Economics of Growth, ECON560 **San Francisco State University**
Michael Bar **Fall 2010**

Final Exam

Thursday, December 16

2 hour, 30 minutes

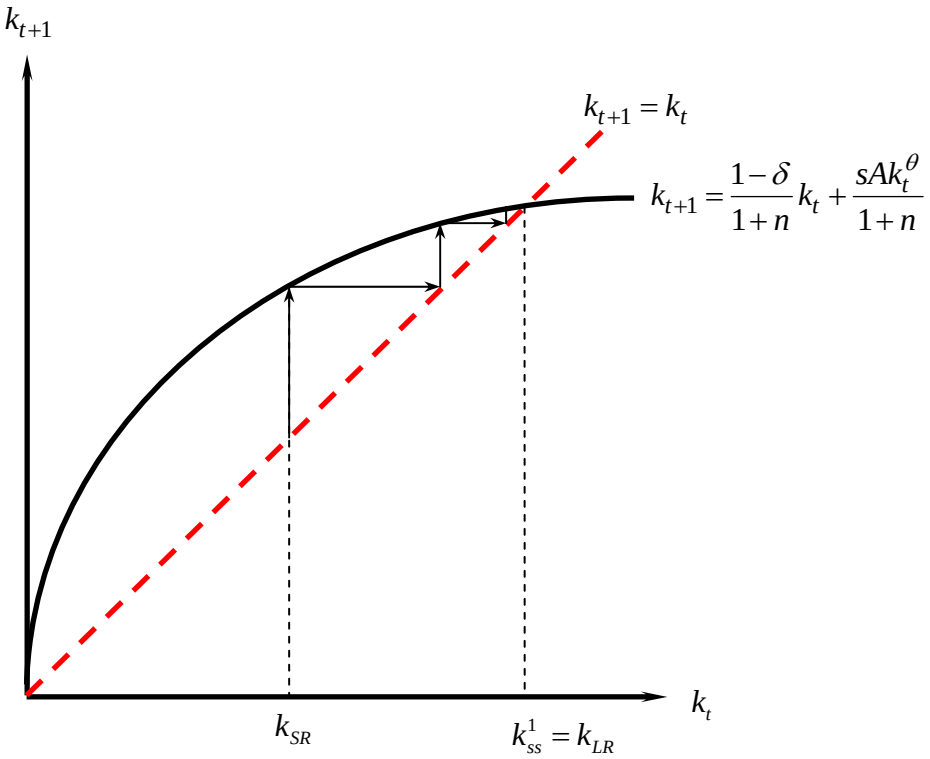
Name: _____

Instructions

1. This is closed book, closed notes exam.
2. No calculators of any kind are allowed.
3. Show all the calculations.
4. If you need more space, use the back of the page.
5. Fully label all graphs.

Good Luck ☺

1. (15 points). Suppose the economy of Haiti is described well by the Solow model.
   a. (5 points). Suppose that productivity in Haiti is not growing. In the next diagram, draw the law of motion of capital per worker, and show the initial steady state capital per worker k_{ss}^1.



   b. (5 points). Suppose an earthquake destroyed a large fraction of physical capital in Haiti. Illustrate in the above diagram the short run and long run impact of the earthquake on the capital per worker in Haiti, assuming that Haiti was initially in the steady state from part a.

In the short run, the capital per worker falls to some level k_{SR}. Notice that this change does not shift the law of motion of capital per worker (which shifts when A, s, n change). In the long run the capital per worker will recover to the initial steady state level.

   c. (5 points). What will be the long run growth rate in standard of living in Haiti? Explain briefly.

Since productivity is not growing in Haiti, the long run growth rate, according to the Solow model, is **zero**. We proved in class that without growth in productivity the economy converges to a steady state, with no growth in capital per worker, output per worker or consumption per worker.

2. (15 points). The next table shows how the average wage increases in years of education in a sample of countries.

Years of schooling	1-4	5-8	9,10,…
Marginal return	1.134	1.101	1.068

a. (5 points). Suppose that workers in Japan have on average 13 years of education, while workers in Indonesia have on average 8 years of education. Calculate the ratio of human capital per worker in the two countries. (Simplify your answer, but there is no need to provide the exact numerical answer).

$$\frac{h_{Japan}}{h_{Indonesia}} = \frac{h_0 \cdot 1.134^4 \cdot 1.101^4 \cdot 1.068^5}{h_0 \cdot 1.134^4 \cdot 1.101^4} = 1.068^5$$

b. (5 points). Based on the following table, where is the biggest contribution to the differences in income per capita of countries *i* and *j* coming from: (circle the correct answer).

i. Differences in the fraction of workers in population
ii. Differences in productivity
iii. Differences in human capital per worker
iv. Differences in physical capital per worker

$\frac{y_i}{y_j}$	$\frac{\alpha_i}{\alpha_j}$	$\frac{A_i}{A_j}$	$\frac{h_i^{1-\theta}}{h_j^{1-\theta}}$	$\frac{k_i^{\theta}}{k_j^{\theta}}$
12	1	?	1.5	2

You first need to calculate the ratios of productivities:

$$\frac{A_i}{A_j} = \frac{y_i / y_j}{\frac{\alpha_i}{\alpha_j}\frac{h_i^{1-\theta}}{h_j^{1-\theta}}\frac{k_i^{\theta}}{k_j^{\theta}}} = \frac{12}{1.5 \cdot 2} = 4$$

c. (5 points). Based on the above table, if the only difference between countries *i* and *j* was in productivity, what would have been the ratio of GDP/capita of the two countries then?

$$\frac{y_i}{y_j} = \frac{A_i}{A_j} = 4$$

3. (10 points). Consider the following growth model with R&D discussed in class and briefly described here. The total (fixed) labor, L, is split so that a fraction γ_A is used in the production of new technologies (R&D), and the rest is producing output Y. The production of output and technology, A, are given by:

$$Y_t = A_t(1-\gamma_A)L$$
$$\hat{A} = \frac{A_{t+1} - A_t}{A_t} = \frac{\gamma_A L}{\mu}$$

where μ is the cost of innovation in units of labor.

   a. (5 points). Prove that in this model, the growth rate of output per worker is the same as the growth rate of technology, i.e. prove that:

$$\hat{y} = \hat{A} = \frac{\gamma_A L}{\mu}$$

Output per worker: $y_t = \frac{Y_t}{L} = A_t(1-\gamma_A)$

The growth rate: $\hat{y} = \frac{y_{t+1} - y_t}{y_t} = \frac{A_{t+1}(1-\gamma_A) - A_t(1-\gamma_A)}{A_t(1-\gamma_A)} = \frac{A_{t+1} - A_t}{A_t} = \hat{A}$

b. (5 points). Based on the above model, consider two countries have the same γ_A and μ, but the population of country 1 is twice that of population of country 2 (i.e. $L_1 = 2L_2$). In this case, output per worker in country 1 will grow twice as fast as the output per worker in country 2. (True)/False, circle the correct answer and provide a mathematical proof.

$$\hat{y}_1 = \frac{\gamma_A L_1}{\mu} = \frac{\gamma_A 2L_2}{\mu} = 2\hat{y}_2$$

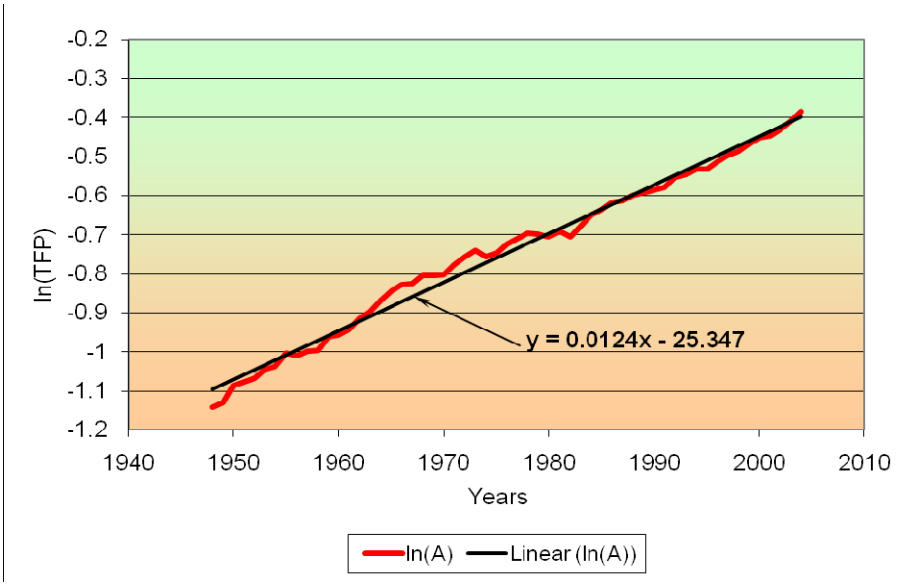
4. (10 points). Suppose that you want to measure the productivity level, *A*, in a given economy, under the assumption that aggregate output is Cobb-Douglas, i.e.

$Y_t = A_t K_t^{\theta} L_t^{1-\theta}, \quad 0 < \theta < 1.$

   a. (5 points). Write the formula that you would use, and describe what data you would need for obtaining a time series on A_t.

$$A_t = \frac{Y_t}{K_t^{\theta} L_t^{1-\theta}}$$

   b. (5 points). Suppose that you plotted $\ln(A_t)$ as a function of time, and the resulting graph, with the fitted linear trend and it equation, are presented below.



Based on the above graph, what is your estimated average growth rate of productivity (in %)?

1.24%

5. (10 points). Assume that the Total Factor Productivity (*A*) depends on technology (*T*) and efficiency (*E*) as follows: $A = T \cdot E$.
   a. (5 points). Suppose that productivity in South Korea is 20 times that of North Korea, i.e. $A_i / A_j = 20$, where *i* is SK. and *j* is NK. Suppose that the technology in the SK is growing at 2% per year, and technologically, NK is 35 years behind SK. Find the approximate ratio of technology in SK vs. NK (T_i / T_j). Hint: recall the rule of 70.

Formally, one needs to solve the following equation:

$$T_i = T_j (1 + 0.02)^{35}$$

$$\frac{T_i}{T_j} = (1 + 0.02)^{35}$$

If technology in the SK grows at 2% per year, it must have doubled over the last 35 years. Thus technology in the SK now is twice what it was 35 years ago, which is the same as NK today. Therefore, technology in SK is twice that of NK:

$$\frac{T_i}{T_j} \approx 2$$

   b. (5 points). Find the ratio of efficiency in South Korea vs. North Korea (E_i / E_j).

$$\frac{A_i}{\underbrace{A_j}_{20}} = \frac{T_i}{\underbrace{T_j}_{2}} \times \frac{E_i}{\underbrace{E_j}_{?}}$$

$$\frac{E_i}{E_j} = 10$$

6. (10 points). In the following table, provide one example for each type of inefficiency:

Type of inefficiency	Example
1. Unproductive Activities	Theft, burglary, rent seeking
2. Idle Resources	Unemployment
3. Technology Blocking	Microsoft attempted to suppress Java programming language, and Netscape browser

7. (10 points). Dexter and Masuka are producers of chocolate cakes. Each one of them can bake at most 2 cakes a day. Each cake sells for $50. Their personal cost of making and delivering the cakes to the bakery is $20 for the first cake and $30 for the second. When they share their revenues, their net payoffs matrix is given by:

		Masuka		
		0	1	2
Dexter	0	0, 0	25, 5	50, 0
	1	5, 25	30, 30	55, 25
	2	0, 50	25, 55	50, 50

Explain why sharing of the revenue leads to the equilibrium where the payoffs are only $30 for each per day.

The unique Nash equilibrium in this game is {1, 1}, i.e. both bake just one cake and enjoy payoffs of $50 each. Notice that if they both backed 2 cakes, they would enjoy payoffs of $50, but that outcome is unlikely. Given that Masuka bakes two cakes, Dexter's best response to that is backing only 1 cake and getting a net payoff of $55. By symmetry, Masuka would also bake only one cake. Intuitively, sharing revenues provides negative incentives to work, since higher effort by others enables one to free ride and enjoy high pay. But since this negative incentive exists for everybody, all end up with low effort and low pay.

8. (10 points). Explain why the comparison of North and South Korea was used to illustrate the importance of regime for economic growth (as opposed to say South Korea and Haiti)?

In 1953 both countries had similar conditions: they were both devastated after the war, had similar natural resources and similar levels of education. So **the main difference between the two countries was the regime**. By the year 2000 South Korea had GDP/cap 16 times higher than that of North Korea.

These two countries are an example of a natural experiment, where the main difference was regime. Comparing South Korea with Haiti does not isolate the effect of regime because the two countries are different along many dimensions, such geography, climate, culture, history, etc.

9. (5 points). Give an example of **one** adverse effect that the tropical climate can have on GDP/capita.

i. Land is less fertile (erratic rain and no frost)
ii. Diseases
iii. Heat lowers human effort