Regional Trends in Renewable Energy Investment

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What is the global trend of regional renewable energy investment over time?

Implementation of renewable energy into electric grids around the world will be key to curbing the effects of climate change. Three quarters of global greenhouse gas emissions result from fossil fuel energy production (Ritchie, Roser, 2020). As put by the International Renewable Energy Agency (IRENA), "meeting international climate and development objectives will require a massive re-allocation of capital toward low-carbon technologies, including renewables, and the mobilization of all available capital sources". In the past, renewable energy technologies such as solar and wind have been expensive forms of generating electricity but, over the last ten years there has been a steep decline in their costs. From 2009 to 2019 the price of electricity from solar power has dropped 89% and the wind has dropped 70% (Roser, 2020). It might seem obvious that renewable portfolios have been growing in recent years as governments and politicians advertise, however does data actually support this? How are investments in renewable technologies changing over time? How does this compare to investment in non-renewable energy?

As climate change becomes an ever more present and increasing threat, detecting these trends can tell us if our world is on the right track to reducing carbon emissions from energy generation. IRENA dives deep into this question in its report, "Global Landscape of Renewable Energy Finance 2020" for the time period of 2013-2018. The IRENA report compares investment to climate goals like the Paris Agreement and makes recommendations on how these goals can be met. It also discusses the sources of the capital for energy projects and dives into off-grid renewable finance. The data used for the analysis in this blog post is from IRENA and the Climate Policy Initiative (CPI) and covers the time period of 2000-2020.

This blog post will take a more streamlined look at the general investment trend of global regions across time with linear regression models. Using a significance level of 0.05, we aim to detect whether the results from the models are statistically significant. This post is by no means a comprehensive study, however it will provide some quick insights.

Data

The IRENA provides the data used in its 2020 finance report available for download from its website in an excel file. To accompany the data IRENA also posts a "Methodology" document that discusses the sources of the data and how its analysis was conducted. According to the methodology report, the data used in this blog post can be, "freely, used, shared, copied, reproduced, printed and/or stored." It should be noted that all the data from this analysis is from IRENA and they hold the copyright for it.

Financial data of the kind used here can be challenging to acquire and can cause some misclassifications of recipients however IRENA has standardized this process to the greatest extent possible for this data. Private investment data can be particularly challenging to find and this information was primarily taken from the Bloomberg New Energy Finance database by IRENA. The reported investment data is conservative according to the methodologies provided by IRENA to prevent "double-counts" as they state "under-reporting of renewable investments is preferred to over-reporting." The methodology report also provides detailed information about data sources, regional breakdowns, and more. The IRENA 2020 report and its methodologies are fully referenced below.

The analysis used in this blog post will annualized totals of investment for each region and therefore does not have a seasonal component. Regional breakdowns were not determined by the author of this post and is directly embedded from the IRENA data.

Analysis Plan

First, a simple static time series model will explore the overall trend of the total annual amount invested in renewable energy by region across time. Regions are broken into Africa, Asia, Central America and the Caribbean, Eurasia, Europe, Middle East, Oceania, and South America. By running this simple model we can get a quick glimpse into the global trend of renewable investment over time. This assumes that only the immediate year in question has an effect on the quantity of investment. This will then be compared to the trend in non-renewable energy source investment over the same time period. As previously mentioned, a significance level of 0.05 will be used to determine statistical significance. The null hypothesis for the first regression will be that there is no relationship of renewable energy investment over time.

Second, a more complex model time series model will be made where we take the simple model and break it up by regional heterogeneity to produce an interaction model. As mentioned earlier, it is no secret that change usually occurs where money flows. Our first trend model provides us with a quick insight into how the world is investing as a whole. However, with agreements like The Paris Agreement we know it will take each country's and region's participation to minimize and eventually reverse the effects of climate change. With this in mind, the simple model produced first hides that certain regions are committing greater investments than other regions. If regions are truly committed to curbing climate change our model will show an overall positive trend. This evaluation will serve as a litmus test to see regional commitment to global climate agreements. The same significance level will be used to test the null hypothesis that within each region there is no change of renewable investment over time. Finally, regional renewable trends will then be compared to their non-renewable counterparts.

Results

Simple Renewable Investment Trend Model

Below is the result of the regression model that tests the effect of year on renewable investment. The output below is from the `summary()` function, which quickly provides summary statistics in R.

```
##
## Call:
## lm(formula = region_sum ~ year, data = region_renewable_fin)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2905.6 -1271.5  -523.4   486.5 11707.5
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -283692.95   53418.15  -5.311 3.13e-07 ***
## year            141.88      26.58   5.339 2.73e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2167 on 184 degrees of freedom
## Multiple R-squared:  0.1341, Adjusted R-squared:  0.1294
## F-statistic:  28.5 on 1 and 184 DF,  p-value: 2.735e-07
```

Using the `summary()` function, we can quickly get some insights from our regression model. From the output above we are most concerned with the coefficient estimate of the year, which is 141.88 million USD. This tells us that, according to this model, with each passing year we are seeing a increase in renewable investment by more than 142,000,000 USD across each region per year. Overall this is a positive trend for renewable investments year over year.

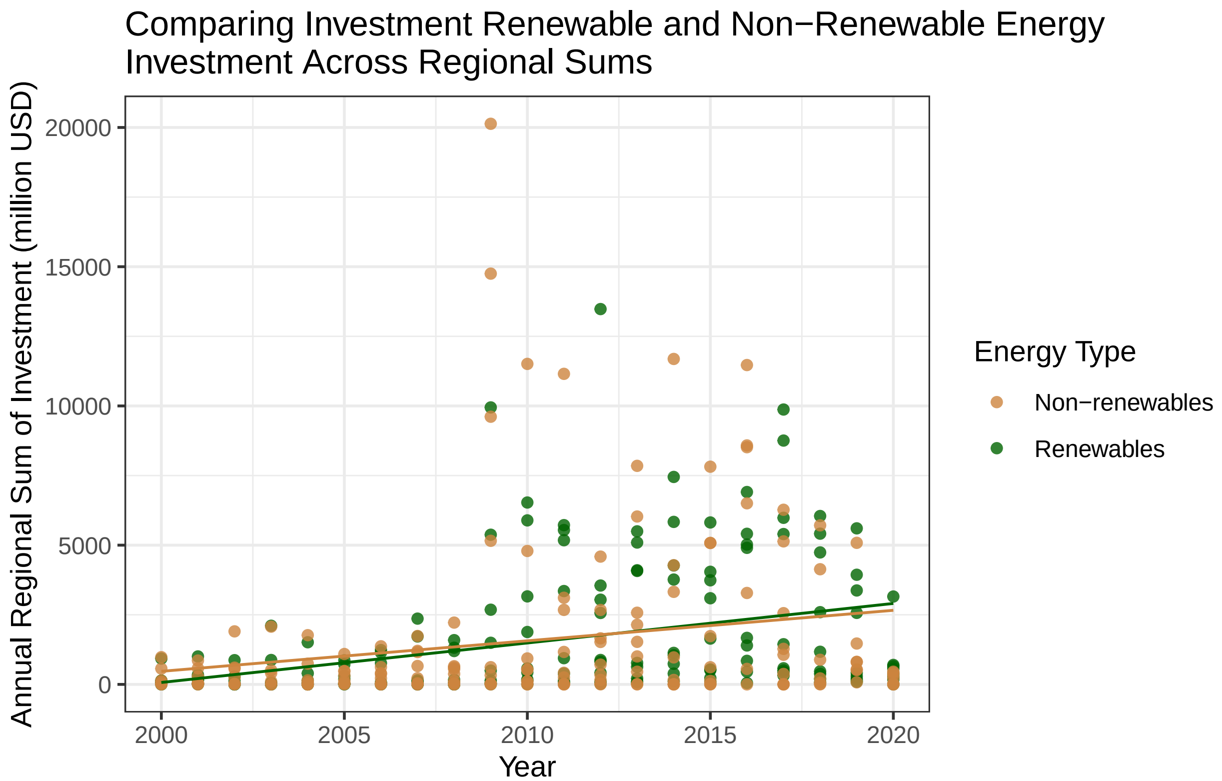
From the `summary()` function we are also able to get a p-value for the trend coefficient. The p-value is represented in the "Coefficients" section of the table under "Pr(>|t|)". The year coefficient has a p-value below 0.001 which gives us confidence in rejecting a null hypothesis that there is no relationship between investment sums across time with a significance level of 0.05. It should be noted that our R-squared value for this model is 0.13 however that is not important for this analysis as we are not focused on predicting outcomes of investment with high precision, but rather the overall trend from the year coefficient and its' associated p-value.

Now that we can see that there is a positive trend in renewable investments, lets compare that to non-renewable investment.

Simple Non-renewable Investment Model

```
##
## Call:
## lm(formula = region_sum ~ year, data = region_non_renewable_fin)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2660.1 -1457.2  -796.8   -24.5 18677.7
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -218612.31   77728.01  -2.813  0.00549 **
## year            109.54      38.67   2.833  0.00518 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2974 on 170 degrees of freedom
## Multiple R-squared:  0.04507,    Adjusted R-squared:  0.03945
## F-statistic: 8.023 on 1 and 170 DF,  p-value: 0.005176
```

From the `summary()` of this model we can see that by country there is also a positive trend of non-renewable investment across regions. According to this model there is an increase in non-renewable investments by 109.54 million USD. With a p-value of 0.005 can confidently reject a null hypothesis of there being no relationship between non-renewable investment over time with a significance level of 0.05. According to these two simple models, there is a larger increase in renewable investments year over year compared to non-renewables but as the standard errors for the models overlap this is not conclusive and this blog post will not be pursuing this question. Below is a plot that compares renewable and non-renewable investments over time, along with their respective models.



Renewable investments from 2000−2020 are increasing at a rate of 141 million USD per year according tc
Non−renewable invesments over the same time period are increasing at a rate of 110 million USD per yea

It can be observed from the graph that there has been significant investment in renewable (green) and non-renewable (tan) energy projects since the 2008 global recession. The plot illustrates just how much variance there is in investment totals across regions in each year. As discussed above the plot does show that there is a larger investment rate in renewables year-over-year. As this data is only from the years 2000-2020 these investment trends do not reflect the historical investments in non-renewable energy sources. As this simple regression only looks at the trend over time we will now see how these investment trends compare across regions. In the original model outlier regional trends could be affecting our investment slopes.

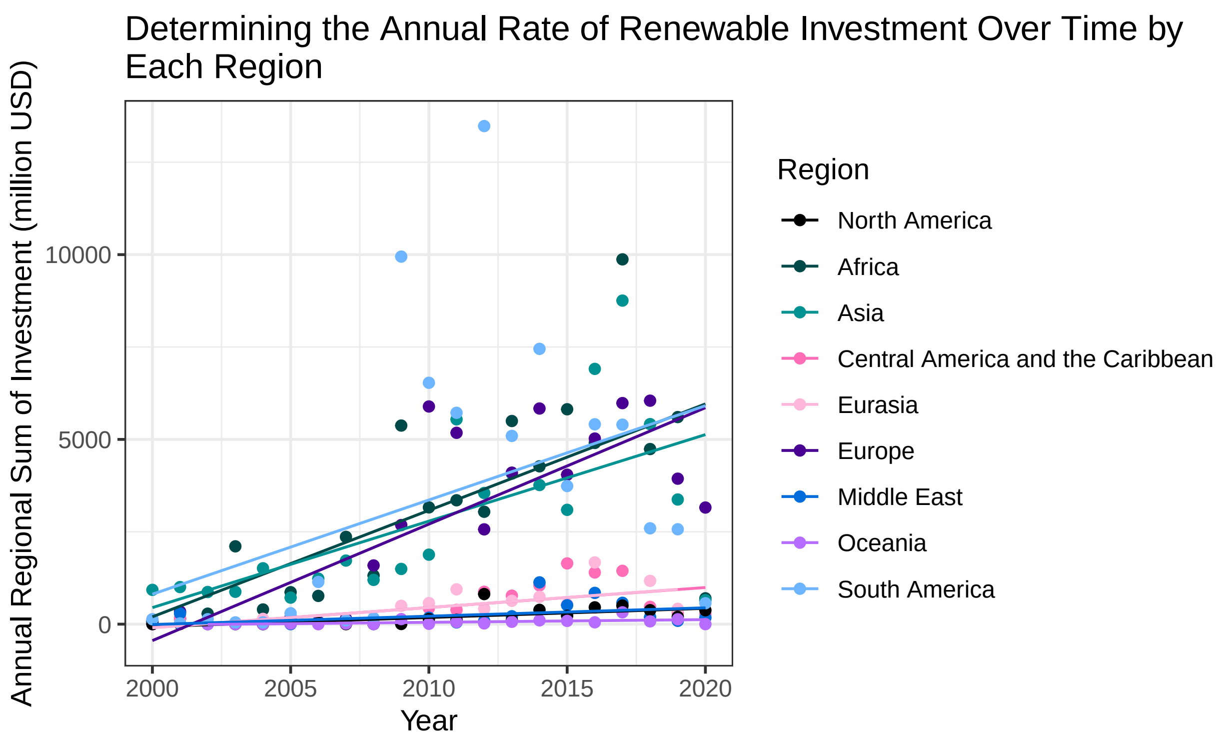
Regional Renewable Investment

For this regression model, the same `summary()` function is used to calculate coefficients and summary statistics for the interaction regression of time and region on annual renewable investment. While the `summary()` function is useful, its' output can be quite messy with interaction models, so a table was made from the results to include the annual investment rates for different regions and their corresponding p-values. In the model the North American region was set as the base level of the regression. This was done because North America contains the United States, the country with the largest GDP in the world and therefore a significant marker to compare against other regions.

Region	Renewable Investment per Year (million USD)	p-value
North America	24.76	0.6615318
Africa	288.09	0.0011902
Asia	234.07	0.0095686
Central America and the Caribbean	54.20	0.7128610
Eurasia	54.84	0.7173467
Europe	315.08	0.0003684
Middle East	22.61	0.9785519
Oceania	7.27	0.8400681
South America	255.03	0.0044462

From this table we can see the annual investment rate of each region according to this linear regression interaction model. The regions with the two highest investment rates over time are Europe and Africa. Europe has widely been seen as a leader in renewable energy development so it is not surprising that it has a high rate. From the original dataset, Africa's renewable energy investment has been particularly high in hydropower throughout various countries. The regions with the two lowest investment rates over time are Oceania and the Middle East. Oceania is primarily made up of island nations with low populations so large investments in these technologies can be challenging. The Middle East produces large quantities of the world's fossil fuels so its lack of investment is also not surprising.

The only regions with p-values below a significance level of 0.05 are Africa, Asia, Europe, and South America. Therefore, for these regions we can reject the null hypothesis that there is no relationship for the region's investment in renewables over time. Below is a plot that shows the regional model and the renewable investment rates over time separated by region.



Renewable investments from 2000−2020 are increasing over time at greater rates for Europe, Africa, South America, and Asia at a much greater rate than compared to the other regions. This graph shows there are two distinct groups of renewable investment rates across time, a high investment group and a low investment group

Our graphic clearly defines two different annual investment rate categories for global regions, a high investment rate group and a low investment rate group. The high rate investment group contains Europe, Africa,South America, and Asia. The low rate of investment group contains North America, Central America and the Caribbean, Eurasia, the Middle East, and Oceania.

Based on the regional interaction regression model above, we are next going to do the same for non-renewable energy investment and will summarize both models into one output table with the renewables investment regression.

Region	Renewable Investment per Year (million USD)	Renewable p-value	Non-renewable Investment per Year (million USD)	Non-renewable p-value
North America	24.76	0.6615318	9.97	0.9456139
Africa	288.09	0.0011902	155.40	0.4086434
Asia	234.07	0.0095686	254.85	0.1649952
Central America and the Caribbean	54.20	0.7128610	6.05	0.9829376
Eurasia	54.84	0.7173467	96.44	0.6229642
Europe	315.08	0.0003684	81.26	0.6852117
Middle East	22.61	0.9785519	35.86	0.8897374
Oceania	7.27	0.8400681	-0.56	0.9573164
South America	255.03	0.0044462	171.52	0.3588261

The above table allows for the comparison of the annual rates of renewable and non-renewable investment over time by each region and their corresponding p-values. The non-renewable regression model has no investment rate p-value below a significance level of 0.05. Therefore no non-renewable investment rate can be considered statistically significant. For renewables, the investment rates for Africa, Asia, Europe, and South America can be considered statistically significant as their p-values are below a significance level of 0.05.

Some interesting regional insights from this table however show that South America, Africa, and Asia are investing heavily in renewable and non-renewable energies over time. These regions have economies that are developing rapidly compared to other regions of the world and it is evident in these investment trends. According to the regression models, Europe has been investing the most in renewables compared to other regions year-over-year but not in non-renewables. However, as mentioned earlier no non-renewable investment rates can be considered statistically significant so it is difficult to comment on non-renewable trends as they may not exist.

Next Steps

This blog post and regression analysis is by no means a comprehensive look at financial investments over time by each region. However, it does give us quick insights into how some regions are investing in renewable technologies at a greater rate over time compared to other regions. To dive further in this analysis, it would be interesting to normalize investment rates with the GDP of each region. One could also compare specific countries and the affect of the type of government on renewable investment energies. Another option would be to compare the investment rates of countries with rapidly developing economies compared to those who have had developed economies to see if there are any trends relevant. As noted before in this post there is a visual trend in the graphs where there is much greater investment into renewable and non-renewable projects after the 2008 recession so a deeper analysis could be done in this trend to see if it actually exists and if it does to try and figure out what has caused it.

References

IRENA, & CPI. (n.d.-a). Global Landscape of Renewable Energy Finance 2020. 88.

IRENA, & CPI. (n.d.-b). Global Landscape of Renewable Energy Finance 2020: Methodology. 16.

Ritchie, H., & Roser, M. (2020). Energy. Our World in Data. https://ourworldindata.org/renewable-energy

Roser, M. (n.d.). Why did renewables become so cheap so fast? Our World in Data. https://ourworldindata.org/cheap-renewables-growth