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Divergence, Big Time

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The basic fact of modern economic history is massive *absolute divergence* in the distribution of incomes across countries. This paper shows that even without actual historical data on incomes in the now poor countries we can reasonably estimate that the ratio of the incomes of the richest to the poorest countries increased at least sixfold between 1870 and today.

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Summary findings

Recently, much attention has been paid in the literature on economic growth to the phenomenon of "conditional convergence," the tendency of economies with lower-level incomes to grow faster, conditional on their rate of factor accumulation.

Pritchett documents that, regardless of conditional convergence, perhaps *the* basic fact of modern economic history is massive absolute divergence in the distribution of incomes across countries.

Discussions of long-run convergence or divergence have been hindered by the lack of reliable historical estimates of per capita income for poor countries. Pritchett shows that to draw reasonable inferences about whether incomes have converged or diverged does not require historical estimates of per capita income as a plausible lower limit for historical per capita incomes combined with estimates of current income in poor countries places a binding constraint on their historical growth rates.

Pritchett estimates that between 1870 and 1985 the ratio of incomes in the richest and poorest countries increased sixfold, the standard deviation of (natural log) per capita incomes increased by between 60 and 100 percent, and the average income gap between the richest and poorest countries grew almost ninefold (from $1,500 to over $12,000).

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Divergence, Big Time

Lant Pritchett

Divergence, Big Time[1]

A resurgence of interest in models of economic growth has brought discussions of convergence, either in the levels of countries' per capita income or in growth rates of per capita income, to the fore. Many have argued that traditional neoclassical growth models (e.g. Solow, Swan) predict a tendency towards either absolute convergence in per capita income (if all countries xqzshare the same technology, savings propensity and population growth) or "conditional" convergence, that is convergence to different levels of per capita income but to the same steady state growth rates (Barro, 1991, Barro and Sala-I-Martin, 1992, 1995, Mankiw, Romer, and Weil, 1992). In contrast, many of the newer endogenous growth models predict that steady state growth rates differ, and hence there is no tendency to convergence in either growth rates or levels of income over time (Romer, 1986, Rebelo, 1991). These differing theoretical perspectives and predictions imply the empirical question of whether the available data show conditional convergence has received a great deal of attention.

However, in the context of renewed attention to economic growth this focussed attention on (conditional) convergence should not lose sight of three points. First, divergence in output per person across countries is perhaps *the* dominant feature of modern economic history. The ratio of per capita income in the richest versus the poorest country has increased by a factor of 6 and

[1] I would like to thank William Easterly, Deon Filmer, Jonathan Isham, Estelle James, Ross Levine, Mead Over, Martin Rama, and Martin Ravallion for helpful discussions and comments.

the standard deviation of (natural log) GDP per capita has increased between 60 percent and 100 percent. The increasingly sophisticated econometric testing of conditional convergence with the thirty or so years of conveniently available, internationally comparable data should not obscure that fact[2].

Second, absolute divergence is compatible with conditional convergence. A tendency for more rapid growth rates with lower initial income, conditional on other variables, is not sufficient for absolute convergence if the conditioning variables (such as physical and human capital investment rates) are themselves are functions of income. I use current data on the inverse relationship between investment rates and levels of income to show that even with relatively strong conditional convergence the data predict continued absolute divergence.

Third, any attempted model of growth over the truly long term must be able to rationalize a number of stylized facts about long run growth rates that are direct and indirect implications of the historically observed combination of absolute divergence and conditional convergence.

I) Massive divergence in per capita income since 1870

The discussion of convergence and long-term growth has always been plagued by the fact that the sample of countries for which historical economic data exists, and has been assembled into

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[2] I hasten to point out that although I use a new technique and calculations to make this point and to create estimates of the magnitude of the divergence, none of these points are new or would come as a surprise to an economic historian. Kuznets (1966, 1971) pointed out that the very low levels of output observed in the now industrialized countries historically and currently poor countries implies that their long-term growth rates must be quite low relative to modern growth. Moreover, models of economic growth based on stages, such as "take off" are based on the experience of the industrial revolution in which some leading countries clearly accelerated their rate of growth vis a vis the lagging countries. Moreover, even those arguing the case for conditional convergence acknowledge the moderate absolute divergence present in the recent data (Barro and Sala-I-Martin, 1995, Mankiw, Romer, Weil, 1992).

convenient form, is completely biased[3]. Countries that are rich now are more likely to have devoted the resources to creating a historical time series on GDP and countries that were historically rich are more likely to have the sources that allow such estimates[4]. However, the lack of historical data on incomes in the currently poor countries need not blind us to reality. Actual data on GDP for all countries is not necessary to know that there has been massive divergence in economic outcomes since the beginning of modern economic growth around 1870[5]. Divergence is obvious from three facts we do know.

One, the leading industrial countries have had relatively rapid and remarkably similar growth in output per person since 1870. The USA, currently the richest country, has grown at roughly 1.8 percent per annum since 1870[6]. Over the entire period most other currently

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[3] This point was made early on in the discussion of convergence in the interchange between Baumol (1986) and DeLong (1988).

[4] Just knowing the way the data is generated is enough to guess that if we took the data for the relatively reich both then and now European countries and their off-shoots (the U.S., Canada, Australia) we would find they have all had roughly the same growth rate, as all countries that were rich a long time ago and have stayed rich grew at about the same pace. Evans (1994) tests the hypothesis of the equality of growth rates among 13 European and offshoot countries and is we are unable to reject it. Countries that grew much faster (e.g. Japan) are now rich but were poor, countries that grew much slower (e.g. Argentina) were rich then but are now poor.

[5] The year 1870 is chosen for the starting point for calculation because principally because much of the data I use (e.g. the Maddison (1991) series on per capita incomes) begins here. Although Maddison (1991) aruges the period 1820-1870 was similar economically to the 1870-1913period, an argument could be made that it roughly marks an important transition in several countries (end of the Civil War in the USA in 1865, the Franco-Prussian War in 1870-1, Meiji Restoration in 1868). Perhaps not coincidentally, Rostow (1990) dates the beginning of the "drive to technological maturity" of the USA, France and Germany around that date (having begun earlier in Great Britain).

[6] In Maddison (1991) US GDP per capita is estimated at $18,329 in 1989 and $2,181 in 1870 (both expressed in 1985 US relative prices). The implied per annum growth rate is 1.78 percent.

industrialized countries growth rates are remarkably similar to that of the USA (table 1)[7]. Hence using any of their historical growth rates as representative of "rich" country growth would not alter substantially the divergence calculations reported below. These growth rates imply that per capita income in the leading countries has increased roughly eight fold since 1870 (almost exactly in the US (8.14), obviously less so in Great Britain (4.8) and (even more) obviously more so in Japan (23.9)).

[7] The similarity over the long run masks large variations, especially that most of these countries grew more slowly than the USA between 1807-1950 and more since, especially in the 1950-73 period (Maddison, 1991).

Table 1: Average per annum growth rates of GDP per capita 1870 to 1989 in the presently high income industrialized countries.	
Country	Growth rate
USA	1.78
Countries with similar growth rates (within .2)	
Belgium	1.63
France	1.69
Portugal	1.70
Italy	1.76
Canada	1.76
Denmark	1.82
Germany	1.96
Laggards (more than .2 less)	
Great Britain	1.32
Australia	1.48
Gainers (more than .2 greater)	
Sweden	2.32
Japan	2.70
Source: Maddison, 1991, 1994.	

Two, even though we lack estimates of historical GDP per capita for nearly all currently developing countries, it is possible to put a reasonable lower bound on what GDP per capita could have been in 1870. This section will just assume this level is P$250 (expressed in 1985 US purchasing power parity (PPP) adjusted dollars, according to the International Comparisons of Product (ICP) methodology) while the entire second section is devoted to defending that level.

Three, many countries in the world in 1985 were relatively near the lower bound on per capita GDP of P$250. By relatively near the lower bound, I mean simply that GDP per capita in many countries was not greater than the assumed lower bound of P$250 by a factor that is larger than the roughly eightfold in GDP per capita that we know the rich countries experienced since 1870.

Together, these three facts imply that poor countries cannot have grown since 1870 anywhere near as fast as the presently (and by and large historically) rich countries because in order for their present low incomes to be consistent with a growth rate as fast as the leading countries they would have to have been impossibly poor in 1870, hence there must have been divergence since 1870. That is, we do know from historical data that income in the industrial countries grew about 8 fold from 1870 to 1985. While we do not have an estimate of GDP per capita in Zaire in 1870, we can be sure income in 1870 in Zaire was not eightfold less that its 1985 value of P$370[8].

To go beyond that simple conclusion and calculate the magnitude of divergence requires making some assumptions. I use two alternative methods to place a range on the magnitude of divergence. One way to create estimates of the distribution of incomes in 1870 across countries is the following three step procedure which I call the "truncation" method; a) start from an actual estimate of all countries' GDP per capita (in say 1960), b) begin the "backcast" of incomes under the assumption that all countries grew into the past at the same rate as the leading country but c)

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[8] This of course ignores the fact that the present national boundaries of Zaire (and many other countries) did not exist in 1870. In everything that is said about "nations" in 1870 the phrase "geographic area which is now the nation" could be substituted without changing the argument. Although the rather arbitrary division of geographic space into countries affects the calculations by determining how many "country" observations there are.

truncate the historically "backcast" GDP per capita at the lower bound. The truncation method of backcasting incomes will stack many of the historical income "estimates" up on the assumed minimum income. This potentially gives a large *over*estimate of the dispersion of incomes in 1870. While this is useful in creating an upper bound in dispersion in 1870 it may significantly *under*state divergence.

An alternative procedure for simulating the income distribution in 1870 which I call the "radial" method is to scale current estimates of per capita incomes in such a way that a) just pushes the poorest country in the initial year (again, say 1960) to the lower bound by 1870, b) pushes the leader (the USA) back to its actual 1870 value and c) preserves all relative rankings amongst the other countries[9].

Table 2 presents the estimates of the divergence of per capita incomes since 1870 based on these methods. Since we have assumed that the minimum is P$250 the ratio of the top to the bottom income countries has increased from 8.7 in 1870 to 38 by 1960 and to 51 by 1985, an almost six fold increase over the entire period. With the truncation method (beginning from 1960)

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[9] That is the growth rate of the lowest country was imposed to reach P$250 at exactly 1870 and the rate of the US was used for the growth at the top. Then each countries growth rate was assumed to be a weighted average of those two rates, where the weights depended on the scaled distance from the bottom country in the beginning period of the simulation. This technique "smushes" the distribution back into the smaller range between the top and bottom while maintaining all cross country rankings. For instance, the formula for estimating GDPPC (the log of GDP per capita) in the ith country in 1870 was $GDPPC_i^{1870} = GDPPC_i^{1960} * (1/w_i)$, where the scaling weight w_i was

$w_i = (1-\alpha_i) * \min(GDPPC^{1960})/P\$250 + \alpha_i * GDPPC_{USA}^{1960}/GDPPC_{USA}^{1870}$ and where α_i is defined by

$\alpha_i = (GDPPC_i^{1960} - \min(GDPPC^{1960}))/(GDPPC_{USA}^{1960} - \min(GDPPC^{1960}))$.

we find that the standard deviation of (log) GDP per capita levels has increased by over 35 percent from .636 in 1870 to .867 in 1960, and by over 60 percent, to 1.02, in 1985. Using the radial method (again, beginnin the backcast in 1960) the increase in the standard deviation is 70 percent to 1960 and a full 100 percent by 1985.

Table 2: Estimates of the divergence of per capita incomes since 1870.

	1870 (Estimates)		1960	1985
Simulation assumption:	Truncation	Radial		
Ratio of GDP per capita of richest to poorest country	8.7	8.7	38.1	51.6
Standard deviation of natural log of per capita incomes	.636	.513	.867	1.025
Standard deviation of per capita incomes	P$435	P$459	P$2,112	P$3,988
Average absolute income deficit from the leader	P$1657	P$1307	P$7748	P$12,662

Notes: The estimates in the columns for 1870 are based on backcasting GDP per capita for each country using the methods described in the text assuming a minimum of P$250.

Dispersion measures based on the ratios of incomes or the natural logs of income per capita do not capture the entire picture. While acknowledging that absolute differences will grow as levels increase even when the relative incomes are maintained, the absolute magnitudes of the differences in per capita incomes are also of interest. Table 2 reports the standard deviation of GDP per capita and the average shortfall of GDP per capita from the leading country (the USA) across all countries. In 1870 the average income difference was between P$1307 and P$1657 (depending on the method). By 1985 this absolute income gap had grown by nearly an order of magnitude, to P$12,662.

Figure 1 shows the truncation method graphically. The time series of US GDP per capita since 1870 (shown as a smoothed log trend with a break in 1960) shows the growth of 1.7 percent per annum, from an 1870 (smoothed) GDP per capita estimate of P$2181. Some representative poorer countries (in 1960) are also displayed to show the effect of assuming that they grew also at 1.7 percent per annum until reaching the minimum level of P$250. The figure shows that with the truncation of the simulated historical income levels of the poor countries as they hit the assumed minimum the income gap closes and dispersion of incomes falls[10].

This basic finding of divergence is robust to alternative assumptions, as shown in table 3. Even much lower levels of GDP per capita than are reasonable for 1870 still indicate substantial divergence. Column 1 of table 3 shows the results if the lower bound were assumed to be P$200, the standard deviation still increases from .567 to .867. Since income in the USA increased by 4.6 times from 1870 to 1960 all countries whose incomes in 1960 are less than 4.6 times higher than whatever minimum level is assumed must have had lower growth than the USA and hence a smaller ratio of 1960 to 1870 GDP per capita than that of the USA and hence the dispersion must have increased. At a minumum level of P$250, 49 countries (of 117 in the sample) would reach the lower bound before 1870 if they were assumed to have the growth rate of the US (which they would have to do to prevent divergence), while 32 countries reach the even lower bound of P$200.

Column 2 of table 3 shows results using the truncation method but instead of assuming

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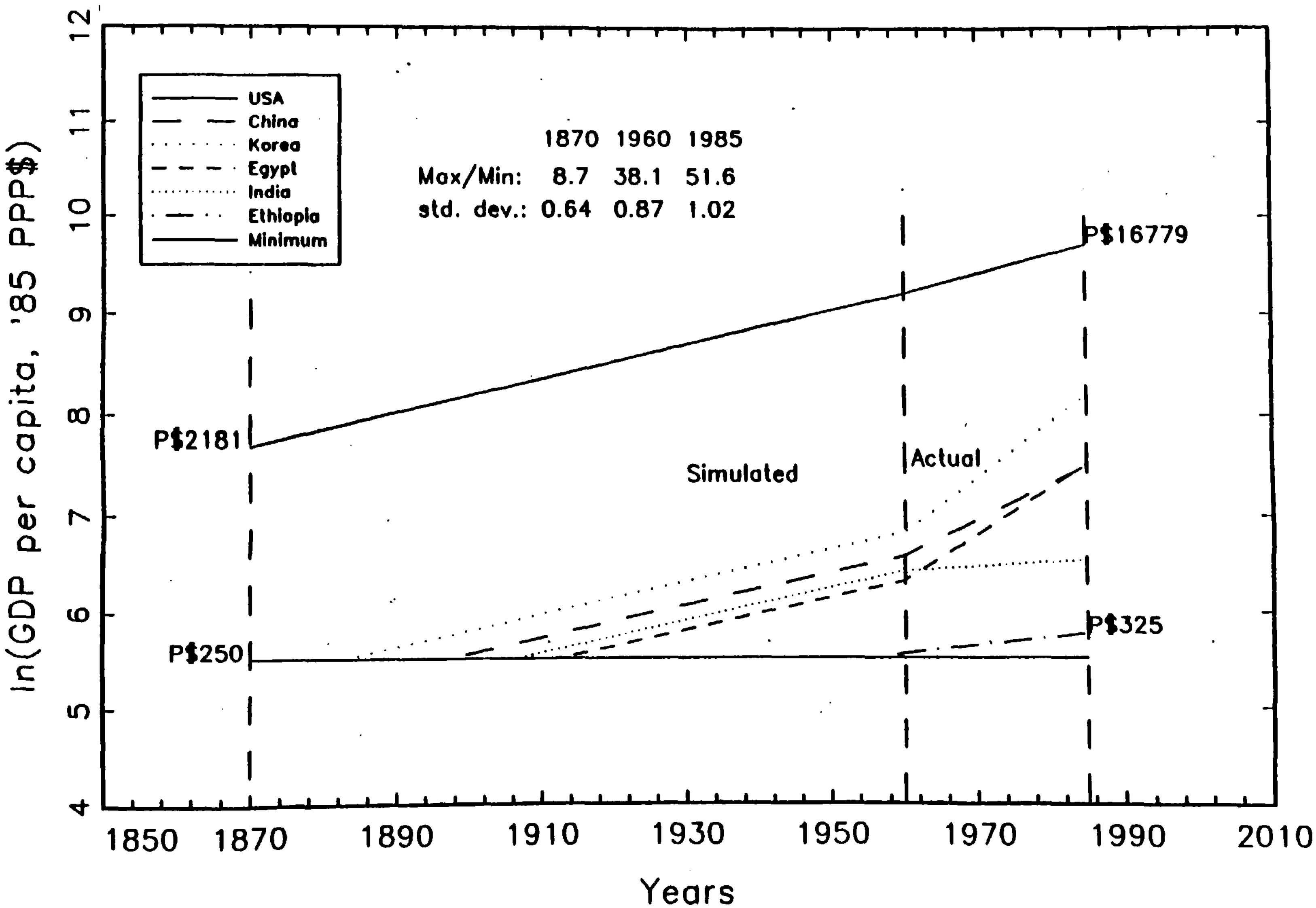
[10] The graphs provides a convenient way of summarizing the four things we need to calculate an estimates of historical divergence even without real data on poor countries historical GDPPC; GDPPC of the USA in 1960, income of the US in 1870, income of the poor countries in 1960, and a lower bound on GDPPC.

Figure 1: Simulation of divergence of per capita GDP, 1870-1985
(showing only selected countries)



countries grew at the US rate, backcasts using each countries' actual post 1960 growth rate calculated from the PWT5 data[11]. Again there is massive absolute and substantial relative convergence, the estimated standard deviation in the initial period is only higher because *more* of the poor countries stack up on the minimum, because growth rates were on average more rapid in the post 1960 period than the historical growth rate of the USA.

Column 4 of table 3 does the divergence calculations going back to 1820, rather than 1870, using the truncation method and P$250. To do this we use the growth rate of the UK, which was the leading country during this period[12]. The obvious implication is even greater divergence, as the UK had already embarked on relatively rapid growth. In 1820 the ratio of top to bottom is 5.8 (versus 51.6 in 1985), the standard deviation of (ln) GDPPC is .49 (versus 1.02 in 1985) and the average income gap is P$1058 (versus P$12,662).

Alternatively, rather than examine the implications for the distribution of income at various assumed levels of initial GDP per capita, one could ask the question, how low would GDP have to have been in order for there *not* to have been divergence? In order for the dispersion of incomes in 1870 to have been as large as in 1985 the per capita income in the poorest countries would have had to have been P$50. As will be detailed below, this number is far, far lower than is plausible or even possible.

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[11] Although given the very low persistence of cross country differences in growth rates over time this is not as good an idea as it might seem (Easterly, et al, 1993).

[12] This reveals a body buried in the previous calculations, that for simplicity the USA is assumed to be the leader all the way back to 1870, when in fact the USA did not overtake the UK until some time in the 1890s. Therefore we only use the growth rate that takes the UK from its 1820 level to the US 1870 level rather than its own.

Table 3: Robustness of estimates of historical divergence since 1870.

	1870 (Estimates)		1820 (Est.), P$250, Truncation	1960	Population weighted	
	P$200, radial	Using actual growth rates (P$250)			1870 (Est.)	1960
Ratio of GDP per capita of richest to poorest country	10.9	8.7	5.8	38.1	8.7	38.1
Standard deviation of natural log of per capita incomes	.567	.706	.492	.867	.167	.197
Standard deviation of per capita incomes in 1985 P$	P$466	P$476	P$264	P$2,112	P$16	P$71
Average income gap	P$1674	P$1533	P$1058	P$7748	P$1630	P$7730

Notes: Column 1 carries out the same simulation as the base case with radial rescaling assumptions, only using P$200 as the minimum. Column 2 simulates GDPPC in 1870 using actual post 1960 growth rates and truncation at the minimum. Columns 4 and 5 use population weights.

Population weights (using 1960 populations) do not make much difference to the increases in divergence. Obviously, India and China dominate any kind of population weighted analysis of income. Since both are relatively poor in 1960 this makes the weighted standard deviation much lower in 1960 than the unweighted but the percentage increases in the standard deviations of per capita income between 1870 and 1960 are about the same.

The consideration of the role of India and China, two countries which account for more than a third of the world's population, does raise a conceptual difficulty implicit in any cross-country analysis. If the question of interest is about the growth experience of *nations*, and it often is as growth theorizing is about the experience of countries since economic policies (e.g. monetary, trade, and industrial) policies are pursued at the national level, then China and India each should count for roughly one observation each[13]. On the other hand if the question is how *individuals* fare then the performance of China and India as particular countries matters a great deal. For instance, suppose we run a "convergence" regression and find that poorer countries grow modestly faster and suppose that one of the observations grows much faster than predicted (has a large positive residual). If we also know that country happens to be China that will not alter the regression line much, which is our answer to the question "how fast is the typical poor country expected to grow?" but it will completely alter the answer to the question "has fast is the country in which the typical person lives growing?"

There is another sense in which population weights are important for these income divergence calculations. Since current national population growth rates are inversely related to per capita income then divergence at the *national* level in per capita incomes will tend to imply even greater divergence at the *individual* level. Between 1960 and 1993 the fraction of the world's population living in the high income countries of the OECD fell from 19.7 to 14.1 percent. Since population growth is already much slower in these high income countries this fraction is forecast to fall further to 10.5 percent in the year 2025 (World Bank, 1995). The combination of absolute divergence and demographic changes implies the rich get both richer and

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[13] I say "roughly" one observation each as there is the possibility that the error variance in GDP growth rates is lower the larger the population and hence these countries should get some additional weight, but almost certainly not a weight proportional to their populations.

fewer.

If one accepts the assumption of the lower bound on historical GDP per capita then the fact of massive divergence is established and the reader can skip the next section, which defends this assumption. The final two sections, show that massive and continued divergence is compatible with even strong conditional convergence and examines the implications of absolute divergence for various growth theories.

II) What was the lowest level of GDP per capita?

The present technique for calculating divergence obviously hinges on the estimate of how low GDP per capita could have been in the poorest countries in 1870. There are five ways of calculating this minimum; a) estimates of current countries, b) poverty line calculations, c) caloric intake, d) relationship of income to health indicators and e) historical data. All five of these methods are consistent with using P$250 as a conservative estimate of a lower bound on GDP per capita and are emphatically incompatible with using estimates that are substantially lower.

Before delving into these calculations, it is important to stress that the effects of the exchange rate adjustment. The ICP methodology attempts to adjust the exchange rates used in creating GDP estimates in a common currency such that GDP per capita figures expressed in PPP$ represent purchasing power over an equivalent bundle of goods. This adjustment raises estimates of GDP per capita markedly in poor countries, primarily because non-tradables are typically much cheaper in poorer countries. The PPP adjusted estimates and the GDP per capita figures at official exchange rate rates (which is how they are nearly always reported in standard UN, World Bank and IMF or even historical sources) are not at all comparable, having seen an estimate of GDP per capita of US$100 or less is not inconsistent with the proposed minimum. The predicted GDP per capita at official exchange rates of a typical country with PPP GDP of P$250 is only around US$70[14]. Because of this important difference between PPP adjusted and official exchange rate dollars the notation P$ for 1985 PPP adjusted dollars and US$ for figures at official exchange rates will be used hereafter.

a) Contemporaneous GDP. The GDP per capita figures from the PWT5 suggest that P$250 is quite low as an income floor. The lowest estimate of GDP per capita averaged over five years in the PWT5 is P$275 for Ethiopia 1961-65 and the next lowest is P$278 for Uganda in 1978-82[15]. The countries with the next lowest level of GDP per capita ever observed, even for a year, are Tanzania P$260 (1961) and Burundi P$299 (1965).

The level of P$250 is extremely low even by the standards of poor countries. As shown in table 4 using this PPP adjusted standard the lowest observed GDP per capita since 1960 in India is P$582 (1961), in Bangladesh P$457 (1972), in Haiti P$826 (1967), and in China P$498 (1962). The proposed minimum is only three fifths the level of the *poorest* either Mali or Malawi have ever been since 1960 and only 40 percent of the lowest India's income has been since 1960. This

[14] If GDP per capita figures from Penn World Tables, Mark 5 (henceforth PWT5) from Summers and Heston, 1991 are regressed on World Bank figures at Atlas exchange rates for 1985 in double log form then the elasticity of the official exchange rate GDP with respect to PPP exchange rate GDP is between 1.15 (developing country only sample) and 1.30 (full sample). This implies that the ratio of unadjusted to adjusted GDP falls as income falls. For instance the predicted level of non-PPP adjusted GDP per capita at $200 is US$52 (ratio 3.84), P$300 is US$92 (ratio 3.26), P$600 is US$204 (ratio 2.94), P$2000 is $816 (ratio 2.45).

[15] The lowest for any country in any year was P$220 in Uganda in 1981. Uganda at that time was in the middle of serious internal unrest and GDP per capita fell from P$325 in 1977 and recovered to P$346 by 1982. Uganda is likely to have been below a level that was sustainable in 1981.

appeal to comparisons with contemporary levels is admittedly an argument that appeals entirely to common sense assessments of the plausible. Nevertheless, it is difficult to imagine that even in 1870 India, where 71 percent of the population in 1989 lived in absolute poverty (Chen, Datt and Ravallion, 1993), was three times as poor as it is presently (see section II.e below for historical evidence on India), or that Malawi (P$543), where half of children under five are chronically malnourished, was ever twice as poor.

Table 4: Lowest observed GDP per capita over the 1960-88 and the most recent PWT5 estimate (either 1985 or 1988) in 1985 PPP $ in various countries.

Country	Lowest GDP per capita (year)	Most Recent (1985 or 1988)
Uganda	220 (1981)	443
Tanzania	260 (1961)	488
Ethiopia	262 (1960)	332
Burundi	299 (1965)	552
Other selected countries		
Mali	398 (1969)	474
Malawi	406 (1964)	543
Bangladesh	457 (1972)	700
China	498 (1962)	2308
India	582 (1961)	786
Haiti	826 (1967)	877

Source: PWT5 (Summers and Heston, 1991).

b) Poverty Line. An alternative way to calculate the minimum level of GDP per capita is to use an internationally comparable poverty line. Ravallion, Datt, and van de Walle (1991) reviewed official poverty lines throughout the world and found that the lowest defensible poverty line was $21 per person per month (in 1985 PPP $)[16]. Therefore an individual with annual consumption expenditures lower than P$252 is considered to be in "extreme absolute poverty." This poverty line is truly "extreme" as a less penurious poverty of line of P$372 per year (the poverty line used by poor countries such as Indonesia, Bangladesh, Nepal, Kenya, Tanzania, and Morocco) was used to calculate "absolute poverty" as opposed to "extreme absolute poverty."[17]

What is the relationship between this poverty line and GDP per capita? First, this poverty measure is based only on personal consumption expenditures, which, even in a very poor economy, are only a fraction of GDP. The average share of personal consumption expenditures in the PWT5 data set for those countries with GDP per capita less than $400 is 75 percent. So mean personal consumption expenditure of $252 would typically require a GDP per capita of $336. Second, GDP per capita is an average of incomes and since distributions of income are skewed (they have a long right tail) the median individual is substantially poorer than the mean income. Most individuals consume substantially less than the mean.

Therefore, if GDP per capita were P$250 then about the most personal consumption expenditures could be is P$225[18]. If we assume a typical income distribution with mean

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[16] This figure comes from two sources. First, it happens to be the poverty line of one very big and quite poor country, India. Secondly, if (the log of) existing poverty lines across countries are regressed on a quadratic in average mean consumption, this figure is the poverty line predicted for the country in their sample with the lowest mean consumption per person per year (Somalia, at $264). The figure of $21 is actually based on the latest revision of the exchange rates in the Penn World Tables (Chen, Datt, and Ravallion, 1993).

[17] For comparison, the poverty line in the U.S. in 1985 was $228 per person per month ($10,989 per year for non-farm family of four) more than ten times the proposed poverty line of $21 per month.

[18] This assumes personal consumption is 90 percent of GDP. This is conservative as it is much higher than the 75 percent average for poor countries but is less than 100, which is necessary as there must be some

expenditures about 30 to 50 percent higher than the median then median personal consumption expenditures would be between P$173 and P$150. Assuming a GDP per capita as low as P$250 implies that half of individuals would be consuming at levels far percent below the line for extreme absolute poverty. It also seems hard to believe consumption levels at, or especially, very far below this level would be physically and demographically sustainable[19].

c) Caloric intake. A complementary calculation to the poverty line is a simple calculation based on caloric intakes. This type of "minimum caloric requirement" calculation is decidedly (and for various reasons, rightly) out of favor, but is sufficient for a concrete illustration of the point at hand. Say average caloric intake per person per day in a poor country consistent with working productively is a per person average of 2000 to 2400[20].

The data on national average daily per capita caloric intake and per capita GDP to establish a relationship a cross sectional relationship. Table 5 shows the predicted levels of daily caloric intake in 1961 for various levels of GDP per capita. At P$250 the predicted level of caloric

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investment even to maintain a low capital/output ratio and some government expenditures.

[19] This argument, that people living so far below the poverty line is actually compatible with large absolute numbers of people living below the poverty line, is true because the average "depth" of poverty is typically very small. That is, if the shape of the income distribution function is quite steep around the poverty line then large numbers of individuals can live in poverty even if not very many are living far below the poverty line. For instance, in South Asia in 1990 where 33 percent of the population was living in "extreme absolute poverty" only about 10 percent of the population would be living at less than P$172 (my estimates from extrapolations of cumulative distributions reported in Chen, Datt and Ravallion, 1993).

[20] The two figures are based on different assumptions about the weight of adult men and women, the mean temperature and the demographic structure. The low figures is about as low as one can go because it is based on a very young population, 39 percent under 15 (the young need fewer calories), a physically small population (men's average weight of only 110 pounds and women of 88), and a temperature of 25 C (FAO, 1957). The baseline figure, although based on demographic structure, usually works out to be closer to 2400 (FAO, 1974).

consumption is only 1544 far less than even the lower "required" minimum of 2000.

Table 5: Predicted caloric intake for various levels of per capita GDP.

Per capita income (in P$)	Average daily caloric intake
200	1478
250	1544
300	1600
1000	2025

Notes: Predictions are based on a cross country log-log regression of annual average caloric intake data (FAO) on P$ GDP per capita from the PWT5 and a trend. The regression estimates, using instrumental variables to account for measurement error, are (t-statistics in parenthesis):

ln(Daily Calories per person)=6.263+.1955*ln(GDP per capita).
(285) (67.4)

Of course, the fact that many countries do have caloric intake consistently below the "requirements" does bring into question the concept of a minimum level. Nevertheless, it is clear that low levels of caloric intake (and of other nutrients, particularly proteins) are associated with greater degrees of malnutrition and morbidity and that these problems get worse as caloric intakes fall. Table 6 shows the lowest levels of caloric availability ever recorded in the FAO data for various countries. Nearly all of the episodes of average daily caloric consumption below 1600 are associated with nasty episodes of natural (e.g. drought) and/or man-made (e.g. civil wars, the Great Leap famines in China) catastrophe and generally with greatly increased mortality and morbidity. Again, this is loose but suggestive evidence that incomes very much below P$250 would produce nutritionally and demographically precarious outcomes.

Table 6: Reported caloric intake for countries in selected years with extremely low intake and the associated GDP per capita.

Country and year	GDP per capita (P$)	Daily caloric intake
Somalia (1975)	816	1610
Ethiopia (1985)	325	1550
Chad (1984)	418	1443
China (1961)	536	1586
Mozambique (1987)	885	1584

Source: FAO for calorie data, Summers and Heston (1991) for income.

Another way to calculate how low GDP could possibly be within the framework of caloric requirements is to assume that all caloric requirements were to met entirely by rice (which it isn't, even amongst the poorest in rice growing regions). Since milled rice has a caloric content in consumption of 2400 per kg meeting minimum intake would require between .83 to 1 kgs of rice per person per day. The average retail price of milled rice in Asian countries in 1985 was 30 cents per kg (IRRI, 1987). Therefore just the purchase of rice for caloric sufficiency would cost between US$91 and US$109.5[21]. Since even in the poorest countries (or amongst the poorest in poor countries) the food share in the budget rarely exceeds 70 percent, this budget for rice would imply per person consumption expenditure between P$130 and P$156 per year[22]. Scaling this personal consumption expenditure up as before by assuming that personal consumption

[21] These are in US dollars because rice is a tradable commodity and so no issues of comparing purchasing power arise.

[22] Expenditure surveys from various countries show that typical values of the food share for the poorest (defined as lowest 10 or 20 percent) and the average (in parenthesis) are; Bangladesh (81/82) 72.9 (66.2), India (Rural, 1983) 76.1 (65.5), Ghana (1987/88) 70.7 (69.1), Philippines (1985) 69.3 (53), Cote d'Ivoire 71.1 (48.9), Guatemala 65.9 (54.8).

expenditures are 90 percent of GDP implies a GDP per capita between P$144 and P$173. Therefore even under the most incredible and unrealistic assumptions of a subsistence economy in which everyone in the economy has the same income, and ate only rice, and ate only enough rice to meet nutritional requirements the GDP per capita is still three times higher than P$50 (which was previously shown to be the minimum assumption on 1870 GDP per capita that implied no divergence).

d) Health Indicators. The strong (and I would argue causal, Pritchett and Summers, 1994) relationship between level of income and health is well-known. This implies that as an economy gets poorer the life expectancy of its population will fall. However, life expectancy can only fall so far and still be compatible with what is known about population stability and population growth rates.

Table 7 shows the results of estimating a relationship between life expectancy or infant mortality and per capita income and a trend term using either current data (PWT5 data on incomes combined with World Bank data on health indicators) or historical data (Maddison (1991) income data with infant mortality from historical sources). These equations are used to predict what life expectancy or infant mortality would have been in 1870 at various levels of income. At per capita income of P$200 both regression models predict either impossibly high (1044) or demographically implausible (844) levels of infant mortality. Life expectancy is predicted to be only 27.3 if income were as low as P$250 and infant mortality is still predicted to be incredibly high.

Table 7: Predicted levels of life expectancy and infant mortality in 1870 at various levels of GDP per capita.

Income level (1985 PPP $)	Predicted Life Expectancy in 1870 (from estimates on current data)	Predicted Infant Mortality (per '000) in 1870 (from estimates using current data)	Predicted Infant Mortality (per '000) in 1870 (from estimates using historical data)
200	26.5	1044	873
250	27.5	990	765
300	28.3	948	686
1000	34.4	712	336
2000	38.5	604	223

Notes: The predicted values of life expectancy and infant mortality rate are based on log-log regressions reported in appendix table 2.1.

The rate of natural increase of population in nearly all poor regions around this period (1870) is reasonably well known and is estimated to be between .25 and 1 percent[23]. These figures for the rates of actual natural increase are not consistent with life expectancy or infant mortality much lower than the ranges predicted for an income of P$250. Income below this level is unlikely to produce the conditions necessary for growing populations.

e) Historical data. The four arguments above have relied on the same basic intuitive counter-factual argument for establishing a lower bound GDP per capita estimate: that if income

[23] For instance, Livi-Basci (1992) reports estimates of population growth in Africa between 1850 and 1900 to be .87 percent and .93 percent between 1900 and 1950, while growth for Asia is estimated to be .27 1850 to 1900 and .61 1900 to 1950. Clark (1977) estimates the population growth rates between 1850 and 1900 to be .435 percent in Africa and India and lower, .33 percent in China.

were (much) below P$250 in 1870 life would have been too nasty, brutish and short. This is not to say that life was not in fact nasty, brutish and short in many countries in 1870. It was. But there is a limit and the four lines of reasoning above place some strict bounds. But for those that remain unconvinced we can examine what evidence does exist about GDP estimates in the very long-run for the now developing countries.

Maddison (1994) presents estimates of indices of constant price GDP per capita, fortunately already expressed in 1985 purchasing power parity adjusted dollars, for a number of developed and now developing countries in starting in 1820. In no case are estimates of GDP per capita anywhere near the lower limit I have used in simulations. The lowest estimates of GDP per capita, for India (490) and China (497) in 1820, periods in which life was unquestionably difficult and living standards extremely low, are still roughly twice the lower bound I have used of P$250[24].

Maddison (1991) also estimates GDP per capita for the Western European countries. In 1700 in the Netherlands at P$1515 and of the UK at P$992. The fact that the most advanced of the European countries almost 300 years ago were 5 and 7.5 fold above our present estimates of the minimum income level is reassuring. Maddison (1991) even ventures to guess at the GDP per capita in Western Europe (average) in 1400 was only P$400. Kuznets (1971) estimates that at its trough in 900 European countries GDP would have been above 1985 US$160, which, if adjusted to P$ by a ratio of 2.5 gives and estimate of P$400. These are still well above the line we are

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[24] Maddison derives these estimates in 1820 for India and China partly by guessing, based on his historical research for India and background information on China, that per capita growth was zero between 1820 and 1870 in these two countries.

using as our 1870 lower bound.

Table 8: Estimates of long-run GDP per capita in P$.				
	1820	1870	1950	Per annum growth, 1870-1950
India	490	490	502	0.03%
China	497	497	454	-0.11%
Indonesia	533	585	650	0.13%
Brazil	556	615	1434	1.06%
Mexico	584	700	1594	1.03%
Thailand		741	874	0.21%
		1890		
Korea		680	757	0.18%
Taiwan (China)		564	706	0.38%
Average for 14 West European countries and their off-shoots	1055	1723	4813	1.29%
Source: Maddison, 1994.				

The second point from table 8 is that, even with this very spotty coverage, the historical data confirms the impression of massive divergence. Whereas India's per capita income was a little less that half of the core group of richest countries in 1870, it was a tenth of the richest countries in 1950. Similar statements apply to all of the Asian countries, none of whom grew faster than .5 percent per annum up until 1950 compared to 1.3 percent average growth in the leading countries over that period. Even the Latin American countries, with reasonable growth, fell further and further behind.

III) Unconditional divergence and conditional convergence

In this section I do not wish to take issue with, nor even survey, all of the issues surrounding the estimation of the magnitude of conditional convergence. I only wish to make the obvious, but nevertheless practically important and sometimes overlooked, point that absolute divergence and conditional convergence are compatible propositions[25]. Conditional convergence need not imply absolute convergence, and that the estimates of growth factors with the current data do not predict convergence for the world at large well into the future.

If we are examining the convergence or divergence of relative (i.e. natural log) per capita incomes then a necessary condition for absolute convergence is that the growth rate must be faster for countries with lower levels of GDP per capita. On the other hand "conditional" convergence means that growth is faster the lower GDP per capita when controlling for some particular set of conditioning variables. Table 9 shows a set of regressions using the standard PWT5 data set (on which nearly all regressions of this type are run). Column 1 shows absolute divergence. If the growth rate from 1960 to 1988 is regressed on the level of GDP per capita relative to the leader then the coefficient is positive. On average, rich countries grew faster (a point acknowledged by all, Nuxoll, (1994))[26]. Column 2 shows conditional convergence. If investment rates and enrollment rates are included in the growth regression then, conditional on the flow of gross investment in physical and human capital, a lower GDP per capita predicted a faster growth rate.

Columns 3 and 4 show that the conditioning variables, investment in physical and human capital, are themselves positively related to per capita income. That is, enrollment rates and investment rates are higher for richer economies. The total coefficient on initial income relative

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[25] This is acknowledged, even stressed, by some of the original authors on conditional convergence as one of their reasons for focusing on "conditional" convergence was to counter the emphasis placed on the absolute divergence (Barro and Sala-I-Martin, 1995, Mankiw, Romer, Weil, 1992).

[26] For illustrative purposes and comparison with the existing literature I am ignoring the fact that investment rates and enrollment rates are enormously horrible proxies for the accumulation of physical and human capital, respectively. For these samples the average share of investment in GDP is uncorrelated with the rate of growth of the capital stock (Pritchett, 1994) and enrollment rates are *negatively* correlated with the growth of human educational capital (Pritchett, 1995).

to the leader on the growth rate is easily derived from the simple system of equations;

$$g = \beta * \ln(YPC_0) + \alpha_I * (INV/GDP) + \alpha_H * Enro$$
$$NV/GDP = \gamma_I * \ln(YPC_0)$$
$$Enroll = \gamma_H * \ln(YPC_0)$$
$$\frac{dg}{\ln(YPC_0)} = \beta + \alpha_I * \gamma_I + \alpha_H * \gamma_H$$

Working out these (simplistic) formula shows (reassuringly) that once the positive effect of initial income on investment and enrollments is taken into account the model predicts both observed facts of absolute divergence and conditional convergence.

Table 9: Divergence, conditional convergence and the relationship of initial incomes to "conditioning" investment variables, 1960-1988.

	Dependent variable: per capita growth rate		Dependent variable:	
	Just initial income	Initial income and investments	Investment levels	Primary School Enrollment
Initial level of GDP per capita relative to leader	.401 (2.02)	-.322 (1.62)	4.43 (5.68)	14.57 (5.87)
Average level of investment		.067 (2.95)		
Average enrollment in primary school		.029 (4.04)		
Constant	2.66 (6.43)	-2.39 (2.91)	26.09 (16.04)	112.86 (21.83)
N	117	117	117	117
R-Squared	.034	.320	.219	.231

Note: absolute value of t-statistics in parenthesis.

This implies that conditional convergence *per se* provides no reason to predict convergence of per capita incomes in the future. If the regression of investment levels and secondary enrollment rates on per capita incomes is run for 1985, and it is assumed that the strength of conditional convergence remained constant over the next 25 years (from 1985) then the standard deviation of natural log per capita incomes would increase from 1.02 to 1.27[27]. Although there might be some forces--like increasing trade integration[28] or better developing country policies (Sachs and Warner, 1995)[29]--that would lead to stronger conditional convergence, these would have to be extraordinarily powerful to overcome the tendency to divergence. In the above simulation to the year 2020 even tripling the conditional convergence coefficient (from -.32 to -.96) does not induce absolute convergence. The fact that, if it were the case that poorer countries had higher rates of investment (in physical and human capital) they could, by virtue of their "backwardness," grow faster that the leading countries, should not obscure the fact that, on average, poor countries have lower rates of investment and hence can be expected to grow slower

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[27] The equations for the simulation (based on estimated regressions in 1985 for investment and secondary enrollment and assumed coefficients on the growth regression)

$$INV/GDP=(27.4)+(4.97)*\ln(YPC_0/YPC_{max})$$
$$Enroll=(94.93)+(24.9)*\ln(YPC_0/YPC_{max})$$
$$g=-.32*\ln(YPC_0/YPC_{max})+(.07)*(INV/GDP)+(.03)*(Enroll)$$

. Applying the predicted growth rates from this regression to the (ln) levels of GDP per capita in 1985 gives the predictions for incomes in 25 years.

[28] Ben-David (1993) argues that the convergence of incomes in the European countries was brought about by and large by the increasing trade integration among them. It has also been suggested that the fact that the advance countries converged over the periods 1870-1913 and 1950-1990 and diverged over the 1913-50 perdiod may have to do with the very different degrees of trade integration over time.

[29] Sachs and Warner (1995) show that of the countries that had "minimally acceptable" property rights and trade regimes there was very strong conditional convergence while not tendency amongst the other countries. However only ten countries traditionally classified as developing were among the the 35 that qualified by this criteria (Barbados, Indonesia, Jordan, Korea, Malaysia, Mauritius, Morocco, Singapore, Taiwan (China), and North Yemen) while 82 developing (and no developed) countries were excluded. Whether the emphasis on the policy conditions for convergence is an optimistic or pessimistic depends on one's view about the scope for policy change.

well into the future[30].

Part of the reason that absolute divergence was the recent experience is that, by and large, the conditional convergence effect is not large. In the simple regression in table 9 the coefficient of -.32 implies that moving from having the initial income of a extremely poor country such as India (P$617) or a Kenya (P$635) to a semi-industrialized country such as Yugoslavia (P$1690) or Turkey (P$1669) would decrease expected growth by a mere .32 percentage points whereas the standard deviation of growth rates in the sample is almost 2 percentage points[31]. The estimated "conditional convergence" advantage of having been the poorest country in 1960 (Ethiopia) versus the richest (USA) is only 1.2 percentage points. In MRW (1992) convergence is quite slow, with only half the gap closing in 35 years, whereas in Barro and Sala-i-Martin (1995) show a stronger effect with convergence estimates that imply a 3 percent per year elimination of the gap, closing half the original gap in 23 years.

This small coefficient implies that the additional predictive power from knowing initial income, conditional on knowing physical and human capital accumulation rates, is also quite small. In my regressions, adding initial income only explains an additional one percent of the variance and hence, in understanding the reasons for differing growth rates, initial income gives very little additional information.

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[30] This is a statement about countries, not about people in the world. Given that China has had very rapid growth and India's growth seems to be accelerating it may be the case that at the individual level there will be convergence, but this, like all "global" conclusions, depends more on what happens within two particular countries rather than what happens to the "typical" poor country.

[31] This appears to be quite close to the effect of -.289 (all non-oil) and -.366 ("intermediate" sample) reported by Mankiw, Romer and Weil (1992).

This does not mean it may not be a very important finding for theoretical purposes. Not every empirical question that is important for theory is also empirically important[32]. Whatever its theoretical importance conditional convergence is not the major empirical force driving growth, a point emphasized by for instance, Mankiw, Romer and Weil (1992) in their conclusion "[f]uture research should be directed at explaining why the variables taken to be exogenous in the Solow model vary so much from country to country."

IV) Implications for models of growth and development

The sections above have, directly or indirectly, established several stylized about economic growth and economic development. This section brings those together along with some other known facts about growth and suggests that in order to accommodate these facts a comprehensive theory of economic growth would have to have at least four features.

A) Eight facts about growth

First, eight facts about economic growth.

1 The last 125 years have seen massive divergence in absolute and relative incomes. Divergence rather that convergence is the primary fact about growth rates. Any model would have to explain why some countries have become enormously wealthy while others remain desperately poor.

2 Steady and near equal growth amongst the leaders over the long haul. Table 1 showed that amongst the countries that were the leaders in 1870 there has been nearly equal growth.

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32 For instance, one critical empirical test between competing models of gravitation was a tiny anomaly in the observed orbit of Mercury that Einstein's theory could explain while basic Newtonian physics could not.

Moreover, that growth has been remarkably steady in the leading country (the US). If per capita income in the US in 1988 is predicted based on growth rates estimated only through data through 1930 this 58 year ahead prediction error is only 2.4 percent[33]. However, most other countries have seen a more noticeable acceleration of growth in the post WWII period, which accounts for the convergence of these countries in the US in the post WWII period.

3 The poorest countries have had historically very very low growth. The implication of the lower bound that implies divergence also places an upper bound on the average cumulated growth rate. We can calculate growth rates back to 1820 for a number of the now advanced countries and find these growth rates are around 1.5 percent. However, if GDP per capita was not lower than P$250 in 1820 then the highest that growth could have been for the 12 countries with GDPPC less than P$500 in 1960 was .5 percent. Similarly the very highest growth could have been for the 40 countries with GDP per capita less than P$1,000 was 1 percent and the highest for the 80 countries with GDPPC less than P$1500 was 1.5 percent.

4 Some countries that began poor in 1960 continued to stagnate. Eighteen developing countries has growth rates less than zero over the 1960-85 period; 28, more than a quarter of the total, had growth rates less than .5 percent per annum; and 40, more than a third of the sample, had growth rates less than 1 percent per annum[34].

5 Some countries that began poor in 1960 have had extremely rapid growth. There have

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[33] Jones (1995) uses this basic fact of the constancy of growth to good effect in creating a compelling argument that the steadiness of US growth implies that endogenous growth models that make growth a function of non-stationary variables, such as the level of R&D spending or the level of education of the labor force are likely incorrect as they imply an accelerating growth rate (unless several variables working in opposite directions just happened to offset each other).

[34] The division into developed and developing is using the criteria that the 22 high income members of the OECD are classified as "developed" and all others developing.

also been episodes of extremely rapid growth. Fourteen (of 107) countries had growth rates more rapid than 4 percent per annum, and 24 countries had growth rates more rapid than 3 percent. Growth rates of this magnitude over an extended period are essentially unparalleled in economic history.

6 (Partially an implication of 4 and 5) Cross sectionally growth has varied enormously in developing countries. Facts 4 and 5 together bring up one of the truly striking stylized facts about the relationship between growth and initial income: not the mean, but the variance of growth rates. The standard deviation of developing country growth rates over the 1960 to 1992 period is more than twice as large as that of developed countries and the range of growth rates is four times as large[35]. Figure 2 shows the scatter plot of growth rates by level of initial income.

Table 10: Differences in the average and in the dispersion of growth rates between developed and developing countries, 1960-90.

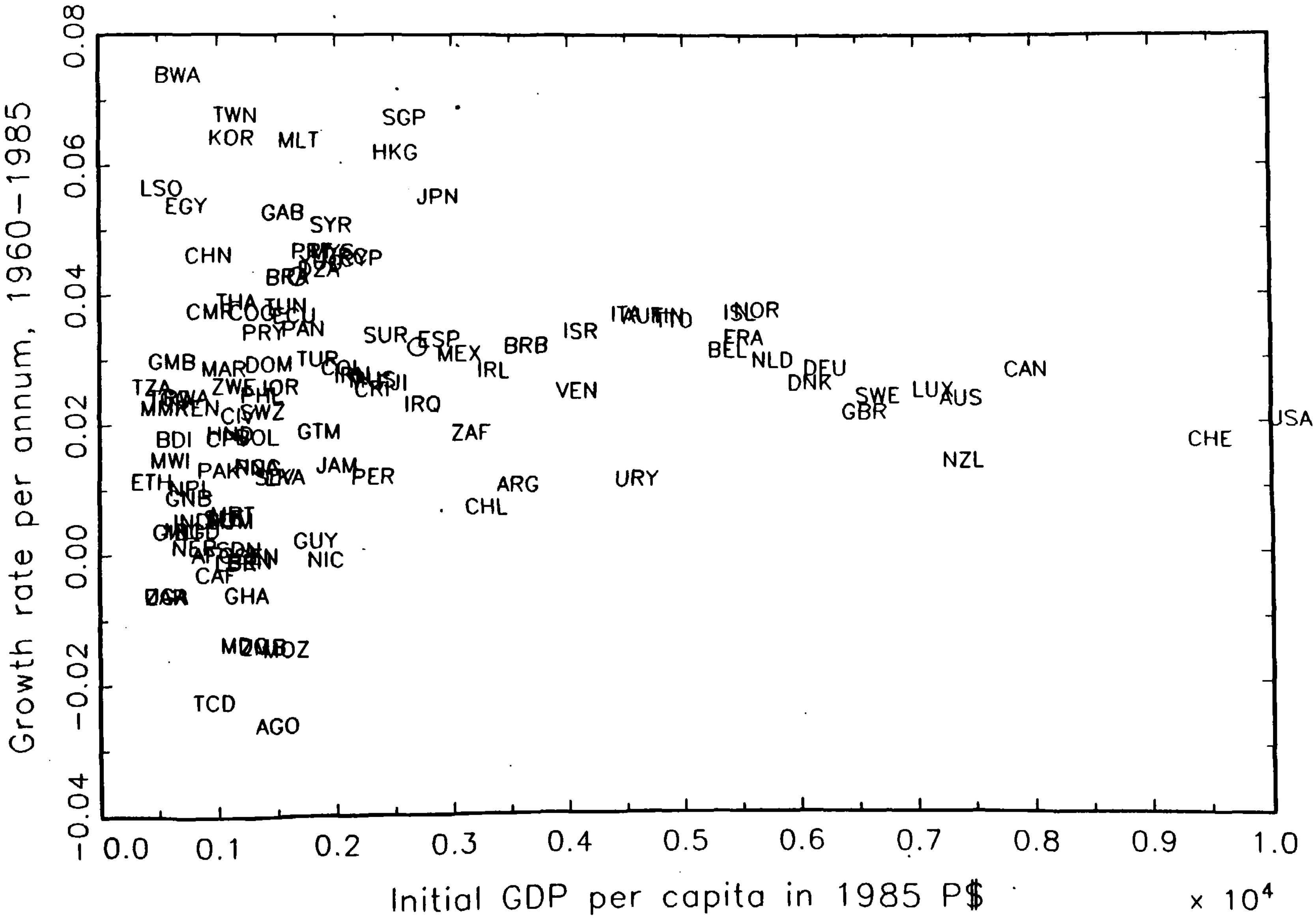
	Developing countries	Developed countries
Average per annum growth rate	1.73	2.67
Standard deviation of growth rates	1.96	.83
Range of growth rates	9.6 (-2.7 to 6.9)	2.4 (1.2 to 3.6)
Number of countries	107	22

Notes: Calculated from PWT5.6 data, using least squares logarithmic growth rates over the longest possible span of data (generally 1960-90).

7 Growth has been much more variable not only across but also within developing countries. The variation of growth rates within countries over time has also been more than twice

[35] Obviously the range for developing countries will be larger simply because there are more of them, but the expected range for a normal distribution with the mean and standard deviation of the developed countries with 107 observations is 4.2 (from 4.5 to .3) versus the observed range for developing countries of 9.6.

Figure 2: Growth rates and initial income



as large for developing countries. The average change in growth rates (in absolute value) in developing countries from one decade to the next is full 3 percentage points. Some countries have had growth accelerate enormously, Indonesia's GDPPC growth rate was .57 from 1960 to 1970, 5.08 percent since. Others have had rapid growth rates come to a complete halt, Brazil's GDPPC grew 5 percent per year until 1980, and only .06 percent yearly until 1992, Mexico's GDPPC grew 3.8 percent per year until 1981 and .05 per year since. Still others have seen growth punctuated with huge falls in output (e.g. Chile's GDP per capita fell 23 percent 1972-76 and 22 percent from 1981 to 1983). Explaining this greater variability of growth both across and within countries seems at least as relevant for a model of economic development as generating conditional convergence.

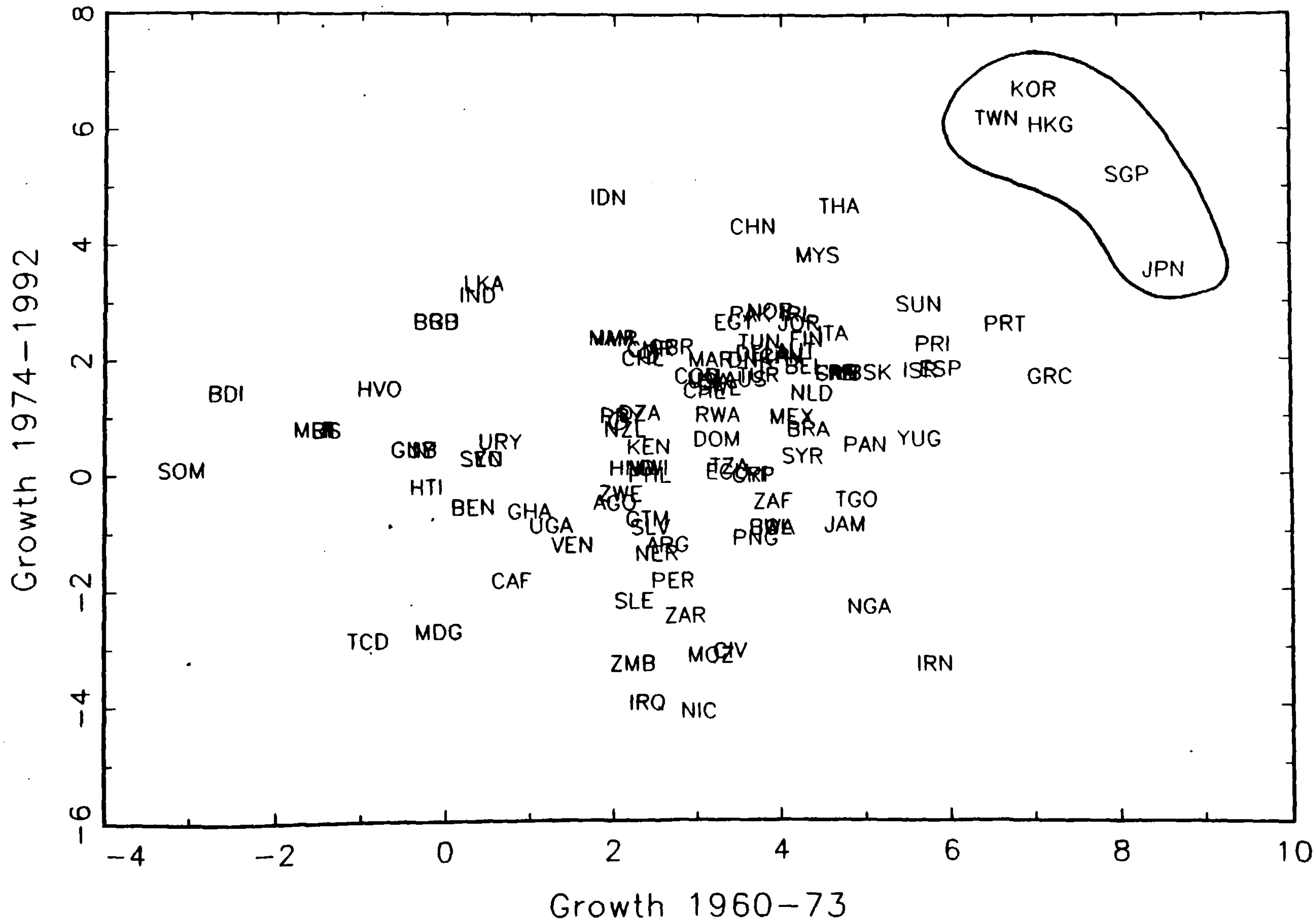
Table 11: Differences in the variability of growth rates between developed and developing countries, 1960-90.

	Developing countries	Developed countries
Standard deviation of the year to year GDP per capita growth rates	6.5	3.1
Average absolute value of the change in individual's countries growth rates between decades.	2.91	1.49
Number of countries	107	22

Notes: Calculated from PWT5.6 data.

8 Growth rates, especially in developing countries, have shown very little persistence. Easterly, Kremer, Pritchett and Summers (1993) demonstrate that the cross country correlation of growth rates is very low, even fairly extended periods, such as 10 or 15 years (see figure 3).

Figure 3: GDP per capita growth rates 1960-1975 verus 1976-1992



Using the data since 1960 one finds that, if one excludes the Four Asian Dragons and Japan, the correlation of growth rates over the beginning and end periods of the sample is only .17[36].

B) Implications for models of economic growth

What would a model look like that could generate all of those empirical features? It would seem to have to have at least four features. First, there has to be the possibility of very long periods of stagnation.

Second, the balances of "advantages" and "disadvantages" to backwardness need to be able to come out on the disadvantages side. At least since Gersehenkron (1962) there has been the idea of an "advantage to backwardness" which allows countries behind the technological frontier to experience episodes of rapid growth driven by rapid productivity catch-up[37]. While not denying the possibility of rapid gains in productivity is a possibility, absolute divergence implies that although there may be some potential advantages to backwardness, the cases in which backward countries, and especially the most backward of countries, actually gain significantly on the leader are historically rare. In poor countries there are clearly forces that create the potential for explosive growth, such as those witnessed in some countries in East Asia. But there are also strong forces for stagnation: a quarter of the 60 countries with initial income less than P$1000

[36] This greater within country variability and low time persistence of growth rates are the reasons it is a very bad idea to test for convergence using panel data that uses shorter time periods. For instance, if output in any given year is equal to a long run equilibrium level determined by capital stocks plus a serially correlated random disturbance then the "conditional convergence" parameter captures both the short-run "business cycle" frequency return to equilibrium plus whatever long run convergence that may exist. Monte Carlo experiments that gnnerate cross country "data" that replicate the large ratio of business cycle to trend and low persistence of growth rates but no long run convergence of growth rates show than using panel data can overestimate convergence relative to the use of long run data by several orders of magnitude.

[37] I say at least since according to Rostow (1993) David Hume more than 200 years ago argued that the accumulated technological advances in the leading countries would give the followers an advantage.

have had growth rates less than zero and a third have had growth rates less than .05 percent. There also have to be forces present for "implosive" decline such as that witnessed in some countries in which the fabric of civic society appears to have disintegrated altogether (a point often acknowledged off-hand or ignored as these countries drop out of our growth regression samples). Overall, the disadvantages to backwardness so far seem to be have been the rule.

Third, there has to be the possibility of extended, reasonably stable, and rapid growth.

Fourth, there has to be considerable variability in growth rates, both across countries and within countries over time.

A model with these features will obviously be more than a model of economic growth, as there are models of economic growth and there are models of economic development. Since growth is typically a major feature of economic development there is considerable overlap in the two types, but there are nevertheless some very large differences. Typical models of economic growth (whether exogenous or endogenous) focus on the determination of long-run growth in relatively advanced economies, why it persists and what explains its variations but are not intended to cover other features relevant to development[38].

While it is easy to build a mathematical (as opposed to economic) model with these features by building in precisely the assumptions that mimic the data reasonably well, specific features about the model will dramatically affect the vision of propects for the future. Table 12 presents simulations of a model of growth that involves steady state growth of the leaders, with the poorer countries moving stochastically between states of stagnation, steady growth, and

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[38] It would be taking Robert Solow very *un*seriously indeed (and I do not think this is what MRW, 1992 implied) to act as if he intended his one sector, two (or even augmented to three) factor growth model to "explain" why the US has grown steadily *and* why Korea has boomed *and* why Tanzania has stagnated *and* why the Brazilian miracle of the 1970s petered out.

convergence booms (the model is described in appendix 1). By choosing the transition probabilities between the states the model can mimic reasonably well both the observed historical divergence and the properties of recent growth rates, e.g high variability, some rapid gainers, low persistence (the results are also described in appendix 1).

While the model is built to predict divergence since 1870, whether this model predicts future divergence or convergence in the future depends critically on what one assumes about the transition probilities out of stagnation. The results in column I of table 12 assume that the transition probability from stagantion is constant, and show continued divergence for the next 125 years. Results in column II assumes that policies can influence the transition from stagnation into growth and that policies improve in the future, in which case there is massive absolute convergence. This is the optimistic message of Sachs and Warner (1995), that every country which adopts reasonable policies will have sufficiently strong conditional convergence to create absolute convergence.

The results in column III of table 12 are derived under the assumption that the transition probability out of stagnation (here classified as growth of .5 percent per annum) increases with the absolute level of income. This captures crudely models with "thresholds" in which growth requires a certain minimum level of accumulation, or "stages of growth" models with a "take-off" effect in which after a long period in which the "pre-conditions" are established countries can have rapid growth (Rostow, 1990). Here again, although there has been absolute divergence over the last 125 years (1870-1995) the next 125 years could see absolute convergence as even the slow growth in the stangation phase pushes more and more countries over the threshold into rapid growth. However, with the slight change in assumptions such that the transition probability out of stagnation is declining with the *relative* gap in incomes (say, successful imitation of the leaders becomes more difficult the greater the relative income gap) then the next 125 years will see massive absolute divergence as those that make it into the "convergence club" get richer while those countries left behind have less and less chance of joining the club (column IV).

Table 12:	Simulations of alternative paths of divergence, depending on the assumptions about transition out of stangation of developing countries.											
Column:	I			II			III			IV		
Transition from stagnation:	Exogenous (at 1.5 percent per year)			Exogenous increase in 1995 due do better policies (to 5 percent per year)			Increasing with higher absolute income			Decreasing with the relative distance from the leader		
	1870	1995	2020	1870	1995	2020	1870	1995	2020	1870	1995	2020
Ratio, min to max	6.6	40.7	340	7.7	44.8	13.4	7.7	46.8	2.8	7.3	45.2	276
Std. Dev. ln(GDPPC)	.49	1.1	1.6	.54	1.14	.472	.53	.99	.15	.53	1.15	1.46
Notes: Based on the simulations of the model described in appendix 1.												

A theory that unifies economic growth and economic development must address at least the four questions:

* what accounts for continued per capita growth and technological progress of those leading countries at the frontier,

* what accounts for the few countries that are able to initiate and sustain period of rapid growth in which they gain significantly on the leaders?

* what accounts for why some countries fade and lose the momentum of rapid growth?

* why do some countries stagnate?

Theorizing about economic growth and its relationship to the appropriate policy needs to tackle these four important, and distinct, questions. While it is conceivable that there is an all purpose answer to the generic question, "what policies would be good for promoting economic growth?", it seems much more plausible that the answer differs. Is the question asked of a mature economic leader (e.g. USA or Germany or France)?, a booming rapidly industrializing (or already industrialized) country trying to prevent stalling on a plateau (e.g. Korea, Indonesia, or Chile), a once rapidly growing and at least semi-industrialized country trying to initiate another episode of rapid growth (e.g Brazil or Mexico or the Philippines)?, or a country still trying to take off into sustained growth (e.g. Tanzania or Myanmar or Haiti)? Discussion of the appropriate policies for economic growth seem at times remarkably undifferentiated, with the principal questions being addressed and the countries to which the discussion is intended to be applicable either ignored entirely or left implicit.

Conclusion

Whichever way the debate about whether there has been some "conditional" convergence in the recent period is settled, the fact remains that one overwhelming feature of the period of modern economic growth is massive divergence of absolute and relative incomes across countries, a fact which must be grappled with in a fully satisfactory model of economic growth and development.

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Appendix 1: Description of a simulation model

The mathematical model is based on simulating a GDP per capita series (y) for each of N countries (N=117) over T periods based on cumulating a series from a starting date;

$$y_t^n = y_{t-1}^n * (1 + g_t^n)$$

The set of countries is divided into two, the "rich" countries and the "developing" countries. In the simulations there are 14 rich countries and 103 developing countries. For the 14 rich countries GDPPC in 1870 was drawn from a uniform distribtion with minimum of 1700 and maximum of 2050. The rich countries grew in every period at 1.8 percent.

The developing countries were more complicated. The initial GDPPC was drawn from an uniform distribution with a minimum of 250 and a maximum 950. The growth rate (g) for each country n in each period t is decided stochastically to be in one of four catogories: stagnation, g=.5 percent; a plateau g=1.8 percent; a boom where $g = (1.8)*(rich\ country\ income^t / y_n^t)$, which implies that booms are faster the poorer a country is when it starts, but that eventutally growth settles down to the "rich" country rate; and an "implosion" period in which $g = -1.8*(y_n^t - 250)/y_n^t$, which creates the possibility of large recessions (especially for poorer countries) but with no country going below the minimum. All poor countries begin the simulation in stagnation.

The rest of the model is given by the matrix of transition probabilities between the various stages, given in table A1.1. All of these probabilites are constant across all simulations except that for the transition from stagnation to growth. The transition from stagnation is in two stages, from stagnation to growth, then to either a plateu stage (.7) or a boom (.3).

Table A1.1 Matrix of transition probabilities between various growth rate states in the base case simulations.

<table>
<tr><th rowspan="2">To:</th><th colspan="5">From:</th></tr>
<tr><th colspan="2">Stagnation</th><th>Implosion</th><th>Plateau</th><th>Boom</th></tr>
<tr><td>Stagnation</td><td colspan="2">.885</td><td>.4</td><td>.1</td><td>0</td></tr>
<tr><td>Implosion</td><td colspan="2">.1</td><td>.6</td><td>0</td><td>0</td></tr>
<tr><td>Plateau</td><td rowspan="2">.015</td><td>.7</td><td>0</td><td>.8</td><td>.1</td></tr>
<tr><td>Boom</td><td>.3</td><td>0</td><td>.1</td><td>.9</td></tr>
</table>

The transition from stagnation to growth (either a plateau or a boom) is different in each of the four simulations reported in table 12, as described in table A1.2. The probability of remaining in stangation is determined residually in each case.

Table A1.2: Different assumptions about transition probability from stangation to growth.		
Column in table 12	Description	Formula
I	Exgogenous and constant	p=.015
II	Exogenous shift.	p=.015 up to 1995, p=.10 thereafter.
III	Increasing with absolute level of income.	Transition to growth if the value of test<.015, where test=x+.2*ln(400)-.2*ln(y), where x is a draw from a random uniform (0,1).
IV	Decreasing with the relative income gap.	Transition to growth if the value of test<.015m, where test=x-.5*ln(top/y)+.5*ln(top/y), where top is the income of the top country in the t[th] period and z is a draw from a random uniform (0,1)

The structure of the model and the transition probabilities were chosen so as generate about the observed magnitude of divergence and to roughly reflect the eight facts about growth rates. The 1870 to 1995 figures show the absolute divergence, while Table A1.3 reports the results of taking the last 30 years of growth rates and calculating statistics about those growth rates.

Table A1.3: Summary statistics of growth rates over the last 30 years of a 125 year simulation in the base case.	
Mean of growth rates	1.77
Standard deviation of "developing" country growth rates	2.3
Range of "developing" country growth rates	8.8 (8.02 to -.76)
Correlation of growth rates of "developing" countries between first and last half of the period.	.12

Appendix 2: Regressions of health status on income

Appendix table 2.1: Regression results			
	Dependent variable		
	ln(Life Expectancy)	ln(Infant Mortality)	ln(Infant Mortality)
GDP per capita	.162 (80.9)	-.238 (20.75)	-.593 (23.73)
Trend		NA	-.013 (32.44)
Trend*(since 1960)	.0043 (17.5)	-.026 (75.7)	-.0025 (14.23)
N	3643	3608	
R-Squared	.675	.780	
Estimation	OLS	OLS with Fixed Effects	OLS with Fixed Effects
Sample	Annual observations on 136 countries, 1960-1990	Annual observations on 136 countries, 1960-1990.	Annual observations on 22 countries, 1870-1988.
Notes: Absolute values of t-statistics in parenthesis.			

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