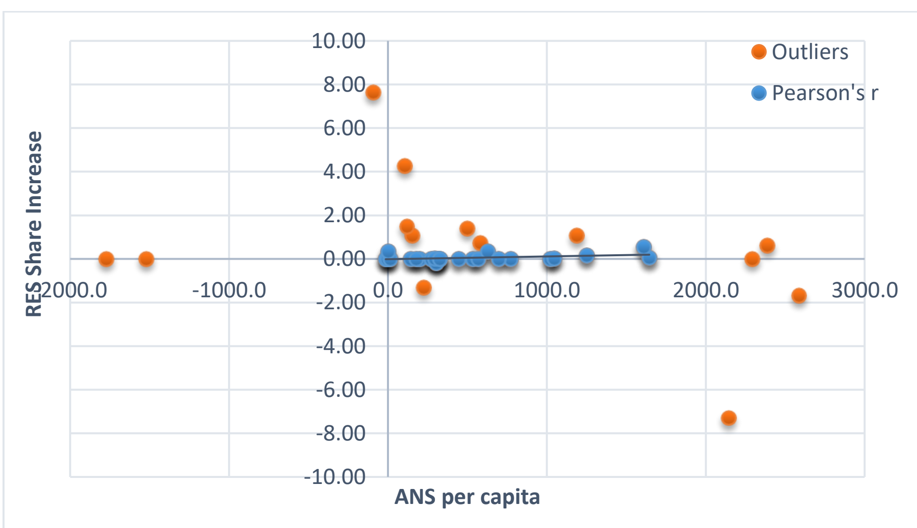
Figure 3.13 - RES/TPES & ANS/cap Correlation Results.

Pearson's R (r) / Spearman's (ρ)	Period	TOTAL	I 2000-05	II 2006-10	III 2011-17	RES STDEV	Source	Comment
OECD	2000-2017	0.189	0.071	0.295	0.165		OECD, WB	
		-0.005	0.037	0.088	0.245	5.5		
EU	2000-2017	0.321	0.001	0.231	0.416		OECD, WB	
		0.254	0.176	-0.039	0.402	4.8		
BRIICSZ	2000-2017	0.154	-0.022	0.237	0.124		OECD, WB	Wo. Saudi Arabia
		0.143	0.179	0.143	0.357	5.7		
LDCs	2000-2015	0.256	0.407	-0.074	0.004		WB	RES (excl. Hydro)
		0.039	-0.192	0.023	0.035	8.5		

Author's created

The first period (2000-2005) overall showed no correlation for the developed countries. On the other hand, for LDCs, Spearman's and Pearson's tests returned with contrasting outcomes: ρ= -0.192 & r= 0.407 (figure 3.13). On closer inspection it was discovered that neither of the coefficients' equations are a fit on this particular sample frame at this particular timeline, because, if half of the countries have reported no change in their non-existent non-hydro RES sector (figure 3.14), then (a) the Pearson's equation will leave almost any renewables' increase or decrease out of the results, and (b) the Spearman's rho gives all the values with zero an equal rank, plus, as experienced in this precise case, consequently ranks countries with non-existent non-hydro RES industry higher than economies that had a decreased share of renewables in TPES. Giving bigger values for no activity at present and in the past in comparison to economies with existing non-hydro renewables, would provide misleading results. In addition, the standard deviation for this sample frame is high – 8.5. For these reasons, the research chose to ignore this particular test's conflicting outcome.

Figure 3.14 - LDCs 2000-2005 Unsuccesful RES & ANS Correlation Test



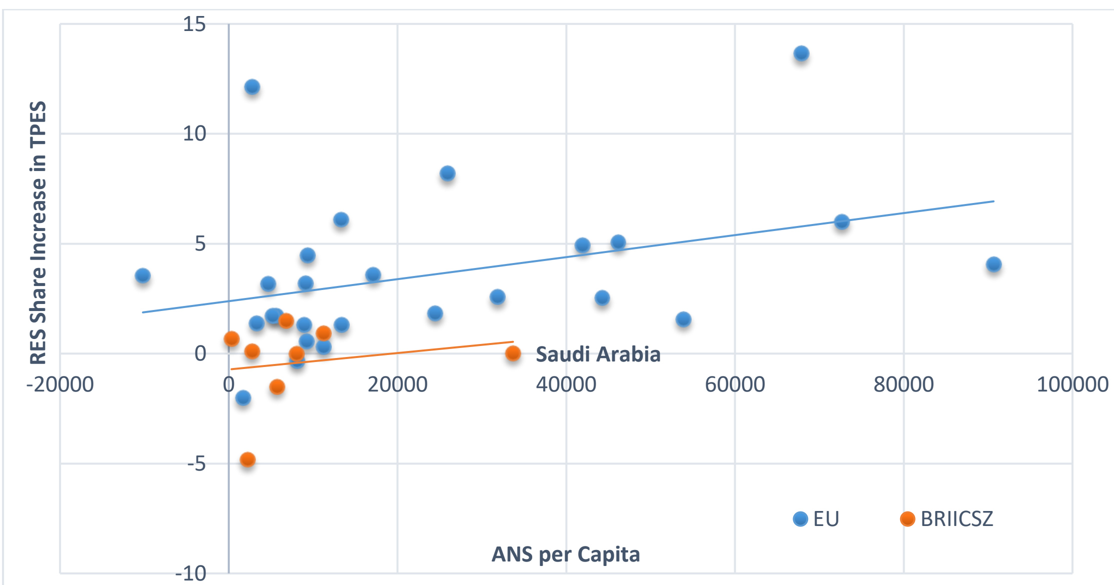
Author's created *Data source: World Bank*

Period II, 2006-2010, shows for LDCs no correlation and for BRIICSZs, OECD and EU all weak positive correlation between RES and ANS/cap increases. BRIICSZ (excl. Saudi Arabia) group of countries was the only sample case that scored positively with both correlation coefficients (figure 3.13).

The 2007-08 financial crisis did not seem to have a negative effect to RES's association with ANS. On the contrary, a slight increase of strength of positive value between the two indicators suggests that the countries that increased their RES share throughout the period accumulated more net savings than the countries that didn't.

2011-2017 reveal positive correlation on all the researched instances besides the couple of tests ran on LDCs, which, indifferent to previous periods, showed no association between the two variables (figure 3.13). Figure 3.15 resembles how countries on both sides, developed and developing (BRIICSZ), are having an association between the two factors at some level, with the EU showing the strongest consistency of the two sample frames.

Figure 3.15 - EU & BRIICSZ (incl. Saudi Arabia) 2011-2017 RES & ANS Correlation



Author's created *Data Source: OECD & World Bank*

Conclusion

While the developed countries (OECD & EU) and the major economies in the BRIICSZ group are trending towards positive in the correlation values between the years of 2000-2017, LDCs showed mostly no correlation throughout the period. Since ANS appears to remain unaffected in cases of small increases of RES share, it confirms what ANS really is – a measure of saving. The development level of LDC's economies has been premature, enough as to not expect any reasonable return from renewables related economic activities, especially to expect savings.

It is worth highlighting from this chapter that BRIICSZ can have a positive RES/ANS correlation even when Saudi Arabia is included in the results – figure 3.15 highlights the state with twice higher ANS than any other country from its group, while at the same time reporting no change in RES implementation. Since BRIICSZ sample frame's selection is relatively small, Saudi Arabia does influence the results of the group significantly. To bring an example, Spearman's ρ value 0.357 in the period of 2011-2017, if Saudi Arabia where to have been included, would be almost twice as weak - $\rho = 0.190$. The reason why Saudi Arabia was decided to be left out of the Spearman's correlation tests (Pearson's r removed Saudi Arabia from the sample frame as a GDP outlier) conducted between RES and ANS, is because, it would have hidden the actual influence renewables implementation has had on economic progress in ANS context in BRIICSZ. To conclude, The ANS/RES correlation results suggest that BRIICSZ states are in most cases progressing from a black to brown growth economy. In other words, the part of the ANS equation that sums up savings from mostly sustainable activities in the economy, accumulates more funds than is the cost of environmentally harmful simultaneous activities.

For the EU and OECD, the developed world, RES and ANS correlation results showed a consistent positive value increase throughout the total researched period. The result shows that as time passes, the developed world gains more savings (economic benefit) with any increase in the share of renewables it makes in TPES.

Conclusion

The goal of this empirical analysis was to discover if renewable energy could have some kind of an effect on modern states' economies. In order to achieve that, the supporting economic indicators of the analysis, like GDP, ANS and EI, were inserted in Spearman's ρ and Pearson's r correlation equations to see how they relate to the increase or decrease of the share of renewable energy sources in the TPES. The 96 correlation tests carried out proved that there is an association between RES/TPES and the enlisted economic variables. The following are the main findings of the conducted tests.

I - The developed (OECD, EU) and the developing countries (BRIICSZ, LDCs) are affected by renewable energy differently.

The conducted trials inspired by Victor's (2010) green growth economy theory proved that a correct categorisation of states was made when constructing the sample frames – even though the groups were deliberately divided to the developing and the developed World, the trials, based on GHG and GDP growths, also confirmed that there's acute difference between the two groups. While the developed countries received a classification of brown growth economies (figure 3.1 & 3.2), meaning that on average their GHGs' emissions decrease while GDP increases, then the developing World could be labelled as mostly black growth economy (figure 3.3), where GHGs emissions and GDP are simultaneously increasing.

Further correlation analysis on the three different economic indicators also confirmed the differences between the two sample frames. First of all, increase in RES' share in TPES showed a very weak positive effect on the economies of the developed countries, but on the contrary proved to have a moderately negative effect on the developing states. The same, but with even more contrastingly, was true with EI – the developed countries succeeded with improvements, but the developing countries' results suggested that RES' implementation could sabotage the economy. And finally, ANS, which proved to be very consistently benefitting from RES' share increase in the first group, while at the same time renewables brought mixed outcomes to developing countries' total amount of savings. The circumstances enlisted above bring us to the next finding.

II – Timing matters: the brown growth and the black growth economies are on different timelines in terms of their ability to effectively increase RES' share in TPES.

Coming back to the results of the correlation tests conducted (figures 3.4, 3.9 & 3.13), an upward trend was discovered by the research which, not only gives credit to RES's influential ability on the economy, but reveals that developments happen, but at different times. With each one of the indicators tested, there was an obvious trend running through the sample frame, where the black growth economies were almost always lagging 5-15 years behind the brown growth economies. Such was the case when between the years of 2000-2017 the brown economies RES/GDP correlation 'climbed' from a moderate negative to a very weak positive value – a result with resemblance to the developed World in the beginning of the century. It was a similar case with EI, where a negative correlation between RES and EI at the beginning of the century turned to report no correlation and, in one instance, a positive correlation in the period of 2011-2017.

A similar phenomenon, but in the opposite direction, was also noticed on the developed countries' sample frames. In both, GDP & EI cases, the developed countries' economies were in 2000-2005 benefitting from RES implementation, but this positive effect waned by 2011-2017, resulting in disassociation between the variables (figures 3.4 & 3.9).

The case can be made that the position on the respective timelines is equal to the development level of the economies. For the developing countries, purchase of expensive RES technologies in 2000-2005 took away from investments for other sectors, including energy efficiency and energy reduction solutions (Zehner, 2012), which are ingredients of EI. On the other hand, decreased costs of renewable energy generation could have removed the negative effect this variable had on the developing economies (IRENA, 2019b, Pollin, 2018). Finally, to explain the loss of RES's influence on GDP and EI in the case of the developed world, a new thesis for research for another time is stated: when technology (e.g. RES) achieves maturity, its positive influence on a developed economy decreases.

III – RES share increase in TPES does not encourage unsustainable expansion of the economy.

The RES industry has been criticised for having motives no different to other capitalistic industries – the goal is to always expand the demand, consequently, the economy (Zehner, 2012). The results of the correlation tests which were carried out on GDP (figure 3.4 & 3.5) showed something different. While renewables' increase in TPES of the developed countries marginally expanded the economy in 2000-2005, then during all the other periods (incl. the values of the developing states) the increase in share of RES showed disassociation or even negative correlation with GDP growth. For this reason, based on the empirical analysis conducted, this paper opposes Zehner's statement.

IV – RES increase does benefit the economy.

The conclusion of the previous point about economic expansion does not mean that RES increase in TPES will not help the economy. On the contrary, the findings of this research are, that if the economy is measured with an indicator that takes into account elements of sustainability - meaning that the aggregate should be able to make distinctions between environmentally harmful and harmless activities (Harris, 2010), then increased use of renewable energy does benefit the economy. The indicator that had the best resemblance to an 'angelised' GDP (Daly, 1973) was ANS (Adjusted Net Worth), which consistently, and with an increasing trend, showed positive weak or moderate correlation with RES. Put differently, at any moment when renewable energy's share in a country's energy portfolio increases, the total savings amount of its economy will have a tendency to increase. This applies to both, the brown growth and the black growth economies.

Thinking retrospectively of the method and techniques used in this empirical analysis, few improvements are recommended for the work. Firstly, the values of the indicators could have been better standardised, or, in a couple instances, used in a different format. For example, the comparison of EU's total RES' versus EU's RES-E (electricity sector only) results delivered inexplicably contrasting values. The difference could have been caused by the use of different databases (Eurostat & OECD), which have collected and worked on the data using different methodology.

Secondly, in addition to correlating the values based on the total change, it is advised to consider also correlation calculations based on the speed of growth of the indicators. For example, if RES percentage in TPES changed during a certain period from 0.5 to 1 percentage, then the total change is 0.5, but the rate of growth is 100%. Both of the versions were used for this work, but the results were limited down to the first option (total change) only to keep the analysis compact.

Finally, but not concluding the list, the research could have offered more depth in terms of the background information on the sample frames, which would have possibly revealed other variables that might be affecting the RES' industry or the global economy. For example, the sample frame of BRIICSZ showed occasionally a fairly strong negative correlation between RES' increase in TPES and GDP (also EI) values' total growth percentages. The theory connected to this phenomenon was that the developing economies were not ready at the specific point of time for expensive RES' technologies, but there, if analysed deeper, could have been political influences, like the rule of oligarchs in Russia for example.

Summary

This paper was written with the purpose to prove that an increase of in renewable energy sources in a modern state's energy portfolio brings it economical success. Leaning on multiple alternative economic progress measuring theories (Victor, 2010; Harris 2013; Daly, 1973), the author expected also to discover if renewable energy increase (RES) in total primary energy supply (TPES) affects countries on different development scale, and with a different GHGs emissions reducing track record, differently. Therefore, the economic variables included in the research along the widely used GDP, were energy intensity (EI) and adjusted net savings (ANS).

To support the aim of the research, two statistical correlation equations were introduced: Pearson's r and Spearman's ρ. These coeficients measure correlation between two variables on the same scale of values, but because of a high variance of some of the constructed sample frames with influential outliers, use of both was necessary. To be honest, in some cases, neither of the coefficients' results looked realistic, since their values were unexpectedly in the opposite sides of the negative-positive correlation scale.

The selection of the countries to the sample frames were made with an intention to distinct the developed and the developing World from each other. The outcome was four groups: the EU, the OECD, authors created 'BRIICSZ' and the LDCs (the least developed countries), with the last two representing the developing part of the World, creating a valuable space for deeper research.

The empirical analysis was divided into two parts. In the first part a trial test based on P. Victor's (2010) theory on black, brown and green growth economies was conducted to create an overview of the GHG track record of the selected groups of countries. The results showed that while the developed world's GHG emissions decrease and GDP increases (brown growth economy), then almost all of the developing countries have GDP and GHG emissions increasing simultaneously (black growth).

The following correlation tests between RES share increase and the dependent indicators (GDP, EI and ANS) were carried through on 4 different timelines and in total of 96 times between the 3 economic aggregates. Since there was an expectation that the correlation results will not be returning strong values, the author picked a strategy of counting multiple weak correlation values instead of looking for a single strong test result, to reveal the direction of effect renewables have on the economies. On the contrary, and unexpectedly, RES increase showed no correlation with GDP growth, but correlated at a reasonable strength with EI and ANS.

The conclusion of the research highlighted four meaningful findings. First of all, this paper emphasizes that renewable energy does not have the same effect on the developing and the developed countries – much depends on the maturity level of the economy and the technology available to be implemented.

Secondly, and tightly connected to the previous finding, it was discovered that the developing countries are almost always lagging behind the developed world by 10-20 years. Therefore, an

RES technology that would bring economic value today in the EU, would be reasonable for a developing country to be implemented in 10 or 20 years time. Meanwhile, it would be more effective for the latter to invest in solutions that increase energy efficiency, thus also decreases EI, creating value for the economy.

The third important finding of the correlation tests conducted, was that renewable energy does not expand the economy. That's because around 80% of the sample frames returned a non-positive correlation between the two variables. This also refutes the criticism that RES industry is unsustainable.

And finally and most importantly, this thesis proved that when the economy is measured with economic indicators, which consider the environment as an asset, like ANS does, then any kind of an RES increase in TPES, would benefit the economy. ANS is not perfect, but since it measures savings - how much money is in the bank, compared to revenue (GDP) - the ability to make money, then at the end of the day, the wealthiest and most prosperous is the nation that has invested the most. With this, the research confirmed the thesis that implementation of renewable energy is beneficial for the economy.

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Appendices

1.1 Appendice 1 – List of Countries in LDC's Sample Frame.

	GDP/capita (constant 2010 US$)		**GDP Growth in period**
Country Name	**1999**	**2015**	**2000-2015**
Niger	339.4230965	386.3045326	14%
Congo, Dem. Rep.	319.562059	411.0205731	29%
Ethiopia	191.5718802	482.6390663	152%
Mozambique	293.6128273	529.0910577	80%

Togo	551.034792	630.3045049	14%
Haiti	762.19692	729.1196298	-4%
Nepal	436.5597065	731.9993357	68%
Benin	676.3366434	827.8354579	22%
Tanzania	511.9469364	871.9983686	70%
Yemen, Rep.	1132.388712	908.7578459	-20%
Tajikistan	389.5968509	935.9998251	140%
Bangladesh	508.3852227	1002.388853	97%
Kyrgyz Republic	628.0693228	1019.876971	62%
Cambodia	398.2881864	1024.621365	157%
Pakistan	812.2556105	1082.766564	33%
Kenya	837.4118776	1093.13417	31%
Zimbabwe	1502.199532	1234.103352	-18%
Myanmar	304.3025442	1335.203872	339%
Senegal	1105.379407	1383.167206	25%
Cameroon	1135.525814	1440.3788	27%
Cote d'Ivoire	1420.32213	1462.283922	3%
Ghana	940.9334409	1624.769624	73%
Zambia	937.9458819	1641.005482	75%
Vietnam	724.479783	1667.171891	130%
India	810.2172832	1751.664378	116%
Uzbekistan	955.9909703	1831.322908	92%
Nicaragua	1262.723642	1835.999	45%
Sudan	983.4368029	1869.552756	90%
Honduras	1539.96832	2052.972454	33%
Moldova	1135.817658	2355.700918	107%
Bolivia	1592.737415	2361.056581	48%
Nigeria	1350.983834	2563.148864	90%
Philippines	1572.891447	2605.493599	66%
Egypt, Arab Rep.	1898.636374	2703.742092	42%
Ukraine	1699.517473	2828.88539	66%
Congo, Rep.	2333.57998	3009.600686	29%
Guatemala	2522.828312	3069.041335	22%
Morocco	1962.993308	3222.054178	64%
Jordan	2772.165598	3275.272194	18%
El Salvador	2655.466164	3314.699221	25%
Sri Lanka	1732.378655	3647.393421	111%
Angola	2201.52946	3748.320623	70%
Kosovo	1915.320297	3802.393915	99%
Indonesia	2071.524683	3824.274885	85%
Mongolia	1596.469382	3895.413362	144%
Armenia	1317.739791	3923.716502	198%
Georgia	1573.159649	3964.510046	152%
Tunisia	2895.015642	4308.415597	49%
Albania	2085.432	4524.684565	117%
Jamaica	4656.620622	4713.647102	1%
Algeria	3474.215313	4776.787543	37%

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