An Example of a Term Paper

Antonio Paez*,[a]

[a] *McMaster University, 1280 Main St W, Hamilton, ON, L8S 4K1 Canada*

Abstract

This is an example of a paper created using the package `rticles`. It is an example of the final deliverable in the course GEO 712 Reproducible Research Workflow. The objective of the paper is to put into practice skills learned in the course, in the form of a self-contained, reproducible document in the format of a journal article.

Notice that for this paper, the instructors will not evaluate the research per se, but rather the reproducibility of the research.

Introduction

The economy of a nation is tied to its consumption of energy, since every process of production requires energy as an input (Warr et al., 2010). However, the strength of the relationship between the economy and the consumption of energy varies. Some countries were more successful than others in terms of decoupling their productive processes from energy after the oil shocks of the 1970s (MacKillop, 1989). This was achieved by increasing the efficiency of production, so that the same output could be produced using less energy, or in somewhat different terms, by improving their energy intensity.

The relationship between economic output and energy consumption is of interest at a time when the effects of a carbon-intense economy is creating a heavy environmental burden. A relevant question is, what countries are more energy-efficient, and can we learn from them. To explore this question we will consider data on national energy use (in barrels of oil per day), economic output (GDP), and CO_2 emissions.

Data Analysis

Data were collected from a variety of sources as documented in the package `packr` (see [paezha/Reproducible-Research-Workflow/Session-07-Creating-R-Packages-and-Documenting-Data/packr]). The summary statistics of the data appear in Table 1. Very large disparities can be observed in terms of all indicators of interest: while some countries have a GDP per capita measures in hundreds

*Corresponding Author
Email address: `paezha@mcmaster.ca` (Antonio Paez)

Table 1: Descriptive statistics: energy and emissions of world countries

Statistic	Population (millions)	GDP per capita (USD)	Energy use (millions of barrels per day)	CO2 1995 (millions kilotonnes)	CO2 2005 (millions kilotonnes)	CO2 2015 (millions kilotonnes)
Mean	38.466	13572.01	0.491	0.121	0.153	0.185
Min	0.005	145.00	0.000	0.000	0.000	0.000
Max	1379.303	100161.00	19.530	5.295	6.175	10.642
Standard Deviation	142.048	18550.58	1.752	0.489	0.649	0.892

of dollars, others measure their GDP per capita in tens of thousands of dollars. Similarly, the difference in consumption of oil between the country with the lowest to the highest use of this resource is three orders of magnitude higher. The table also illustrates how emissions of CO_2 for the worst polluters increased by a factor of two between 1995 and 2015; emissions at the bottom, in contrast, increased by a factor of approximately 1.5 in the same period of time.

Figure 1 is a scatterplot of energy consumption to GPD. It can be seen that in general, greater economic output is associated with greater consumption of energy. However, there are some important differences. If we fit a regression line to this relationship, the line would indicate the *expected* economic output for a given level of energy consumption. Points below the line would use more energy for a lower level of economic output than expected, whereas points above the line would represent greater economic output than expected, given their energy consumption.

The regression line is estimated as follows:

$$GDP_i = \beta_0 + \beta_1 \text{bblpd}_i + \epsilon_i$$

This is a linear model and can be estimated using ordinary least squares. The scatterplot of energy to GDP with this line is shown in Figure 2. Clearly, some countries are more efficient than others in that they can produce more with less energy. The more a point deviates from the regression line, the more efficient that economy is.

> (Note: figures can also be multi-panel plots. One ways of doing this is by using the package `gridExtra`, which creates *tables* of figures. As an example, see Figure 3, which reproduces Figures 1 and 2 but using a side-by-side paneling format.
>
> A second example that uses `gridExtra` is Figure 4, which shows Figures 1 and 2 as a two-panel figure with one column and two rows).

Another question of interest is the way energy is related to the emission of Greenhouse Gases (GHG), particularly CO_2. Figure 5 suggests that for some

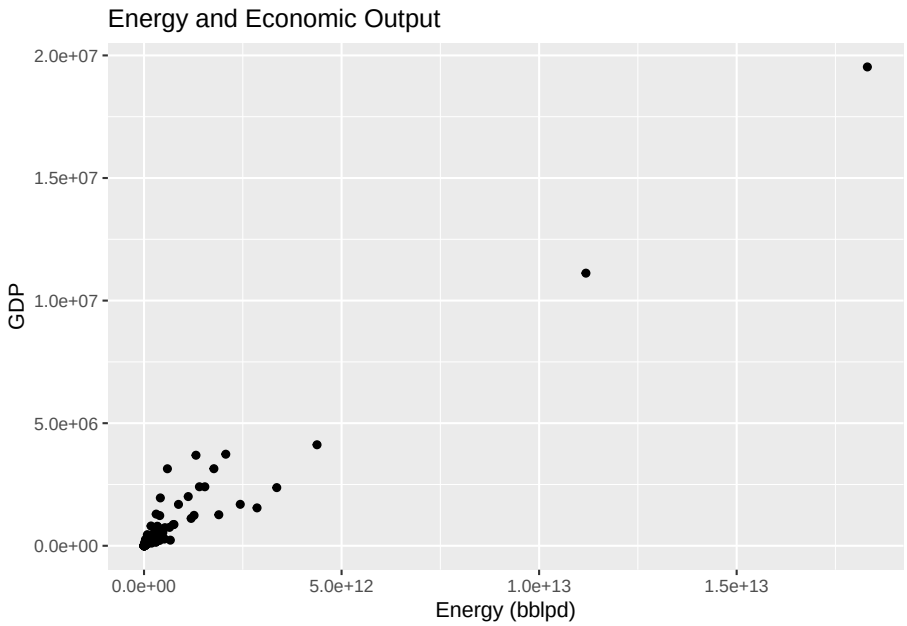

Figure 1: The relationship between energy consumption and economic output by world countries

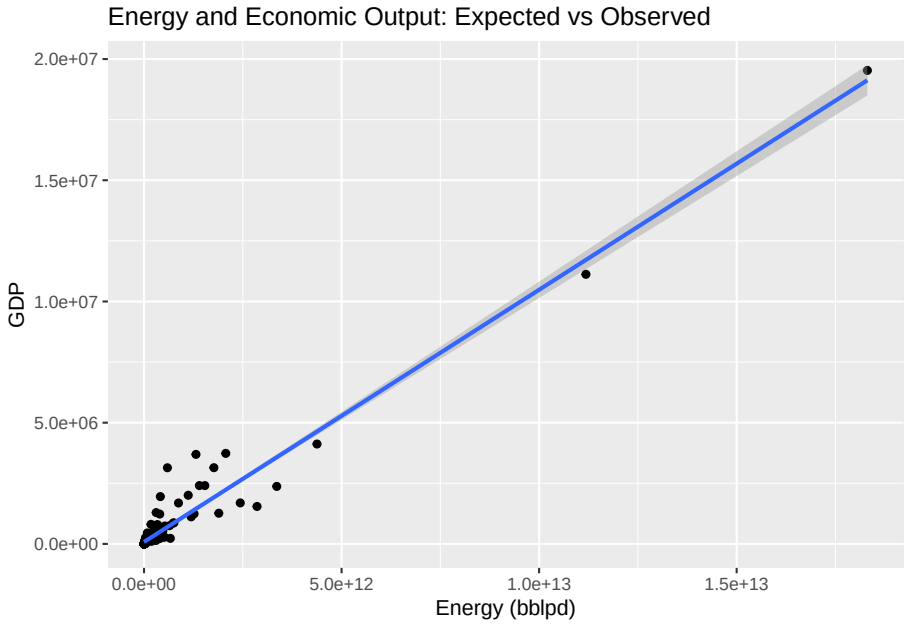

Figure 2: A regression line gives the expected values of GDP given energy consumption

countries, emissions increased over time more than proportionally relative to GDP.

To quantify the change in emissions by economic output, we can estimate regression models as follows:

$$CO2_{iy} = \beta GDP_{iy} + \epsilon_{iy}$$

for country i and years $y = 1995, 2005, 2015$.

The estimated models are found in Table 2. It is noteworthy that the amount of CO_2 per million dollars of economic output increased from an average of 0.2899 kilotonnes in 1995, to 0.3749 kilotonnes in 2005, to 0.4481 in 2015. As well, notice how the coefficient of determination R^2 declines over that period of time, which indicates that there amount of unexplained variance has increased as well. Whereas in 1995, approximately 94% of the variance in CO_2 emissions by world countries was explained by GDP, by 2015 less than 70% was. Could this be a result of increased decoupling of the economy from energy? This is a question for future research.

Conclusions

This document is an example of a term paper, and illustrates the following features:

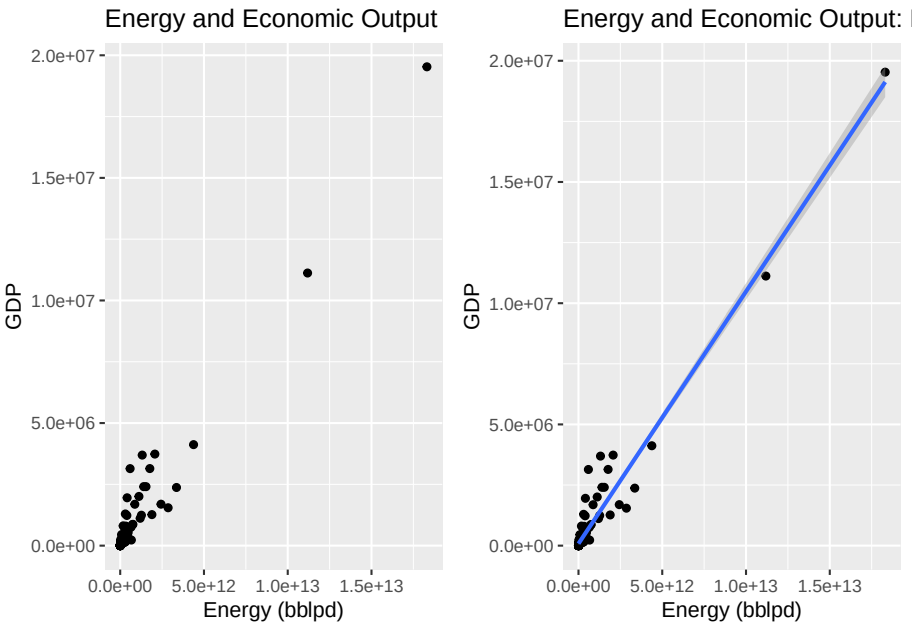

Figure 3: Two plots in a single figure; left panel is Figure 1 and right panel is Figure 2

Table 2: Regression results: Emissions by GDP by year

Variable	1995		2005		2015	
	β	p-val	β	p-val	β	p-val
GDP	0.2899	< 0.0001	0.3749	< 0.0001	0.4481	< 0.0001

Note:
R^2 (1995) = 0.94
R^2 (2005) = 0.9
R^2 (2015) = 0.69

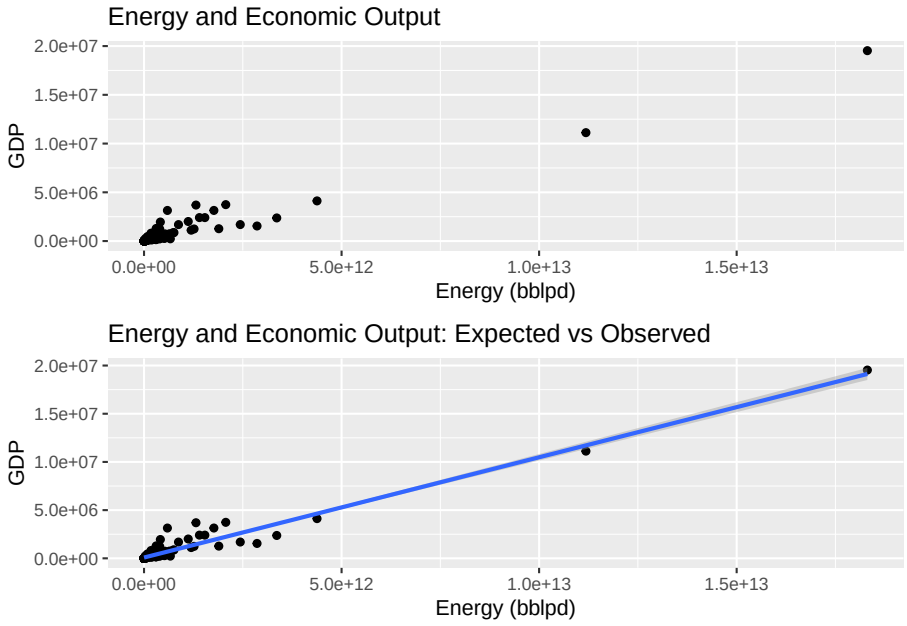

Figure 4: Two plots in a single figure; top panel is Figure 1 and bottom panel is Figure 2

- An R Markdown document created using the package `rticles` and the template for Elsevier articles
- Mathematical notation in LaTeX
- Graphical output
- References, including bibliographical references using BibTeX
- Tables

The PDF file was produced from source files in R Markdown. The analysis presented in this paper is self-contained and reproducible. The source documents can be downloaded from the link below:

https://github.com/paezha/Reproducible-Research-Workflow/tree/master/Session-11-Rticles-Tables-and-Citations/Elsevier-Template

References

MacKillop, A., 1989. Decoupling—recoupling and oil shock. Energy Policy 17, 311–322.

Warr, B., Ayres, R., Eisenmenger, N., Krausmann, F., Schandl, H., 2010. Energy use and economic development: A comparative analysis of useful work supply in austria, japan, the united kingdom and the us during 100 years of economic growth. Ecological Economics 69, 1904–1917.

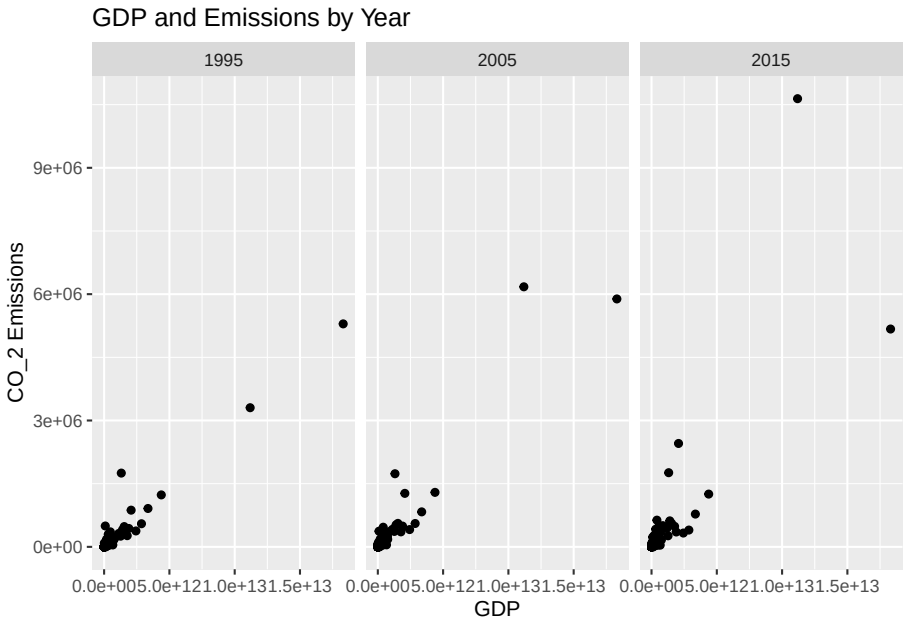

Figure 5: CO_2 emissions versus GDP by year