AAE/IS 374

Problem Set 3:
Conditional Convergence and Examining the Sources of Growth

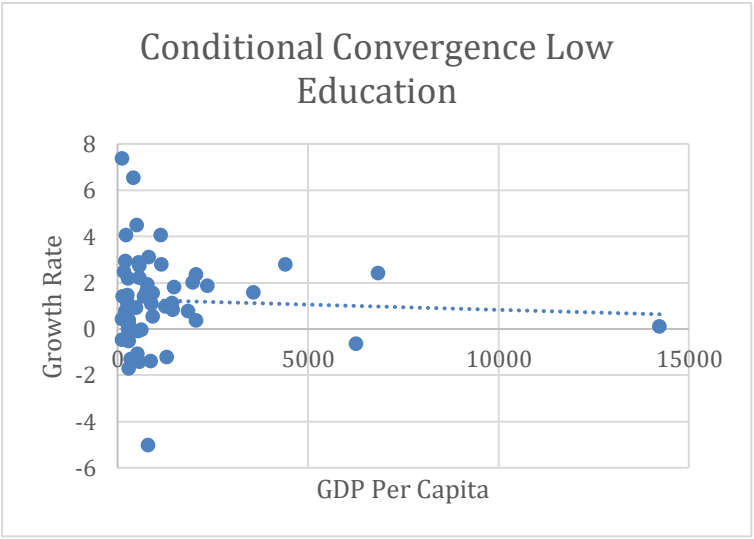
due on March 31

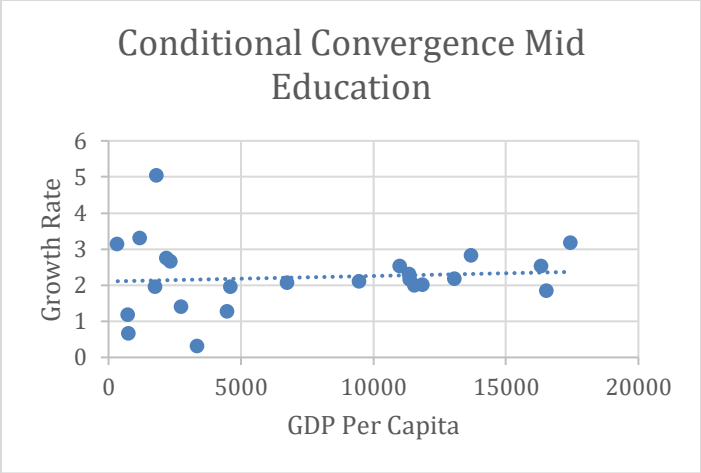
Note: Please hand in all your TYPED work. This includes any graphs, tables for summary statistics and Excel (or equivalent) work. You don't need to print out all country results on Excel. Choose the first 15 countries (in alphabetical order) for printing purposes, i.e. to show your work. You may also combine Excel results for questions 2. a), c) and d) to save paper.

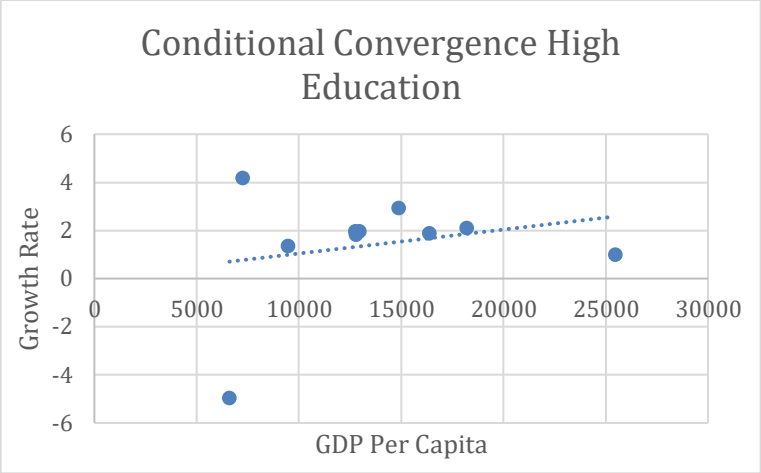
1. We have seen that one implication of the Solow model is `convergence'. Convergence means that, all else equal, countries with lower levels of income will grow more rapidly than countries with higher levels of income. In Problem Set 2 you tested whether 'unconditional convergence' held for the data. (This meant that you did not take the 'all else equal' part of the above statement very seriously in the analysis.) After discussing human capital we have now seen that countries with different levels of human capital will have different steady state levels of income. According to the augmented Solow Model, conditional on the level of human capital, countries with lower incomes should grow more quickly.

   The first worksheet of pset3.xls is called 'Conditional Convergence.' This spreadsheet includes data on GDP/worker in 2005, GDP/worker in 1970, average years of schooling in the population over the age of 15 in 1970, and infant mortality in 1970 (deaths per 1000 live births of infants under the age of one).

   a. **Group countries into those with low (less than or equal to 4 years), medium (greater than 4 but less than or equal to 8 years), and high (greater than 8 years) levels of education and for each group of countries draw a scatter plot (so three in total) with 1970 GDP/worker on the x or horizontal axis and the 1970-2005 annual Growth Rate on the y or vertical axis. Then add in a trend line. Please discuss any patterns apparent in your scatter diagram. Does it appear to support conditional convergence? Does it show divergence, or any other visible pattern?**

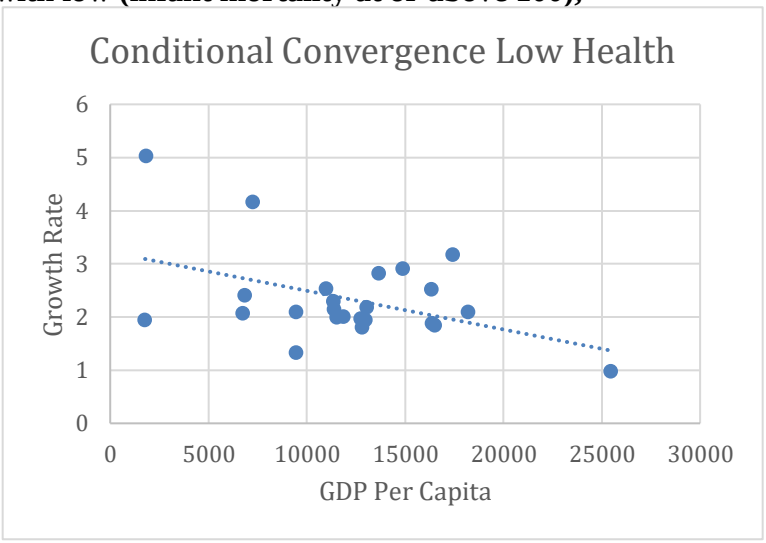


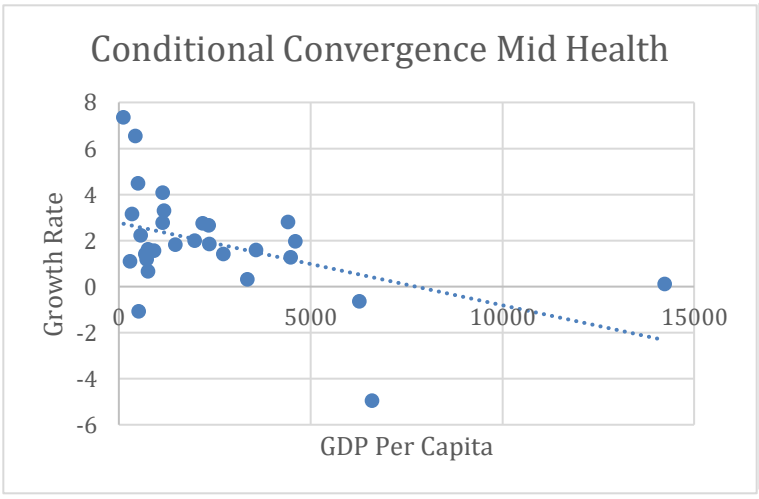


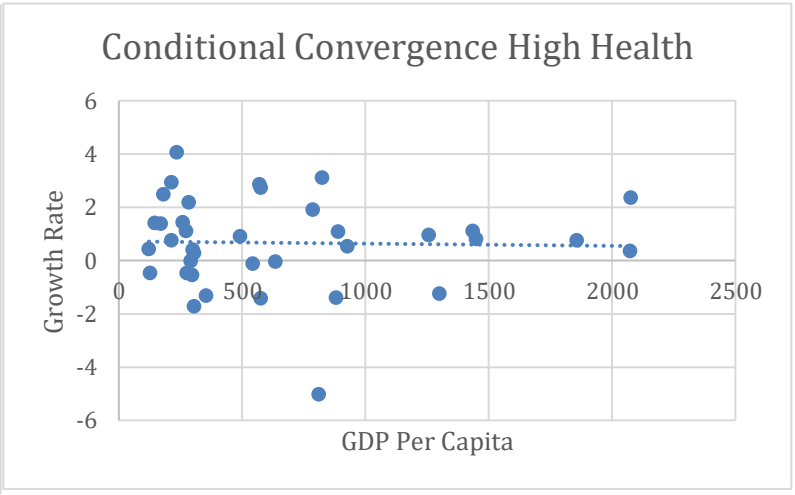


The low education countries is the only grouping that shows convergence. As education levels increase, the amount of divergence grows.

b. Now group countries into those with low (infant mortality at or above 100), medium (above 35 but below 100), and high (below 35) levels of health and repeat the previous exercise (so three more scatter plots). Please discuss any patterns apparent in your scatter diagram. Does it appear to support conditional convergence? Discuss differences and similarities that arise when carrying out this exercise for education versus carrying out this exercise for health.







Counties with medium health levels show the most evidence for convergence, while countries with high levels of health show the least. Similar to the education scatter plots, the countries with the highest levels of health show the least evidence for convergence. However, unlike the education scatter plots, both the medium and high levels of health plots show convergence, (while the education scatter plots show divergence for these levels).

2. **The next part of the course will begin to examine technological change. This problem invites you to begin looking at patterns of technological change in the global economy by analyzing a total factor productivity measure of technological change.**

   The 'TFPG' worksheet in pset3.xls provides the data taken from the Penn World Tables and World Bank sources on the following measures for a sample of 54 countries:

   - GNP per-worker, 1970 and 2005
   - Physical Capital Stock per-worker, 1970 and 2005
   - Human Capital per-worker, 1970-2005

   Human capital per-worker is defined as the percentage of the working age population that has at least attended some secondary school. (Unfortunately, we have not been able to find an updated capital stock information so that economic performance of more recent years may be analyzed.)

   The Weil text (section 7.3) presents a decomposition of growth based on the two factor production function, $Y = A\,K^{\alpha}L^{1-\alpha}$, showing that $\hat{A} = \hat{y} - \alpha\hat{k}$, where a '^' over a variable means its growth rate (e.g., $\hat{y}$is the growth rate of *y*).

   In discussion sections, your TA will discuss both this two factor decomposition as well as the decomposition for the production function which expresses production as a function of three inputs:

$$Y = A\,K^{\alpha}\,S^{\beta}\,P^{1-\alpha-\beta}$$

   where *Y* is output, *A* is the technology multiplier (total factor productivity) term, *K* is physical capital, *S* is human capital and *P* is labor force. Because the production function exhibits constant returns to scale, we can express per-worker output as:

$$y = A\,k^{\alpha}s^{\beta}$$

   where the lower case letters indicate per-worker figures. (Note that *s* represents per worker human capital in this case). By taking logs and differentiating, we can decompose the rate of per-capita growth in the economy as:

$$\hat{y} = \hat{A} + \alpha\,\hat{k} + \beta\,\hat{s}$$

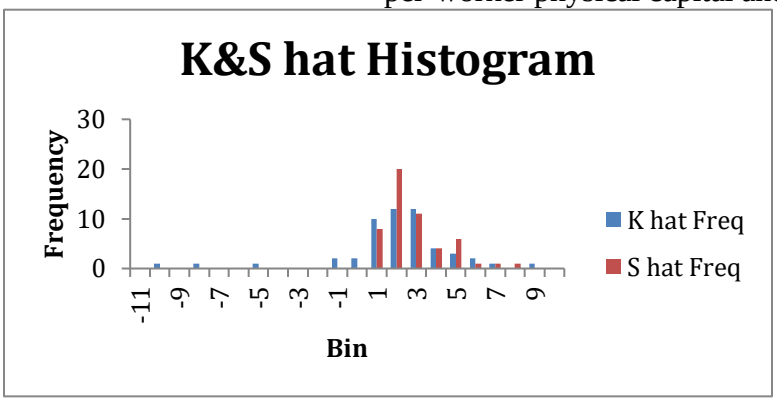
Simple algebra allows us to rewrite this expression as,

$$(*) \quad \hat{A} = \hat{y} - \alpha\,\hat{k} - \beta\,\hat{s}$$

where $\hat{y}, \hat{k}, \hat{s}$ and $\hat{A}$ are, respectively, the growth rates of output per-worker, capital per-worker, human capital per-worker, and the rate of growth in total factor productivity growth (TFPG). The terms α and β are elasticities of output with respect to physical and human capital. For your analysis here, assume that α = 0.39 and that β = 0.27.

a. Using the data for the full sample of countries given in pset3.xls, please calculate the growth rates for GNP per-worker, physical capital per-worker and human capital per-worker over the 1970-2005 period. (**Use geometric formula**).

b. Using your results from part a), compare the distributions of the growth rates for per-worker physical capital and per-worker human capital.



i. Which factor of production has grown fastest over the last 35 years? **Use a t-test to evaluate whether the difference in the means is significant.**

S (per worker human capital) has the greatest average growth rate (2.33 versus 1.54), so it has grown the fastest over the last 35 years.

The T-test returns a value greater than 5%, meaning that the difference in the means is significant.

ii. Which factor growth is more variable or exhibits the largest spread?

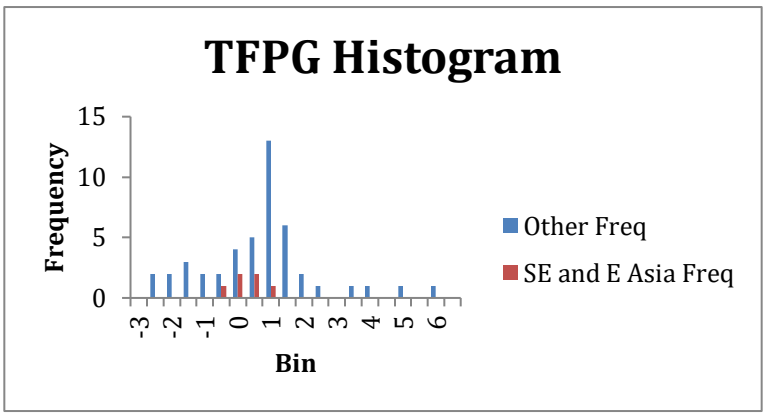
Per-worker physical capital growth rate (K hat) has more variance. K hat has a variance of 9.63, while S hat has a variance of 2.57.

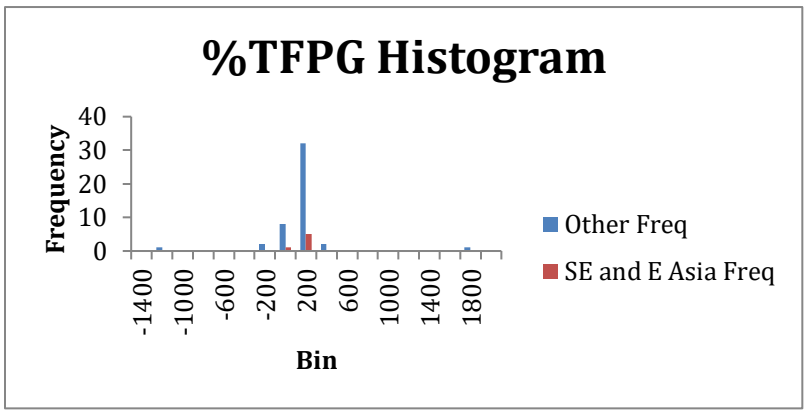
Please answer these questions by calculating the mean and the median growth rates for both factors. Also, please calculate the variance and the standard deviation of these rates. **Present these results in a table.** Using a histogram to examine the distribution of these growth rates, please indicate which growth rate seems to have varied the most. Please explain your answer carefully and clearly and include your graphs with the material that you turn in. Label your graphs and make clear reference to the graphs and your numerical measures of level and spread in your analysis.

c. Using the expression (*) above, calculate TFPG for all the countries in the full sample.

d. Calculate for each country the percentage of total growth accounted for by TFPG. (Note, this percentage can be negative if calculated TFPG is negative. A negative number indicates that a country is estimated to have become less good at extracting outputs from its measured inputs of labor, physical and human capital. For such a country to have had its per-capita GDP grow at all, it is necessary for the growth of its inputs to have been strong enough to overwhelm the negative TFPG growth.)

e. Has TFPG been extraordinarily high in East and South East Asia compared to other world regions? To answer this, you will need to examine the distribution of TFPG (and TFPG as a percent of total growth) for East and South East Asian countries (i.e., Japan, Indonesia, India, Philippines, Thailand, and Malaysia, to name a few) versus the distribution for the rest of the world. **This means creating two histograms with both regions in the same graph, one for TFPG**





(raw data) and TFPG as a percentage of total growth. Examine both the mean and median values of your TFPG measures for both East and South East Asian countries and the rest of the world. **Create two tables, one for SE Asia and one for the rest of the world. Interpret your results.**

South Eastern and Eastern Asian countries have had a higher average TFPG compared to other countries, but a lower median. Also, their % TFPG is lower. However, the differences in amount of growth is not large. In addition, there is only 1 SE Asian country in this data set that has a negative % TFPG, meaning that as a whole SE Asian countries have remained efficient at extracting outputs from their capital inputs.

Non SE Asia	TFPG	%TFPG
Mean	0.467133	39.47359
Median	0.608555	41.78959
SE Asia	TFPG	%TFPG
Mean	0.539204	11.14905
Median	0.559324	16.57725