ESM 201 HW 1

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Question 1 Calculate $\frac{dN}{Ndt}$

a. Describe how annual population are used to calculate $\frac{dN}{Ndt}$

$\frac{dN}{Ndt}$ is the per capita rate of change of the population. Annual population data can be used to calculate the per capita rate of change (r) by taking the natural log of the number of individuals in the population at time t and divide by the number of individuals in the population at time t+1, multiplying it by $\frac{1}{(t+1)-t}$. In this case, the per capita rate of change would be the natural log of the number of individuals in the population in 1964 divided by the number of individuals in the population in 1963. For the difference from 1964 to 1963, the final term $\frac{1}{(t+1)-t}$ would be 1 and is not necessary to include in the equation.

b. Equations for calculating $\frac{dN}{Ndt}$

- Brazil - $r = ln\left(\frac{81972001}{79602001}\right)$
- India - $r = ln\left(\frac{486639001}{476632001}\right)$
- Japan - $r = ln\left(\frac{96959001}{95929001}\right)$
- Mexico - $r = ln\left(\frac{43052001}{41715001}\right)$
- South Korea - $r = ln\left(\frac{27767001}{27138001}\right)$

c. Calcuate $\frac{dN}{Ndt}$ for Mexico for all years 1963-2004

Table 1: Calculated vs. Actual Per Capita Rate of Population Change by Country

Country	Calculated dNNdt	Actual dNNdt
Brazil	0.0293	0.0293
India	0.0208	0.0208
Japan	0.0107	0.0107
Mexico	0.0315	0.0315
South Korea	0.0229	0.0229

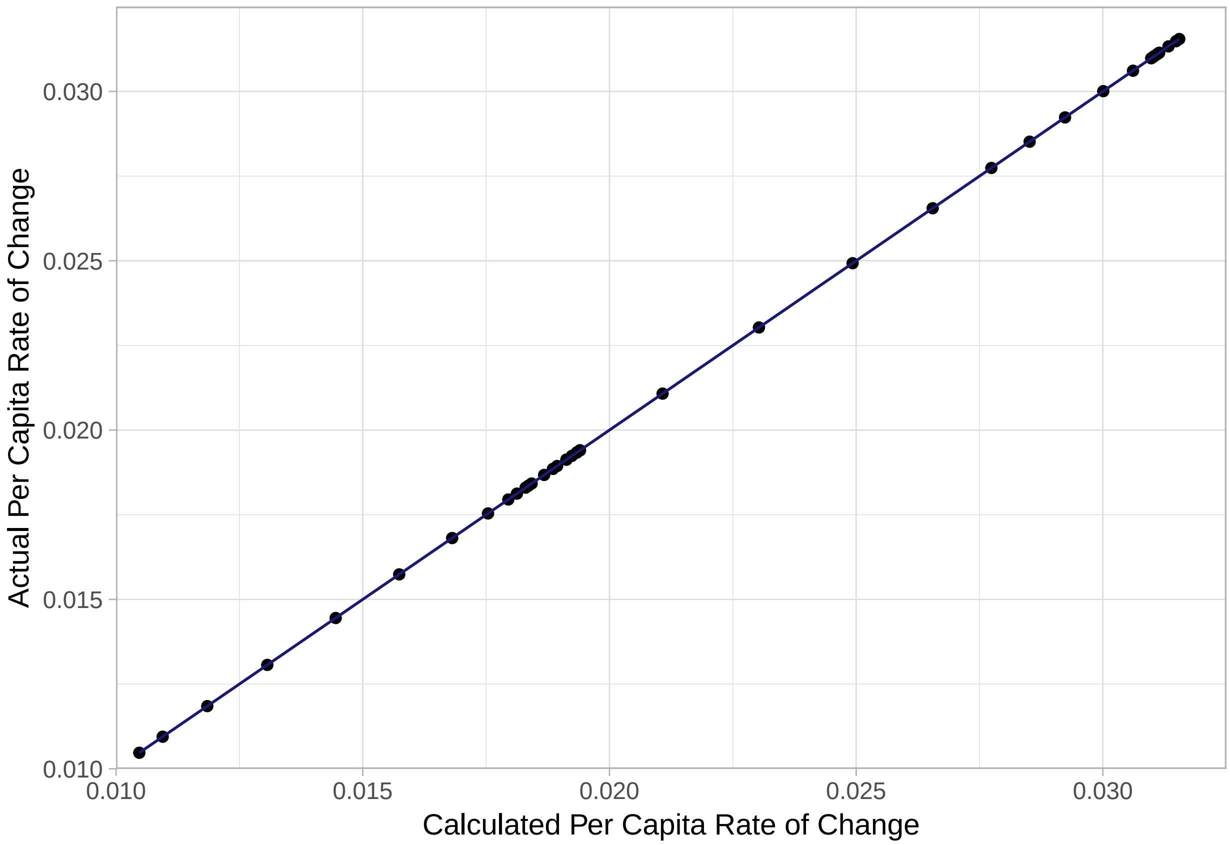

Figure 1: Mexico's Actual vs. Calculated Per Capita Rate of Change. The graph depicts the actual vs. calculated per capita rate of change for Mexico's population between 1963 and 2003. The trendline shows the linear relationship between actual and calculate values for the per capita rate of population change.

Question 2 Graph $\frac{dN}{Ndt}$ vs. $\mathbf{N_t}$

a. For Each Country Plot $\frac{dN}{Ndt}$ vs. $\mathbf{N_t}$

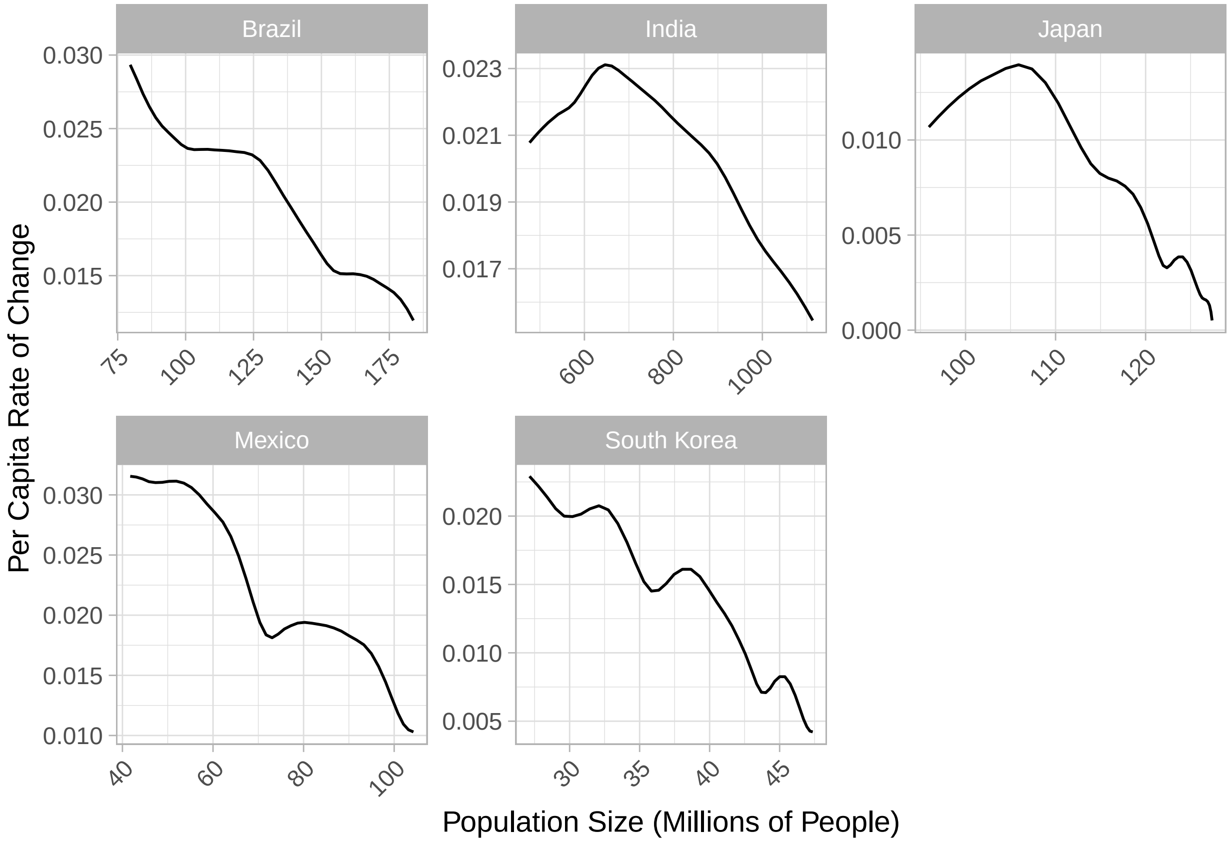

Figure 2: Rate of Population Change by Country. The per capita rate of change of the population is shown against the population size in millions of people for each of the five countries.

b. Estimating Carrying Capacity

Carrying Capacities:

- **Brazil:**
  $Population = 2.607 * 10^8 - 6.392 * 10^9(\frac{dN}{Ndt})$
  Carrying capacity (K) = population when $\frac{dN}{Ndt} = 0$
  $K = 2.607 * 10^8$
- **South Korea:**
  $Population = 5.282 * 10^7 - 1.054 * 10^9(\frac{dN}{Ndt})$
  Carrying capacity (K) = population when $\frac{dN}{Ndt} = 0$
  K = $5.282 * 10^7$

c. Modified Plots

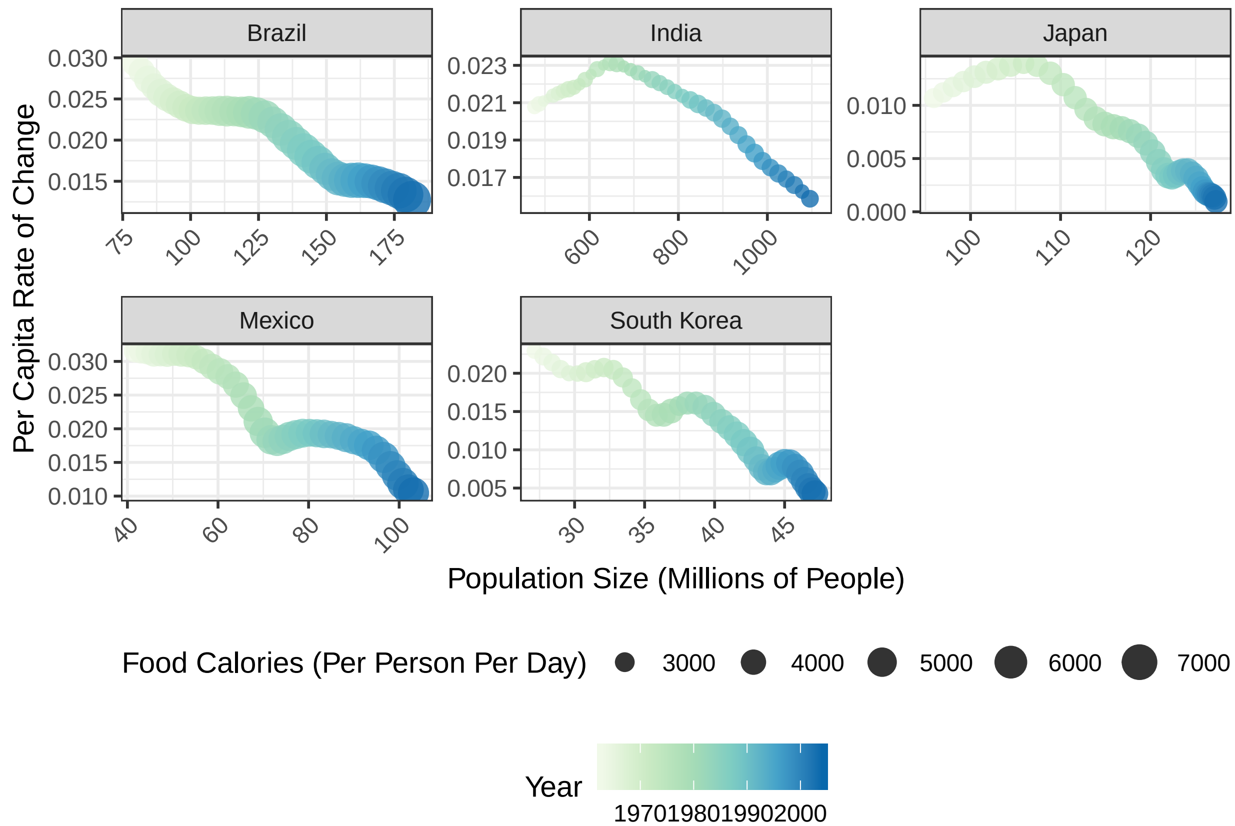

Figure 3: Rate of Population Growth by Country Over Time. The per capita rate of change of the population is shown against the population size in millions of people for each of the five countries. The color of the lines represents the progression through time and size of the points depicts the food calories per person per day.

Question 3 What Influences Growth

Multiple Linear Regression

Table 2: Regression Results.

	Dependent variable:					
	Per Capita Rate of Change (dN/Ndt)					
	All	Brazil	India	Japan	Mexico	South Korea
	(1)	(2)	(3)	(4)	(5)	(6)
Years of Education	-0.0022489^{***}	-0.0024205^{***}	-0.0015234^{***}	-0.0038341^{***}	-0.0022801^{***}	-0.0027568^{***}
	(0.0000871)	(0.0003427)	(0.0002867)	(0.0002543)	(0.0002600)	(0.0003569)
Food Calories Per Person Per Day	0.0000001	-0.0000012^{**}	-0.0000004	-0.0000020^{**}	-0.0000053^{***}	-0.0000004
	(0.0000002)	(0.0000005)	(0.0000017)	(0.0000009)	(0.0000007)	(0.0000010)
Constant	0.0297466^{***}	0.0363112^{***}	0.0260048^{***}	0.0506058^{***}	0.0588777^{***}	0.0385817^{***}
	(0.0009831)	(0.0019296)	(0.0037913)	(0.0027957)	(0.0021538)	(0.0011457)
Observations	205	41	41	41	41	41
R^2	0.7702826	0.9259760	0.6185119	0.9150605	0.9638313	0.9518230
Adjusted R^2	0.7680082	0.9220800	0.5984336	0.9105900	0.9619277	0.9492874
Residual Std. Error	0.0036645 (df = 202)	0.0013327 (df = 38)	0.0013202 (df = 38)	0.0013266 (df = 38)	0.0013046 (df = 38)	0.0012854 (df = 38)
F Statistic	338.6707000^{***} (df = 2; 202)	237.6735000^{***} (df = 2; 38)	30.8049700^{***} (df = 2; 38)	204.6885000^{***} (df = 2; 38)	506.3163000^{***} (df = 2; 38)	375.3790000^{***} (df = 2; 38)
Note:						$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Description of Variables

- Years of Education:
  - All: For every increase in one year of education, we would expect the rat of change for the population to decrease by 0.0022489 if all other variables in the model remain the same.

  - Brazil: For every increase in one year of education, we would expect the rate of change of the for the population to decrease by 0.0024205 if all other variables in the model remain the same.

  - India: For every increase in one year of education, we would expect the rate of change of the for the population to decrease by 0.0015234 if all other variables in the model remain the same.

  - Japan:For every increase in one year of education, we would expect the rate of change of the for the population to decrease by 0.0038341 if all other variables in the model remain the same.

  - Mexico: For every increase in one year of education, we would expect the rate of change of the for the population to decrease by 0.0022801 if all other variables in the model remain the same.

  - South Korea: For every increase in one year of education, we would expect the rate of change of the for the population to decrease by 0.0027568 if all other variables in the model remain the same.
- Food Calories:
  - All: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000001, all other factors remaining equal.

  - Brazil: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000012, all other factors remaining equal.

  - India: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000004, all other factors remaining equal.

  - Japan: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000020, all other factors remaining equal.

  - Mexico: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000053, all other factors remaining equal.

  - South Korea: For every additional calorie consumed per person per day, we would expect the rate of change of the population to decrease by 0.0000004, all other factors remaining equal.