

## Problem Set #2: Long-Term Economic Performance

Revised: March 19, 2012

*I had software problems, had to kill off some of the formatting to get this to work.*

*You may do this assignment in a group of up to five people. Whatever you hand in should be the work of your group.*

**Solution:** Brief answers follow, but see also the spreadsheet posted on the course website.

1. Sources of Korean success (35 points). The Republic of Korea (“South Korea”) has been one of the great economic success stories of world history. Since the end of the Korean War in 1953, GDP per capita has risen by a factor of 15. Over the same period, US income rose by a factor of 3. As a result, the gap between the two countries has shrunk. In 1953, average income in Korea was 11% of US income, but by 2007 (the most recent comparable number) it was 56%.

Was Korea a classic productivity story, or did capital formation and hours worked play more important roles than in other countries? We know, for example, that the saving rate and hours worked are both unusually high. Let’s check the numbers and see where the differences in GDP per person come from.

The numbers:

	Korea	United States
GDP per person (Y/POP)	\$23,850	\$42,887
GDP per worker (Y/L)	\$47,723	\$84,342
Capital-output ratio (K/Y)	4.41	3.25
Capital per worker (K/L)	\$210,432	\$274,080
Employment rate (L/POP)	0.500	0.508

The numbers come from the Penn World Tables, Version 7.0. All of them are for 2007.

- (a) What is the ratio of GDP per person in the two countries (Korea over US)? (5 points)
- (b) Use the production function to derive total factor productivity (TFP) in each country from the numbers in the table. What is the ratio of the two countries? How does it compare to the ratio you computed in (a)? (10 points)
- (c) Overall, what factors contribute to the difference in GDP per person? How important is capital? What would the GDP ratio be if the capital-output ratio in Korea equalled that of the US? (10 points)

- (d) You have heard that Koreans work exceptionally long hours. The OECD reports that the average employee in Korea worked 2266 hours in 2007, while the average American worked only 1799 hours. How would this information change your calculation of TFP? How does it change your assessment of the relative productivity of Korea and the US? (10 points)

**Solution:** Brief answers follow. See the spreadsheet for the calculations.

- (a) The ratio is  $0.556 = 23.850/42.887$ : Korea has, by this measure, a living standard equal to 55.6% of the US's. The rest of the question is devoted to explaining the sources of this difference.
- (b) We compute productivity the usual way: if the production function is  $Y/L = A(K/L)^\alpha$  then  $A = (Y/L)/(K/L)^\alpha$  where (as usual)  $\alpha = 1/3$ . The ratio of productivities is  $0.618 = 8.023/12.984$ , which is a bit higher than the ratio of GDP per capita.
- (c) What we had in mind was two level comparisons, one with the given capital data, the other when we give Korea the same capital-output ratio as the US. The traditional level comparison gives us

$$\begin{aligned}\frac{(Y/POP)_K}{(Y/POP)_{US}} &= \left( \frac{(L/POP)_K}{(L/POP)_{US}} \right) \left( \frac{A_K}{A_{US}} \right) \left( \frac{(K/L)_K}{(K/L)_{US}} \right)^{1/3} \\ &= 0.984 \times 0.618 \times 0.916 = 0.556.\end{aligned}$$

The second comparison is optional. The idea is to redo the calculation when Korea's capital-output ratio is the same as the US. Since the ratio is  $1.357 = 4.41/3.25$ , we divide Korea's  $K/L$  by 1.357. The new calculation (a "counterfactual") gives us

$$\frac{(Y/POP)_K}{(Y/POP)_{US}} = 0.984 \times 0.618 \times 0.827 = 0.503.$$

Note that only the last term changes. This tells us that the lower capital-output ratio drops GDP per person to 0.503.

- (d) This question is intentionally more demanding. We modify the production function to include hours of work. There's more than one route to this answer, among them  $Y/L = A(K/L)^\alpha h^{1-\alpha}$  and  $Y/hL = A(K/hL)^\alpha$ . Either way, productivity ("corrected" for hours worked) is now 0.0465 in Korea and 0.0878 in the US (the use of hours data changes the units). The ratio is 0.530, well below our earlier calculation of 0.618. In words: part of what we attributed to productivity before was really long hours. Put another way: Korea looks better (relative to the US) in a comparison of output per worker than in a comparison of TFP, because output per worker includes a contribution from long hours.

2. Argentina and Chile (35 points). Argentina and Chile have each experienced dramatic growth and painful reversals over the last century. Argentina was one of the richest countries in the world in 1900, but mixed economic performance since then has dropped it back into the world of emerging markets. Chile suffered a traumatic change in government in the 1970s, but emerged a decade later as a fast-growing democracy. Chile now has the highest per capita GDP in Latin America. Your mission is to tell us how — and maybe why — their experiences have differed.

Country	Year	POP	Employment	Y/POP	K/POP
Argentina	1960	20.6m	8.1m	7,838	12,713
Argentina	2004	39.1m	16.2m	10,939	24,343
Chile	1960	7.59m	2.55m	5,086	16,666
Chile	2004	15.67m	6.57m	12,678	29,437

In the table, POP is population (millions), Employment is the number of people working (millions), Y/POP is per capita GDP (2000 US dollars), and K/POP is per capita capital (2000 US dollars). Data are from the Penn World Tables, version 6.3.

- Compute the (average annual continuously compounded) growth rates of GDP per capita and GDP per worker in the two countries over the period reported in the table. (10 points)
- Use our growth accounting methodology to allocate growth in output per worker to growth in TFP and capital per worker. Which factor has been most important over the last 40+ years? (15 points)
- Use the World Bank's [Governance Indicators](#) to comment on the differences in the political environment between the two countries. (Click on the chart for each country for a nice visual summary.) What role do you think these institutional differences played in the countries' economic performance? (10 points)

**Solution:** GDP per capita in Chile has gone from well below Argentina in 1960 to significantly above in 2004. How did this happen? Most of this problem is concerned with aggregate data: how much comes from capital, TFP, etc? The last part is an opportunity to look further into features of the two economies that might account for what we find in the production function numbers.

- The (continuously compounded annual) growth rate of GDP per capita for Argentina is

$$\gamma = \log(10,939/7,838)/(2004 - 1960) = 0.758\%. (!)$$

(We give 3 digits here to allow you to compare your own numbers, but it's excessive accuracy, not justified by the quality of the data.) Refer to the discussion of growth rates in "Sources of Growth" if you're not sure why this works.

A similar calculation gives us 2.076% for Chile. GDP per worker is GDP per capita times the population then divided by the number of workers. Its growth rates are 0.639% (Argentina) and 1.572% (Chile). Bottom line: faster growth in Chile, in part because a larger fraction of the population is working.

(b) We use the production function

$$Y/L = A(K/L)^{1/3},$$

so TFP is  $A = (Y/L)/(K/L)^{1/3}$ . In growth rates, with the adjustment for employment, this translates into

$$\gamma_{Y/POP} = \gamma_{L/POP} + \gamma_A + \alpha\gamma_{K/L},$$

where  $\alpha = 1/3$  as usual. This allows us to decompose growth in per capita GDP into components due to the employment rate, productivity, and capital per worker. A few calculations give us

	$Y/POP$	$L/POP$	$A$	$K/L$
<i>Argentina</i>				
Growth rate (%)	0.758	0.119	0.186	1.358
Contribution to growth (%)	0.758	0.119	0.186	0.453
<i>Chile</i>				
Growth rate (%)	2.076	0.503	1.309	0.789
Contribution to growth (%)	2.076	0.503	1.309	0.263

Here “growth rate” is computed as in (a) and multiplied by 100 to give us a percentage. “Contribution” modifies these growth rates as they occur in the formula: the growth rate of  $K/L$  gets multiplied by  $\alpha = 1/3$  (its exponent in the production function). The numbers tell us that most of the difference in growth reflects differences in TFP growth.

The question calls for a slightly simpler calculation: to compute the components in growth of GDP per worker. It’s the same, except we skip the growth rate of  $L/POP$ . In Argentina, for example, the growth rate of GDP per worker (0.639%) consists of growth in capital per worker (0.453%) and growth in TFP (0.186%).

(c) The World Bank’s Governance Indicators include these percentile ranks:

	Argentina	Chile
Voice and accountability	57.3	82.0
Political stability	45.3	67.5
Govt effectiveness	46.9	83.7
Regulatory quality	26.8	91.4
Rule of law	32.7	87.7
Control of corruption	39.7	90.9

Almost all of the institutional indicators are stronger for Chile than Argentina, so perhaps it's not surprising that economic performance has been better. Much of this has come in the last 25 years, as Chile has reestablished a stable democracy with sensible economic policies. Argentina continues to fluctuate between policies that favor long-term performance and those that focus on the short term to the detriment of the long term.

Our belief is that the strong economic and political foundations Chile has laid will continue to generate higher growth than we'll see in Argentina. For one thing, we've had different parties in power over the last 20 years, yet the same basic economic policies have been followed. One we find intriguing is a privatized social security system, which helped them develop a domestic capital market.

A temporary factor is copper prices, which play an unusually important role in Chile. It's a tricky measurement issue, since high prices tend to show up as high GDP and therefore high TFP. History tells us that probably won't last. With that in mind, the government saved revenue from copper for several years, despite intense political pressure to spend it. When the crisis hit, they had a pot of money they could use to mitigate its effects.

3. Labor market conditions (30 points). Your first day on the job at General Electric, you are given 4 hours to collection information for a 5-minute presentation to your group summarizing the labor market conditions a manufacturer would face in Brazil, Poland, and Singapore. Once you get over your initial panic, you contact your Global Economy professor, who suggests you look at the [resource page](#), especially

- The Bureau of Labor Statistics' [International Labor Comparisons](#) page includes wage rates in a number of different countries, collected on a comparable basis. Click on a country name to get a summary table.
- The World Bank's [Global Development Indicators](#) includes information about the education and literacy of the population.
- The World Bank's Doing Business website includes institutional information about the labor market, labeled [Employing Workers](#).

Use this information to put together a short report summarizing labor market conditions in these three countries.

**Solution:** The basic tradeoff here is between cost (the wage data) and quality, including the quality of the institutions in which you'd be operating. Here's a table:

	Brazil	Poland	Singapore
Hourly compensation (USD)	10.08	8.01	19.10
Literacy of adults (%)	90	100	95
Primary school enrollment (%)	127	97	—
Secondary school enrollment (%)	101	97	—
Minimum wage (monthly, USD)	300	386	—
Severance (weeks, 20 years experience)	33.3	0	0
Strictness of employment protection (index)	2.75	1.9	—
Average years of school	4.9	9.7	7.0

The lines represent different sources; in the order they appear, BLS, World Bank, Doing Business, OECD, and UN via Nationmaster.

A quick summary:

- Singapore: educated workers, flexible labor market, most expensive.
- Brazil: the least educated of the three, also the least flexible labor market, but less expensive.
- Poland: similar cost to Brazil, better educated workers, somewhat more flexible labor market.