Lecture Note on the Growth and Development

Econ 570

Spring 2004

1. Some Empirics

A key point about economic growth is how recent it is, at least in the modern sense. To see this note the vivid description of Jones:

> Conservative estimates suggest that humans were already distinguishable from other primates 1 million years ago. Imagine placing a time line corresponding to this million year period along the length of a football field. On this time line, humans were hunters and gatherers until the agricultural revolution, perhaps 10,000 years ago that is, for the first 99 yards of the field. The height of the Roman empire occurs only 7 inches from the right most goal line, and the Industrial Revolution begins less than one inch from the field's end. Large, sustained increases in standards of living have occurred during a relatively short time equivalent to the width of a golf ball resting at the end of a football field.

We thus need to distinguish *modern economic growth* (Kuznets) from the period of Malthusian stagnation. In the latter, growth was slow as per-capita income growth led to population increase. That is why the growth rate of per-capita income is so low prior to 1800 in figure 1.3. In the post-Malthusian period we see rapid economic growth, due to technological change, and *positive* feedback. Something clearly changed. That is why we think of modern economic growth.

Should one theory explain both?

Now some would argue that it is all determined by nature:

- e.g., Diamond, who argues that geographic determinants are crucial – "the striking differences between the long-term histories of peoples of the different continents have been...[due to]...differences in their environment (405)." He links modern prosperity to the conditions for the emergence of agriculture in Neolithic times.

- Sachs shares the strong geographical position, emphasizing disease environments, transport costs. He emphasizes the strong role of coastlines.

But these theories do not explain the dramatic changes in the fortunes of regions in recent periods. Consider the following table, figure 1.1 from Maddison, which compares two groups of countries and looks at per-capita GDP over very long horizons. The two groups are Western Europe, Western European offshoots (like the US, Canada, Australia), and Japan. Group B is everyone else: Latin America, Eastern Europe and FSU, Asia excluding Japan, and Africa.

Table 1–9b. Level of Per Capita GDP, Groups A and B, 1000–1998
(1990 international dollars)

	1000	*1500*	*1600*	*1700*	*1820*	*1998*
Average Group A	405	704	805	907	1 130	21 470
Average Group B	440	535	548	551	573	3 102

Figure 1.1:

Notice that per-capita income levels start to diverge somewhere between 1000 and 1500, but that the key period is that last.[1] That is when the differences become very significant. Figure 1.2 is very instructive in this regard.

The key point here is that the rise of the West is very recent. One always wants to know why China lost its advantage? We want to know why Japan has grown so fast since Meiji restoration. This is where the Diamond-type arguments fail. It cannot explain how, *within* the temperate zones, economic performance is so varied.

To reinforce the lessons of 1.2 we can look at per-capita output in Western Europe for the last 2000 years [figure 1.3]. This suggests how recent the takeoff

[1] This reflects modern consensus, as opposed to the Bairoch claim that China was well ahead of Western Europe in 1800. The key point of this debate is whether Western Europe was richer than other areas when colonization started. It seems that it was.

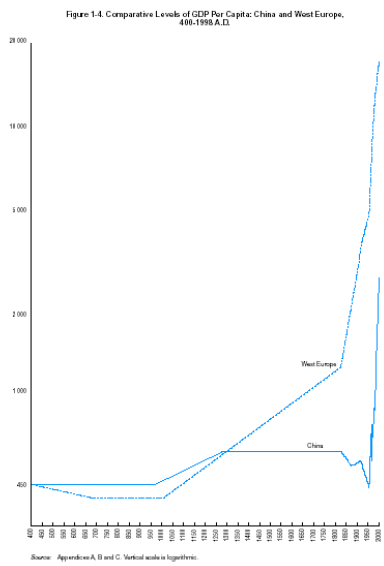

Figure 1.2: China and Western Europe, 400 to 1998

really is. The sharp impression from figure 1.3 is that of a sharp break. There is a fundamental non-convexity here that occurs somewhere in the 19th century. It is the most dramatic qualitative change in human history since at least the start of the bronze age.

Another way to think about this is cross-country at a point in time.

In 1960, for example, for 113 countries for which gdp per-capita was available at PPP, the riches country Switzerland ($14,980) was 39 times higher than the poorest, Tanzania ($381). The mean was $3390 (1996 dollars). The richest country was 39 times the poorest. By 2000 we have date for 150 countries, and the dispersion has grown as has the mean ($8490). The richest, Luxembourg is 91 times that of Tanzania ($482).[2] The US is second ($33,350) and this is 69 times Tanzania. So dispersion has grown (std deviation of the log of gdp increased from 0.89 to 1.12.

This about this. If Tanzania were to grow at the long-term US growth rate of 1.8% (1870 to 2000) it would take *235 years* to reach the 2000 level of US gdp. At the Japanese growth rate of 2.75% it would take *154* years.

[2] Actually the Democratic Republic of Congo is poorer, but there is no data.

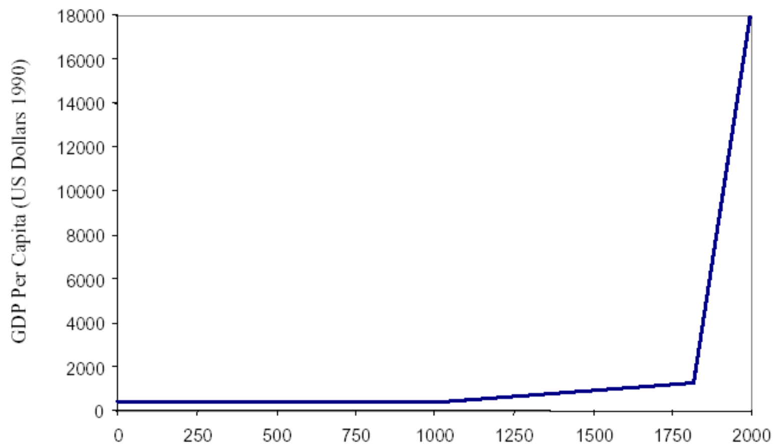

Figure I(a)
Output Per Capita in Western Europe in the year 0- 2000
Data source: Maddison [2001]

Figure 1.3: Per-Capita Output in Western Europe

Comparing 1960 with 2000 we can see that 16 countries had negative growth rates of real per-capita gdp (DRC, Central African Republic, Niger, Angola, Nicaragua, Mozambique, Madagascar, Nigeria, Zambia, Chad, Comors, Venezuela, Senegal, Rwanda, Togo, Burundi, Mali). All but Nicaragua and Venezuela were in sub-Saharan Africa. Of course, if not for missing data there would be more: data are more likely to missing from those that do worst.

- one thing to note about this list is that none of these countries with negative growth rates is rich, they are all relatively low income

- the oil shock increased the variation in growth rates as it reduced average levels

- another thing is that if we had split the sample: 1960-72 and 1973-2000, only one country had a large (-3%) negative growth rate in the first period (Burundi), several in the second (Nicaragua over -4% and four over -3%); a total of 32 countries had negative growth rates for this sub-sample.

Several countries also had growth rates over 5% during this period, and really moved up in the rankings: Taiwan, Singapore, South Korea, Hong Kong, Botswana, Cyprus, Thailand. China has done real well for half the period.

So the differences in performance over 40 years are huge. The problem is to explain why.

Let us start with some of the *new* stylized facts of growth.

SF 1 *Factor accumulation does not account for the bulk of cross-country differences in the level or growth rate of GDP per capita. Rather it is TFP, whatever that means.*

TFP growth is the great free lunch. With the same inputs we get more output. In the Solow model it is really manna from heaven. Now we want to endogenize it. But first we need to document its importance.

1.1. Lucas Paradox

The key question of growth and development economics is how to combine the notion of increasing returns – which is critical to raising per-capita incomes – with diminishing returns which is the key to explaining allocation. The Solow model explains this with exogenous technical change. But this is unsatisfying for economists, precisely because it is exogenous.

The Lucas paradox is a good way to start thinking about this. Consider the standard production function in intensive form:

$$y = Ak^{\beta}. \tag{1.1}$$

TFP is represented by A? Countries differ not only in their capital-labor ratios but in their levels of productivity as well. Suppose this were not the case. India's per-capita income is about $\frac{1}{15}$ that of the US. If $A_{India} = A_{US}$, it follows that

$$15 = \frac{k_{US}^{\beta}}{k_{India}^{\beta}}$$

Now a good estimate of β (capital's share of national income) would be 0.4 (a rough average of the two countries). This would imply that the capital-labor ratio in the US is $15^{2.5} \approx 871$. This is obviously way too high. It would imply that we save at a rate 800 times that of India. Since our savings rate may be 17% we know this cannot be true. Moreover, if the capital labor ratio were really this much higher in the US than in India, the return to capital in India would be about 58 times higher.

Why? To see this, note that if we ignore A, the marginal product of capital per worker is $r = \beta k^{\beta-1}$. From expression 1.1 it follows that $k = y^{1/\beta}$. Now using this in the expression for r, we obtain $r = \beta y^{\frac{\beta-1}{\beta}}$. Since $y_{US} = 15 * y_{India}$, we have $r_{India} = r_{US} 15^{\frac{3}{2}}$. Now $15^{1.5}$ is about 58, so the rate of return would have to be 58 times higher in India than the US.[3] But this should mean that capital should flow from the US to India. Some does, but not that much.[4] Why? One reason could be TFP differences: $A_{India} < A_{US}$ would alter the rate of return calculation.[5] Explaining these differences is one of the most important issues in development economics. But we will ignore them here (for the most part).

Notice that because it is measured as a residual, it is really many things, that include real technological advances, real cost reduction (Harberger, [**?**]), improvements in institutions and policies.

This is an exercise in growth accounting. Some results across regions are given in table 1.4. Note the importance of TFP growth in the advanced countries and the lesser role in the Tigers.

The results of Alwyn Young [**?**] called this into question for Asian Tigers. His well-known claim is that factor accumulation played a much larger role in these cases. This immediately raises the question of why they did not succumb to the extensive growth trap that the Soviet Union could not escape from. One explanation might be that capital flowed primarily into exporting sectors of the economy. Since these were small open sectors they did not encounter diminishing returns. A second point could be that financial institutions prevented really bad investments (this was easier to say before the Asian crisis).

But the interpretation of his results may be wrong.

- First, interest is in per-capita growth not output growth.

[3] To see this, note that if we ignore A, the marginal product of capital per worker is $r = \beta k^{\beta-1}$. From expression 1.1 it follows that $k = y^{1/\beta}$. Now using this in the expression for r, we obtain $r = \beta y^{\frac{\beta-1}{\beta}}$. Since $y_{US} = 15 * y_{India}$, we have $r_{India} = r_{US} 15^{\frac{3}{2}}$. Now $15^{1.5}$ is about 58, so the rate of return would have to be 58 times higher in India than the US.

[4] This is sometimes referred to as the Lucas Paradox. Robert Lucas first pointed out that capital flows to developing countries were too small compared with predictions of standard economic models.

[5] You can see this by taking the opposite assumption: $r_{US} = r_{India}$, and letting differences in A explain the higher US output.

Table 1: Selected Growth Accounting Results for Individual Countries

	α	GDP Growth	Share Contributed by: Capital	Labor	TFP
OECD 1947-73					
France	0.40	5.40%	41%	4%	55%
Germany	0.39	6.61%	41%	3%	56%
Italy	0.39	5.30%	34%	2%	64%
Japan	0.39	9.50%	35%	23%	42%
United Kingdom	0.38	3.70%	47%	1%	52%
United States	0.40	4.00%	43%	24%	33%
OECD 1960-90					
France	.42	3.50%	58%	1%	41%
Germany	.40	3.20%	59%	-8%	49%
Italy	.38	4.10%	49%	3%	48%
Japan	.42	6.81%	57%	14%	29%
United Kingdom	.39	2.49%	52%	-4%	52%
United States	.41	3.10%	45%	42%	13%
Latin America 1940-1980					
Argentina	0.54	3.60%	43%	26%	31%
Brazil	0.45	6.40%	51%	20%	29%
Chile	0.52	3.80%	34%	26%	40%
Mexico	0.69	6.30%	40%	23%	37%
Venezuela	0.55	5.20%	57%	34%	9%
East Asia 1966-90					
Hong Kong	0.37	7.30%	42%	28%	30%
Singapore	0.53	8.50%	73%	32%	-5%
South Korea	0.32	10.32%	46%	42%	12%
Taiwan	0.29	9.10%	40%	40%	20%

OECD figures from Christenson, Cummings, and Jorgenson (1980) and Dougherty (1991)
Latin American figures from Elias (1990).
East Asia figures from Young (1994).

Figure 1.4: Growth Accounting

- Second, and much more important, some capital accumulation is induced by productivity growth. Suppose $y = Ak^{\alpha}$ then if there is a productivity shock – i.e., a shock to A then the marginal product of capital increases and this raises capital accumulation. But this should be attributed to productivity growth not factor accumulation. But if growth in capital is taken as exogenous then this is ignored.

To see the problem more clearly, suppose that output and capital are growing at rate x. Using growth accounting we attribute ax of the steady state output growth to capital and $(1-\alpha)x$ to TFP. Now in the standard Solow model with exogenous technical change, in the absence of TFP output and capital do not grow at all. So *in a clear sense* we are under-valuing the role of TFP in generating this growth. It only occurred due to TFP. The problem is that the growth of capital is *endogenous* but growth accounting treats it as *exogenous.* Now if TFP itself is truly exogenous then one could say that differences in TFP show up one-for-one in differences in output growth.

This could help explain the difference with the Soviet case. In that case factor accumulation was high in the face of negative productivity shocks – the economy was becoming less efficient. In the Asian Tigers case there were positive productivity shocks that allowed capital accumulation to proceed at very fast rates without reducing returns.

Growth accounting exercises thus suggest that TFP plays the major role in explaining per-capita output growth. This is evident in figure 1.5 from Easterly and Levine. Notice that TFP is more important in the fastest growing countries. How to interpret the group of countries with positive growth in capital-per worker but negative TFP growth (and hence negative output growth)? Clearly it is not technical regress. More likely, it is very bad policies which cause inputs to be used much less efficiently than before. Increases in transaction costs would be one example.

What happens when human capital accumulation is added to the investigation? Very little.

1.1.1. Variance Decomposition

Easterly and Levine perform a variance decomposition to see how much of the variation in the growth of per capita output, y, is explained by factor accumulation versus TFP growth. Start with $y = Ak^{\alpha}$, and let $\alpha = 0.4$. Taking logs

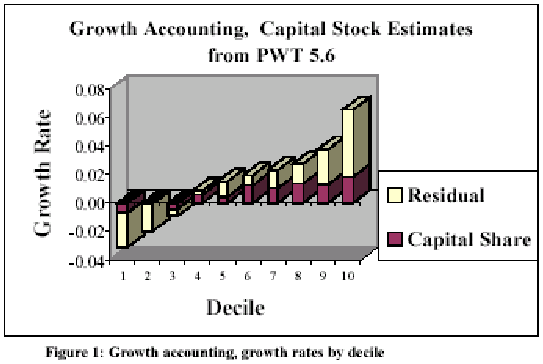

Figure 1.5: Growth Accounting by Country Groups

and differentiating with respect to time we have the familiar growth accounting expression:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + 0.4\frac{\dot{k}}{k}$$

so the variance of output growth can be written as:

$$var\left(\frac{\dot{y}}{y}\right) = var\left(\frac{\dot{A}}{A}\right) + (0.4)^2\left[var\left(\frac{\dot{k}}{k}\right)\right] + 2(0.4)\left[cov\left(\frac{\dot{A}}{A}, \frac{\dot{k}}{k}\right)\right] \tag{1.2}$$

One can also consider human capital by looking at factor accumulation per worker, f, defined as $\frac{\dot{f}}{f} = \frac{\left(\frac{\dot{y}}{y}+\frac{\dot{h}}{h}\right)}{2}$ where h is educational attainment per worker. Expression (1.2) is now:

$$var\left(\frac{\dot{y}}{y}\right) = var\left(\frac{\dot{A}}{A}\right) + (0.7)^2\left[var\left(\frac{\dot{f}}{f}\right)\right] + 2(0.7)\left[cov\left(\frac{\dot{A}}{A}, \frac{\dot{f}}{f}\right)\right]$$

The results are given in table 1.6 for both estimations. Notice that TFP growth accounts for almost 60% of the variation in growth rates, and that factor accumulation alone is not that important, at least in the 1980-1992 period.

Table 2: Variance Decomposition

I. Without human capital

(60 non-oil countries)	g(tfpk)	Contribution of: g(k)	cov[g(tfpk), g(k)]
(a) 1960-1992:	0.58	0.41	0.01
(b) 1980-1992:	0.65	0.21	0.13

II. With human capital

	g(tfpkh)	Contribution of: g(kh)	cov[g(tfpkh), g(kh)]
(a) 1960-1992 (44):	0.94	0.52	-0.45
(b) 1980-1987 (50):	0.68	0.20	0.12

Figure 1.6: Variance Decomposition

2. Development Accounting

Development accounting is the analog for levels to growth accounting. The latter shows how input growth and tfp growth determine differences in growth rates. The former tries to explain differences in levels of income.

Suppose we relate income to factors and efficiency:

$$Y_i = F(I_i, E_i)$$

if factors explain differences then the problem for development is to explain low accumulation – this is the classical development approach. If differences in efficiency are critical then we have to figure that out. The analytical problem is how to specify the functional form, and how to carefully measure inputs. Think of the Solow residual. When Solow first estimated his growth equation most of the effect was due to technological change. As we measure inputs better the impact of technical change is reduced. For example, accounting for improvements in the quality of labor and other inputs. Similar effect may be critical for development.

This approach was pioneered by Hall and Jones. Hall and Jones [**?**] show that cross-country productivity differences, measured in levels, are large, and cannot be explained by differences in input use, both physical and human.

Let output be produced according to Cobb-Douglas production function:

$$Y_i = K_i^{\alpha}(A_i H_i)^{1-\alpha} \tag{2.1}$$

where H_i is the amount of human capital-augmented labor used in production, and A_i is a labor-augmenting measure of productivity. The former is given by $H_i = e^{\phi(E_t)} L_i$, where the function (E) reflects the efficiency of a unit of labor with E years of schooling relative to one with no schooling ($\phi(0) = 0$).[6] The derivative $\phi'(E)$ is the return to schooling estimated in a Mincerian wage regression: an additional year of schooling raises a worker's efficiency proportionally by $\phi'(E)$. We can re-write (1) in terms of output per worker

$$y_i = \left(\frac{K_i}{Y_i}\right)^{\frac{\alpha}{1-\alpha}} h_i A_i \tag{2.2}$$

where $h \equiv \frac{H}{L}$. The nice thing about (2.2) is that we can use it to decompose differences in output per worker into differences in capital-output ratios, levels of human capital, and levels of productivity.[7]

Hall and Jones use data from 1988 to measure productivity differences, using Penn World Tables. They correct for natural resource endowments by subtracting value added from mining from GDP. This prevents Saudi Arabia from being the world leader in productivity.[8] They use a value of $\alpha = \frac{1}{3}$, and assume that ϕ is

[6] The rationale for this functional form is as follows. Given our production function, perfect competition in factor and good markets implies that the wage of a worker with s years of education is proportional to his human capital. Since the wage-schooling relationship is widely thought to be log-linear, this calls for a log-linear relation between h and s as well, or something like $h = e^{\phi(E)}$, with ϕ a constant. However, international data on education-wage profiles (Psacharopulos, 1994) suggests that in Sub-Saharan Africa (which has the lowest levels of education) the return to one extra year of education is about 13.4 percent, the World average is 10.1 percent, and the OECD average is 6.8 percent. Hall and Jones's measure tries to reconcile the log-linearity at the country level with the convexity across countries.

[7] Notice the use of capital output ratio rather than capital-labor ratio. This follows the lead of David (1977), Mankiw et al. (1992) and Klenow and Rodriguez-Clare (1997) in writing the decomposition in terms of the capital-output ratio rather than the capital-labor ratio, for two reasons. First, along a balanced growth path, the capital-output ratio is proportional to the investment rate, so that this form of the decomposition also has a natural interpretation. Second, consider a country that experiences an exogenous increase in productivity, holding its investment rate constant. Over time, the country's capital-labor ratio will rise as a result of the increase in productivity. Therefore, some of the increase in output that is fundamentally due to the increase in productivity would be attributed to capital accumulation in a framework based on the capital-labor ratio.

[8] Is this procedure really correct? This rationale is inherently dubious (then why not substracting the value added of agriculture and forestry, that also use natural resources abundantly?).

piecewise linear.[9]

This analysis shows that productivity levels and output per worker are highly correlated. Figure 2.1 plots these in logs.

Figure 1: Productivity and Output per Worker

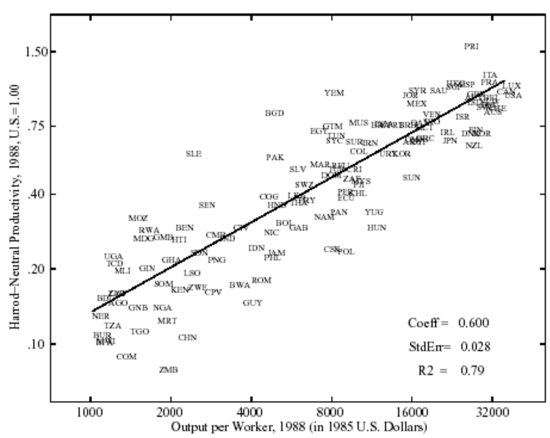

Figure 2.1: Productivity and Output Per Worker

From table 2.2 we can see the role of productivity differences in explaining output differences. Notice that the values are ratios to US levels.

To see what goes on in this table look at the row for the Soviet Union. In the Soviet Union investment was extremely high as was the capital-output ratio. In addition, human capital intensity was also high. But it also had a rather low productivity level.

For the developing countries in the table, differences in productivity are the most important factor in explaining differences in output per worker. For example, Chinese output per worker is about 6 percent of that in the United States, and the bulk of this difference is due to lower productivity: without the difference in

[9] With respect to human capital, Psacharopoulos (1994) surveys evidence from many countries on return-to-schooling estimates. Based on his summary of Mincerian wage regressions, we assume that (E) is piecewise linear. Specifcally, for the first 4 years of education, we assume a rate of return of 13.4 percent, corresponding to the average Psacharopoulos reports for sub-Saharan Africa. For the next 4 years, we assume a value of 10.1 percent, the average for the world as a whole. Finally, for education beyond the 8th year, we use the value Psacharopoulos reports for the OECD, 6.8 percent.

Table 1: Productivity Calculations: Ratios to U.S. Values

		——Contribution from——		
Country	Y/L	$(K/Y)^{\alpha/(1-\alpha)}$	H/L	A
United States	1.000	1.000	1.000	1.000
Canada	0.941	1.002	0.908	1.034
Italy	0.834	1.063	0.650	1.207
West Germany	0.818	1.118	0.802	0.912
France	0.818	1.091	0.666	1.126
United Kingdom	0.727	0.891	0.808	1.011
Hong Kong	0.608	0.741	0.735	1.115
Singapore	0.606	1.031	0.545	1.078
Japan	0.587	1.119	0.797	0.658
Mexico	0.433	0.868	0.538	0.926
Argentina	0.418	0.953	0.676	0.648
U.S.S.R.	0.417	1.231	0.724	0.468
India	0.086	0.709	0.454	0.267
China	0.060	0.891	0.632	0.106
Kenya	0.056	0.747	0.457	0.165
Zaire	0.033	0.499	0.408	0.160
Average, 127 Countries:	0.296	0.853	0.565	0.516
Standard Deviation:	0.268	0.234	0.168	0.325
Correlation w/ Y/L (logs)	1.000	0.624	0.798	0.889
Correlation w/ A (logs)	0.889	0.248	0.522	1.000

Note: The elements of this table are the empirical counterparts to the components of equation (3), all measured as ratios to the U.S. values. That is, the first column of data is the product of the other three columns.

Figure 2.2: Productivity Calculations

productivity, Chinese output per worker would be more than 50 percent of U.S. output per worker.

The bottom half of Table 1 reports the average and standard deviation of the contribution of inputs and productivity to differences in output per worker. According to either statistic, differences in productivity across countries are substantial. A simple calculation emphasizes this point. Output per worker in the very countries in 1988 with the highest levels of output per worker was 31.7 times higher than output per worker in the very lowest countries (based on a geometric average). Relatively little of this difference was due to physical and human capital: differences in capital intensity and human capital per worker contributed factors of 1.8 and 2.2, respectively, to the difference in output per worker. Productivity, however, contributed a factor of 8.3 to this difference: with no differences in productivity, output per worker in the very richest countries would have been only about four times larger than in the very poorest countries. In this sense, differences in physical capital and educational attainment explain only a modest amount of the difference in output per worker across countries.

The reason for the lesser importance of capital accumulation is that most of the variation in capital-output ratios arises from variation in investment rates. Average investment rates in the very richest countries are only 2.9 times larger than average investment rates in the very poorest countries. Moreover, this difference gets raised to the power $\frac{\alpha}{1-\alpha}$ which for a neoclassical production function with $\alpha = 1/3$ is only 1/2 so it is the square root of the difference in investment rates that matters for output per worker. Similarly, average educational attainment in the very richest countries is about 8.1 years greater than average educational attainment in the very poorest countries, and this difference also gets reduced when converted into an effect on output: each year of schooling contributes only something like 10 percent (the Mincerian return to schooling) to differences in output per worker. Given the relatively small variation in inputs across countries and the small elasticities implied by neoclassical assumptions, it is hard to escape the conclusion that differences in productivity the residual play a key role in generating the wide variation in output per worker across countries.

2.1. Caselli Decomposition

Caselli alters the decomposition. Rather than use (2.2) he uses

$$y_i = A_i k^{\alpha} h^{1-\alpha} \equiv A_i y_{kh}. \tag{2.3}$$

The reason is that the impact of differences in A are cleaner – the Hall and Jones measure is not invariant to differences in tfp since A affects y.[10] This measure allows one to ask quite strictly, what would the world income distribution look like if all countries had the same level of A.

Using (2.3) we can decompose the variance in $\log y$ as

$$var[\log y] = var\left[\log(y_{kh}) + var(\log(A)\right] + 2cov\left[\log(A), \log(y_{kh})\right]. \quad (2.4)$$

If all countries have the same level of A, then the $var(\log A)$ =0, thus one measure of success would be

$$success_1 = \frac{var \log(y_{kh})}{var[\log y]}$$

Caselli uses PWT6.0 to estimate this counterfactual and finds $var \log(y_{kh}) = 0.5$, and the observed $var[\log y] = 1.25$, so $success_1 = 0.4$. The only problem with this measure is that it is sensitive to outliers, so it may be useful to look at inter-percentile differences. He defines

$$success_2 = \frac{y_{kh}^{90}/y_{kh}^{10}}{y^{90}/y^{10}}$$

where y^x is the x_{th} percentile of the distribution of y. In the data the value of the $y_{kh}^{90}/y_{kh}^{10} = 7$, and the value of $y^{90}/y^{10} = 20$, so the value of $success_2 = 0.35$.

Notice that with either measure the variance of $\log y$ is much greater than the variance of $\log y_{kh}$ which is why there is so much interest in TFP differences. But it is interesting that there is also some significant variation in y_{kh} as well. We will return to this when we talk about the relative price of investment, for example.

2.1.1. Subsamples

It is interesting to look at subsamples. Consider table 2.3. We observe that the variance in per-capita income is lower in richer countries – this is obvious. In Africa – the poorest regions – the variance is highest. More important, it is clear that the simple model explains richer countries better than poorer countries (compare the above and below median success variable, for example).

The one apparent puzzle is Europe – but that is entirely due to the inclusion of Romania, which has high human capital but low per-capita income. It has the typical transition legacy. If you drop Romania Europe looks like the Americas.

[10] Obviously $\left(\frac{k}{y}\right)^{\frac{\alpha}{1-\alpha}} h = k^\alpha h^{1-\alpha} A^{-\alpha}$.

Sub-sample	Obs.	var[log(y)]	var[log(y_{KH})]	$success_1$
Above the median	47	0.174	0.112	0.643
Below the median	46	0.586	0.257	0.438
OECD	24	0.077	0.047	0.606
Non-OECD	69	1.001	0.378	0.376
Africa	26	0.843	0.271	0.322
Americas	25	0.341	0.175	0.513
Asia and Oceania	25	0.652	0.292	0.448
Europe	17	0.128	0.033	0.255
All	93	1.246	0.501	0.400

Figure 2.3: Success in Subsamples

One conclusion from this exercise is that the factors only model works *worst* where we need it *most* – in the poorest regions.

2.2. Chipping Away

Can we chip away at the differences? That is, can we improve the fit of the factor-only model to reduce the impact of A? Notice first, that one important variable is α. Since countries differe more in terms of k than in terms of h, if you have a higher capital share you can explain more of the cross country differences. If capital received 60% of income you could do pretty well. But this is just too high.

2.2.1. Human Capital Adjustments

There are various issues here. First what are we really measuring.There are two views of human capital:

1. typical view: resource cost incurred in learning the world's stock of knowledge. i.e., as a factor of production

2. alternative view: human capital allows one to absorb new techniques at lower cost (Nelson and Phelp, 1968). On this view schooling is learning how to learn; not that much of what is learnt is useful

Hard to say which view is correct. Econometric evidence indicates that human capital has negligible effects on productivity, but is positively associated with *improvements* in productivity.[11]

On the second view low human capital impedes the ability to follow. But perhaps causation runs the opposite way: when the conditions exist for entrepreneurship and innovations there is a large demand for human capital to implement these innovations.

Klenow [**?**] conducted an interesting test of these two hypotheses using US data on manufacturing industries. He noted that if the rival human capital story is correct then those industries where labor intensity is high should have higher productivity growth. Higher labor intensity would signal more human capital accumulation. If the Romer idea is correct, on the other hand, then industries with

[11] In Communist economies human capital was high and productivity was low, but so was the growth rate of productivity.

low labor intensity, and high capital intensity would have the higher productivity growth.

Klenow tested this using growth rates (1959-1991) for 449 4-digit US manufacturing industries. He found that TFP growth is faster in the industries that are more intensive in capital and intermediate goods, and less intensive in labor – favoring the idea models.[12]

A second big issue is measurement.

First, results are sensitive to how. M-R-W used secondary school enrollment. This varies more across countries than other measures, so it explains more. Klenow and Rodriguez-Clare added primary school enrollment, for example, and this reduced the explanatory power of human capital. They also constructed an index that used returns to schooling with years of schooling. This also reduced the explanatory power of human capital.

Aside from this we have practical issues. First, not all human capital is identical.

Education Most adjustments to education do not account for the differences. For example, hours worked varies across countries, is *inversely* related to per-capita income. So accounting for this would actually raise labor input in the poor countries, and leave more to explain. Unemployment rates could differ, but there seems to be no pattern. Of course, underemployment may differ, but again this is probably higher in the poorer countries, so again it does not help.

2.3. Quality

The quality of human and physical capital may differ. Perhaps this can explain some of the difference. It could be that h is lower in poor countries, but this is hard to measure, and it does not seem to explain much.

The most important element could be health and nutrition. This could indicate that labor input is less in poorer countries. Weil (2001) uses as a proxy for health the Adult Mortality Rate (AMR), which measures the fraction of current 15 year old people who will die before age 60, under the assumption that age-specific

[12] Klenow uses an interesting analogy. This paper could have been typed on a 1970 typewriter. Correcting spelling errors would have been tedious using the human capital accumulated to type. Even using the human capital accumulated in the PhD program. But the word processing program made it trivially easy. No change in typing human capital, but ideas embedded in the pc and in the software dramatically improved productivity.

death rates in the future will stay constant at current levels. In practice, this is a measure of the probability of dying "young," and is therefore a plausible (inverse) proxy for overall health status. Suppose then that $h = A_h e^{\phi(E)}$ as before, but that

$$A_h = e^{\phi_{amr} AMR} \tag{2.5}$$

where $\phi_{amr} < 0$, since a higher adult mortality ratio means a less energetic workforce. Using Weil's preferred value for $-\phi_{amr}(x100)$ is 1.68. This allows for a big improvement in explanatory power of the factors only model – by at least one third. Weil's estimate puts a high value on health – equal to a year's human capital and thus a year's human capital worth of wages.[13] Is this too high? Hard to tell.

2.4. Social versus Private Returns

Note that the estimates of ϕ that are used measure private returns to schooling, but what is important for growth are social returns. What if there are externalities from a more educated workforce? The question is which way do they go?

- what if rent-seeking is higher in the poorer countries? Governments may employ graduates in poor countries to a greater extent than in rich countries. Then the social return might be lower in poor countries. This could mean that h is higher in rich countries and could explain income variation.

3. Quality of Physical Capital

It could be that physical capital varies in quality across countries. Since most countries import capital goods from a small number of countries it is possible to use imports of capital as a proxy for investment. Furthermore, the R&D content of investment goods differs as well, so this may proxy for the quality of capital goods.

[13] Weil uses published micro-level estimates from three developing countries to infer the elasticity of human capital to height. He then uses time series data from Korea and Sweden to estimate a relationship between height and the AMR. He then combines these two pieces of information to infer the elasticity of human capital to the AMR. In essence, he is using the AMR to predict height, and then applies to the predicted height the microeconomic estimate of the effect of height on wages.

Suppose that

$$Y = B\left[\sum_{p=1}^{P}(x_p)^{\gamma}\right]^{\frac{1}{\gamma}}, \gamma < 1 \tag{3.1}$$

where x_p are intermediate goods and B is a TFP term. Suppose further that intermediate goods are produced by

$$x_p = A_p(h_pL_p)^{1-\alpha}(K_p)^{\alpha} \; 0 < \alpha < 1 \tag{3.2}$$

where h_pL_p is human capital augmented labor in sector p, and A_p is TFP in that sector. The key assumption is that capital is heterogeneous: there are P distinct types of capital, and each type is product specific, in the sense that intermediate p can only be produced with capital of type p. The assumption that ■ < 1 implies that — in producing aggregate output — all these activities are imperfect substitutes.

Notice also that A_p is product specific – this implies that the embodied technology content of good p may be greater because the industry producing equipment of type p is more R&D intensive. With*in* a country the law of one price should be enough to insure that we are measuring physical differences. But in a cross-country setting we would also have to worry about the relative price of investment, which is differs across countries.

Now suppose that we can let $h_p = h$ for all sectors – labor is mobile. Then it is possible to write (3.1) as

$$Y = K^{\alpha}(hL)^{1-\alpha}B\left[\sum_{p=1}^{P}(A_p)^{\frac{\gamma}{1-(1-\alpha)\gamma}}(\xi_p)^{\frac{\alpha\gamma}{1-(1-\alpha)\gamma}}\right]^{\frac{1-(1-\alpha)\gamma}{\gamma}} \tag{3.3}$$

where $\xi_p = \frac{K_p}{K}$ is the share of the capital stock in sector p. The important point about this equation is evident if we compare this with the expression we have been using to explain output differences, something like: $Y = AK^{\alpha}(hL)^{1-\alpha}$. It is evident that (3.3) provides an expression for A in terms of the composition of the capital stock. This suggests, perhaps, that variation in equipment shares could imply variation in the quality of capital, and this could, over and above variation in the quantity of K explain income variations.

The only problem is that if you look at expression (3.3) you can see that it is extremely sensitive to variation in γ. And it is hard to know what the proper value is – recall this measures how difficult it is to substitute different types of capital.

Hence, it is hard to know if capital differences account for income variation. It could be the case, but with current data it is still too hard to tell. But it is a promising idea.

3.1. Public vs Private Capital

Another important point is that capital may differ in its productivity if it is the result of private or public investment. PWT does not distinguish. Government investment may not be as productive – rent-seeking. Or it could be more productive if there are large externalities – ala Aschauer. The important point, however, is that in poorer countries governments play a larger role in investment decisions. If poorer governments have more corruption or less effective cadres then we might expect capital to be less efficient in poorer countries.

If the data existed, one could re-calculate the capital stock in the manner of

$$K_t = I_{private,t} + \gamma I_{public,t} - \delta K_{t-1}$$

but it is hard to find such series. Moreover, you would have to deflate them appropriately for purchasing power. We will discuss some evidence on the productivity of state investment a bit later.

- Notice that what this exercise would be doing is to peer into the institutional differences that account for differences in A, since one reason we expect corruption to matter is the efficiency of investment

3.2. Sectoral Differences

Caselli also looks at sectoral and industry differences. For example, TFP could differ across industries and countries differ in the mix. Similarly, TFP could differ across sectors, and poor countries have larger agricultural sectors. But still one would want to know why the sectors or industries have different TFP's.

It is worth noting the interesting finding of Gregory Clark with respect to cotton mills: He examined the productivity of cotton mills around the world in the early years of the twentieth century. He shows that, assuming constant capital-labor ratios, the textile industries of Britain and New England would have had a huge cost disadvantage relative to India, Japan, and many other countries. Yet, British cotton textiles dominated export markets. Clark shows that the various countries' industries used identical equipment, and that the expertise to organize and run the mills could not have differed too much. Rather, the source of the productivity differences boils down to the fact that each English worker was willing to tend to a much larger number of machines. In low-productivity countries workers were idle most of the time. Why this was so remains a bit of a mystery, and one shouold be cautious in assuming that this finding would still hold up one century later. Nevertheless, Clark's findings reinforce the case that labor practices may be an important source of observed differences in productivity.

This is clearly somehow an institutional difference, but we need models to understand how exactly.

3.3. Tentative Conclusion

With the evidence to date, development accounting still shows that TFP accounts for most of the differences in income variation across countries. It could be that low substitution of capital types or of capital for human capital explains a lot, but not at the current level of knowledge.

4. Growth and Externalities

here are several key stylized facts of cross-country growth that indicate the importance of spillovers.

- The growth slowdown that began in the mid-1970s was a world-wide phenomenon. It hit both rich countries and poor countries, and economies on every continent.
- Richer OECD countries grew much more slowly from 1950 to around 1980, despite the fact that richer OECD economies invested at higher rates in physical and human capital.
- Differences in country investment rates are far more persistent than differences in country growth rates.
- Countries with high investment rates tend to have high levels of income more than they tend to have high growth rates.