Vegetarianism as a Variable in Economic Sustainability

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Abstract

Many people turn to a vegetarian diet due to the perceived environmental impact of consuming meat and animal products. In this paper, I estimated the environmental impact of country-wide rates of vegetarianism while accounting for countries' economic state, progressiveness, and geographical region. Since no country-wide vegetarian variable exits, I used the number of vegan and vegetarian restaurants in a country, from HappyCow, as a proxy. Using an ordinary least squares regression, vegetarian restaurants per capita appears to have a statistically significant negative relationship with country-wide CO2 emissions.

Introduction

Recently, there has been a significant shift towards individuals reducing their meat consumption and transitioning towards a relatively more plant-based diet. According to a 2013 survey in the United Kingdom, 25% of the public reduced its meat consumption in the past year, and 34% of the public indicated a willingness to consume less meat (Vegetarian Society, 2013). There are multiple reasons why one would reduce their meat consumption and possibly follow a vegetarian diet. Common reasons include a concern for animal welfare, health, religious beliefs, and the environment (Ruby, 2012). It appears that roughly 2-7% of vegetarians – from a variety of research studies – listed environmental concern as a main motivation for their vegetarianism (Ruby, 2012). Because environmental consciousness is a hot topic, I felt that it would be useful to see if vegetarianism – on a country-wide basis – is at all linked to sustainability.

There is little, if any, research indicating whether vegetarianism on a country-wide basis is linked to a country's levels of CO2 emissions. Evidence suggests that, on an individual level, consuming less meat is associated with a decrease in an individual's CO2 emissions, such that vegans have the relatively lowest CO2 emissions per day, with the next highest being vegetarians, then fish-eaters, low meat-

eaters, medium meat-eaters, and, finally, high meat-eaters (Scarborough, et al., 2014). Additionally, it appears that meat-based diets require more energy, land, and water resources relative to vegetarian diets (Pimentel & Pimentel, 2003). And in Finland, researchers estimated that – relative to the average Finnish diet – a strict vegan diet would "nearly halve the agricultural GHG emissions, but reduction of the total emissions would be about 8%" (Risku-Norja, Kurppa & Helenius, 2009). While these findings are important, this study was completed using only data from Finland, so it is difficult to generalize the results to other countries.

In summary, it appears that having more vegetarian people in a country *should* be associated with lower CO2 emissions in that country. However, the significance to this hypothesized relationship is somewhat ambiguous, and it is also unclear whether other variables may influence the impact of vegetarianism on CO2 emissions. In this study, I aim to account for countries' levels of progressiveness, economic state, and location to understand the impact of country-wide rates of vegetarianism on a country's CO2 emissions.

Estimation Approach

In this research, I created two models – one model in which I used country-wide rates of vegetarianism as the dependent variable and another model in which I used CO2 emissions as the dependent variable. Both models are log-log models, by which, in the regression, I transform each of the numeric variables – both dependent and independent – by its natural logarithm.

The first major limitation of my research is that data for country-wide rates of vegetarianism is only available for 10 countries. Because of this lack of data, I hypothesized that vegetarian restaurant listings on HappyCow – a website that shares information about vegan and vegetarian restaurants across the world – could stand as a proxy for the number of vegetarians in a country. Further, by dividing the

number of vegetarian restaurant listings on HappyCow by the population of each country, I have vegetarian restaurants per capita, which could stand as a proxy for country-wide rates of vegetarianism.

I hypothesized that the number of vegetarian restaurants per capita is a function of a country's progressiveness, education level, economic state, levels of tourism, and geographical location. The most difficult of these variables to measure is, in my opinion, progressiveness, as it is the least quantitatively comprehensible variable. I used urban population percentage as well as the proportion of the population ages 15-64 as proxies for progressiveness, as I believe that relatively progressive countries will likely have a substantial proportion of its population living in urban areas within the country, and progressive countries will likely consist of working-age adults. I hypothesized that there be a positive relationship between each of these variables and vegetarian restaurants per capita.

For education level, I expected that countries in which the public had relatively more years of education would have more vegetarian restaurants per capita, as adopting a vegetarian diet typically requires some sort of education – whether formal or informal – to understand morality, health, and the environment for its adoption. To estimate a country's level of education, I used mean years of schooling for people 25 and older. Thus, I hypothesized that there be a positive relationship between education and vegetarian restaurants per capita.

Additionally, I hypothesized that the economic state of a country would be the most significant variable in determining what drives vegetarian restaurants per capita in a country. At least in the United States, adopting a vegetarian diet is often viewed as a "high-class" lifestyle change, as people who are less wealthy may not have the time or resources to think about adopting a relatively unusual diet. To account for the economic state of a country, I used GDP per capita PPP, adjusted for constant 2011 dollars. Thus, I expected that there would be a positive relationship between GDP and vegetarian restaurants per capita.

I also anticipated that tourism would have a significant relationship with vegetarian restaurants per capita, as countries may have more vegetarian restaurants if that country tends to attract vegetarian or upper-class tourists. I used international tourism, number of arrivals to quantify a country's levels of tourism with the hypothesis that if a country has a greater number of tourists arriving, that country will have a greater number of vegetarian restaurants per capita.

Lastly, I included country region in this regression – as found on HappyCow's website – as there may be some other location-related variables that I am not accounting for which may influence vegetarian restaurants per capita. For example, it is possible that countries in a relatively more tropical climate may be more vegetarian, as this climate allows for the growth of many fruits that and vegetables that people in colder climates could not grow. From HappyCow's website, the regions I included were Asia, Africa, Australia, Europe, North America, and South America. I hypothesized that, holding all other variables constant, Africa would have the lowest coefficient, with North America and Asia having the highest coefficients, indicating that North and America would be the most "vegetarian-friendly" continents, with Africa being the least.

In my second model, I hypothesized that CO2 emissions (in kilotons) is a function of a country's level of education, progressiveness, vegetarianism, tourism, manufacturing, food exports, and location. To measure progressiveness, I used the same proxies that I used for the previous model – the proportion of the population ages 15-64 and urban population as a percent of the total population. I hypothesized that urban population percentage would share a positive relationship with CO2 emissions, as having more urban populants in a country may indicate that there be more amenities that accompany an urban environment – factories, buildings, and buses. Thus, there may be greater CO2 emissions in an urban-centric country than there would be in a relatively rural-centric country. Similarly, I assumed that there would be a positive relationship between the proportion of the population aged 15-64 and CO2 emissions, as a country having more working-age individuals may mean that there is substantial use of cars and other forms of transportation to travel to and from work.

Like in the previous model, I used mean projected years of schooling for adults aged 25 and older as a proxy for education. I hypothesized that a country with relatively more educated people would have relatively low CO2 emissions, as this may indicate that the country has higher quality universities and research that provides better ways to control and educate the public regarding CO2 emissions.

For vegetarianism, I used vegetarian restaurants per capita. I hypothesized that this would have a negative relationship with CO2 emissions, such that more vegetarian restaurants per capita would be associated with lower levels of CO2 emissions. My intuition is that more vegetarian restaurants indicates less meat consumption, which would lead to a decrease in CO2 emissions.

I expected tourism to share a positive relationship with CO2 emissions, as more tourism indicates more transportation – ships, cars, and buses – within a country. I used the same variable – number of arrivals – as I did in the previous model.

For manufacturing, I used manufacturing value added as a percentage of a country's GDP, as I believed that countries that would have a large proportion of its GDP allocated to manufacturing would likely have a lot of factories. Factories are notable pollutants, so this would likely cause an increase in CO2 emissions.

Similarly, I hypothesized that food exports would share a positive relationship with CO2 emissions, as countries that export more food likely have to bear the pollution-related burden that food growth and exportation creates. I used food exports as a percentage of merchandise exports to quantify a country's level of manufacturing. Additionally, I included manufacturing in my model because I felt that it could help isolate the effect of vegetarian restaurants per capita on CO2 emissions.

For location, I hypothesized that relatively more industrialized regions would have a higher likely have more carbon emissions. I used the regions from HappyCow like in the previous model for this

purpose. I predicted that North America and Europe would have the highest coefficients, whereas Africa would have the lowest.

Data Description

All of the non-vegetarian related variables were from the World Bank in 2010. I used 2010 data in favor of more current data because there was a substantial number of missing values from more current years.

The vegetarian-related data is from HappyCow, a website that lists vegan and vegetarian restaurants and stores in different cities across the world. The vegetarian-related data is cumulative, in that this data is the number of vegetarian restaurants in a country as of May 2018.

A major limitation of my research is that it is entirely built upon proxies for the variables that I am truly interested in. For example, I don't actually believe that the number of vegetarian restaurants in a country is important. However, I believe what the number of vegetarian restaurants in a country stands for – a country's tendency to eat less meat and possibly even progressivism – is important. Nonetheless, I could only use variables that were available to me, so this is the best that I could reasonably do.

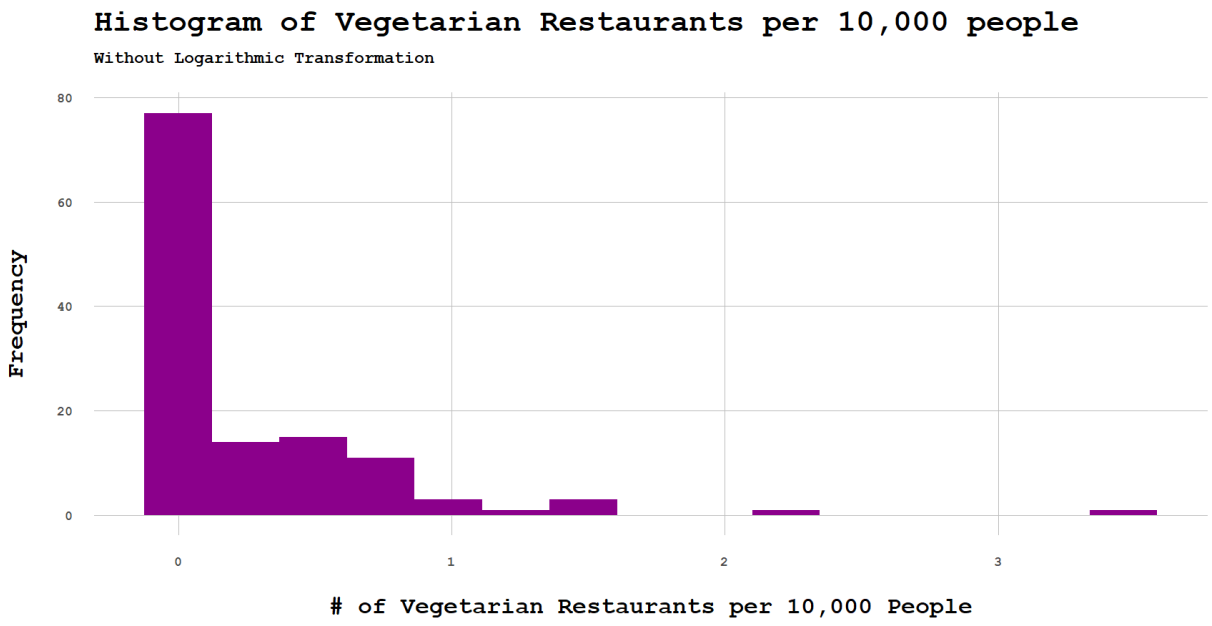
Below is a table for summary statistics of the numeric variables in my research.

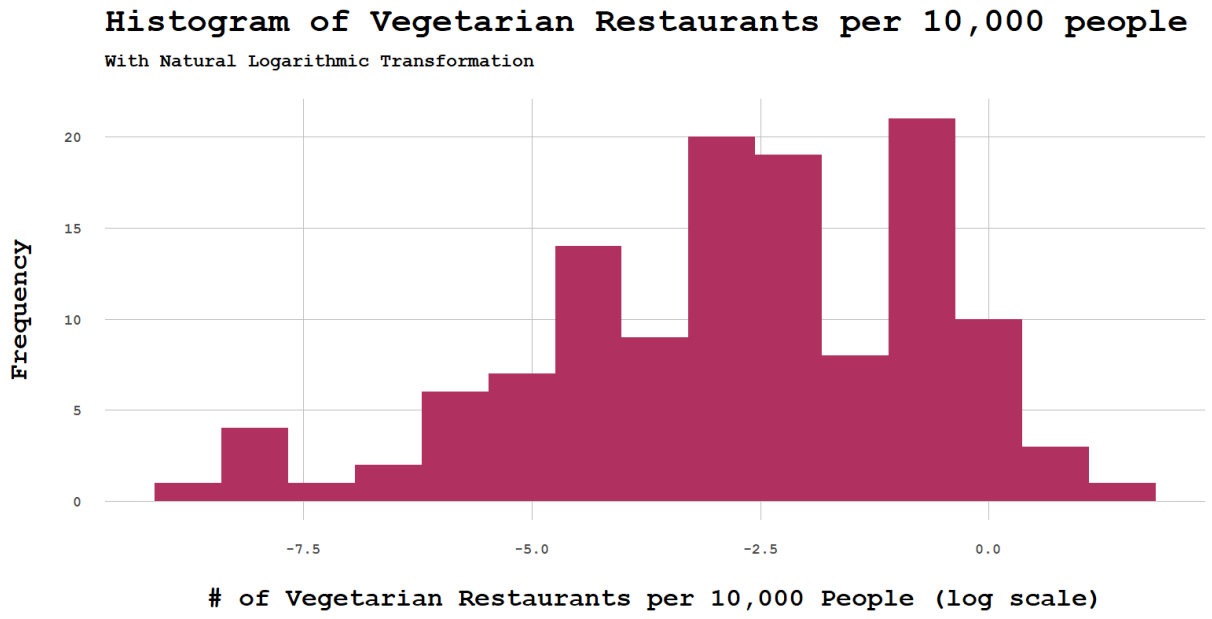
Summary Statistics

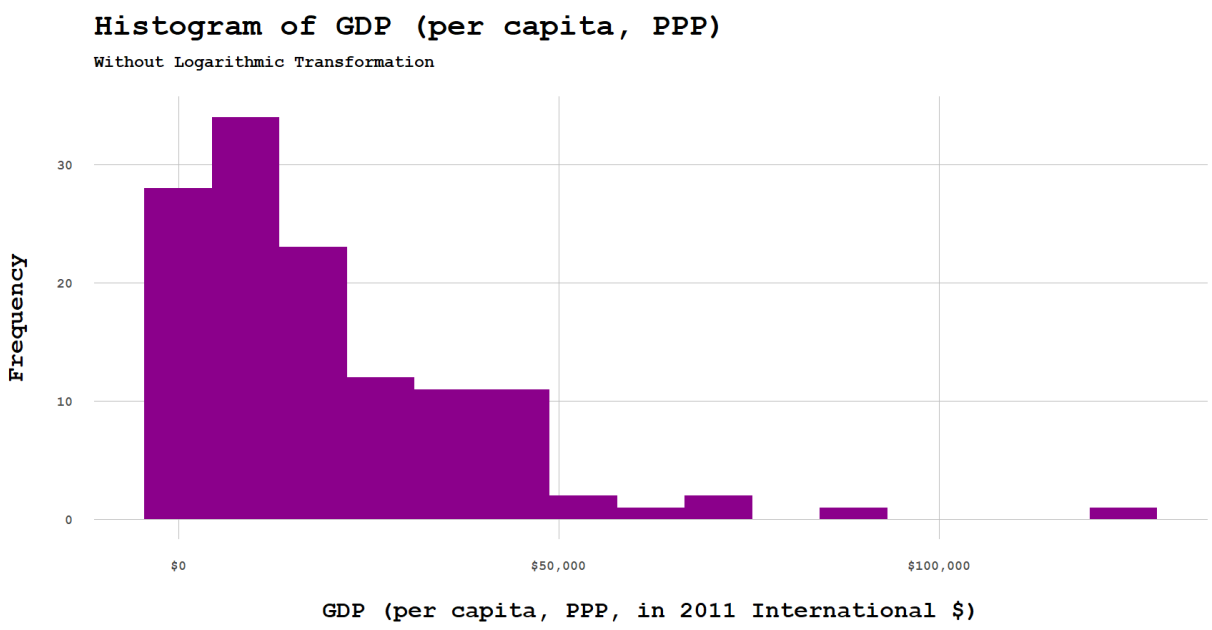
Statistic	N	Mean	St. Dev.	Min	Max
Vegetarian Restaurants (per capita)	126	0.00003	0.00005	0.000	0.0003
Vegetarian Restaurants (Total)	126	546.405	2,057.916	1	21,589
CO2 Emissions (kt)	126	243,354.600	937,847.400	121.011	8,776,040.000
Manufacturing Value Added (% of GDP)	126	14.241	6.489	2.270	45.593
GDP (per capita, PPP)	126	19,671.370	19,592.890	917.764	125,140.800
Mean Years of Schooling (Projected 25+)	126	8.817	2.869	1.700	14.200
Population Ages 15-64 (% of Total Population)	126	64.849	6.360	48.473	85.872
Total Population	126	50,355,891.000	165,119,401.000	109,315	1,337,705,000
Urban Population (% of Total Population)	126	60.215	22.788	9.092	100.000
Tourism (# of arrivals)	126	6,879,810.000	12,423,453.000	41,000	76,647,000
Food Exports (% of Merchandise Exports)	126	23.112	23.646	0.00002	96.151

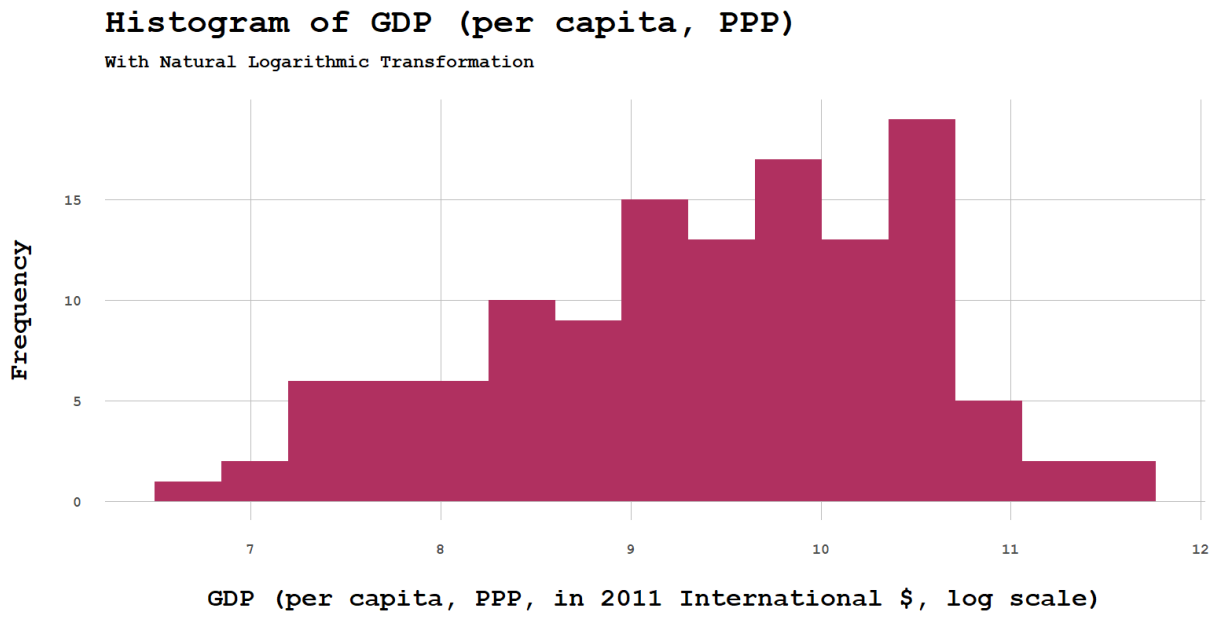
As observed in the table, on average, each country has 546 vegetarian restaurants. The country with the fewest number of vegetarian restaurants has 1, while the country with the greatest number of vegetarian restaurants – the United States – has over 21,000 vegetarian restaurants. On a per capita basis, the average number of vegetarian restaurants per capita is 0.00003 restaurants per person, or 0.3 vegetarian restaurants per 10,000 populants. Iceland has the highest vegetarian restaurants per capita, at roughly 0.0003 vegetarian restaurants per person – or 3.5 restaurants per 10,000 populants.

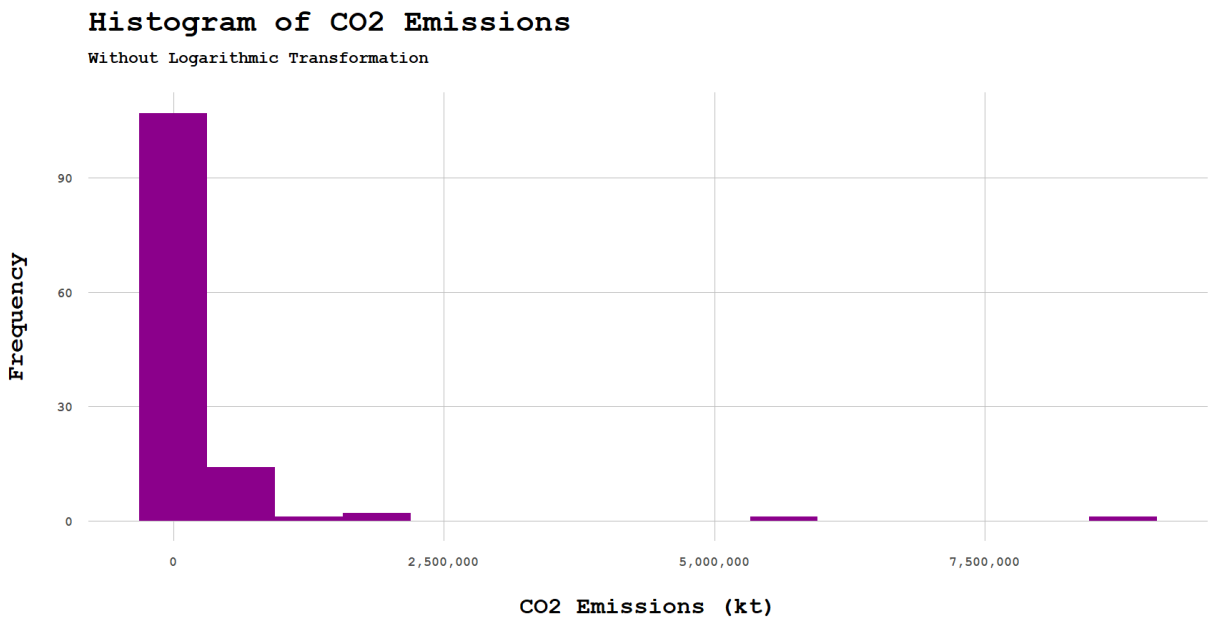
For regression modeling, it is important to visualize and understand the distribution of each of my variables of interest, so that each variable can be properly transformed for optimal modelling. Below are frequency histograms for vegetarian restaurants per 10,000 people, GDP, and CO2 emissions along with their logarithmically transformed counterparts.

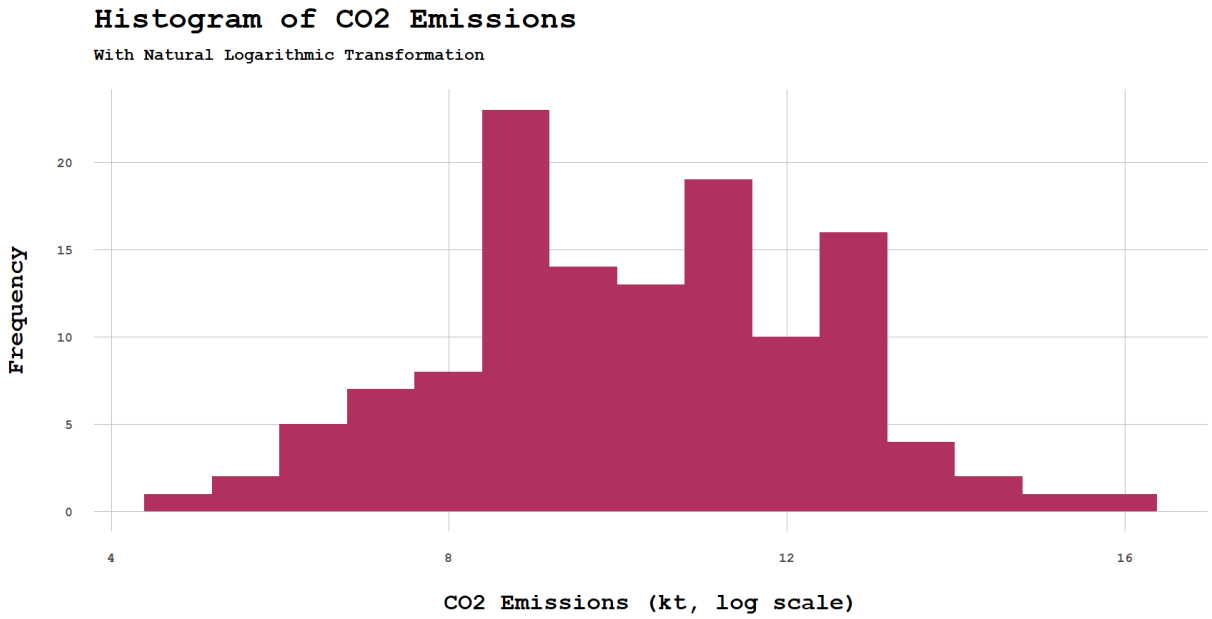

Histogram of Vegetarian Restaurants per 10,000 people
Without Logarithmic Transformation
Frequency
80
60
40
20
0
0
1
2
3
# of Vegetarian Restaurants per 10,000 People


Histogram of Vegetarian Restaurants per 10,000 people
With Natural Logarithmic Transformation
Frequency
20
15
10
5
0
-7.5
-5.0
-2.5
0.0
# of Vegetarian Restaurants per 10,000 People (log scale)


Histogram of GDP (per capita, PPP)
Without Logarithmic Transformation
Frequency
30
20
10
0
$0
$50,000
$100,000
GDP (per capita, PPP, in 2011 International $)

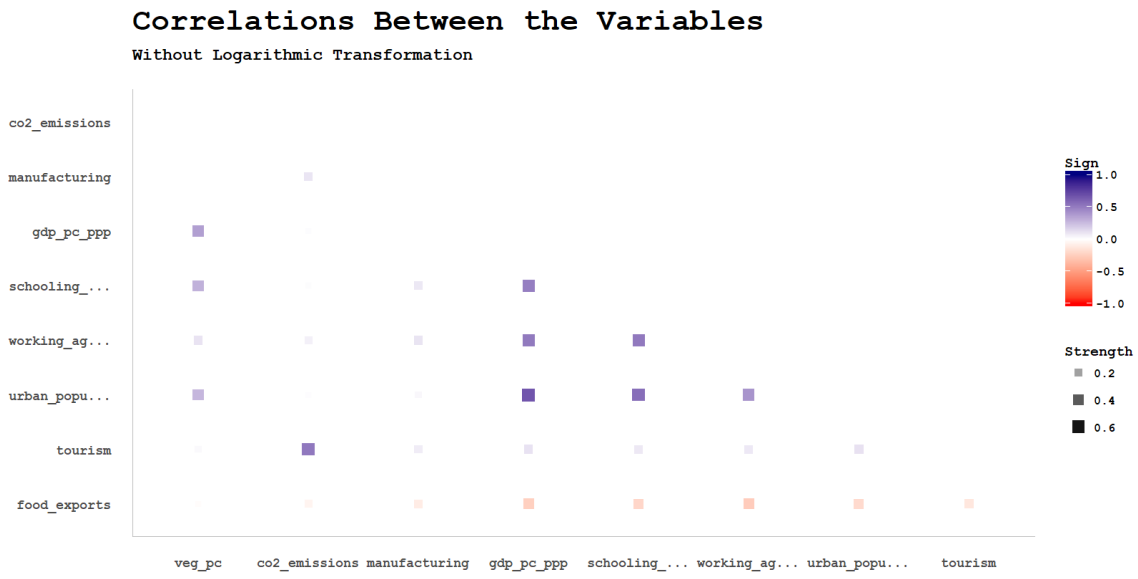

Histogram of GDP (per capita, PPP)
With Natural Logarithmic Transformation
Frequency
15
10
5
0
7
8
9
10
11
12
GDP (per capita, PPP, in 2011 International $, log scale)


Histogram of CO2 Emissions
Without Logarithmic Transformation
Frequency
90
60
30
0
0
2,500,000
5,000,000
7,500,000
CO2 Emissions (kt)


Histogram of CO2 Emissions
With Natural Logarithmic Transformation
Frequency
20
15
10
5
0
4
8
12
16
CO2 Emissions (kt, log scale)

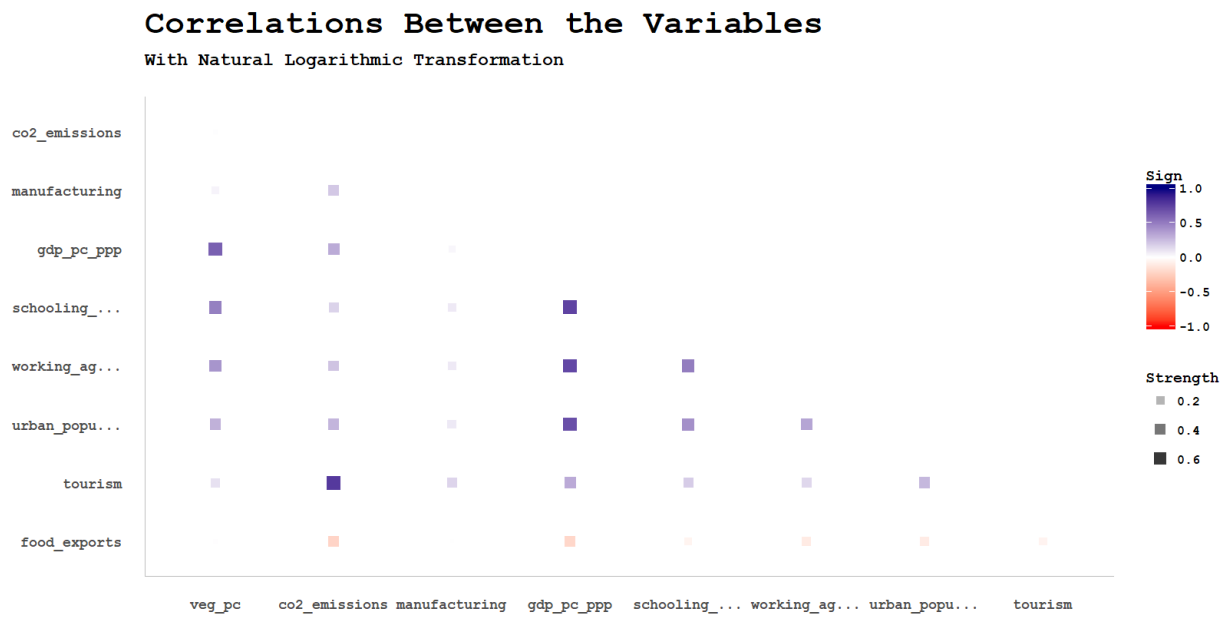
Because each of these variables is significantly positively skewed, I logarithmically transformed each of them by taking the natural logarithm of each data point. This helped alleviate the asymmetry in the data, allowing the variables to better work within a linear model. Because each of these variables were highly skewed, I used a log-log model – taking the natural logarithm of all numeric variables – to maintain consistency within coefficient interpretation.

Next, to get an idea for the results I should expect in the regressions, I plotted the Pearson correlation coefficients between each of the numeric variables.



As seen above, tourism and CO2 emissions, GDP and urban population percentage, and mean years of schooling and urban population percentage appear to be the most strongly positively correlated variables. Food exports appears to be the only variable that shares a significant negative relationship with any variables – holding negative relationships with GDP, mean years of schooling, the proportion of the population aged 15-64, and urban population percentage.

Because I'm employing a log-log model, I also created the same plot for the logarithmically transformed variables.



Not much significantly changes in this plot from the last one. Strong positive relationships are now evident between vegetarian restaurants per capita and GDP as well as between mean years of schooling and GDP. Again, food exports appears to be the only variable to consistently share a negative relationship with other variables.

Much to my surprise, in both plots, vegetarian restaurants per capita appears to share a weak relationship with CO2 emissions. This goes against my intuition that these variables would share a strong negative relationship – however, I still use this variable in my regression analysis.

Results

First, I used vegetarian restaurants per capita as the dependent variable to attempt to see what other variables drive a country's number of vegetarian restaurants. Below is the results from the regression.

Regression Model 1 Results

	Dependent variable:
	Vegetarian Restaurants (per capita, natural log.)
GDP (per capita, PPP, natural log.)	0.874***
	(0.257)
Tourism (# of arrivals, natural log.)	0.019
	(0.096)
Mean Years of Schooling (Projected 25+, natural log.)	0.096
	(0.508)
Urban Population (% of Total Population, natural log.)	-0.203
	(0.409)
Population Ages 15-64 (% of Total Population, natural log.)	2.191
	(2.165)
Asia	0.157
	(0.509)
Australia	2.672***
	(0.847)
Europe	1.706***
	(0.562)
North America	1.674***
	(0.549)
South America	1.271**
	(0.606)
Constant	-29.992***
	(8.044)
Observations	126
R^2	0.598
Adjusted R^2	0.564
Residual Std. Error	1.417 (df = 115)
F Statistic	17.139*** (df = 10; 115)
Note:	*p<0.1; **p<0.05; ***p<0.01

The only variables that appear to share a significant relationship with vegetarian restaurants per capita are GDP and the region dummy variables. This does not surprise me much, as I hypothesized that GDP would share a significant positive relationship with vegetarian restaurants per capita. Interestingly, in contrast to my hypothesis, Australia appears to be the most "vegetarian-friendly" country.

So, in summary, the vegetarianism of a country appears to be driven almost entirely by the geographical region of the country and that country's economic well-being. Now, using vegetarian restaurants per capita as an independent variable, I will attempt to see its impact on CO2 emissions. The regression results for this model are below.

Regression Model 2

	Dependent variable:
	CO2 Emissions (kt, natural log.)
GDP (per capita, PPP, natural log.)	7.438**
	(3.030)
Squared GDP (per capita, PPP, natural log.)	0.861
	(1.327)
Vegetarian Restaurants (per capita, natural log.)	-0.479***
	(0.078)
Food Exports (% of Merchandise Exports, natural log.)	-0.110
	(0.071)
Tourism (# of arrivals, natural log.)	0.904***
	(0.077)
Mean Years of Schooling (Projected 25+, natural log.)	-0.100
	(0.401)
Urban Population (% of Total Population, natural log.)	-0.001
	(0.314)
Population Ages 15-64 (% of Total Population, natural log.)	2.910*
	(1.729)
Manufacturing Value Added (% of GDP, natural log.)	0.686***
	(0.220)
Asia	0.492
	(0.407)
Australia	0.953
	(0.675)
Europe	0.429
	(0.449)
North America	0.512
	(0.454)
South America	1.200**
	(0.495)
Constant	-22.599***
	(7.638)
Observations	126
R^2	0.791
Adjusted R^2	0.765
Residual Std. Error	1.070 (df = 111)
F Statistic	30.044*** (df = 14; 111)
Note:	*p<0.1; **p<0.05; ***p<0.01

Much to my surprise, vegetarian restaurants per capita is one of the most statistically significant variables in the regression, with a significance level of less than 1%. This model indicates that increasing the number of vegetarian restaurants per capita by 10% is associated with a decrease in CO2 emissions by 4.8%, holding all other variables constant. This is extremely surprising, as, if you recall, there did not appear to be a significant relationship between CO2 emissions and vegetarian restaurants per capita.

Interestingly, in contrast to the previous model, this model indicates that geographic region has little significance in its impact on CO2 emissions. That may mean that this model adequately accounted for all that impacts CO2 emissions within a country, such that geographic region is not a proxy for any missing variables, or it may mean that geographic region itself is, plainly, not a significant variable.

GDP appears to share a significant positive relationship with CO2 emissions, as, holding all other variables constant, increasing GDP per capita by 10% is associated with a 74.4% increase in CO2 emissions. Based on research of the Environmental Kuznets Curve, I included squared GDP as an independent variable in the regression. However, squared GDP does not appear to be significantly related to CO2 emissions, indicating that there likely is not an Environmental Kuznets Curve in this situation.

Also surprising to me was that tourism was the most significantly related variable to CO2 emissions. Frankly, I am unsure of what is driving this relationship, as I do not think that tourism should have such a significant relationship when manufacturing, GDP, and education of a country are accounted for. Nonetheless, this is interesting and could be an area for future research.

Conclusion

All in all, it appears that vegetarian restaurants per capita shares a significant relationship with CO2 emissions. The question here is whether this relationship is due to vegetarian restaurants per capita being a proxy for a missing variable – possibly progressiveness or health-consciousness – or if there is genuinely some important aspect in vegetarian restaurants per capita that influences CO2 emissions. In this case, it would be extremely helpful to know the country-wide rates of vegetarianism to see whether vegetarian restaurants per capita is purely a proxy for country-wide rates of vegetarianism, or if there is some other variable for which vegetarian restaurants per capita is standing.

This research could have interesting policy implications. First, this research indicates that there may be reason for individuals to reduce their consumption of meat. After all, if we assume that vegetarian restaurants per capita is a proxy for country-wide rates of vegetarianism, then, holding all other variables constant, countries with less meat consumption tend to have lower CO2 emissions. Thus, there may be a benefit to individuals reducing their meat intake and turning to a more vegetarian diet. Additionally, this may mean that the government should reduce its subsidies to the meat and dairy industry, as these subsidies provide an incentive for consumers to purchase and consume meat and dairy. The subsidies, after all, are a discount, for the consumer, to purchase these products. Removing these subsidies – or even taxing meat and dairy – could provide an incentive for individuals to reduce their meat intake, potentially leading to lower CO2 emissions.

Hopefully, future researchers can better estimate country-wide rates of vegetarianism. Ideally, country-wide vegetarian data would be available for every country. Until then, using a proxy like vegetarian restaurants per capita should suffice.

References

Norja, H., Kurppa, S., & Helenius, J. (2009). Dietary choices and greenhouse gas emissions – assessment of impact of vegetarian and organic options at national scale. Progress In Industrial Ecology, An International Journal, 6(4), 340. doi: 10.1504/pie.2009.032323

Pimentel, D., & Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. The American Journal Of Clinical Nutrition, 78(3), 660S-663S. doi: 10.1093/ajcn/78.3.660s

Ruby, M. (2012). Vegetarianism. A blossoming field of study. Appetite, 58(1), 141-150. doi: 10.1016/j.appet.2011.09.019

Scarborough, P., Appleby, P., Mizdrak, A., Briggs, A., Travis, R., Bradbury, K., & Key, T. (2014). Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. Climatic Change, 125(2), 179-192. doi: 10.1007/s10584-014-1169-1

Vegetarian Society - Fact Sheet - Statistics - Introduction. (2013). Retrieved from https://www.vegsoc.org/statistics

(2018). Retrieved from https://www.happycow.net/