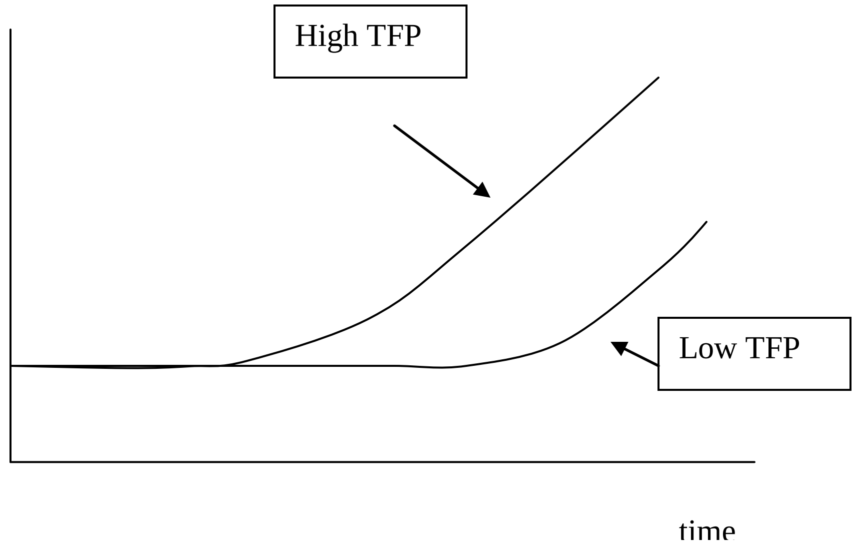
International Income Differences:
Proximate and Fundamental Causes

I. Introduction

In the previous chapter, we presented a unified theory of growth where an economy's escape from the Malthusian era had to wait until the minimum cost of producing a unit of output using the Solow technology fell below one. According to the model, this take-off date is inevitable on account that technological change in the Solow production technology forever increases and because the rental prices of capital and labor in the Malthus only steady state are constant.

The unified growth theory identifies two key factors that possibly account for the huge observed differences in starting dates between countries. These are the TFP parameter, A_s, in the Solow technology and the savings rate parameter, s. Figure 1 show how a difference in TFP in the Solow production function translate into different starting dates, with the low TFP country starting the process of economic growth later. The figure with different savings rates, although not shown, is similar except that the two countries would start out with different living standards in the pre-1700 era. This is because the Malthusian steady state is affected by the savings rate.

Figure 1: Different Starting Dates



We further showed that with a capital share in the Solow technology equal to 1/3, the model predicted that a year 2000 late starter had a TFP that was 10% of the level of a 1750 starter. Moreover, in a home problem you showed the required size of this difference in TFP became a lot smaller if the Solow technology capital share parameter is larger. For example, for $\theta=2/3$, the required factor difference in TFP is around 3. Additionally, you showed in the problems that the required difference in savings rates between the 1750 and 2000 starter implied by the model is 5000 when $\theta=1/3$ and 40 when $\theta=1/2$.

In this chapter, we look more deeply at the data in order to see if these size differences in TFPs and savings rates are plausible. In doing so, we will make use of a number of important studies by researchers. We will conclude from this analysis that TFP is the far more plausible explanation for the different starting dates. This is the first part of the chapter. Once we look at the empirical evidence and conclude that only TFP offers a plausible explanation, we will want to determine what determines a country's TFP. In particular, we will look at what factors such as policies lead one country to have a larger TFP. For the purpose of making policy advice, it is insufficient to tell leaders that the key to making a region or country rich is to increase its TFP. This is not very meaningful advice. However, if we know how policy affects TFP, then we can make specific recommendations. This is the second part of the chapter.

TFP differences, and to a deeper extent policy differences that determine these differences, are what researchers identify as proximate causes of international income differences. Economists distinguish these causes from fundamental ones. Proximate causes, such as policy differences, allow us to understand why one country is rich and another is poor, and one can clearly make important and meaningful recommendations on reforming economies. However, there is still the question of why such policies evolved in one society and not another. Factors that caused countries to have different policies or institutions are what growth economists define as the *Fundamental Causes* of international income difference. The final part of the chapter will discuss some of the *Fundamental Causes* that economists have suggested are important in understanding international income differences.

II. Proximate Causes

Savings Rates

We know from examining the *Penn World Tables* that savings rates between the rich and poor countries do not differ all that much- at most around a factor of 3. Hence, the combined model would seem to rule out savings as a plausible source of the 250 year delay in starting dates. However, as investment is generally defined as any use of resources that increases either future profits or profitability, we need to consider other forms of savings besides those that translate into new machines and structures. The best example of this is education expenses, which translate into knowledge and skills embodied in students- so called *schooling capital* or *human capital*.

The strongest case made in the literature that savings broadly defined is the key factor in understanding differences in international income differences is by Greg Mankiw, David Romer and David Weil (MRW) in their 1992 paper published in the *Quarterly Journal of Economics*. They do not consider this issue within a unified growth model, but in augmented Solow model that includes human capital as a separate input. The law of motion for human capital is the same as the physical capital equation, except it is governed by a different depreciation rate and savings rate. The augmented model is

(C). $$N_t c_t = (1 - s_h - s_k) Y_t$$

(Y) $$Y_t = A K_t^{\theta} H_t^{\alpha} [(1+\gamma)^t N_t]^{1-\alpha-\theta}$$

(K) $K_{t+1} = (1-\delta_k)K_t + s_k Y_t$

(H) . $H_{t+1} = (1-\delta_h)H_t + s_h Y_t$

(Pop GR) $N_{t+1} = (1+n)N_t$

The per capita representation:

(c) $c_t = (1 - s_h - s_k) y_t$

(y) $y_t = Ak_t^{\theta} h_t^{\alpha} (1+\gamma_s)^{t(1-\alpha-\theta)}$

(k) $(1+\gamma_n)k_{t+1} = (1-\delta_k)k_t + s_k y_t$

(h) $(1+\gamma_n)h_{t+1} = (1-\delta_h)h_t + s_h y_t$

Although the model includes a second form of capital, solving for its Balanced Growth Path (BGP) growth rates and income level is not so difficult. To solve for the growth rates along the BGP:

Step 1. Divide (k) by k_t and invoke bgp condition that $k_{t+1}/k_t=1+g_k$.

$$\Omega_k \equiv (1+\gamma_n)(1+g_k) - (1-\delta_k) = s_k y_t / k_t \tag{1}$$

Since the left hand side of (1) does not depend on time, we conclude that $k_{t+1}/k_t = y_{t+1}/y_t = 1+g$.

Step 2. Divide (h) by h_t and invoke BGP condition that $h_{t+1}/h_t=1+g_h$.

$$\Omega_h \equiv (1+\gamma_n)(1+g_h) - (1-\delta_h) = s_h y_t / h_t \tag{2}$$

Since the left hand side of (2) does not depend on time, we conclude that $h_{t+1}/h_t = y_{t+1}/y_t = 1+g$.

Step 3. Next use the balanced path growth rate results in Steps (1) and (2) together with the production function (y)

$$\frac{y_{t+1}}{y_y} = (1+\gamma_s)^t \left(\frac{k_{t+1}}{k_t}\right)^{\theta} \left(\frac{h_{t+1}}{h_t}\right)^{\alpha} \tag{3}$$

to conclude that $1+\gamma_s = 1+g$

Having solved for these growth rates, we can solve for the balanced growth rate path levels for k_t, h_t, and y_t. The steps are:

Step 1. Take the ratio of (1) and (2)

$$\frac{\Omega_k}{\Omega_h} = \frac{s_k}{s_h}\frac{h_t}{k_t}. \tag{4}$$

Step 2. Solve for h_t in (4)

$$h_t = \frac{\Omega_k}{\Omega_h}\frac{s_h}{s_k}k_t \tag{5}$$

Step 3. Now substitute (5) into (y)

$$\Omega_k = s_k A k_t^{\theta} h_t^{\alpha}(1+\gamma)^{t(1-\alpha-\theta)} = s_k A(1+\gamma)^{t(1-\theta-\alpha)} k_t^{\theta+\alpha}\left(\frac{\Omega_k}{\Omega_h}\frac{s_h}{s_k}\right)^{\alpha} \tag{6}$$

Step 4. Rearranging (6), we arrive at

(k-BGP) $$k_t = A^{1/(1-\alpha-\theta)}(1+\gamma)^t \left(\frac{s_k}{\Omega_k}\right)^{(1-\alpha)/(1-\alpha-\theta)} \left(\frac{s_h}{\Omega_h}\right)^{\alpha/(1-\alpha-\theta)}$$

Step 5. Use (k-BGP) and (5) to solve for h_t

(h-BGP) $$h_t = A^{1/(1-\alpha-\theta)}(1+\gamma)^t \left(\frac{s_k}{\Omega_k}\right)^{\theta/(1-\alpha-\theta)} \left(\frac{s_h}{\Omega_h}\right)^{(1-\theta)/(1-\alpha-\theta)}$$

Step 6. Lastly use (k-BGP) with (h-BGP) and (y) to solve for the balanced growth output per capita

(y-BGP) $$y_t = A^{1/(1-\alpha-\theta)}(1+\gamma)^t \left(\frac{s_k}{\Omega_k}\right)^{\theta/(1-\alpha-\theta)} \left(\frac{s_h}{\Omega_h}\right)^{\alpha/(1-\alpha-\theta)}$$

Having derived the balanced growth path for per capita output (y-BGP), MRW proceed to take the log of both sides which yields the following equation:

(log-y)

$$\ln y_t = \ln A^{1/(1-\alpha-\theta)} + t\ln(1+\gamma) + \frac{\theta}{1-\alpha-\theta}\ln\left(\frac{s_k}{(1+\gamma_n)(1+\gamma_S)-(1-\delta_k)}\right)$$
$$+\frac{\alpha}{1-\alpha-\theta}\ln\left(\frac{s_h}{(1+\gamma_n)(1+\gamma_S)-(1-\delta_h)}\right)$$

MRW assume that $\delta_k=\delta_h$ and $\delta + \gamma = .05$. They then use cross section data on y, s_k, and s_h for 1985 to estimate the parameters of the model using *Ordinary Least Squares*. The savings rate on physical capital variable is the investment rate in the Penn World Tables. The savings rate on human capital variable is the average years of schooling in the Barro and Lee Educational Attainment Data Set. This data set is based on survey/census information collected by UNESCO and EUROSTAT. Variables included in the data set are: average years of schooling attained by the population, percentage of no schooling attained in the population, percentage of primary schooling attained in the population, percentage of secondary attained in the population, and percentage of tertiary schooling attained in the population.

In estimating equation (y-log) using ordinary least squares, MRW assume the same intercept term for each country. Importantly, they find an R^2=.78, from which they conclude that differences in savings rates account around three-fourths of the disparity in international incomes. As for the estimated coefficients, their regression yields a value

Solow Residuals, Growth Accounting and the Productivity Slowdown

Robert Solow's contribution to growth theory goes beyond his 1956 paper. In 1957, Solow published a paper in the *Review of Economics and Statistics* that introduced the practice of growth accounting and led to the term "Solow Residuals". What Solow did in his 1957 was impute TFP in the production function. More specifically, taking the production function for aggregate output we can solve for output per unit of composite input, i.e. $\frac{Y_t}{K_t^{\theta} N_t^{1-\theta}} = A(1+\gamma)^{(1-\theta)t} \equiv A_t$. The right hand side of this equation is referred to as the Solow Residual or TFP. Notice, that if we use the data on GDP, capital stock, and labor input, we can solve for the Solow Residual, A_t.

This is effectively what Solow did in 1957, although he did the exercise in growth rates and not levels. For growth rates, we take the natural log of both sides of the aggregate production function, and differentiate with respect to time. Assuming all variables including TFP are continuous functions of time, one can solve for the growth rate of TFP, namely, $g_A = g_Y - \theta g_K - (1-\theta) g_K$ using the value for θ=1/3. Thus, the growth rate of TFP is the growth of GDP less the contribution of growth from capital input less the contribution of growth from labor inputs.

What Solow found was that approximately half of the growth in US output over the 1909-1949 period was the result of TFP growth. Researchers have subsequently applied this procedure to the second half to the 20th Century and were surprised to find that between 1973 and 1995 the growth rate of TFP was cut in half.

of human capital share parameter, α, equal to .28 and a value of the physical capital share parameter, θ, equal to 30.

Total Factor Productivity

The MRW finding was first challenged by Andres Rodriguez-Clare and Peter Klenow in a 1995 paper later and by Robert Hall and Charles Jones in a 1999 paper. These researchers pointed out several problems with the MRW analysis. Importantly, they pointed out that the approach used by MRW produced measures of human capital that were inconsistent with the labor literature that measured the returns to schooling. These empirical studies, which go under the heading of Mincerian wage regressions, suggest a 6 to 10 percent increase in wage earnings associated with an additional year of schooling in the United States. Hall and Jones and Klenow and Rodriguez-Claire both conclude that when human capital stocks are estimated based on these Mincerian returns to education, TFP differences are strongly and positively related to the level of development. More importantly, they find that roughly two thirds of the differences in per capita output are attributed to differences in TFPs.

The analysis underlying the findings of Klenow and Rodriguez-Clare and Hall and Jones uses a Solow production function to impute TFP in a growth (actually a level) accounting exercises for countries for the year 1988. As explained in the text box above, in this type of exercise, one imputes the value of TFP using data on GDP, physical capital, and human capital. The formula for TFP is

$$TFP^i = \frac{GDP^i}{(K^i)^{1/3}(H^i)^{2/3}}.$$

Hall and Jones (1999) use 1988 GDP and physical capital stock measures from the *Penn World Tables.* The authors use average years of schooling attained in the population variable from the Barro and Lee Educational Attainment Data Set together with the Mincerian estimated returns to schooling to calculate each country's per capita human capital stock according to the following equation $h^i = e^{.06s^i}$ where s^i is average years of schooling and .06 is the Mincerian estimate for the return to schooling.

With these measures of the capital stocks, they find that a country's level of income is systematically related to its TFP. They report a correlation coefficient between the log of TFP and the log of output per worker equal to 0.89. Table 1 presents a representative sample of their findings for some large benchmarked rich, middle income, and poor countries. The difference in TFP implied by this theory between the rich and the middle income is of the order of two. Between the rich and the poor, the factor difference is between four and six. Recall that the combined model implied a required factor 10 difference when θ=1/3 and a required factor difference of 3 when θ=2/3. This is strong support for the view that differences in TFP account for the huge differences in starting dates.

Table 1: Implied TFP Differences: 1988

Country	Per Worker Output	Relative TFP
United States	1.00	1.00
West Germany	.82	.91
France	.82	1.13
U.K.	.73	1.01
Japan	.59	.66
South Korea	.38	.58
Portugal	.37	.75
Malaysia	.27	.45
Thailand	.16	.37
Philippines	.13	.22
India	.09	.27
Kenya	.06	.17

Micro Evidence

In addition to examining aggregate level data, researchers have also used industry level and firm level data for evidence of differences in TFP across countries. Industry-level and firm level evidence have the advantage that the reasons for productivity differences are often transparent. In such cases, there is information as to the nature of the machines used in production and the skills needed to operate this equipment.

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Relative Industry Productivities Across Countries

The *McKinsey Global Institute* (MGI) has undertaken a large number of studies that analyzes industrial productivity in a number of countries that includes the United States, the UK, France, Japan, Germany, Poland, Russia, India, and Brazil. The results of some of these studies are summarized in Baily (1993), Baily and Gersbach (1995) and most recently by Lewis (2004). These studies show that industry value added per worker varies a lot across countries, even among the large rich countries. In some industries, the factor difference among the large rich countries is as big as three. Moreover, no single country is the most productive country in all industries. Productivity in service sector industries is uniformly higher in the United States. However, in manufacturing, Japan is more productive than the United States in a number of industries.

Tables 2.a-c show the value added per worker in a variety for a variety of industries across a number of countries from the MGI studies. All comparisons are made relative to the US level, which is normalized to 100 in each sector.

Table 2.a: Relative Value Added Per Worker: Germany, Japan, and the United States

Manufacturer's Industries

Industry	Japan	Germany
Automobiles	116	66
Automobile Parts	124	76
Metal Working	119	100
Steel	145	100
Computer	95	89
Consumer Electronics	115	62
Food	33	76
Beer	69	44
Soap and Detergent	94	76

Table 2.b Relative Value Added Per Worker Rich Countries

Service Center Industries

Industry	Japan	Germany	U.K.	France
Retailing	44	96	82	69
Telecommunications	66	50	38	56
Banking	–	68	64	–

Table 2.c Relative Value Added Per Worker Rich and Poor Countries

Service Center Industries

Industry	*France*	*Japan*	*Korea*	*Poland*	*Russia*	*Brazil*	*India*
Retailing	--	50	32	24	24	14	6
Housing Construction	80	45	70	25	8	35	8

Baily (1993), Baily and Gersbach (1995) and Lewis (2004) conclude that differences in value added per worker reflect differences in TFP. They rule out differences in physical capital per worker as the reason for these differences after determining that per worker capital stocks differ by very little. They rule out differences in schooling capital or skills per worker as well. Two observations lead to this conclusion. One is that the investigators, after examining the skills of the workers and the skills required for each industry, conclude that workers in each country are qualified to work in their industry in any of the other countries: it is not a matter of the highly productive steelworkers in Japan carrying out sophisticated operations that U.S. and German steelworkers cannot. The other observation is that if workers in one country are better educated than workers in another, the better educated country should be more productive in all industries in all sectors. This is not the observed pattern. For the same reason, differences in work ethics can be ruled out as a plausible explanation for these differences in value added per worker.

These researchers also rule out differences in stocks of useable knowledge in each country. While intellectual propriety rights exist, those rights do not effectively reduce the stock of useable knowledge that a country has at its disposal. As those researchers point out, there are licensing agreements and direct investments which allow proprietary information to be used in different countries. Moreover, there are many multinational corporations operating within the set of large rich countries. Plants of these corporations operated in different countries surely have access to the same knowledge.

What does differ from one country to another, however, is the amount of this knowledge that is used, as well as work practices. Ford Europe, for instance, has failed to adopt Japanese just-in-time production in producing automobiles, but Ford U.S.A. has adopted it. In the beer industry, much of the high technology machinery used in Japanese and U.S. plants is manufactured in Germany. Yet German breweries fail to use these more productive technologies. The less productive airline sector in Europe vis-à-vis the United States is the result of overstaffing.

Why doesn't Ford Europe use the better technology used by Ford U.S.A.? Why don't German brewers use the equipment German firms sell to the more productive U.S. brewers? And why are European airlines overstaffed? The answer that Baily (1993) and Baily and Gersbach (1995) give to these questions is that firms in some countries are more constrained in changing their work practices and using better technologies. German breweries, for example, cannot adopt the better technologies that are used in the United States and Japan, even though the equipment to run those technologies is made in

Germany, because of explicit rules and regulations that govern beer production there. Similarly, zoning laws in the United Kingdom, France, and Germany prevent entry by stores with new retailing formats. In Tokyo, inefficient mom-and-pop stores are able to survive due to subsidized loans and preferential tax treatment. In Russia, more efficient large retailers such as Carrefour cannot compete with the small kiosks because the latter do not have to pay taxes and are allowed to smuggle in goods. In India, there are regulations that require that many consumer goods be produced only by small scale plants. India prevents the entry by large foreign retailers by outright prohibiting foreign direct investment in to this sector. European airlines cannot reduce staffing because of union rules and political opposition.

Theory of Relative Efficiencies

The last section presented both aggregate level and industrial level data that shows that TFP varies a lot across countries. The industrial and firm-level data was particularly insightful in that it suggests that differences in the constraints society places on the choice of its citizenry determine the efficiency at which it uses its resources to produce goods and services, or stated alternatively, how much of the available knowledge in the world it uses to produce final goods and services.

In this section we show how policy at the firm level affects TFP at the aggregate level based on these insights. A theory of TFP is essential to our study of differences in international income levels. Absent a theory of country-specific TFP, the theory of the evolution of international income levels is sterile because it offers no policy guidance.

What is needed is a policy-based theory of why TFP differs across countries at a point in time.

Before presenting some mappings from policy to TFP, it is useful to review our specification of the Solow Production Function. Recall, that we wrote the Solow production function as

(Y_S) $$Y_{St} = A_S \Gamma_{St}^{1-\theta} \; K_{St}^{\theta} \; N_{St}^{1-\theta} \, .$$

TFP is correctly the entire term $A_S \Gamma_{St}^{1-\theta}$ There are really two components to TFP as we have specified the production function. First, there is the technology component of TFP, Γ_{St}. This is common across countries. It is the same across countries because the stock of productive knowledge that is available for a country to use does not differ across countries. Much of the stock of productive knowledge is public information, and even proprietary information can be accessed by a country through licensing agreements or foreign direct investment.

The second term, A_S, is the efficiency component. This part of TFP will vary across countries and depend on country specific policies. For this reason, we should really index this parameter with a superscript to denote a specific country. The efficiency component is a number in the (0,1] interval. An efficiency level less than one implies that a country operates inside the production possibilities frontier, whereas an efficiency level equal to one implies that a country operates on the production possibilities frontier. Differences in efficiency, therefore, imply differences in TFP.

We shall focus on two types of constraints, or policies. The first type constrains how a particular plant technology can be operated. The second type constrains the choice of which plant technologies can be operated. Certainly, these are not the only type of constraints that will affect a country's TFP. A number of other types of policy have a similar effect. For example, Schmitz (2001) suggests a mapping of government subsidies to state-owned enterprises and aggregate efficiency. This is supported by the MGI studies in comparing the productivity of state owned firms versus privately owned firms in the same industry and country.

The first type of policy constrains how a given technology is operated. A policy that gives rise to this type of constraint is a work rule, which dictates the minimum number of workers or machines needed to operate a plant technology. In particular, suppose constraints are such that the input to a $b = (k,n,y)$ type plant must be $\phi_K k_b$ and $\phi_N n_b$ for all plant types where ϕ_K and ϕ_N each exceed one. This implies that a particular technology, if operated, must be operated with excessive capital and labor. With these constraints, the aggregate production function is

$$Y = A_S \Gamma^{1-\theta} K^{\theta} N^{1-\theta}, \qquad (7)$$

where $A_S \equiv \phi_K^{-\theta} \phi_N^{\theta-1}$. This is the Solow aggregate production function. If the nature of the constraints were to double the capital and labor requirements, then the efficiency measure would be one-half. If the nature of constraints is to quadruple both the capital and labor requirements, then the efficiency measure would be one-fourth.

The second type of constraint is over the choice of technologies. The mapping we consider was developed by Parente and Prescott (2002). This type of constraint maps into the efficiency parameter of an aggregate production function with a composite capital stock made up of both physical and intangible components. Any policy that serves to increase the amount of resources the production unit must spend in order to adopt a better technology is a constraint of this nature. Such policies and practices take the form of regulation, bribes, and even severance packages to factor suppliers whose services are eliminated or reduced when a switch to a more productive technology is made. In some instances, the policy is in the form of a law that specifically prohibits the use of a particular technology. The empirical evidence suggests that this second type of constraint is more prevalent than the first.[1]

The Parente and Prescott mapping or theory of TFP was motivated by a book by Hernando DeSoto called *the Other Path*. DeSoto's book examines the low productivity of the Peruvian economy. DeSoto attributes this low productivity to the huge amount of red tape and bureaucracy that prevails in Peru. This imposes a large cost on firms, the result of which causes many of them to choose to operate illegally. Operating illegal, however, is hardly efficient because illegal firms have to spend resources to avoid being detected by government authorities. Such firms typically operate out of back rooms in people's houses, where they tend to operate smaller and older technologies to avoid detection and fines. This gives a very intuitive sense of how policies affect the choice of technology and hence the amount of knowledge used by a country.

[1] See Parente and Prescott (2002) for a survey of this evidence.

Following Parente and Prescott (2002), let the output of a quality b plant be given by the following equation:

$$y_t = b\, k_{Pt}^{\theta_P} [\min(n_t, \bar{n})]^{\theta_n} \qquad \bar{n} > 0, \quad \theta_P < 1. \tag{8}$$

With this technology, a minimum number of workers, $\bar{n}$, is required to operate a plant. The variable k_P denotes the physical capital input. The subscript P is introduced in order to differentiate physical capital from intangible capital later in the analysis. There are no increasing returns to scale in the economy, because if the inputs of the economy are doubled, the number of plants doubles.[2]

A plant's quality is a choice variable. To improve its quality, resources are needed. This resource cost is the product of two components. The first component is technological in nature and reflects the cost in the absence of constraints. The second component, denoted by $\phi_I > 1$, reflects the constraint itself. The function that gives the required resources a plant must expend to advance its quality from b to b' is

$$x_{bb'} = \phi_I \int_b^{b'} \left(\frac{s}{W_t} \right)^{\alpha} ds. \tag{9}$$

Here W_t is the stock of pure knowledge in the world in period t. Its growth rate is exogenous and equal to γ_W. Thus,

$$W_t = W_0 (1+\gamma_W)^t. \tag{10}$$

Integrating (9) and defining $x_{It} \equiv x_{bb'}$ yields

[2] See Hornstein and Prescott (1993) for a detailed coverage of this technology.

$$x_{It} = \phi_I \frac{b_{t+1}^{\alpha+1} - b_t^{\alpha+1}}{W_0^{\alpha}(1+\gamma_W)^{\alpha t}(1+\alpha)} .$$

Let

$$k_{It} \equiv \frac{\phi_I \, b_t^{\alpha+1}}{W_0^{\alpha}(1+\gamma_W)^{\alpha(t-1)}(1+\alpha)} .$$

The variable k_{It} has the interpretation of the plant's intangible capital stock; it is the value of the plant's past investments in quality improvements. Making a change of variables, the plant technology can be rewritten as

$$y_t = \mu \phi_I^{-\theta_I} (1+\gamma_W)^{\alpha \theta_I t} k_{It}^{\theta_I} k_{Pt}^{\theta_P} [\min(\bar{n}, n_t)]^{\theta_n} , \tag{11}$$

with

$$k_{It+1} = (1-\delta_I) k_{It} + x_{It} , \tag{12}$$

where δ_I and μ are functions of α, γ_W , ϕ_I, and W_0, and $\theta_I = 1/(1+\alpha)$. The sum of θ_I and θ_P is strictly less than one, so there is an optimal plant size, with all operated plants having $n*$ workers and equal amounts of both capital stocks.

Aggregating over plants implies the following equilibrium aggregate production relation:

$$Y_t = A_S \Gamma_0 (1+\gamma_S)^t K_{It}^{\theta_I} K_{Pt}^{\theta_P} N_t^{1-\theta_P-\theta_I} , \tag{13}$$

with $A_S \equiv \phi_I^{-\theta_I}$ and $(1+\gamma_S) = (1+\gamma_W)^{\alpha \theta_I}$. The laws of motion for the aggregate capital stocks are

$$K_{I,t+1} = (1-\delta_I) K_{It} + X_{It} \tag{14}$$

$$K_{P,t+1} = (1-\delta_P) K_{Pt} + X_{Pt} , \tag{15}$$

where $(1-\delta_I) = 1/(1+\gamma_W)^{\alpha}$.

Now if intangible capital has the same depreciation rate as physical capital, then the model with these two capital stocks is isomorphic to the model of subsection 2B with a single capital stock. The single capital stock, K_t, is a composite of the intangible and physical capital stocks where

$$K_{It} = \frac{\theta_I}{\theta_I + \theta_P} K_t \tag{16}$$

$$K_{Pt} = \frac{\theta_P}{\theta_I + \theta_P} K_t . \tag{17}$$

The capital share in the single capital stock model, θ, is just the sum of θ_I and θ_P, and investment in the single capital stock model, X_t, is just the sum of the investments in physical and intangible capital, $X_{It} + X_{Pt}$.

For the sake of consistency and brevity, we continue to use the model economy with a single capital stock in our presentation of the unified theory of the evolution of international incomes. In those instances where we wish to consider the role of intangible capital, we proceed by assigning a value to the capital share parameter in the modern production function that exceeds 0.40, the share of physical capital's output in the national income accounts. We solve out the model economy with a single capital stock and then impute the intangible and physical capital components, as well as their investments. This can effectively be done using equations (16) and (17) given a decomposition of the total capital share into its intangible and physical components

Intangible Capital.

What we have seen is that the required factor difference in TFPs decreases as the capital share increases. This is important to note because there are other types of capital besides physical capital that are clearly important in production. Two such types of capital are human capital and organizational capital. Human capital is the skills and knowledge embodied in an individual. Organizational capital is the skills and knowledge embodied in firms, or more generally in groups of people. Human capital is acquired in a number of ways. Schooling is one such way. Additionally, on the job training and on-the-job-learning are other ways. Professors for instance spend a lot of time reading the research results of others. This is a big part of their daily work, and yet it is an example of an investment in human capital. Organizational capital can be acquired through learning. People in firms learn which people in the firm know what. Another form of intangible capital investment comes in the form of Research and Development. Research and Development expenses such as the salaries paid to scientists and engineers are all investments in intangible capital.

From a theoretical standpoints, there is not much of a difference between intangible capital and tangible (physical) capital. However, from an accounting standpoint, there is a huge difference between the two capital stocks. Investments in physical capital are included in the NIPA while investment in intangible capital are not. Investment in the National Income and Product accounts includes only those expenditures on equipment, structures and houses. With the exception of education, investments in intangible capital are not measured either as product, expenditures or income.

Estimates of Aggregate Relative Efficiency

The mappings developed in the preceding subsection allow us to impute the aggregate relative efficiency associated with the modern production function for various constraints. In general, the size of the effect of the constraint on a country's aggregate efficiency depends on the factor input affected by the constraint and on that input's share in the production function. In the special case where the constraints affect all inputs equally, that is, $\varphi = \varphi_n = \varphi_I = \varphi_P$, the individual factor shares are unimportant and the efficiency level of a country is just $A_s = \phi$. Hence, the implied difference in relative efficiencies is equal to the implied cost differences of policy. Thus, if the cost difference in policies between two countries is a factor of five, the implied factor difference in aggregate relative efficiency is also five.

Is a five-fold factor difference in costs of adoption reasonable? Some estimates of the cost differences associated with some country-specific policies do exist. Studies that estimate the costs of certain policies of individual countries that affect the technology and

Intangible Capital - continued

Why are investments in intangible capital excluded from the NIPA? The answer lies in the fact that the current accounting system treats an investment in intangible capital as an ordinary business expense. Consider the following example. Suppose that a firm pays $1000 to have a computer expert, Mr. Hardrive, to run a week long seminar for its workers on how to use a new software. In the NIPA, this transaction would lead to a $1,000 entry in Proprietor's income. The transaction would also lead to a $1,000 reduction in Corporate Profits. Remember that Corporate Profits is by definition a residual. In particular,

Corporate Profits = Value Added – wages, salaries, and other compensation- net interest paid by businesses- indirect business taxes-depreciation- business transfers.

The purchase of the computer expert's services is by current accounting procedures an intermediate good purchase of the firm that reduces its value added by $1,000, and hence corporate profits by the same amount. Thus, the transaction does not affect measured income in the economy. Since income =output, the investment in intangible capital is unmeasured in the NIPA either in the form of output, income, or expenditures.

Computer software is a perfect example of this omission. Until only recently, software purchases by firms were treated as ordinary business expenses. Thus, the corporate profits were reduced by the amount of the software purchase. There is hardly any doubt that software is a form of capital that is used to produce output. In the 1990's expenditures on capital were 10 percent of GDP. This is a big number. Recently, the US government has changed its accounting procedures so that software purchases are measured as an investment purchase.

How large are the investments in unmeasured investment? It is hard to put an exact number on the size of these investments as they are unmeasured. However, if we look at the micro level it is possible to get some idea of the size. Parente and Prescott (2000) argue that the size of these investments could easily be as large as 1/3 of measured GDP.

work practice choices of the production units located there do find that these costs vary systematically with income levels, with large differences existing between rich and poor countries. These studies suggest that factor differences in relative efficiencies could easily be as great as five.

For example, Djankov et al. (2002) calculate the costs associated with the legal requirements in 75 countries that an entrepreneur must meet in order to start a business. They find that the number of procedures required to start up a firm varies from a low of 2 in Canada to a high of 20 in Bolivia and that the minimum official time required to complete these procedures ranges from a low of 2 days in Canada to a high of 174 days in Mozambique. These costs do not reflect any unofficial costs involved with starting a firm, such as bribes or bureaucratic delays. Because these official cost measures are positively correlated with indexes that incorporate measures of bribes, the true difference in start-up costs between low-cost and high-cost countries is surely even larger than those reported in the study. The Djankov et al. study has motivated the World Bank to compile a yearly data set on the costs that regulations impose on businesses, called the Ease of Doing Business.

Now some policy is clearly helpful and needed. Economic theory calls for government intervention when markets fail, particularly when there are externalities. Governments are also needed to enforce contracts and protect private property. Pollution is an excellent case in point. Environmental regulation, even though it reduces TFP, may be a very desirable policy. Thus, none of us are calling for a removal of all government regulations. However, in the case of the very poor countries, it appears that most of the regulations have had little to do with the environment or preventing monopoly type elements. Djankov and his coauthors in fact investigated whether countries with higher costs to entry had more competitive markets or higher environmental quality and found that they did not.

Instead, what case studies suggest is that most of this growth inhibiting policy exists to protect special interest groups and groups aligned with the status quo. These groups expect a reduction in profits or earnings in the case that someone enters with a better technology. History is full of examples where groups have fought hard to prevent the introduction of better technology.

III. Fundamental Causes

Although the evidence strongly supports a TFP based theory of starting dates, and supports a view that society imposed policies are the source of these differences, it does not really say why societies differ in this respect. For sure, much of these constraints are put in place to protect certain groups and segments of society. However, we have not really said why societies have evolved differently in this dimension.

A very recent branch of the growth literature argues that differences between societies that go way back in time are the ultimate causes of these policy and TFP difference. For example, one branch examining genetic differences between societies finds and shows that a country's genetic difference with another determines its relative income difference. Another branch considers genetic diversity within a society and argues that either too little or too much genetic diversity is bad for a regions long term development. The human race started in East Africa, and it is this group of peoples that had the greatest diversity. From East Africa, subsets of the population spread out to the four corners of the globe along various migration routes. The subsequent migrators took with them less and less genetic diversity. The richest societies tend to be located in Europe, and these correspond to earlier to middle settlements out of Africa. In terms of genetic diversity, these groups have less than their East African counterparts, but more than later populations say in the Americas. To read more about this literature, go to the websites of Oded Galor, David Weil, both at Brown University or Roman Wacziarg at UCLA.

IV. Conclusion

According to our calibrated unified growth theory, a 10-fold factor difference in Solow TFP or a 40-fold difference in savings rate implied a 250 year delay in industrialization dates. We started this chapter asking whether the empirical evidence suggests that TFP or savings rates differences account for the huge delays in starting dates across countries. We found that the TFPs are systematically correlated with income differences, and that these Solow Residuals were close to a factor 10 between rich and poor countries.

The evidence strongly suggests that production units in poor countries are severely constrained in their choices, and the costs associated with these constraints are large. This prompts the question, Why does a society impose these constraints? A large number of studies, some of which are surveyed in Parente and Prescott (2000), suggest that constraints typically are imposed on firms in order to protect the interests of factor suppliers to the current production process. These groups stand to lose in the form of reduced earnings if new technology is introduced. These losses occur because either the input they supply is specialized with respect to the current production process or the monopoly power granted to them over the supply of a particular input is eroded.

Designing policy that will make it not in the interests of such groups to lobby the government for protection is the key to riches. This is not an easy task. One factor that seems to help weaken the strength of these groups is international trade. Indeed, going back to the MGI studies, Japan tends to be the most productive in industries in which it faces international competition; in non-tradeable good sectors, its productivity in between half and one third of the corresponding US level. In an interesting study dealing with the US Iron-ore industry, Galdon and Schmitz (2004) show how productivity responded to the amount of competition from world suppliers. As the world becomes smaller, and international competition intensifies, constraints should be harder to maintain, and income gaps should fall.

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