Decomposing Growth of CO_2 Emissions
Sample Assignment 2

Use the data and tools of the Climate Analysis Indicators Tool (CAIT) to do this assignment. To access CAIT, go online to http://cait.wri.org/. If you are not already a registered user, click 'Register and Access CAIT.' Use your email address as your Login Name and create a password.

1. Graph CO2 emission trends for the US, Germany, Russia, China, and India for the period 1990-2006. Insert a copy of the graph into your assignment.
   (*Hint: select 'Graph Trends' from navigation bar on left of CAIT page, then select 'Compare Countries'. Use the pull down menus to select variables, time period, and countries to be graphed. Right click on the graph and select 'Save image as' to save a copy of the graph on your computer.)*
   a. Which countries experienced the highest growth in emissions?
   b. Which countries experienced a decrease in emissions during this period?

2. For the same countries and time period, create graphs of population, income per capita, per capita energy use, and carbon intensity of energy use. Insert copies of your graphs into your assignment.
   a. What influence did population changes have on CO2 emissions growth in each country?
   b. What influence did per capita income changes have on CO2 emissions growth in each country?
   c. What influence did per capita energy use changes have on CO2 emissions growth in each country?
   d. What influence did changes in carbon intensity of energy use have on CO2 emissions growth in each country?

3. Select 5 countries (include a mix of developed and developing countries), calculate the percentage growth in CO2 emissions from energy for the period 1990 to 2005 for each and decompose the emissions growth into the four components of the Kaya identity.
   a. Create a bar chart to compare the results of your decomposition for your 5 countries.
   b. Briefly explain any similarities and differences across the 5 countries.

   To do this assignment you will need to create a spreadsheet with data for your chosen countries for CO2 emissions from energy, population, Gross Domestic Product (GDP), and energy consumption for the years 1990 and 2005. Use the 'Calculate Trends' function of CAIT to obtain the data that you will need.

   The Kaya identity is given by the equation

   $$C = P * (I/P) * (E/I) * (C/E)$$

   where C is CO2 emissions, P is population, I is income, and E is total energy consumption. This identify can be used to decompose growth in CO2 emissions into contributions from growth in population, per capita income, energy intensity of the economy, and carbon intensity of the energy mix. For small changes, the decomposition can be approximated as

   $$\% \Delta C = \% \Delta P + \% \Delta (Y/P) + \% \Delta (E/y) + \% \Delta (C/E)$$

   or percentage change in population, plus percentage change in per capita income, plus percentage change in energy intensity of the economy, plus percentage change in the carbon intensity of energy consumed.

For larger changes, as would be observed over a period of several years, this simple decomposition becomes inaccurate. A commonly used method for decomposition for larger changes is the Logarithmic Mean Divisia Index (LMDI; see Ang (2005).

The additive LMDI equations for decomposing emissions growth yield the change in CO2 emissions attributable to the effects of each component of the Kaya identity. The decomposition equestions are:

$\Delta C_{pop} = (C_T - C_0)/(\ln C_T - \ln C_0) * \ln (P_T/P_0)$
$= $ population effect

$\Delta C_{inc} = (C_T - C_0)/(\ln C_T - \ln C_0) * \ln [(I_T/P_T)/(I_0/P_0)]$
$= $ income effect

$\Delta C_{energy} = (C_T - C_0)/(\ln C_T - \ln C_0) * \ln [(E_T/I_T)/(E_0/I_0)]$
$= $ energy intensity effect

$\Delta C_{E\text{-}mix} = (C_T - C_0)/(\ln C_T - \ln C_0) * \ln [(C_T/E_T)/(C_0/E_0)]$
$= $ carbon intensity of energy mix

The subscripts 0 and T refer to the first and last year of the period of analysis, 1990 and 2005 respectively for this assignment. To facilitate comparison across countries, display the 4 effects as percentages of the total change in CO2 emissions.

Tip: to double check that you've implemented these equations correctly in your spreadsheet, sum the four effects for each country. They should sum to equal the total change in CO2 emissions from 1990 to 2005.