Advanced Macroeconomics I: Assignment

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The executable code that was used in solving the problems below is available at https://github.com/maxmheinze/macro1.

Problem 1

Using the data from the Penn World Table 10.1, available at http://www.rug.nl/ggdc/productivity/pwt/,

- Perform an unconditional β-convergence analysis for the period 1960-1990 and another one for the period 1990-2019 for all countries of the world for which data are available. How has the global income convergence pattern across countries changed over time?
- Perform an conditional β-convergence analysis for both periods, controlling for differences in population growth rates and investment shares (average over the period, both of these variables are available in the Penn World Table dataset). How does the interpretation of your results differ from that of the previous question?

Unconditional Convergence

To perform an unconditional β-convergence analysis, we first subset all countries which have data in both 1960 and 1990 and then calculate the yearly growth of GDP as

$$\left(\frac{\dot{(Y/L)}}{Y/L}\right)_i = \frac{\log(Y/L)_{1990} - \log(Y/L)_{1960}}{1990-1960}. \tag{1}$$

We then regress this growth rate on the logarithmized baseline GDP level of 1960. The exact same process is repeated for years 1990 and 2019. We then run the regression[1]

$$\left(\frac{\dot{(Y/L)}}{Y/L}\right)_i = \beta_0 + \beta_1 \log\left(\frac{Y}{L}\right)_{\text{baseline},i} + e_i. \tag{2}$$

The following table shows in Column (1) the results for the former period and in Column (2) the results for the latter period. Evidently, we do not observe unconditional convergence in the period from 1960 to 1990, as the coefficient associated with log(rgdpe) is not significantly different from zero. However, we

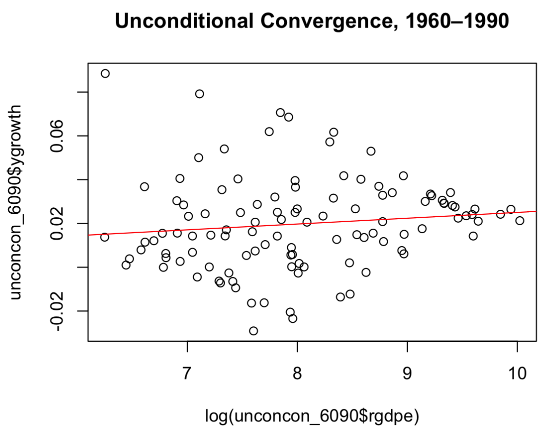
[1] The variable $\left(\frac{\dot{(Y/L)}}{Y/L}\right)$ is called ygrowth in the code and regression output, and the variable $\left(\frac{Y}{L}\right)$ is called rdgpe.

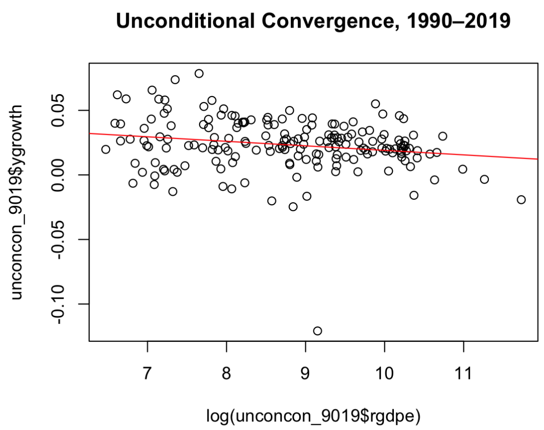
do observe unconditional convergence in the period from 1990 to 2019, as the coefficient is significantly different from zero and negative. This means that economies seem to converge to a common steady state, but only in the second period we examine.

This can also be seen from the visualization in the scatter plot below the table.

Table 1: Unconditional Convergence

	Dependent variable:	
	ygrowth	
	1960–1990	1990–2019
	(1)	(2)
log(rgdpe)	0.003	-0.004^{***}
	(0.002)	(0.001)
Constant	-0.002	0.056^{***}
	(0.017)	(0.012)
Observations	111	181
R^2	0.014	0.039
Adjusted R^2	0.005	0.033
Residual Std. Error	0.021 (df = 109)	0.021 (df = 179)
F Statistic	1.555 (df = 1; 109)	7.237^{***} (df = 1; 179)
Note:		*p<0.1; **p<0.05; ***p<0.01





Conditional Convergence

We conduct a similar analysis again, this time checking for conditional convergence instead of unconditional convergence. To do this, we calculate the average growth rate of population the same way we calculated the average growth rate of output, and we calculated the average of all yearly investment shares in the period in question. We then run the regression[2]

$$\left(\frac{(\dot{Y/L})}{Y/L}\right)_i = \beta_0 + \beta_1 \log\left(\frac{Y}{L}\right)_{\text{baseline},i} + \beta_2 s_i + \beta_3 n_i + e_i \tag{3}$$

and get the following results:

Table 2: Conditional Convergence

	Dependent variable:	
	ygrowth	
	1960–1990	1990–2019
	(1)	(2)
log(rgdpe)	-0.005^{**}	-0.007^{***}
	(0.002)	(0.002)
csh_i	0.061^{***}	0.088^{***}
	(0.017)	(0.020)
pgrowth	-0.915^{***}	-0.334^{***}
	(0.221)	(0.125)
Constant	0.068^{***}	0.075^{***}
	(0.020)	(0.013)
Observations	111	181
R^2	0.269	0.152
Adjusted R^2	0.248	0.137
Residual Std. Error	0.018 (df = 107)	0.020 (df = 177)
F Statistic	13.093^{***} (df = 3; 107)	10.543^{***} (df = 3; 177)
Note:		*p<0.1; **p<0.05; ***p<0.01

A significantly negative coefficient associated with logged baseline GDP indicates convergence conditional on population growth and the investment share, and, this time, we observe convergence in *both* periods considered. The difference in interpretation to the previous case, where we examined unconditional convergence, is treating conditional correlations after accounting for differences in the population growth rate and the investment share. Thus, we can interpret conditional convergence as an economy approaching a country-specific steady state that depends on population growth and investment share.

[2] The variable $\left(\frac{(\dot{Y/L})}{Y/L}\right)$ is called ygrowth in the code and regression output, the variable $\left(\frac{Y}{L}\right)$ is called rdgpe, the variable s is called csh_i, and the variable n is called pgrowth.

Problem 2

In their seminal paper A Contribution to the Empirics of Economic Growth, Mankiw, Romer and Weil include human capital in the Solow model and present empirical evidence about the role that education plays as a determinant of economic growth. You can find the data used in the paper here: https://github.com/HariharanJayashankar/mrw1992.

- Making use of the data used in the paper, replicate Table VI (page 429 of the original paper, that can be found here: https://scholar.harvard.edu/sites/scholar.harvard.edu/files/mankiw/files/contribution_to_the_empirics.pdf.
- Is the effect of human capital on economic growth different in African countries as compared to the rest of the world? Test this hypothesis making use of the model which is presented in Table VI.
- Is the speed of conditional income convergence implied by this model different in African countries as compared to the rest of the world?

Replicating Table VI

This assignment submission takes Mankiw, Romer, & Weil (1992) seriously. Consequently, we replicate table VI from the paper:

Table 3: Replicated Table VI

	Dependent variable:		
	log difference GDP per working-age-person 1960-1985		
	Non-oil	Intermediate	OECD
	(1)	(2)	(3)
log(Y60)	-0.298^{***}	-0.372^{***}	-0.402^{***}
	(0.060)	(0.067)	(0.069)
log(I/GDP) - log$(n + g + \delta)$	0.501^{***}	0.506^{***}	0.395^{**}
	(0.082)	(0.095)	(0.152)
log(SCHOOL) - log$(n + g + \delta)$	0.235^{***}	0.266^{***}	0.241
	(0.059)	(0.080)	(0.142)
Constant	2.457^{***}	3.090^{***}	3.554^{***}
	(0.473)	(0.530)	(0.634)
N	98	75	22
Adjusted R^2	0.465	0.437	0.659
Note:			*p<0.1; **p<0.05; ***p<0.01

Effect of Human Capital on Economic Growth (Africa vs. Rest of the World)

Next we test the hypothesis whether the effect is different in African countries by including an interaction term between Africa and the coefficient for $s_h - \log(n + g + \delta)$. We can then test the hypothesis whether the effect of human capital on economic growth differs compared to the rest of the world. Column (1) presents evidence that the effect of schooling on income differences is stronger in Africa than in other parts of the world. The interaction is statistically significant and positive. However the sample restrictions, where only countries classified as non-oil (2) and intermediate (3), do not present evidence of differential effects in Africa. Nonetheless, since the full sample supports the notion of a stronger effect of human capital on economic growth in Africa, there is based on this particular model and data suggestive evidence that supports the hypothesis.

The introduction of an interaction term of human capital and Africa could be interpreted as a variant of testing the Nelson-Philipps hypothesis. It resembles testing whether human capital has a positive effect on economic growth by speeding up the adoption of new technologies. The Africa dummy would then act as a lump indicator of $(A_f/A - 1)$, the distance to the technological frontier. By including the Africa dummy one assumes that all African countries in the sample are equally far away from the technological frontier, which seems implausible. Taking into account these limitations, specification 16 is in line with the finding that human capital speeds up the adoption of technology.

Table 4: Effect of Human Capital on Growth, Africa vs. Rest of the World

	Dependent variable:		
	log difference GDP per working-age-person 1960-1985		
	All Countries	Non-oil	Intermediate
	(1)	(2)	(3)
log(Y60)	-0.290^{***}	-0.289^{***}	-0.369^{***}
	(0.049)	(0.060)	(0.067)
log(I/GDP) - log(n + g + δ)	0.571^{***}	0.537^{***}	0.549^{***}
	(0.083)	(0.086)	(0.105)
log(SCHOOL) - log(n + g + δ)	0.054	0.112	0.171
	(0.104)	(0.107)	(0.126)
(log(SCHOOL) - log(n + g + δ)):AFRICA	0.169^{*}	0.125	0.108
	(0.090)	(0.091)	(0.110)
Constant	2.347^{***}	2.357^{***}	3.026^{***}
	(0.406)	(0.476)	(0.534)
N	104	98	75
Adjusted R^2	0.509	0.470	0.437
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

The implied speed of income convergence is given by the coefficient on log(Y60). We convert the estimate into λ, the implied speed of conditional income convergence. We find for $t = 25$

$$-0.29 = -(1 - \exp(-\lambda t)) \implies \lambda \approx 0.014 \tag{4}$$

Thus, for countries to move half way to steady state, it takes about 51 years. The implied speed of income convergence is lower in this model.

Fully Interacted Specification

In an alternative specification we included both an Africa dummy as well as an interaction term with the school variable. There is no evidence for a differential effect of education on income per capita once baseline differences are accounted for.

Table 5: Effect of Human Capital on Growth, Africa vs. Rest of the World (Alternative Specification)

	Dependent variable:		
	log difference GDP per working-age-person 1960-1985		
	All Countries	Non-oil	Intermediate
	(1)	(2)	(3)
log(Y60)	-0.321^{***}	-0.342^{***}	-0.369^{***}
	(0.052)	(0.064)	(0.068)
log(I/GDP) - log(n + g + δ)	0.558^{***}	0.524^{***}	0.548^{***}
	(0.082)	(0.084)	(0.106)
log(SCHOOL) - log(n + g + δ)	0.095	0.178	0.172
	(0.106)	(0.109)	(0.127)
AFRICA	−0.205	-0.282^{**}	−0.008
	(0.124)	(0.123)	(0.170)
log(SCHOOL) - log(n + g + δ):AFRICA	0.060	−0.028	0.103
	(0.111)	(0.111)	(0.153)
Constant	2.638^{***}	2.836^{***}	3.029^{***}
	(0.440)	(0.510)	(0.542)
N	104	98	75
Adjusted R^2	0.518	0.493	0.429
Note:			*p<0.1; **p<0.05; ***p<0.01

Speed of Conditional Income Convergence (Africa vs. Rest of the World)

Finally, we introduce the interaction term log(Y60):Africa, capturing the difference in speed of income convergence between African and non-African countries. While the coefficient for non-African countries is -0.323 ($p < 0.01$), we can observe a 0.034 higher coefficient (in absolute values) for African countries ($p < 0.05$). This leads, following Equation 4, to $\lambda_{\text{non-African}} \approx 0.0156$ and $\lambda_{\text{African}} \approx 0.0177$. As this difference is statistically and economically significant, we can speak of a significant difference in terms of speed of conditional income convergence between African and non-African countries. This significant difference also exists when we just look at the non-oil countries, leading to $\lambda_{\text{non-African}} \approx 0.0161$ and $\lambda_{\text{African}} \approx 0.0183$.

Table 6: Difference in Conditional Income Convergence, Africa vs. Rest of the World

	Dependent variable:		
	log difference GDP per working-age-person 1960-1985		
	All Countries	Non-oil	Intermediate
	(1)	(2)	(3)
log(Y60)	-0.323^{***}	-0.331^{***}	-0.373^{***}
	(0.050)	(0.060)	(0.067)
log(I/GDP) - log(n + g + δ)	0.540^{***}	0.526^{***}	0.522^{***}
	(0.077)	(0.080)	(0.098)
log(SCHOOL) - log(n + g + δ)	0.145^{**}	0.162^{**}	0.227^{**}
	(0.064)	(0.063)	(0.097)
log(Y60):AFRICA	-0.034^{**}	-0.036^{***}	-0.012
	(0.014)	(0.013)	(0.017)
Constant	2.679^{***}	2.742^{***}	3.085^{***}
	(0.413)	(0.470)	(0.532)
N	104	98	75
Adjusted R^2	0.522	0.498	0.433
Note:			*p<0.1; **p<0.05; ***p<0.01