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Abstract

We present new data on real output per worker, schooling per worker, human capital per worker, real physical capital per worker for 168 countries. The output data represent all available data from Maddison. The physical capital data represent all available data from Mitchell. One major contribution is a new set of human capital per worker, the foundation of which comes mostly from Mitchell. We provide original estimates of schooling per worker & per young worker. With our preferred measure of human capital, between 66 percent to 90 percent of all the variation in long run growth can be explained by variation in the growth of inputs per worker, and only 10-34 percent from variation in TFP growth! Furthermore between 66 percent and 80 percent of the variation in log levels can be explained by variation in the log input levels and only 20 percent to 34 percent is explained by variation in log TFP levels!

1 Introduction

Since 1820, which we will consider the beginning of the Industrial Revolution, the disparity in income per capita has increased dramatically. In 1820, the Netherlands, with highest output per worker ($5500), was 5 times richer than Myanmar, the country with the lowest output per worker ($1100).[1] In 2007, the top to bottom distance is between the United States ($76,000) and Zaire ($750), or a factor of 100![2] The variance of the log of output per worker has increased from .39 in 1820 to 1.15. The primary objective of this paper is to account for the factors that have resulted in the growth of output per worker as well as the increase in dispersion output per worker. To this end, we use data from Maddison, Mitchell, and Lindert to produce a data set that has measures of output per worker, physical capital, and human capital that covers 168 countries and covers the onset of the Industrial Revolution for every region of the world. Over this long horizon, the growth in factors of production account for eighty percent of output per worker growth. More striking, the variation in the growth rates of inputs can account for eighty percent of the variation in the growth rate of output per worker! This is in marked contrast to previous work over shorter time

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[1] All values are expressed in 2000 PPP dollars.

[2] Luxembourg is the most productive country with output per worker of more than $160,000 in 2007, but we chose to go with the second most productive country instead.

horizons that find that TFP growth variation is much more important in explaining output per worker growth variation than input growth variation. For example Klenow & Rodriguez-Clare (1997) find less than 20% of output growth variation is explained by input growth variation. Baier, Dwyer and Tamura (2006), hereafter BDT, have a longer time series, but still find that barely 20% of output per worker growth variation is explained by input per worker growth variation.

In this paper we develop a new data set, which dramatically expands the data available in BDT. The number of countries is expanded from 145 to 168, but more importantly, the length of coverage for all countries is dramatically increased. Further we have the growth of formal schooling in every region from illiteracy to universal primary schooling, near universal secondary schooling and rising attendance in higher education. Using a Bils-Klenow definition of human capital, we find that variation in growth rates of output per worker is equally captured by variations in growth rates of inputs and variations in growth rates of TFP. If one uses intergenerational human capital accumulation technology, most of average growth in output per worker can be explained by the growth in real physical capital per worker and human capital per worker. Furthermore we find that this intergenerational human capital accumulation specification can help to explain even more of the variation in growth rates across countries. Specifically we find that the new human capital model can explain between 66 percent to 90 percent of growth variations across countries. Additionally most of log level differences, between 66 percent and 80 percent, are explained by log level differences in inputs, rather than differences in log TFP. Both of these findings strongly support the ability of intergenerational human capital accumulation models to explain long run growth differences, and long run development differences.

One important caveat to bear in mind. We take the time path of input accumulation, physical capital and human capital as given. In particular we think that high quality institutions matter a great deal in providing both a higher return on existing inputs, more output per worker, as well as greater incentives to accumulate. To the degree that inputs explain output per worker differences at a point in time, and differential growth rates of inputs explain differential output per worker growth rates, then institutions can be primary. The list of contributors to this line of research is large, but certainly includes: Acemoglu, Johnson and Robinson (2001,2002, 2005a,b), Canaday and Tamura (2009), Gwartney and Lawson (2008), Keefer and Knack (1997a,b), Kormendi and Meguire (1985), North (1981, 1990), Parente and Prescott (1994, 1999, 2002) and Tamura, Simon and Murphy (2012).

The paper is organized as follows. In the next section we give a brief overview of the data used in the paper. The interested reader can read our companion Data Appendix (2011) for more details. Section 3 contains the growth accounting. Section 4 contains our variance decomposition of growth. We use three different measures of input importance for capturing disparate economic performance. We present intergenerational human capital in Section 5, with and without spillovers. Section 6 examines the robustness of our conclusions. Evidence from micro data is presented in Section 7. Section 8 concludes.

2 Data

We use Maddison for data on real PPP per capita output.[3] All values are in real 2000 dollars. We use Mitchell (2003a,b,c) for historical data on labor force.[4] For investment rates in physical capital we used

[3]Data was taken from his personal website: http://www.ggdc.net/maddison. Also we used the growth rate of PPP output per capita from 2006 to 2007 from *World Development Report 2009* to produce our 2007 value.

[4]See our Data Appendix (2011) for greater detail. For 2007 labor force we used the *World Development Indicators*.

both Mitchell (2003a,b,c) for historical values as well as Summers, Heston and Aten (2009).[5] From these base data we produce measures of PPP real output per worker. We use the standard perpetual inventory method to produce real physical capital per worker.[6]

For human capital, we first produce original estimates of schooling for each country by age cohort as well as the average schooling in the labor force.[7] This is an original contribution to the literature as prior to this the earliest measures of years of schooling are contained in Baier, Dwyer and Tamura (2006). To compute our initial human capital, we use the same method as in Baier, Dwyer and Tamura (2006), Hall & Jones (1999) and Klenow & Rodriguez-Clare (1997). We use cross sectional evidence from labor economists to compute human capital as a function of schooling and experience.[8]

$$h_t = exp(f(\text{schooling}) + g(\text{experience})) \tag{1}$$

$$f(E) = .10E \tag{2}$$

$$g(\text{experience}) = .0495\text{experience} - .0007\text{experience}^2 \tag{3}$$

Notice that if all countries have reached the same schooling level, as well as the same average experience, then all countries will have the same human capital.[9] This implies that human capital is bounded by the level of schooling and experience. Since schooling cannot grow without bound, then eventually growth will cease, unless technological progress induces factor accumulation. Furthermore this convergence result predicts very rapid convergence in levels of income across countries as their schooling levels become more similar. Both of these assumptions will be relaxed in later sections in order to better explain the distribution of income across the countries of the world.

If, however countries permanent differences in the level of schooling, then there would be permanent differences in human capital input. Consider two countries, one with 13.6 years of schooling and the other with 1.4 years of schooling.[10] Ignoring the experience term, the relative amount of human capital in these countries would be given by:

$$\frac{h(13.8)}{h(1.4)} = exp(.1[13.6 - 1.4]) = exp(1.2) \tag{4}$$

[5]We used overlapping year observations to produce PPP real investment rates for years not covered in Summers, Heston and Aten (2009). See our Data Appendix (2011) for greater detail.

[6]One major change between this data and that in Baier, Dwyer and Tamura (2006) is in the treatment of physical capital depreciation. In the earlier paper used a 7% annual depreciation rate. This produced implausibly small capital-output ratios, typically less than 2. In this paper we used a range of depreciation rates, which rise with the level of output per worker. The range for depreciation rates is 3% to 5%. For a commonly assumed capital output ratio of 3, a 5% depreciation rate produces a depreciation charge against output of 15% of output, which is at the high end of rates used in public finance. With the lower depreciation rates, this paper produces much more plausible capital-output ratios. See our Data Appendix (2011) for more detail.

[7]We use enrollments in schooling for all years that are available in Mitchell's three volume set, as well as modern day sources like *Human Development Reports* and *World Development Reports*. In addition we use literacy information contained in Morris and Adelman (1988) and Steckel and Floud (1997). We follow the rule that it takes three years to become literate, so if 20 percent of the adult population is literate, we assume that 20 percent of the population attended school for 3 years, producing a measured schooling level of 0.6 years in the population. For more on the details of the computation of schooling in the labor force see our companion data appendix, *Data Appendix for Economic Growth in the Long Run*.

[8]One big difference is that unlike Hall & Jones and Klenow & Rodriguez-Clare, we do not assume decreasing returns to additional years of schooling. In Turner, Tamura, Mulholland and Baier (2007) there was little evidence of decreasing returns to schooling over the 160 years of US state data. Thus the human capital input in high schooling countries will be higher and TFP correspondingly lower than their counterparts computed in Hall & Jones and Klenow & Rodriguez-Clare.

[9]The choice of parameters on experience returns reflects two points, (1) that the returns per year of experience starts at .0495 and peak earnings occurs at 33.5 years of experience

[10]These are the 2007 values of the second most educated country, United States, and the least educated country, Bhutan.

With perfect physical capital mobility, and no difference in technology levels, the model would predict that the higher schooling country would be 3.4 times as productive per worker than the lower schooling country. The gap between the US and Bhutan in 2007 is about 11, $76,000 vs. $7000. Human capital measured in this way explains only about one-third of the gap in output per worker.

We summarize the data in graphical form in the following four graphs. We present regional average real output per worker, regional average real physical capital per worker, regional average schooling per worker, regional average human capital and regional average TFP. In computing these regional averages we depart from BDT and present the population weighted values for each region. We keep a region as long as the existing countries represent at least 50 percent of the labor force in 2007.[11] Unlike BDT where the graphs represent the regional average growth rates, these figures allow for effects of changing country composition. Thus the changing sample as countries appear in the data, as time moves forward, can change regional average levels if their initially observed real output per worker (real physical capital per worker, schooling per worker, TFP) differ from the regional average. However with the extension of data, many regions are dominated by countries that appear all at once, say 1820. Regions that have almost complete coverage in 1820 include: *Western Countries*, *Southern Europe*, *NIC*, *Asia* and *North Africa.* In the case of the *Western Countries*, we observe France, Germany, Netherlands, Sweden, UK and the United States by 1800.[12] These six countries constitute 83 percent of the labor force in 2007. The five countries of the *Southern Europe* region observed in 1820 contain more than 99 percent of the labor force in 2007. All of the *NIC* countries are observed in 1820. In the *Asia* region, we observe eight countries in 1820. These include China, India, Indonesia, Thailand. All eight of these countries constitute 87 percent of the labor force in 2007. Of the five countries in *North Africa*, four are observed in 1820. These constitute 96 percent of the labor force in 2007.

Figure 1 below contains the regional average real output per worker. The *Western Countries* region have been home to the world's highest output per worker countries for nearly the last two centuries. In 1820 real output per worker in *Western Countries* was 42 percent higher than in *Southern Europe*, almost double *NIC*, more than double *Asia*, and more than 2.5 times higher than workers in *North Africa.* Fifty years later, workers in *Western Countries* were more than twice as productive as their counterparts in *Southern Europe* and *NIC*, more than three times as productive as those in *North Africa* and four times more productive than workers in *Asia.* Whereas real output per worker grew in every region except *Asia*, it is clear that the Industrial Revolution begins with *Western Countries.* Just before the onset of World War I, workers in *Western Countries* are twice as productive as their counterparts in *Southern Europe*, more than three times as productive as those in *NIC*, six times those of *Asia*, four times those in *North Africa.* It appears that the Industrial Revolution diffused to *Southern Europe* and the *NIC* by 1910, which kept the relative productivity gap constant. However *Asia* and *North Africa* lag further behind. World War II induced divergence between the *Western Countries* and the rest of the world, despite damage to the France, UK, and Germany. Since 1950 there is evidence of conditional convergence.

Figure 2 below contains the regional average real physical capital per worker. Physical capital mirrors real output per worker, with the exception of the dramatic declines arising from World War I and II in *Western Countries*, and World War II for the *NIC.*[13]

Figure 3 below contains the regional average schooling per worker. If one takes 3 years of schooling as

[11] For all regions except for the Western Countries and Sub-Saharan Africa, this is 1820. For the Western Countries their first observation is 1800. For Sub-Saharan Africa we chose to include it all the way back to 1820, even though it is only South

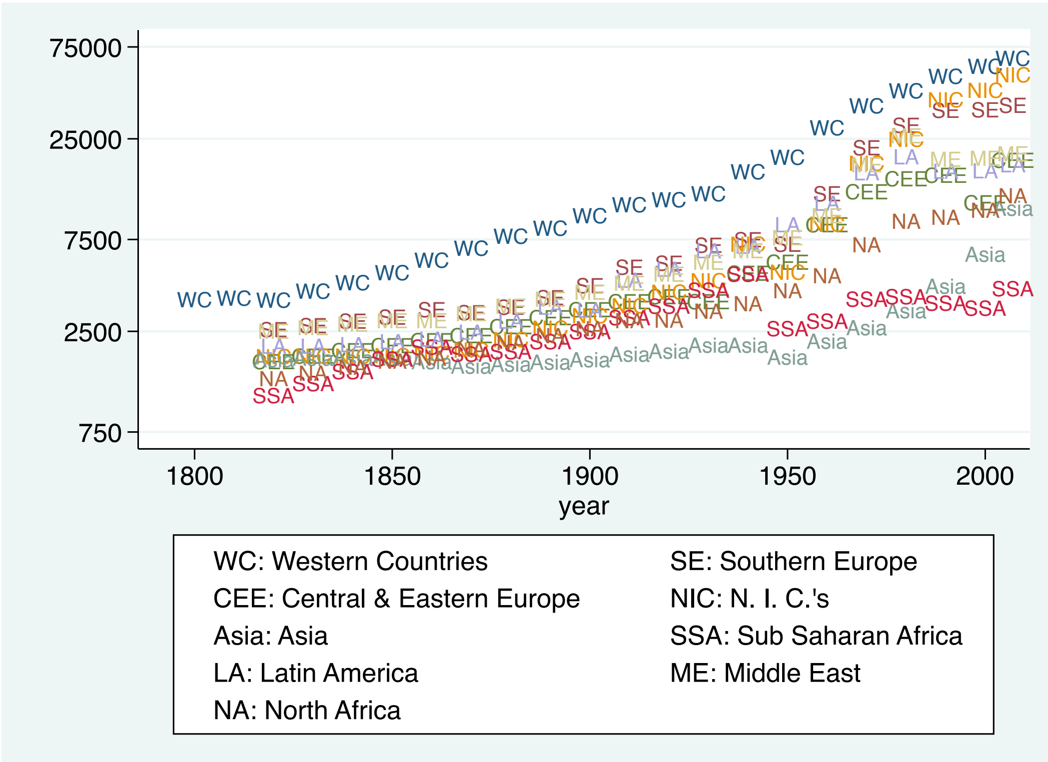

Figure 1: Real Output Per Worker: by Region

sufficient to provide basic literacy, then one observes literacy in the average worker of *Western Countries* occurred in 1850. Literacy of the typical worker outside of this region happened much later: 1920 *Southern Europe*, 1930 *Central & Eastern Europe*, 1910 *NIC*, 1965 *Asia*, 1977 *Sub-Saharan Africa*, 1950 *Latin America*, 1972 *Middle East*, and 1970 *North Africa*. Thus the regions that behaved most like *Western Countries*, *Southern Europe*, *Central & Eastern Europe*, and *NIC*, attained literate work forces no later than 80 years after *Western Countries*' attainment. Those that lagged behind took at least a century or more to educate their workers.

This can be seen in Figure 4, where we graph the average years of schooling of the youngest worker cohort, by region. Young workers were literate in *Western Countries* by 1830, followed by young *Southern Europe* workers a half century later, 1880. Young workers of *Central & Eastern Europe* did not attain literacy until 1905. The young workers of *NIC* became literate by 1895. Young workers in *Asia* became literate by 1950, soon after World War II. The typical young *Sub-Saharan African* worker did not attain basic literacy until 1965. Youngsters of *Latin America* were literate by 1930, but their *Middle East* brethren did not become literate until 1960. Young workers of *North Africa* were literate by 1955.

Using the Klenow & Rodriguez-Clare (1997), Hall and Jones (1999) method for computing human capital based on schooling and average experience we construct human capital by region. These are

Africa. In 1870 we observe Ghana as well, for all other countries in this region we seen them at the earliest 1950.

[12] We observe the UK in 1801.

[13] This is by construction. We increased depreciation rates of physical capital during the war years to take into account explicit destruction as a consequence of the War, e.g. Germany and UK, or due to reduced maintenance, e.g. Australia, Canada and the US. For more details see our data appendix.

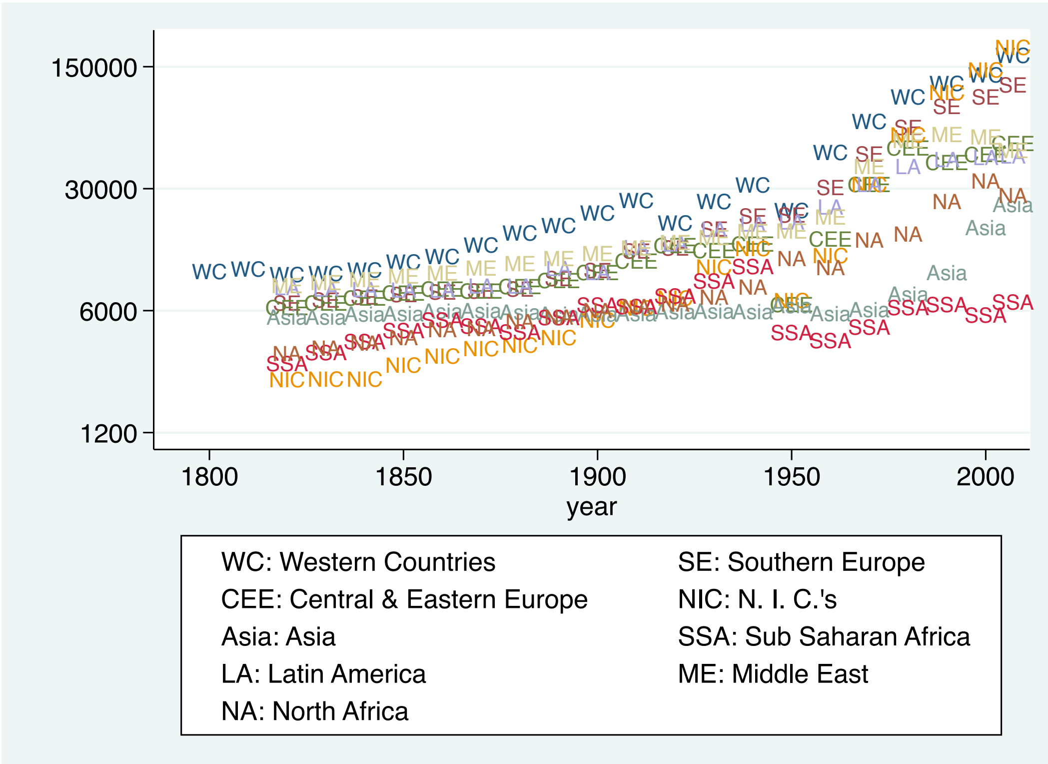

Figure 2: Real Physical Capital Per Worker: by Region

presented in Figure 5. Since 1950 there has been convergence in human capital, whereas prior to 1950 there appears to have been divergence.[14]

Assuming a Cobb-Douglas aggregate production function, with physical capital share of .33, figure 6 contains the regional average TFP. The results are consistent with those found earlier in BDT. As before *Western Countries* have been the world leader in TFP, although since 1950 the *NIC* and *Southern Europe* have converged. These regions aside, however, there appears to be a slight tendency of divergence in the world. As the scale is logarithmic, the vertical distances, and hence proportional gaps, between regions appears to be slowly increasing. In fact in 1820 the gap between the top region and the bottom region was almost 3 to 1, 96 to 33. In 2007 the gap between top and bottom is almost 4 to 1, 313 to 80. In fact even excluding *Middle East* and *Sub-Saharan Africa*, the gap between the top and bottom regions in 1820 is about 2 to 1, 96 to 50, but in 2007 it is about 2.5 to 1, 312 to 127.

[14]The *NIC* appears to have been an exception, with convergence since 1870.

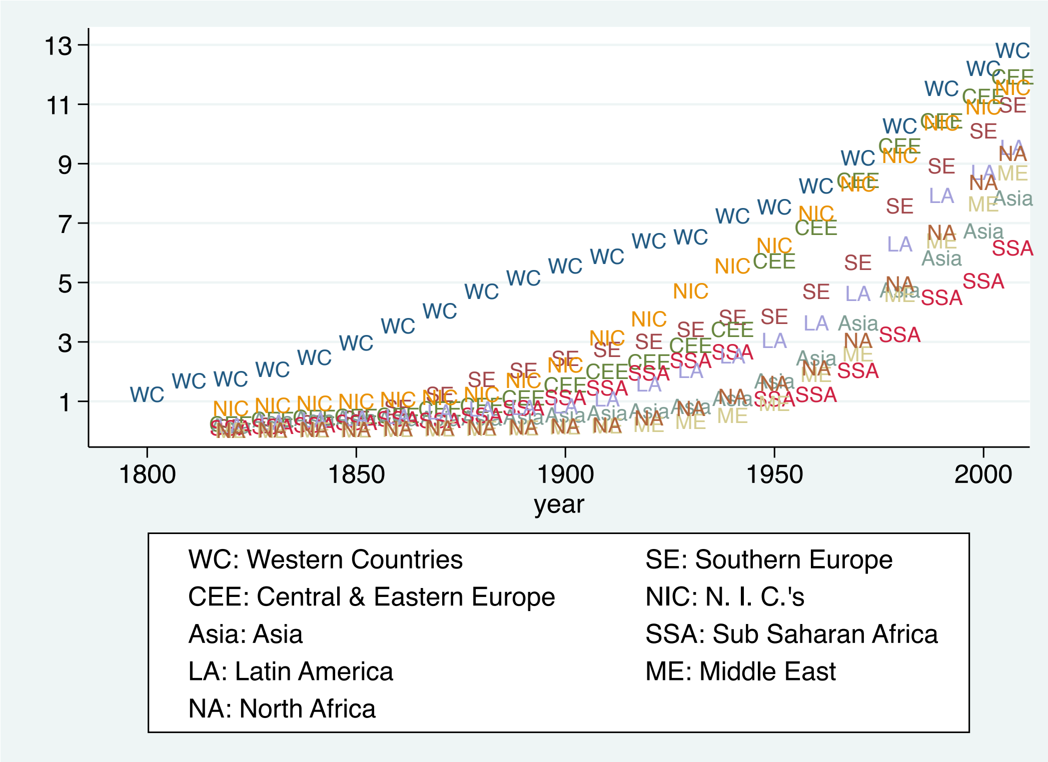

Figure 3: Education Per Worker: by Region

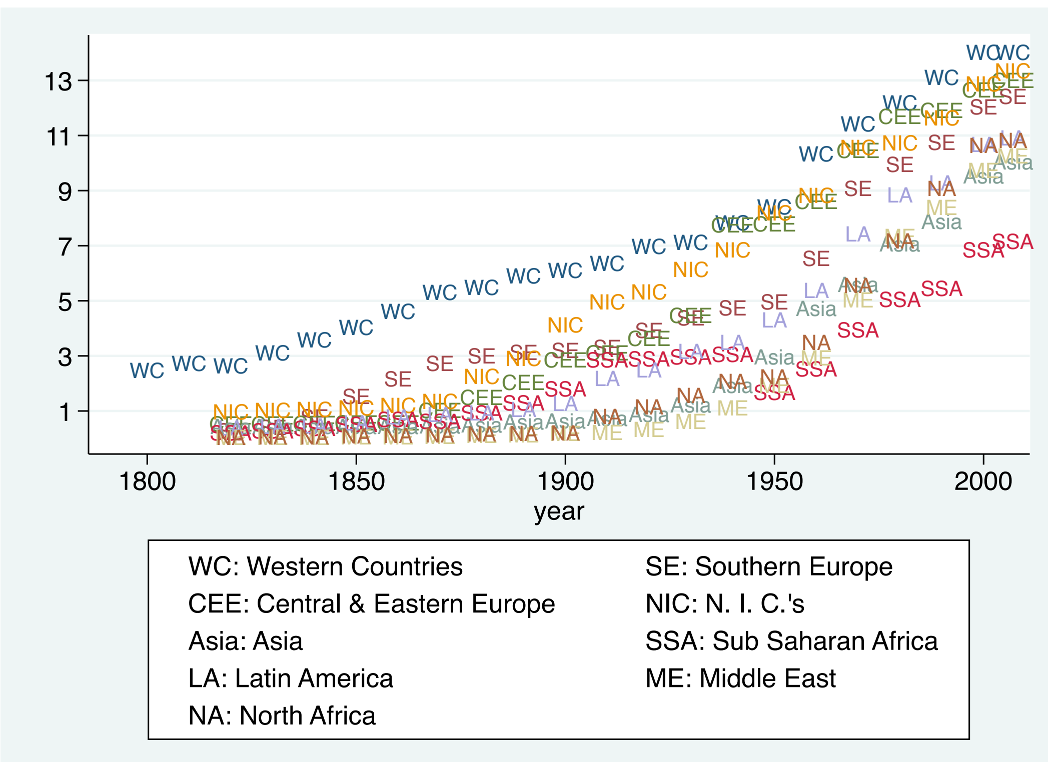

Figure 4: Education Per Young Worker: by Region

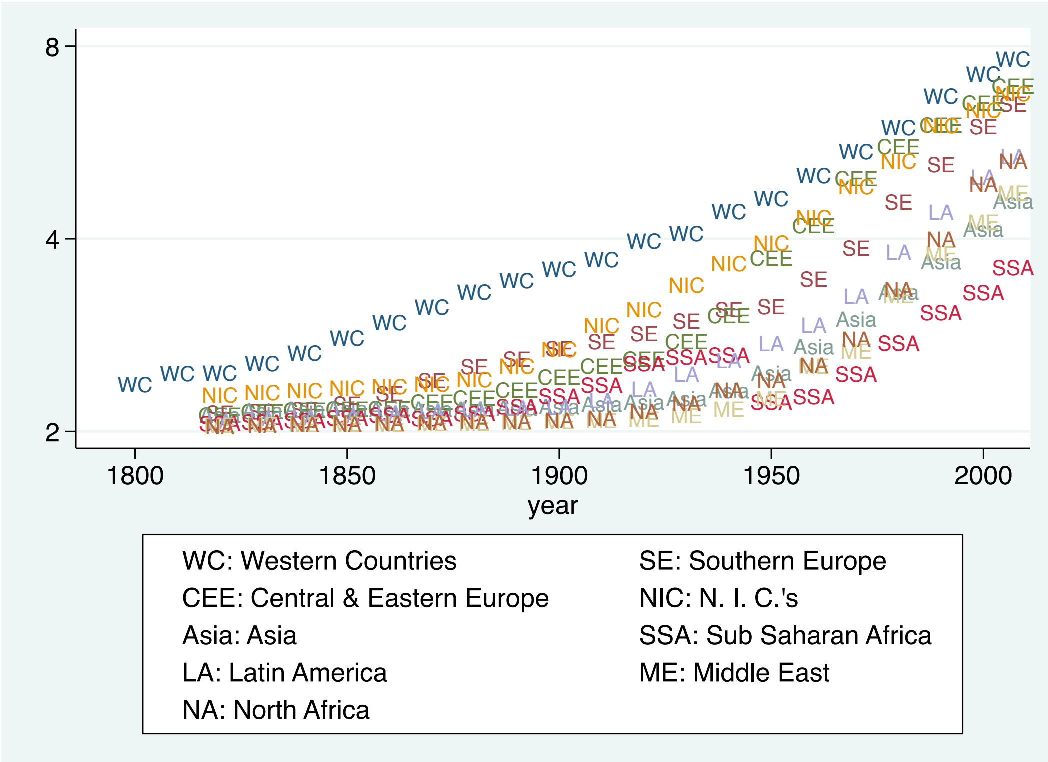

Figure 5: Human Capital Per Worker, Base: by Region

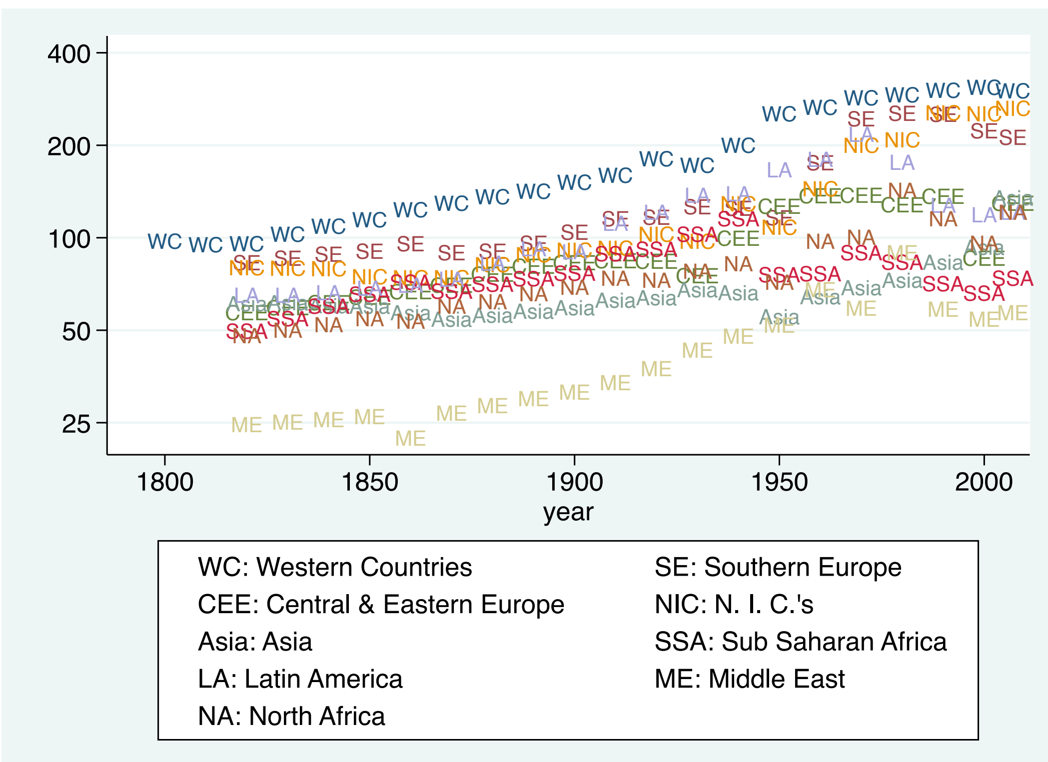

Figure 6: Total Factor Productivity, Base: by Region

3 Growth Accounting

Here we report the results of the growth accounting from the new data. We summarize the data in three ways. The first way weights the data by the 2007 population multiplied by the number of years of observation; we call this the *population-duration* estimates. The second method weights each country by their 2007 population. The final method treats every country equally. In earlier works, like Klenow & Rodriguez-Clare (1997), each country's growth rates are equally weighted. In data sets where all countries are observed over the same time period this makes some sense. However it does have the disadvantage of equally weighting economic performance achieved in a country like China, with over one billion people, the same as a country with less than one million people, like Fiji. In addition if the number of years a country is observed differs greatly, then a country that achieves annualized growth rate of 1.2% for 150 years is treated the same as a country which manages annualized 1.2% growth for 20 years. In the former living standards are 6 times their initial value, whereas in the latter case living standards are barely 27% higher than the initial observation.

For any country i, we assume a standard Cobb-Douglas production technology, combining physical capital per worker, K_{it}, and human capital per worker, H_{it}, to produce output per worker, Y_{it}:

$$Y_{it} = A_{it} K_{it}^{\alpha} H_{it}^{1-\alpha}, \tag{5}$$

where $\alpha = .33$, similar to that found in Gollin (2002), and used by Caselli (2005). In the first third of Table 1 we present the *population-duration* weighted results. The middle third of the table weights each country's observation by their 2007 population, and the final third of the table is unweighted. For the *population-duration* weighted results, real output per worker growth is 1.17% per year, with real input per worker growth of 0.72% per year.[15] Input growth explains 61 percent of output per worker growth, with a range of 57% for *Asia* to 80% for *Sub-Saharan Africa*. Real output per worker growth is quite homogeneous across regions. Whereas in the unweighted case, real output per worker growth ranged from a low of 0.86% per year in *Central & Eastern Europe* to a high of 2.55% per year in *Southern Europe*, in the *population-duration* case, the range of real output per worker growth is 0.96% per year to 1.81% per year. Overall in both weighted cases, all regions have positive TFP growth, and in the unweighted case only one region, *Central and Eastern Europe*, has negative TFP growth. In the weighted cases, TFP growth ranges between 0.12% per year in *Central and Eastern Europe* to 0.63% per year in *NIC*. The population weighted results are very similar to the *population-duration* weights results.

In the unweighted case, the worker in the typical country had annualized growth rates of 1.34% for output, 1.05% for inputs, and 0.29% for TFP. In contrast, in BDT, the worker in the typical country had annualized growth rates of 0.74% for output, 1.55% for inputs, and −0.81% for TFP. A comparison of the different regions shows that all regions now have positive economic growth. They range from a high of 2.55% per year real output growth in *Southern Europe* to a low of 0.86% per year in *Central & Eastern Europe*. Only one region, the *Middle East*, has negative TFP growth.[16]

[15] Letting α be capital's share in production, the total growth rate of inputs is $\alpha g_k + (1-\alpha) g_h$.

[16] In the unweighted results of BDT, one region had negative real output per worker growth, *Central & Eastern Europe*, and 5 regions had negative TFP growth rates, *Central & Eastern Europe*, *Asia*, *Middle East*, *Sub-Saharan Africa* and *Latin America*. With new data per worker output growth increased. *Central & Eastern Europe* moves from −0.84% to 0.86%. *Asia* goes from 1.05% to 1.49%. *Middle East* countries go from 0.09% to 0.99%. *Sub-Saharan Africa* growth increases from 0.17% to 1.32%. *Latin America* has almost no change between BDT, 1.23%, and here, 1.24%. However TFP growth has moved from −.29% in BDT to .23% here.

Table 1: Growth Accounting

Region	N	Annualized Growth Rates g_y	g_k	g_{hc}	g_x	g_z	share$_{g_x}$	share$_{g_z}$
Population-Duration Weights								
World	168	1.17%	1.11%	0.53%	0.72%	0.46%	0.611	0.389
(WC) Western Countries	18	1.45	1.56	0.60	0.92	0.54	0.631	0.369
(SE) Southern Europe	7	1.45	1.56	0.59	0.91	0.54	0.630	0.370
(CEE) Central and Eastern Europe	24	1.28	1.26	0.72	0.89	0.38	0.699	0.301
(NIC) Newly Industrialized Countries	5	1.81	2.36	0.59	1.18	0.63	0.652	0.348
(Asia) Asia	20	1.05	0.89	0.45	0.60	0.45	0.572	0.428
(SSA) Sub-Saharan Africa	48	1.06	1.10	0.77	0.85	0.21	0.805	0.195
(LA) Latin America	28	1.19	1.02	0.60	0.75	0.45	0.626	0.374
(ME) Middle East	13	1.17	1.08	0.58	0.68	0.49	0.584	0.416
(NA) North Africa	5	1.17	1.13	0.51	0.70	0.47	0.598	0.402
Population Weights								
World	168	1.18%	1.17%	0.58%	0.77%	0.41%	0.651	0.349
WC	18	1.46	1.57	0.60	0.92	0.54	0.630	0.370
SE	7	1.47	1.59	0.59	0.92	0.54	0.630	0.370
CEE	24	0.96	1.15	0.72	0.85	0.12	0.880	0.120
NIC	5	1.81	2.36	0.59	1.18	0.63	0.652	0.348
Asia	20	1.12	1.02	0.49	0.67	0.46	0.592	0.408
SSA	48	1.03	1.14	0.81	0.89	0.14	0.863	0.137
LA	28	1.19	1.04	0.65	0.79	0.41	0.659	0.341
ME	13	1.39	1.42	0.75	0.89	0.34	0.637	0.363
NA	5	1.18	1.16	0.54	0.72	0.46	0.612	0.388
Unweighted								
World	168	1.34%	1.62%	0.79%	1.05%	0.29%	0.782	0.218
WC	18	1.69	1.95	0.59	1.04	0.65	0.615	0.385
SE	7	2.55	3.37	0.75	1.63	0.93	0.637	0.363
CEE	24	0.86	1.15	0.76	0.87	-0.01	1.010	-0.010
NIC	5	1.87	2.43	0.55	1.18	0.70	0.629	0.371
Asia	20	1.49	1.92	0.71	1.11	0.38	0.746	0.254
SSA	48	1.32	1.57	0.88	1.10	0.22	0.832	0.168
LA	28	1.24	1.38	0.83	1.02	0.23	0.818	0.182
ME	13	0.99	1.16	0.96	0.88	0.11	0.889	0.111
NA	5	1.24	1.40	0.73	0.88	0.36	0.709	0.291

4 Variance Decomposition

In this section we present the results of the variance decomposition of growth rates. We construct plausible upper bounds on the share of real output per worker growth variance explained by variations in real input growth rates and variations in TFP growth rates. We proceed as in BDT (2006). We aggregate inputs, physical capital per worker and human capital per worker, into the single measure X_t. Thus output per worker is given as:

$$X_t = K_t^{\alpha} H_t^{1-\alpha} \tag{6}$$

$$Y_t = Z_t X_t \tag{7}$$

Taking logs and using g_s represent growth rate of s produces:

$$g_y = g_z + g_x \tag{8}$$

Although our countries all are observed in 2007, some we observe as early as 1800, others as late as 1990.[17] However the log difference between the 2007 observation and the first observation of the country divided by the number of years between first and last observation produces estimates of annualized growth rates of output per worker for all countries. The variance of the annual growth rate of output per worker across these countries is given by:

$$\sigma_{g_y}^2 = \sigma_{g_z}^2 + 2\sigma_{g_x,g_z} + \sigma_{g_x}^2 \tag{9}$$

Now it is standard in much of the empirical growth and development literature to allocate one-half of the covariance terms to the inputs and one-half of the covariance terms to the residual, TFP, term, see Klenow & Rodriguez-Clare (1997), Caselli (2005), Weil (2009). This "egalitarian" assignment is then used to discuss the proportion of the variance of annual growth rates in output per worker "explained" or "accounted" for by inputs and the remainder allocated to TFP. This assignment implies can also be written as:

$$\sigma_{g_y}^2 = \sigma_{g_x,g_y} + \sigma_{g_z,g_y} \tag{10}$$

$$1 = \frac{\sigma_{g_x,g_y}}{\sigma_{g_y}^2} + \frac{\sigma_{g_z,g_y}}{\sigma_{g_y}^2} \tag{11}$$

Klenow & Rodriguez-Clare (1997) also argue that a better way to think about the contributions of input growth and TFP growth is to only credit variations in the growth rate of capital intensity to inputs. We modify this slightly by crediting human capital growth rates as not being induced by TFP growth rates, but acknowledge that growth rates of physical capital could be induced by TFP growth rates. Thus rewrite

[17] Recall that East Germany is only observed from 1950-1990.

the output equation as:

$$Y_t = (\frac{K_t}{Y_t})^{\frac{\alpha}{1-\alpha}} Z_t^{\frac{\alpha}{1-\alpha}} H_t \tag{12}$$

$$Y_t = \hat{Z}_t \hat{X}_t \tag{13}$$

$$\hat{X}_t = (\frac{K_t}{Y_t})^{\frac{\alpha}{1-\alpha}} H_t \tag{14}$$

$$\hat{Z}_t = Z_t^{\frac{\alpha}{1-\alpha}} \tag{15}$$

Proceeding as before we can compute the growth rates of output per worker, and the new inputs per worker and TFP and produce:

$$\sigma^2_{g_y} = \sigma_{g_{\hat{x}}, g_y} + \sigma_{g_{\hat{z}}, g_y} \tag{16}$$

$$1 = \frac{\sigma_{g_{\hat{x}}, g_y}}{\sigma^2_{g_y}} + \frac{\sigma_{g_{\hat{z}}, g_y}}{\sigma^2_{g_y}} \tag{17}$$

These two variance decomposition methods proposed by Klenow & Rodriguez-Clare (1997) arise from priors as to the causal link of the correlation of growth rates of inputs and TFP. Under (11) the proportion of growth rate variations that co-vary with input (TFP) growth variations is assigned to inputs (TFP). Under (11) a priori TFP growth variations induce physical capital growth rate variations, and only physical capital intensity growth rate variations are ascribed to inputs. Further it is assumed in (11) that human capital growth rate variations are not induced by TFP growth rate variations.[18]

Returning to the original variance decomposition and dividing by the variance of growth rate of output per worker also produces:

$$1 = \frac{\sigma^2_{g_z}}{\sigma^2_{g_y}} + \frac{\sigma^2_{g_x}}{\sigma^2_{g_y}} + 2\rho_{x,z}\frac{\sigma_{g_x}\sigma_{g_z}}{\sigma^2_{g_y}} \tag{18}$$

However as noted above the correlation of growth rates of inputs and total factor productivity growth is not 0. There are two sets of theories that explain the correlation between input growth and TFP growth. The exogenous technological growth neoclassical growth model implies that factor accumulation is induced by the growth in TFP. Additionally Romer (1990) has the same implication that endogenous technological progress drives all capital accumulation and growth in the economy. At the other end, Romer (1986), Lucas (1988), and Tamura (2002,2006) construct theories in which physical capital accumulation or human capital accumulation induces endogenous TFP growth. These theories imply that the correlation between TFP growth and input growth are due to input growth and hence the correlated or predictable component should be assigned to input growth.

If TFP growth induces factor accumulation, then the predictable or correlated portion of input growth should be assigned to TFP growth, the share of growth of output per worker variation can be written as:

$$1 = \frac{(\sigma_{g_z} + \sigma_{g_x}\rho_{g_x,g_z})^2}{\sigma^2_{g_y}} + \frac{(1-\rho^2_{g_x,g_z})\sigma^2_{g_x}}{\sigma^2_{g_y}} \tag{19}$$

where the first term is now a plausible upper bound on the proportion of the variation in growth rates of

[18] in Klenow & Rodriguez-Clare (1997) they also assume that human capital growth rates maybe induced by TFP growth rates, and hence only capital intensity, inclusive of both physical capital intensity and human capital intensity are varying "independently" from TFP growth rate variations.

output per worker caused by variation in growth rates of TFP.[19] If the predictable or correlated component of TFP growth arises from endogenous factor accumulation, then assigning this predictable component to factor accumulation produces the following variance decomposition:

$$1 = \frac{(\sigma_{g_x} + \sigma_{g_z}\rho_{g_x,g_z})^2}{\sigma^2_{g_y}} + \frac{(1-\rho^2_{g_x,g_z})\sigma^2_{g_z}}{\sigma^2_{g_y}} \tag{20}$$

The first term is now the proportion of the variation of growth rates of output per worker that is explained by variation in input growth.[20] Since it is not obvious which of the theories is true, we propose to let the data guide us. We construct the average of the contributions for inputs and TFP and compare them with the other decompositions. Thus we produce the average BDT decompositions as:

$$\overline{S}_{g_x} = \frac{\sigma^2_{g_x}}{\sigma^2_{g_y}} + \frac{1}{2}\frac{\rho^2_{g_x,g_z}\left(\sigma^2_{g_z} - \sigma^2_{g_x}\right)}{\sigma^2_{g_y}} + \frac{\sigma_{g_x}\sigma_{g_z}\rho_{g_x,g_z}}{\sigma^2_{g_y}} \tag{21}$$

$$\overline{S}_{g_z} = \frac{\sigma^2_{g_z}}{\sigma^2_{g_y}} + \frac{1}{2}\frac{\rho^2_{g_x,g_z}\left(\sigma^2_{g_x} - \sigma^2_{g_z}\right)}{\sigma^2_{g_y}} + \frac{\sigma_{g_x}\sigma_{g_z}\rho_{g_x,g_z}}{\sigma^2_{g_y}} \tag{22}$$

The results of these three bounds, (10), (16), (20)-(21), are contained in Table 2.[21] Columns (1) and (2) present the relative importance based on covariance shares of input growth rates and TFP growth rates. Columns (3) and (4) contain the covariance shares of relative input intensity growth rates and TFP growth rates. Columns (5) and (6) contain the shares from the average BDT decomposition. We also report the average BDT decomposition, but using the BDT data. Comparing the results for all countries, there is a big increase in explanatory power contained in input growth variation compared with BDT and Klenow & Rodriguez-Clare (1997). The increase in years of coverage as well the increase in number of countries observed, results in a substantial rise in the input share of growth rate variation. Whereas only 22% of growth rate variation is explained using the BDT average decomposition before, column (7), now half of output growth rate variation is explained by input growth variation. Using the Klenow &Rodriguez-Clare covariance share, produces a similar 46% explanatory share for input growth rate variations. Only the more restrictive covariance share of physical capital intensity variations lowers the explanatory power of input growth rate variations, 19%. Still this is a sharp increase from the 3% share found by Klenow & Rodriguez-Clare.

[19] One way of seeing that the least squares decomposition holds for this representation is to note that the variance decomposition is $var(y) = \beta^2_{y,a} var(a) + var(e_{y|a})$, where $\beta_{y,a}$ is the regression coefficient from a regression of y on a and $e_{y|a}$ is the regression residual.

[20] One way of seeing that the least squares decomposition holds for this representation is to note that the variance decomposition is $var(y) = \beta^2_{y,x} var(x) + var(e_{y|x})$, where $\beta_{y,x}$ is the regression coefficient from a regression of y on x and $e_{y|x}$ is the regression residual.

[21] See Table A2 in the Appendix in which both (18) and (19) are presented. All of these calculations assumes that the correlation between growth of inputs and growth of TFP is positive. A negative correlation has several possible explanations. One that does not make economic sense is forgetting. While it is possible to forget technology, and it has happened to peoples in Europe after the fall of the Roman Empire, as well in China after the fall of the Qin Empire and the rise of the Han Empire, over the 1800-2007 period there is much less of sense of forgetting. It is possible that the conversion of economies toward central planning after World War II in Central and Eastern Europe and the switch back from central planning to market based economies after the fall of the Soviet Union can be captured as forgetting. Communist collectivization and rising capital accumulation would more likely than not produce falling TFP, e.g. Maoist China. Centrally planned accumulation of inputs that have extremely low returns, building zero value public roads, investing in "critical" private sector industries that no profit making investor would ever authorize, spending on "education," but failing to provide the basics such as textbooks, blackboard an chalk, qualified teachers, etc. All of these would be measured as productive factor accumulations, that have 0 or possibly negative returns. Of course institutional change that reduces property rights, that fosters corruption, etc. can produce large negative TFP shocks.

Table 2: Growth Variance Decomposition: Plausible Shares

Region	N	$\frac{\sigma_{g_x,g_y}}{\sigma^2_{g_y}}$ (1)	$\frac{\sigma_{g_z,g_y}}{\sigma^2_{g_y}}$ (2)	$\frac{\sigma_{g_{\hat{x}},g_y}}{\sigma^2_{g_y}}$ (3)	$\frac{\sigma_{g_{\hat{z}},g_y}}{\sigma^2_{g_y}}$ (4)	$\overline{S}_{g_x}$ (5)	$\overline{S}_{g_z}$ (6)	BDT$_{g_x}$ (7)	BDT$_{g_z}$ (8)
World	168	.460	.540	.194	.806	.500	.500	.22	.78
WC	18	.621	.379	.435	.565	.535	.465	.46	.54
SE	7	.659	.341	.492	.508	.502	.498	.50	.50
CEE	24	.353	.647	.034	.966	.412	.588	.28	.72
NIC	5	.201	.799	-.193	1.193	.283	.717	.64	.36
Asia	20	.494	.506	.245	.755	.499	.501	.40	.60
SSA	48	.528	.472	.296	.704	.517	.483	.37	.63
LA	28	.478	.522	.221	.779	.496	.504	.22	.78
ME	13	.343	.657	.019	.981	.528	.472	.44	.56
ME not OPEC	4	.617	.383	.428	.572	.601	.399		
ME OPEC	9	.326	.674	-.006	1.006	.524	.476		
NA	5	2.605	-1.605	3.395	-2.395	.608	.392	.84	.16
larger regions									
(1): WC & SE	25	.655	.345	.485	.515	.512	.488		
(2): (1) & NIC	30	.653	.347	.483	.517	.513	.487		
(3): (2) & NA	35	.643	.357	.467	.533	.580	.420		
(4); (3) & SSA	83	.541	.459	.315	.685	.526	.474		
(5): (4) & Asia	103	.530	.470	.299	.701	.520	.480		
(6); (5) & CEE	127	.484	.516	.230	.770	.493	.507		
(7): (6) & LA	155	.484	.516	.229	.771	.492	.508		
(8): (7) & ME not OPEC	159	.485	.515	.232	.768	.494	.506		

The rising input share is broad based, encompassing all regions, except for *Southern Europe*, *NIC* and *North Africa*. In comparison to previous work, e.g. Klenow and Rodriguez-Clare (1997), there is a marked increased input share of cross sectional variation in growth. However there is still much left unexplained, and to that we now turn.

5 New Human Capital Calculation

One conclusion from above is that despite adding many additional years of observations, and a nontrivial number of new countries, output per worker growth rate variation is equally captured by TFP growth rate variation (average BDT decomposition or covariance decomposition), or mostly captured by TFP growth rate variation (Klenow & Rodriguez-Clare capital intensity input). To see how robust TFP growth differences are for explaining differential growth, we return to some theories of endogenous growth. In particular we examine the role of human capital accumulation in promoting growth of output per worker. The original Lucas (1988), and Becker, Murphy and Tamura (1990) papers introduce the idea that time spent away from production can be used to accumulate human capital. In Lucas infinite lived agents perpetually accumulate human capital, whereas in Becker, Murphy and Tamura parents spend time away from production and educate their children. In both of these models human capital builds off of the existing human capital, hence accumulation has the property of standing on the shoulders of others. Allowing for human capital spillovers across borders as in Tamura (1991, 1996, 2002, 2006) produces the following specification for country i between generations t and $t+1$:

$$h_{it+1} = \mathrm{A}\overline{h}_t^{\rho} h_{it}^{\beta} \exp(f(\text{schooling}) + g(\text{experience})) \tag{23}$$

where h_{it} represents the human capital of the parent, $\overline{h}_t$ represents the frontier human capital in the world, ρ is the degree to which the frontier human capital can be diffused, taught to the children, and the two functions, f and g in the exponential are defined as in (2) and (3), $0 < \rho, \beta < 1, \rho + \beta \leq 1$.[22] The key innovation here is that we allow for intergenerational accumulation in human capital.[23] We initialized 15-24 year old human capital in a country using information on the output per worker relative to the US and human capital relative to the US using Schoellman (2012).[24] The virtues of this method are twofold: (1) it allows for human capital across generations to accumulate, while allowing for the possibility of late developers to converge to the human capital level of early developers via the spillover effect, (2) it keeps a demographic age structure of human capital in the population that incorporates the Mincer age earnings quadratic profile. That is to say, if we compare individuals in a country of the same age, but different schooling levels, their earnings would differ by $exp(f(schooling) + g(experience))$ and be consistent with Mincerian wage regressions on returns to schooling. Second if we compare individuals in a country over their life cycle, their human capital has the standard inverted U-shape age earnings profile consistent with Mincerian wage regressions. Now consider the ability of this specification to capture differences in long run human capital levels. First assume that there is no spillover, i.e. $\rho = 0$. Consider two economies, one where each generation attains 14.5 years of schooling, and one where each generation attains only 1.4 years of schooling, this is equal to the 2007 gap between the least schooled country, Bhutan, and the schooling of the young workers in the United States. Ignoring experience returns, the stationary human capital values

[22]If $\rho+\beta = 1$, then perpetual endogenous growth is possible; this formulation is used in Tamura, Simon and Murphy (2011) examining human capital convergence across states and races in the US from 1840 to 2000. If $\rho + \beta < 1$, then a steady state human capital level exists, once schooling becomes constant. Either technological progress in output production, or rising A would be required for perpetual growth. One possibility for rising A would be if A grew as a function of those enrolled in higher education. These would be consistent with Jones (1995a,1995b, 2001).

[23]This is similar to the specification in Bils and Klenow (2000), although in their model they do not allow for spillovers across countries.

[24]We did not follow an explicit rule in that we allowed some deviations. A brief description of our assignment methodology is as follows. We construct initial output per worker relative to the US output per worker in the comparable decade. Let E_{it}^{15-24} be the 15 to 24 year old cohort's education in initial year t in country i. Let E_{USt}^{15-24} be the 15 to 24 year old US cohort's education in year t. Schoellman (2012) finds that a very good approximation to human capital adjusting for school quality differences is simply given by exp(.2*years of schooling). Thus using Schoellman (2012) we construct initial relative young human capital as $exp(.2 * [E_{it}^{15-24} - E_{iUS}^{15-24}])$. Our initial young human capital for country i in year t relative to the US is well described by a log linear regression on log relative output per worker, log relative human capital from Schoellman (given above), region dummies and a few other region or country variables. Table A1 in the Appendix lists the initial human capital for workers age 15-24 and the initial average human capital for each country, as well as the 2007 values. See section 1.3 of our data appendix for full details.

of these respective countries are given by:

$$h(14.5) = A^{\frac{1}{1-\beta}} exp(\frac{1.45}{1-\beta}) \tag{24}$$

$$h(1.4) = A^{\frac{1}{1-\beta}} exp(\frac{.14}{1-\beta}) \tag{25}$$

$$\frac{h(14.5)}{h(1.4)} = exp(\frac{1.31}{1-\beta}) \tag{26}$$

Compared to the human capital specification without intergenerational human capital accumulation, this specification accentuates permanent differences in schooling. For a value of $\beta = .35$, the model delivers a 7.5 relative human capital gap between these two countries, almost 70% of the 2007 income difference between the US ($76,000) and Bhutan ($7000)! Without intergenerational human capital the human capital gap between these two countries would be 3.7 or about 35% of the income difference between the US and Bhutan.

The human capital in the economy is therefore a population weighted average of human capital of 5 age groups, 15-24, 25-34, 35-44, 45-54, 55-64. Thus human capital in country i in year t is:

$$H_{it} = s_{15-24,t}h_{15-24,t} + s_{25-34,t}h_{25-34,t} + s_{35-44,t}h_{35-44,t} + s_{45-54,t}h_{45-54,t} + s_{55-64,t}h_{55-64,t} \tag{27}$$

where s_i is the share of the population in age category i, and human capital accumulates via the age earnings profile from above, for example:

$$h_{35-44,t+1} = h_{25-34,t} \exp(g(\text{experience+10}) - g(\text{experience})) \tag{28}$$

where each generation is assumed to have an average schooling and hence their first set of expected experience in the age group 15-24 is given by:

$$\text{experience}_{15-24} = \max(0, \text{average age - 6 - average schooling}) \tag{29}$$

and from then on, every observation they age 10 years.[25] For the new generation, represented by h_{15-24} we assume that the parents are between the ages of 35-54 today. That is to say we use the arithmetic average human capital of adults 25-34 and 35-44 in the prior observation to produce human capital for current 15-24 children. This assumes parents had their children between the ages of 20-39. Our intergenerational

[25] In terms of the human capital of *Central and Eastern Europe* we generally kept their schooling human capital attained prior to the fall of the communist system using this method of experience returns. However after 1989 we eliminated all human capital accumulation from experience, and restarted their experience measure at 0 in year 1990. We do this to capture the shock of a completely new system of production, mixed or market based, and the complete depreciation of experience arising from life under the communist system.

human capital accumulation equation is:

$$h_{15-24,t} = \mathrm{A}\overline{h}_{t-1}^{\rho} \left(\frac{h_{25-34,t-1} + h_{35-44,t-1}}{2} \right)^{\beta} \exp(f(\text{schooling}) + g(\text{experience})) \quad (30)$$

where, $\beta = .35$, A=.50, f(schooling) and g(experience) are given by (2) and (3), where initial experience is max(0,average age - 6 - expected schooling of cohort born in period t-1). Our choice of the value of β and A come after conducting a grid search of values from $\beta = .05$ to $\beta = .8$, and from .25 to .65 for A. Interestingly our $\beta = .35$ is midpoint of the estimates of the intergenerational elasticity of parental contributions to child human capital found in Table 4 of Lefgren, Lindquist and Sims (2012).[26] In these calculations the time subscripts refer to birth cohort, and typically are spaced 10 years apart. Thus for the US where birth cohorts are exactly 10 years apart until the last one in 2007, the human capital of 15-24 year olds in 1860 use the school enrollment rates in 1850 to produce an estimate of expected years of schooling.

We first assumed no spillover in the human capital accumulation function, i.e. $\rho = 0$. Figures 7 and 8 present the regional graphs of human capital per worker and TFP. In both figures we computed the average human capital and TFP weighting by the population. There is more rapid growth in human capital and a consequent slower growth in TFP as a result. The results of the growth accounting and variance decomposition of growth rates are contained in Tables 3 and 4. There is little change in the share of overall growth explained by input growth. However this masks the changes across regions. All regions except for Central & Eastern Europe, Asia, Sub-Saharan Africa have rising shares from input growth. The declining shares from the three regions above essentially exactly offset the rising shares in all other regions. In contrast, Table 4 indicates the value of introducing parental human capital into human capital accumulation.

Whereas Table 2 shows that variation in input growth explains about 50 percent of the variation in output per worker growth, the introduction intergenerational accumulation raises the share of input growth rate variation to about three-fourths, using either the covariance share or the average BDT decomposition! The increase is broad based; eight of nine regions have higher shares of growth rate variation captured by input growth rate variation, when comparing average BDT decompositions.[27] The share of growth rate variation arising from input growth rate variation under the more restrictive physical capital intensity input exceeds three-fifths![28] Recall that Klenow & Rodriguez-Clare find only 10% input share under this specification. Using the Klenow & Rodriguez-Clare covariance share of input growth rates, eight regions increase compared to the simple Mincer cross section human capital measure.[29] When we look at larger regions, the rising ability of input growth variations to explain output per worker growth variations

[26] We report on the robustness of our results in a later section.

[27] The ninth region, North Africa, remains constant at 84% share, but this is an increase when compared with a 61% share under the Mincer cross section returns human capital definition.

[28] All regions show dramatic improvements, except for North Africa which goes from 340% share to 35% share.

[29] North Africa falls from 260% share to 56% share.

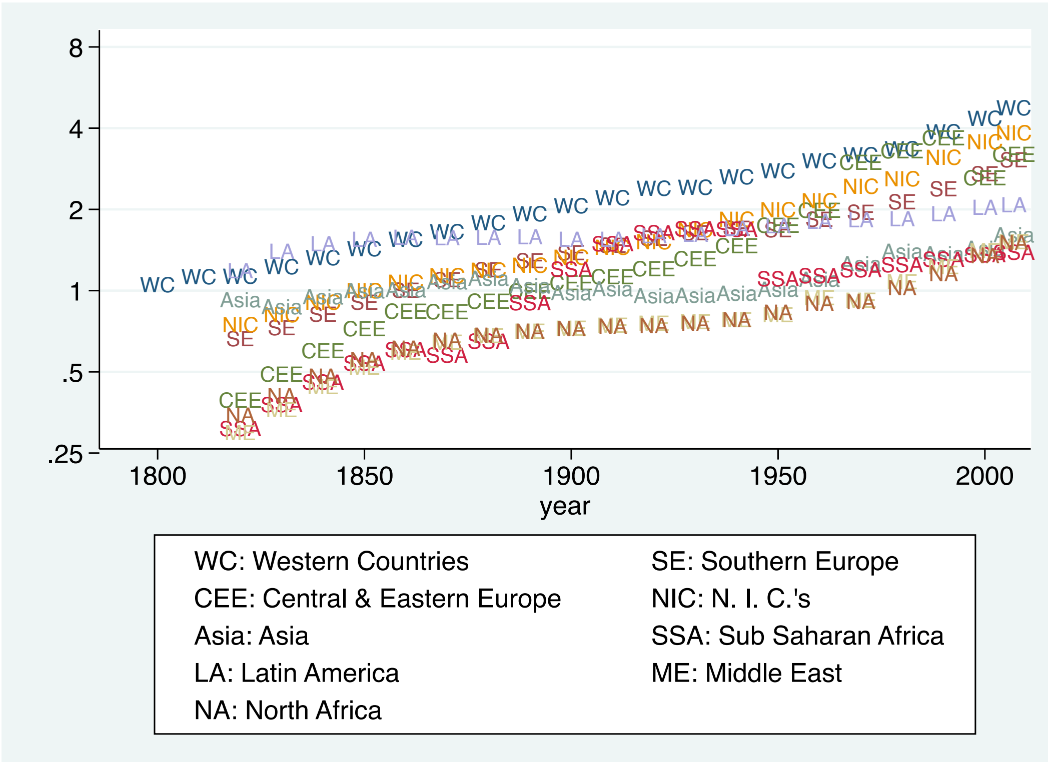

Figure 7: Human Capital Per Worker, $\beta = .35, \rho = 0$: by Region

continues and in fact becomes larger. About 70% of growth rate variations are captured by input growth rate variations for *Western Countries*, *Southern Europe*, *NIC* and *North Africa* contrasted with 58% in the model without intergenerational human capital accumulation. By the end, when all countries except for OPEC countries of the Middle East are included, over 75% of the growth variation is explained by input growth variation compared with 50% in the model without intergenerational human capital. We find that input growth variation is more important than TFP growth variation.

5.1 Spillovers

The previous sub-section showed that intergenerational links between parents and children improve our understanding of growth differences. In this section we examine the role of international spillovers to explain cross country growth differences. In other words, what is left to do is to find reasonable values for ρ, the spillover, the determination of $\overline{h}$. We assume that human capital spillover arises from the maximum human capital country, which is the US. [30] The importance of this human capital spillover is dependent on the schooling of the population. As a country becomes more educated, it can better draw on the body of knowledge in the world. This is similar to Tamura (1996, 2002, 2006), but instead of a step function, we

[30]The US certainly led the world in universal secondary schooling, c.f. Goldin (2001) and Goldin and Katz (2008), and tertiary schooling. A few countries have observed primary school enrollment rates higher than the US in the first third of the nineteenth century, e.g. Netherlands, however literacy was quite high in the US from the initial settlement.

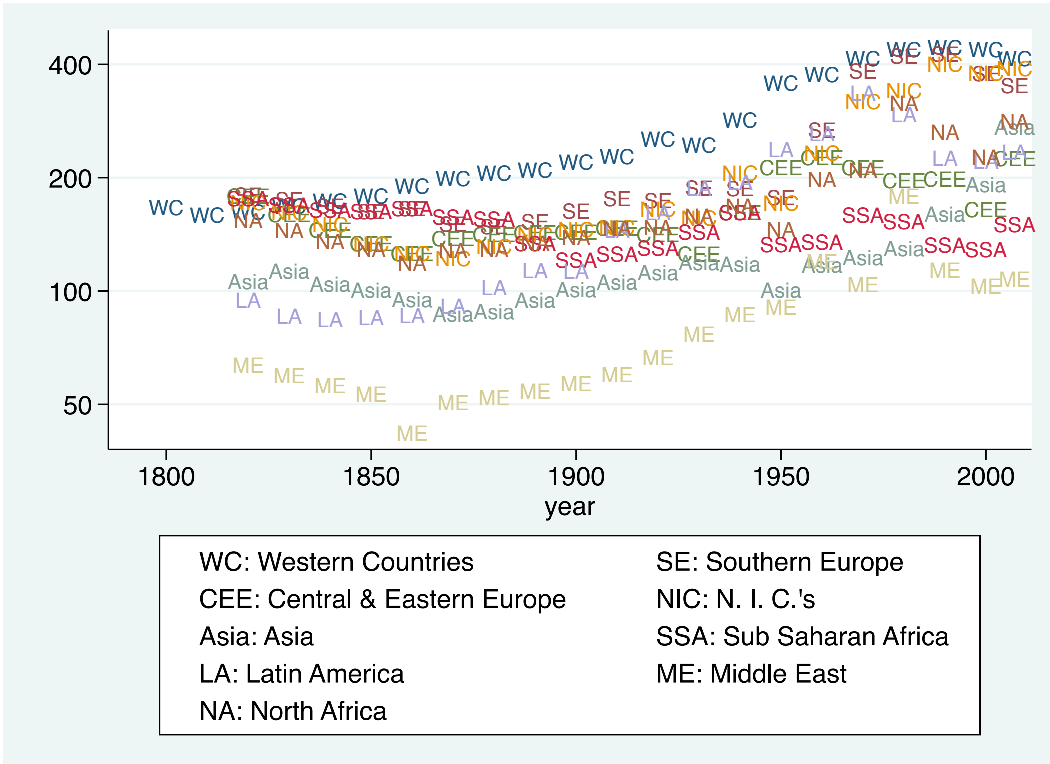

Figure 8: Total Factor Productivity, $\beta = .35, \rho = 0$: by Region

assume a continuous function of child schooling, S:.

$$\rho = \min\left\{.35, \frac{S}{43.75}\right\}$$

In this specification the lower bound for ρ is 0 and the upper bound is .35. Thus at the lower extreme there is no convergence in human capital, unless schooling was identical across countries. At the upper extreme, human capital converges at a rate of 1.75 (0.875) % per year, depending on a generation of 20 (or 40) years. In the upper bound case, it would take a country 39 (78) years to close the gap by 50 percent. With the data at hand, the more rapid convergence can be seen by the *NIC*'s, as well as China and India recently. For low levels of schooling, the slow convergence, would just as likely appear to be non convergence.

Again, suppose we compare the US with a country like Bhutan. As an approximation, let's assume that $\rho = 0$ for Bhutan, but is given by the above for the US. These would produce a stationary human capital for the US and Bhutan of:

$$h(14.5) = A^{\frac{1}{1-\beta-\rho}} exp(\frac{1.45}{1-\beta-\rho}) \tag{31}$$

$$h(1.4) = A^{\frac{1}{1-\beta}} exp(\frac{.14}{1-\beta}) \tag{32}$$

$$\frac{h(14.5)}{h(1.4)} = A^{\frac{1-\beta}{1-\beta-\rho}} exp(\frac{1.45}{1-\beta-\rho} - \frac{.14}{1-\beta}) \tag{33}$$

For a value of young schooling in the US of 14.5, $\rho = .33$. For $\beta = .35$, and an $A = .5$, the stationary relative income gap between the US and Bhutan would be almost 18.3, which is even greater than the observed gap of about 11. In the data, the gap between the US and lowest output per worker country in 2007 is slightly over 100. The US produces about $76,000 output per worker per year, and Zaire produces $750 per year. Zaire schooling is 5.4 years overall, and 4.8 years of the young workers. So the model does not exactly fit. However the next lowest output per worker country in 2007 is Somalia. Real output per worker in Somalia worker is $1200 per year, and average schooling is 1.8. Ignoring experience and the spillover for Somalia, the predicted stationary relative human capital gap between the US and Somalia is 17. The observed income gap is 63. Thus while allowing for convergence for those countries with well educated young workers, the model also allows for an even greater relative income gap between the richest countries and the lowest schooling countries.

The results of this new calculation for human capital are contained in Figure 9. We plot the weighted average human capital by region. Unlike the previous human capital accumulation, there is less evidence of convergence. Outside of the *NIC* and *Southern Europe*, prior to 1950 there was much stronger evidence of divergence in human capital levels. The gap between *Sub-Saharan Africa* and the *Western Countries* is not much different in 2007 than the gap in 1950. In 1950 under the original calculation of human capital, the *Western Countries* average human capital is 5.4, and the *Sub Saharan African* average is 2.3. Under the new method of computing human capital, the 1950 average human capital in *Western Countries* is 6.1 and the *Sub-Saharan African* average was 1.0. So whereas the gap in the first case is 2.3 the new gap is 6.1. The relative output gap between these two regions in 1950 was 8.2. The new method allows for more chance for human capital to capture the difference in productivity based on input variations than before.

In Figure 10 we plot the new TFP levels for regions. In contrast to the previous TFP graph, there is slower long term trend growth in TFP across regions, and a more prominent post 1980 TFP decline in the advanced countries, *Western Countries*, *Southern Europe*, *NIC*. These three regions have indistinguishable levels of TFP in 2007. Four other regions appear to be in their own equivalence class of TFP: *Central & Eastern Europe*, *Asia*, *Latin America* and *North Africa*. *Sub-Saharan Africa* remains in the next to the bottom category, and the *Middle East* is the lowest TFP region. As with the case with no spillovers, there is substantial TFP growth for the *Middle East* and negative TFP growth for the *Sub-Saharan Africa* region

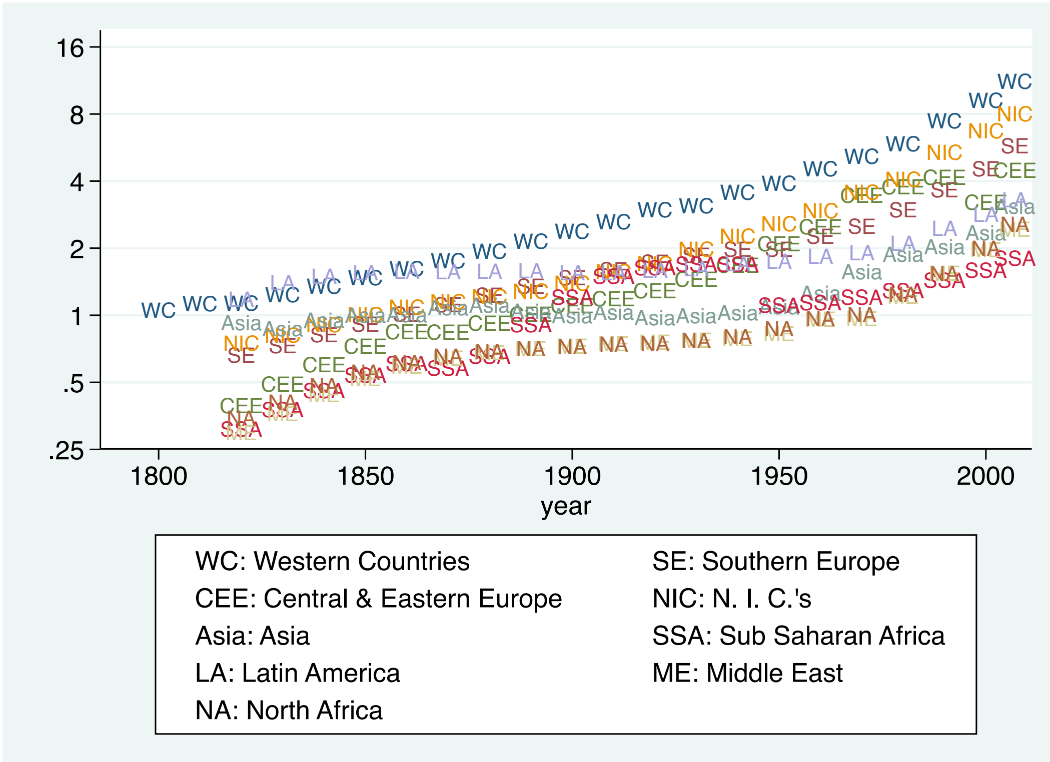

Figure 9: Human Capital Per Worker, $\beta = .35, \rho > 0$: by Region

since 1820.[31]

Table 5 presents the results for growth accounting using the new measure of human capital with spillovers. The new method dramatically increases the share of output growth that is explained by input accumulation relative to TFP growth. Using either *Population - Duration* weights, population in 2007 times the number of years of observations per country, or only 2007 population weights, less than one fifth of real output growth per worker is captured by TFP growth. Recall the comparable figure from both the base model and the model with only intergenerational human capital accumulation is two fifths. This result is similar across regions. From a low of -1 percent of growth explained by TFP growth, Sub-Saharan Africa, to a high of only 13 percent of growth explained by TFP growth, Western Countries, we find that the new measure of human capital captures the growth of output per worker.

Table 6 presents the results in the variance decomposition of growth rates. While the new measure of human capital accounts for between five sixths and 100 percent of the growth rate of output per worker, perhaps more stunning is the rising explanatory power of the variation in input growth in explaining the cross sectional variation of output growth. For the world as a whole, the new human capital model explains more than 80 percent of the cross country variations in growth rates using either the covariance share

[31] However in 1820 there is only one country in the *Sub-Saharan Africa* region, South Africa. All the countries except for Ghana appear in 1950. In the non spillover case there is TFP growth in this region from 1950 to 2007, however once one accounts for international spillovers, there is no growth in TFP over this period.

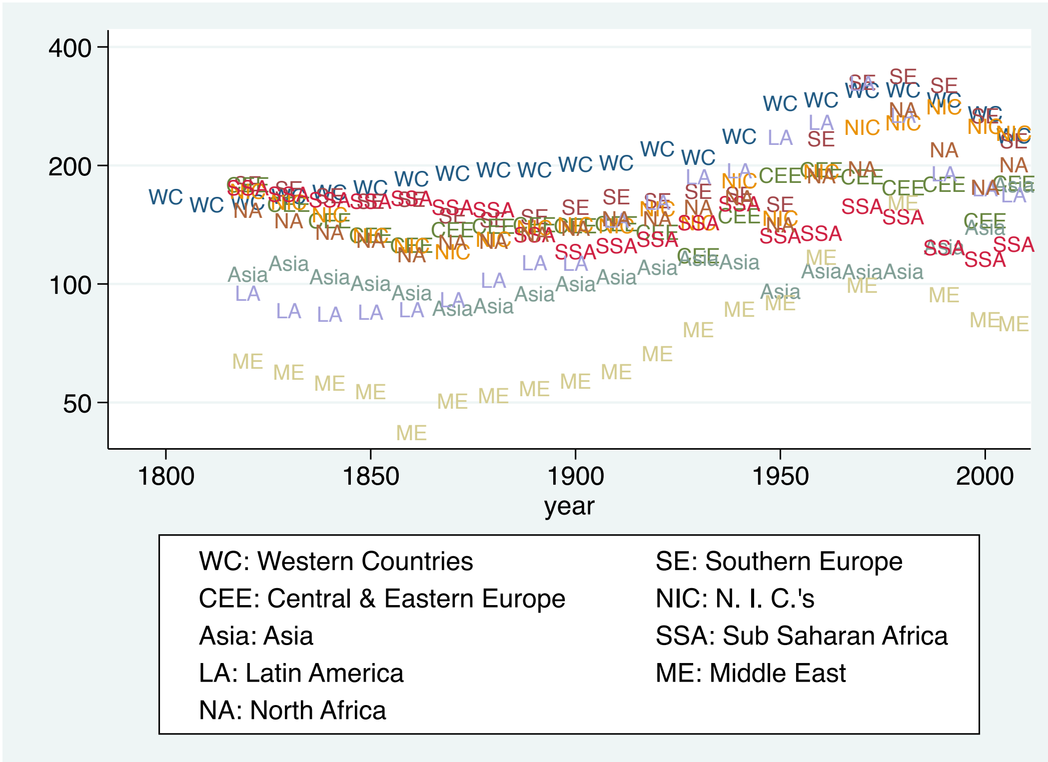

Figure 10: Total Factor Productivity, $\beta = .35, \rho > 0$: by Region

of Klenow &Rodriguez-Clare or average BDT decomposition. With the much more restrictive covariance share of capital intensity growth rate variation, inputs explain almost three-quarters of the growth rate variations! This is an marked increase from the 19% and the 62% of cross country growth rate variation attained in the base model and the intergenerational human capital accumulation without spillovers. For the *Western Countries*, *Southern Europe Asia* countries, the new human capital model explains better than 95% of the variation in growth rates, with the *NIC* right behind at 93%. In all regions the variation in input growth explains better than three-fifths of the variation in growth rates. Under the restrictive capital intensity case, three regions have input explanatory shares of 98% or better, and one more at 90%. Only the *Middle East* has explanatory share less than 50%, and this is driven by the OPEC countries.

Aggregating the regions into larger groupings reveal even stronger results. Combining the *Western Countries* and *Southern Europe*, the model explains over 95 percent of the cross country growth rate variations. Adding the *NIC* and *North Africa*, increases the model's power to over 99 percent! Including *Sub-Saharan Africa* countries drops the model's ability, but still it remains over 85 percent. The addition of the 20 *Asia* countries marginally improves the fit, as the variation of input growth rates explains 92% of growth rate variation. Adding in *Central and Eastern Europe*, *Latin America* and *North Africa* drops the model to 86%explanatory power.

Table 3: Growth Accounting: New Human Capital $\beta = .35$, $\rho = 0$

Region	N	Annualized Growth Rates						
		g_y	g_k	g_{hc}	g_x	g_z	share_{g_x}	share_{g_z}
Population-Duration Weights								
World	168	1.17%	1.11%	0.53%	0.73%	0.44%	0.624	0.376
(WC) Western Countries	18	1.45	1.56	0.71	1.00	0.46	0.685	0.315
(SE) Southern Europe	7	1.45	1.56	0.85	1.08	0.36	0.748	0.252
(CEE) Central & Eastern Europe	24	1.28	1.26	0.88	1.01	0.27	0.789	0.211
(NIC) Newly Industrialized Countries	5	1.81	2.36	0.93	1.41	0.40	0.778	0.222
(Asia) Asia	20	1.05	0.89	0.33	0.52	0.53	0.495	0.505
(SSA) Sub-Saharan Africa	48	1.06	1.10	0.64	0.86	0.20	0.808	0.192
(LA) Latin America	28	1.19	1.02	0.73	0.91	0.28	0.764	0.136
(ME) Middle East	13	1.17	1.08	0.94	1.00	0.17	0.856	0.144
(NA) North Africa	5	1.17	1.13	0.90	1.00	0.18	0.850	0.150
Population Weights								
World	168	1.18%	1.17%	0.53%	0.76%	0.42%	0.642	0.358
WC	18	1.46	1.57	0.72	1.00	0.46	0.686	0.314
SE	7	1.47	1.59	0.85	1.10	0.37	0.750	0.250
CEE	24	0.96	1.15	0.40	0.65	0.31	0.676	0.324
NIC	5	1.81	2.36	0.93	1.41	0.40	0.778	0.222
Asia	20	1.12	1.02	0.38	0.59	0.53	0.527	0.473
SSA	48	1.03	1.14	0.58	0.84	0.19	0.818	0.182
LA	28	1.19	1.04	0.71	0.89	0.31	0.744	0.256
ME	13	1.39	1.42	1.00	1.21	0.18	0.871	0.129
NA	5	1.18	1.16	0.89	1.01	0.17	0.855	0.145
Unweighted								
World	168	1.34%	1.62%	0.71%	1.03%	0.31%	0.768	0.232
WC	18	1.69	1.95	0.81	1.19	0.51	0.701	0.299
SE	7	2.55	3.37	1.36	2.03	0.52	0.795	0.205
CEE	24	0.86	1.15	0.19	0.51	0.35	0.592	0.408
NIC	5	1.87	2.43	1.04	1.50	0.37	0.803	0.197
Asia	20	1.49	1.92	0.79	1.17	0.33	0.781	0.219
SSA	48	1.32	1.57	0.78	1.06	0.26	0.802	0.198
LA	28	1.24	1.38	0.59	0.90	0.34	0.726	0.274
ME	13	0.99	1.16	0.95	0.99	0.00	0.998	0.002
NA	5	1.24	1.40	0.81	1.12	0.13	0.899	0.101

Table 4: Growth Variance Decomposition: Plausible Shares, New Human Capital $\beta = .35$, $\rho = 0$

Region	N	$\frac{\sigma_{g_x,g_y}}{\sigma^2_{g_y}}$ (1)	$\frac{\sigma_{g_z,g_y}}{\sigma^2_{g_y}}$ (2)	$\frac{\sigma_{g_{\hat{x}},g_y}}{\sigma^2_{g_y}}$ (3)	$\frac{\sigma_{g_{\hat{z}},g_y}}{\sigma^2_{g_y}}$ (4)	$\overline{S}_{g_x}$ (5)	$\overline{S}_{g_z}$ (6)	BDT_{g_x} (7)	BDT_{g_z} (8)
World	168	.742	.258	.615	.385	.736	.264	.22	.78
WC	18	.756	.244	.636	.364	.605	.395	.46	.54
SE	7	.852	.148	.779	.221	.514	.486	.50	.50
CEE	24	.740	.260	.613	.386	.727	.273	.28	.72
NIC	5	1.064	-0.064	1.095	-0.095	.936	.064	.64	.36
Asia	20	.903	.097	.855	.145	.904	.096	.40	.60
SSA	48	.775	.225	.665	.335	.707	.293	.37	.63
LA	28	.530	.470	.299	.701	.548	.452	.22	.78
ME	13	.532	.468	.301	.699	.585	.415	.44	.56
ME not OPEC	4	.769	.231	.655	.345	.517	.483		
ME OPEC	9	.531	.469	.299	.701	.565	.435		
NA	5	.563	.437	.347	.653	.837	.163	.84	.16
larger regions									
(1): WC & SE	25	.851	.149	.778	.222	.623	.377		
(2): (1) & NIC	30	.850	.150	.777	.223	.656	.344		
(3): (2) & NA	35	.843	.157	.765	.235	.697	.303		
(4): (3) & SSA	83	.788	.212	.683	.317	.701	.299		
(5): (4) & Asia	103	.814	.186	.723	.277	.771	.229		
(6); (5) & CEE	127	.807	.193	.712	.288	.778	.222		
(7): (6) & LA	155	.786	.214	.681	.319	.763	.237		
(7); (6) & ME not OPEC	159	.786	.214	.681	.319	.762	.238		

Table 5: Growth Accounting: New Human Capital $\beta = .35$ & $.35 \geq \rho > 0$

Region	N	Annualized Growth Rates g_y	g_{hc}	g_x	g_z	share_{g_x}	share_{g_z}
Population-Duration Weights							
World	168	1.17%	0.85%	0.97%	0.20%	0.826	0.174
WC	18	1.45	1.12	1.26	0.19	0.869	0.131
SE	7	1.45	1.18	1.30	0.14	0.901	0.099
CEE	24	1.28	1.16	1.19	0.08	0.933	0.067
NIC	5	1.81	1.32	1.67	0.14	0.922	0.078
Asia	20	1.05	0.70	0.76	0.28	0.730	0.270
SSA	48	1.06	1.01	1.08	-0.02	1.023	-0.023
LA	28	1.19	0.59	1.15	0.04	0.966	0.034
ME	13	1.17	1.28	1.16	0.01	0.990	0.010
NA	5	1.17	1.05	1.08	0.09	0.921	0.079
Population Weights							
World	168	1.18%	0.87%	1.00%	0.18%	0.847	0.153
WC	18	1.46	1.12	1.27	0.19	0.869	0.131
SE	7	1.47	1.19	1.32	0.15	0.902	0.098
CEE	24	0.96	0.87	0.95	0.01	0.988	0.012
NIC	5	1.81	1.32	1.67	0.14	0.922	0.078
Asia	20	1.12	0.75	0.84	0.29	0.745	0.255
SSA	48	1.03	0.98	1.08	-0.05	1.050	-0.050
LA	28	1.19	0.64	1.12	0.08	0.935	0.065
ME	13	1.39	1.44	1.41	-0.02	1.016	-0.016
NA	5	1.18	1.05	1.10	0.08	0.931	0.069
Unweighted							
World	168	1.34%	1.19%	1.34%	-0.00%	1.000	-0.000
WC	18	1.69	1.28	1.50	0.19	0.888	0.112
SE	7	2.55	1.94	2.42	0.14	0.946	0.054
CEE	24	0.86	0.91	0.98	-0.11	1.129	-0.129
NIC	5	1.87	1.40	1.74	0.13	0.930	0.070
Asia	20	1.49	1.18	1.43	0.06	0.959	0.041
SSA	48	1.32	1.23	1.35	-0.03	1.025	-0.025
LA	28	1.24	0.94	1.19	0.05	0.959	0.041
ME	13	0.99	1.51	1.25	-0.27	1.270	-0.270
NA	5	1.24	1.08	1.24	-0.01	1.000	-0.000

Table 6: Growth Variance Decomposition: Plausible Bounds, New Human Capital $\beta = .35$, $.35 \geq \rho > 0$

Region	N	$\frac{\sigma_{g_x,g_y}}{\sigma^2_{g_y}}$ (1)	$\frac{\sigma_{g_z,g_y}}{\sigma^2_{g_y}}$ (2)	$\frac{\sigma_{g_{\hat{x}},g_y}}{\sigma^2_{g_y}}$ (3)	$\frac{\sigma_{g_{\hat{z}},g_y}}{\sigma^2_{g_y}}$ (4)	$\overline{S}_{g_x}$ (5)	$\overline{S}_{g_z}$ (6)	BDT$_{g_x}$ (7)	BDT$_{g_z}$ (8)
World	168	.814	.186	.722	.278	.825	.175	.22	.78
WC	18	.984	.016	.976	.024	.986	.014	.46	.54
SE	7	1.000	.000	.999	.001	.956	.044	.50	.50
CEE	24	.721	.279	.583	.417	.678	.322	.28	.72
NIC	5	.932	.068	.898	.102	.932	.068	.64	.36
Asia	20	.989	.011	.983	.017	.958	.042	.40	.60
SSA	48	.881	.119	.822	.178	.847	.153	.37	.63
LA	28	.748	.252	.624	.376	.771	.229	.22	.78
ME	13	.590	.410	.388	.612	.626	.374	.44	.56
ME not OPEC	4	.990	.010	.985	.015	.993	.007		
ME OPEC	9	.579	.421	.372	.628	.594	.406		
NA	5	1.330	-0.330	1.493	-0.493	.663	.337	.84	.16
larger regions									
(1): WC & SE	25	1.004	-0.004	1.007	-0.007	.979	.021		
(2): (1) & NIC	30	1.004	-0.004	1.006	-0.006	.986	.014		
(3): (2) & NA	35	.995	.005	.992	.008	.993	.007		
(4): (3) & SSA	83	.903	.097	.855	.145	.876	.124		
(5): (4) & Asia	103	.923	.077	.884	.116	.921	.079		
(6); (5) & CEE	127	.870	.130	.807	.193	.858	.142		
(7): (6) & LA	155	.863	.137	.795	.205	.858	.142		
(7); (6) & ME not OPEC	159	.864	.136	.797	.203	.860	.140		

6 Robustness: Development Accounting, Alternative Parameter Specifications, & First Half and Second Half Results

In this section we present evidence on the robustness of the results. First we examine a range of other parameter specifications. Second we split the data into to two equal time periods. For each country we found the closest midpoint year observation and then produced samples with that midyear observation as the terminal and initial value. This evidence is consistent with the conclusion that the model with intergenerational human capital accumulation with spillovers fits the data well.

6.1 Development Accounting

We have shown that variations in growth rates are captured mostly by the variations in input growth rates when inputs include intergenerational human capital accumulation. Does this also hold for variations in levels of output per worker? To this question we now turn. Similar to variance decomposition analysis of growth rates, we conduct a variance decomposition analysis on log levels of output per worker. Once again we can combine the factors of production per worker into the variable x. Assuming a Cobb-Douglas production function produces the following result:

$$\ln y_{it} = \ln z_{it} + \ln x_{it}, \tag{34}$$

$$\ln x_{it} = \alpha \ln k_{it} + (1-\alpha) \ln h_{it} \tag{35}$$

As with our variance decomposition of growth rates, we use the two covariance decompositions suggested by Klenow, Rodriguez-Clare (1997). In the first, we assume that output variations arise from both input variations and TFP variations:

$$\sigma^2_{\ln y_t} = \sigma_{\ln x_t, \ln y_t} + \sigma_{\ln z_t, \ln y_t} \tag{36}$$

In the second, we assume that higher TFP induces input accumulation of physical capital, and hence only the variations in physical capital intensity and variations in human capital are variations in inputs that account for variations in output per worker. Thus we have:

$$\sigma^2_{\ln y_t} = \sigma_{\ln \hat{x}_t, \ln y_t} + \sigma_{\ln \hat{z}_t, \ln y_t} \tag{37}$$

$$\ln \hat{x}_t = \frac{\alpha}{1-\alpha} [\ln k_t - \ln y_t] + \ln h_t \tag{38}$$

$$\ln \hat{z}_t = \frac{\alpha}{1-\alpha} \ln z_t \tag{39}$$

Finally under the view that TFP induces factor accumulation, and that the predictable or correlated portion of inputs should be assigned to TFP, the share of output per worker can be written as:

$$1 = \frac{(\sigma_{\ln z} + \sigma_{\ln x}\rho_{\ln x, \ln z})^2}{\sigma^2_{\ln y}} + \frac{(1 - \rho^2_{\ln x, \ln z})\sigma^2_{\ln x}}{\sigma^2_{\ln y}} \tag{40}$$

where the first term is now a plausible upper bound on the proportion of the variation in log output per worker explained by variation in log TFP. At the other end of the theoretical spectrum, the predictable or correlated component of TFP arises from endogenous factor accumulation. Assigning this predictatble component to factors produces the following variance decomposition:

$$1 = \frac{(\sigma_{\ln x} + \sigma_{\ln z}\rho_{\ln x, \ln z})^2}{\sigma^2_{\ln y}} + \frac{(1 - \rho^2_{\ln x, \ln z})\sigma^2_{\ln z}}{\sigma^2_{\ln y}} \tag{41}$$

The first term is now the proportion of the variation of output per worker that explained by variation in inputs. We examine these for the initial conditions as well as the terminal observation.[32] Thus the shares of the variance of log output per worker are given by:

$$\overline{S}_{\ln x} = \frac{\sigma^2_{\ln x}}{\sigma^2_{\ln y}} + \frac{1}{2}\frac{\rho^2_{\ln x, \ln z}\left(\sigma^2_{\ln z} - \sigma^2_{\ln x}\right)}{\sigma^2_{\ln y}} + \frac{\sigma_{\ln x}\sigma_{\ln z}\rho_{\ln x, \ln z}}{\sigma^2_{\ln y}} \tag{42}$$

$$\overline{S}_{\ln z} = \frac{\sigma^2_{\ln z}}{\sigma^2_{\ln y}} + \frac{1}{2}\frac{\rho^2_{\ln x, \ln z}\left(\sigma^2_{\ln x} - \sigma^2_{\ln z}\right)}{\sigma^2_{\ln y}} + \frac{\sigma_{\ln x}\sigma_{\ln z}\rho_{\ln x, \ln z}}{\sigma^2_{\ln y}} \tag{43}$$

Figures 11 - 13 contain the time series of the share of variations in log output per worker explained by variations in log inputs per worker. In each graph we present three different cases, the base case with no intergenerational human capital accumulation, and intergenerational human capital accumulation, $\beta = .35$ with no spillover, $\rho = 0$, and with spillover $\rho \geq .35$. The thick curves in each of the three human capital specifications are the results from using all of the data. The thinner curves, in each of the three human capital specifications, are the results from each decade cross section. We present them in order of rising input ability to explain log level variations in output per worker. Thus we start wight the most restrictive assumption that only physical capital intensity variations contribute to input explanations of log level output per worker variations. This is contained in Figure 11.

Both intergenerational human capital models significantly improve on the base Mincer human capital cross section model. In every cross section they outperform the base Mincer human capital model in explaining cross sectional output per worker differences. The average highest share of the variance of log output per worker comes from the international human capital model with spillovers. The average explanation in this case is 55%![33] in contrast the human capital model without spillovers explains 50%.[34] The base Mincer human capital model explains only 30% of log output per worker differences.[35].

[32] All terminal years are 2007, except for East Germany, which has a terminal observation in 1990.
[33] When we use all years, this model explains 52%.
[34] When we use all years, this model explains only 41%.
[35] When we use all years, this model explains 31%

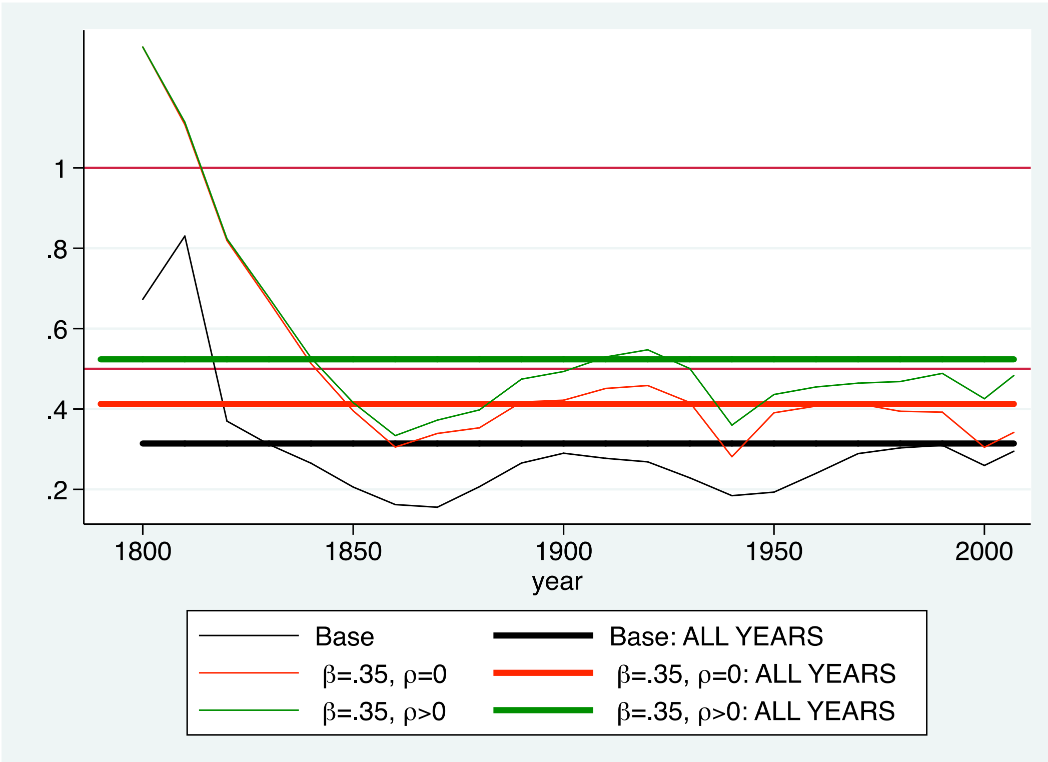

Figure 11: Covariance Development Accounting (Klenow, Rodriguez-Clare): Base, $\beta = .35, \rho = 0$, $\beta = .35, \rho > 0$

Early on there is little difference between the intergenerational human capital models with and without spillovers. Not until roughly 1860 does the model with spillovers diverge from the model without spillovers. In all years since 1850 the model with spillovers does a better job of capturing log output per worker differences than the model without spillovers.

Figure 12 contains the results for the covariance share decomposition without the limitation on the physical capital input to physical capital intensity, $\frac{k}{y}$. This implies that the covariance of log input per worker with log output per worker is credited to inputs. The time series of all three human capital models are identical to the previous case, except for level. Under the assumption that inputs per worker include only physical capital intensity and human capital, all three human capital models explained less than 40 percent of output per worker variations. When inputs include physical capital and human capital, all three models explain better than 50 percent of output per worker differences. The model without spillovers explains 61% of log output per worker differences, and the model with spillovers explains 68% of output per worker differences.

Allowing the data to determine how much of the correlation or predictable component of log input and log TFP to allocate to each other produces the final metric on the importance of input variations. Figure 13 contains the results for the three human capital specifications. For the base Mincer human capital

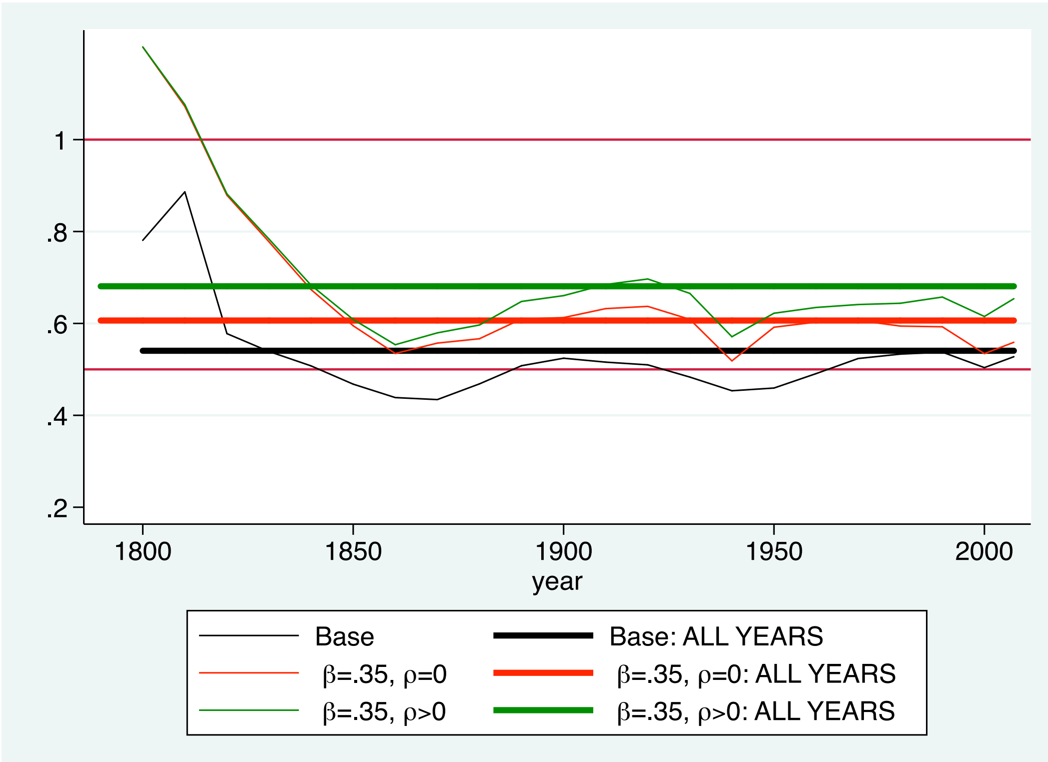

Figure 12: Covariance Development Accounting: Base, $\beta = .35, \rho = 0$, $\beta = .35, \rho > 0$

model, there is essentially no change from the results in Figure 12. Log input variations explain 52% of the difference in log output per worker. For the intergenerational human capital models, however, there is further improvement. For the model without spillovers, log input per worker variation now explains 68% of log output per worker variation. For the model with spillovers, log input per worker variation explains 74% of log output per worker variation. Thus we find that input variations are quite capable of explaining at least half of the observed variation in output per worker. Only under the assumption that all correlation between log TFP and log physical capital is induced by log TFP does one produce estimates of input share significantly below 40 percent. Once one allows the data to help inform about the importance of the association, we find that log input variation explains at least half if not three quarters of the variation in log output per worker.

6.2 Alternative Parameter Specifications

In this section we show that the results of the previous section are robust to different parameter values. Thus our conclusion that intergenerational human capital accumulation models with spillovers dramatically help to explain variation in long run growth rates, as well as variations in living standards is robust. We examine a range of values on the triple (A, ρ, β) with the restriction that the unweighted average growth

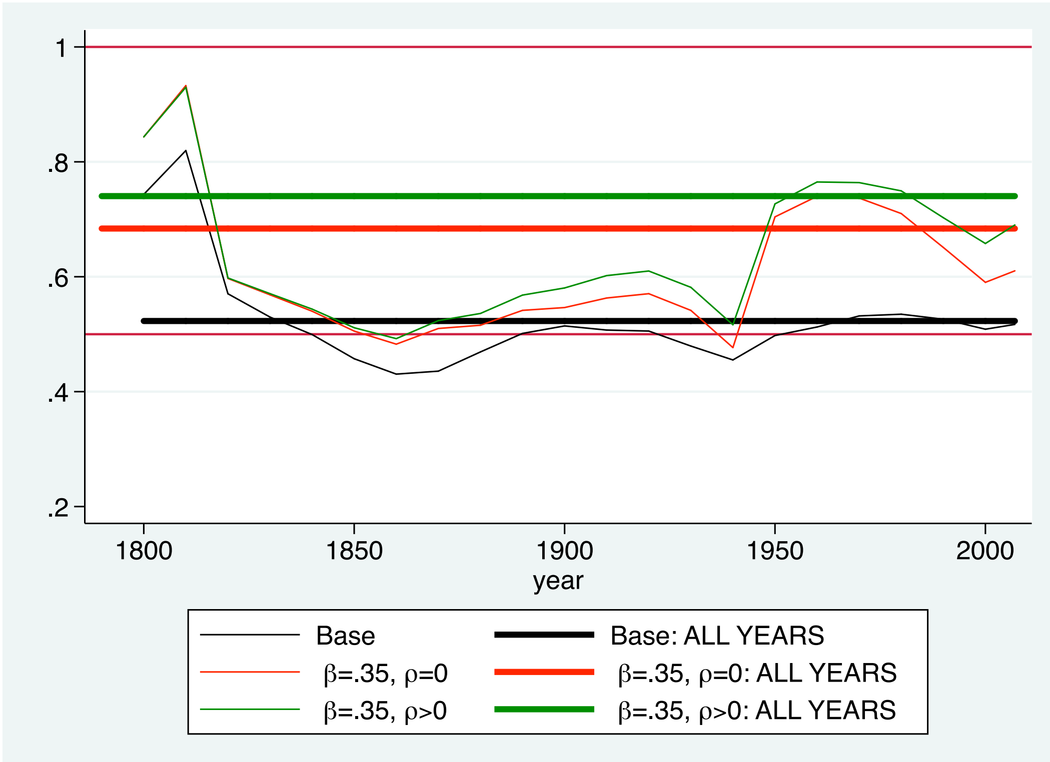

Figure 13: Development Accounting: Base, $\beta = .35, \rho = 0$, $\beta = .35, \rho > 0$

rate of output per worker is fully explained by input growth.[36] For various combinations of (A, ρ, β) we show that between two-thirds to ninety percent of the variation in growth rates of output per worker is captured by input growth variations. We also conduct development accounting exercises, and show that between one-third and three-quarters of the variation in log levels of output per worker are explained by variations in inputs per worker, with stronger belief towards the higher range.

We searched over a wide range of values of β and ρ. For β we examined values from $[.05, .80]$, and for ρ we examined values from $[0, .65]$ with the constraint $\beta + \rho \leq 1$. We combine both the variance decomposition of growth results and the development accounting results in Table 7.[37] The first two columns of the growth variance decomposition contain the covariance accounting results. The first allows input share to be from the covariance of input growth with output growth. The second restricts input growth to be

[36]This implies that the average growth rates produced by input growth, weighted either by length of observation multiplied by 2007 population, or 2007 population, are less than the appropriately weighted average growth rates of output per worker. This implies that the models generally explain between 80% to 90% of weighted output per worker growth.

[37]We present the results of the grid on β. We think of this exercise as one of quantitative identification. That is the parameters chosen in the ρ function and the A function are picked in order to best fit both the growth accounting and the variance decomposition of growth rates. This exercise is conducted similar to Tamura and Simon (2012), Murphy, Simon and Tamura (2008) and Tamura (2006). Their models are forced to fit actual time series, and the forcing variables, such as price of space, or efficiency of schooling time, are allowed to be whatever they need to be to fit the series. That is given a specific model, what must parameters be in order to fit the data. In theory we could use a search algorithm for the best fitting parameters that minimizes a loss function. We leave that to future research. We experimented with other combinations of (A, β, ρ) but the overwhelming majority of those specifications performed worse than those presented in Table 7 either in the variance decomposition of growth rates or the variance decomposition of log levels.

human capital growth and physical capital intensity growth. The column marked World is the average BDT decomposition. In the column marked Region, we examined each of the regions separately, producing the average BDT decomposition for each and then averaged the results using arithmetic means, weighted arithmetic means, harmonic means and weighted harmonic means. We then averaged each of these four expectations to form the Region average.[38] With only seven exceptions out of 52 possible cases, inputs explain between two-thirds and 90% of growth rate variations! In the seven exceptions all but one of them have input shares over 50%, and all but two of them have input shares exceeding 60%. It is fair to say, that in the variance decomposition of growth rates the model with human capital spillovers explains between three-fifths and ninety percent of the growth variations!

In the development accounting portion of Table 7, the first four columns contain the covariance decompositions. The first is the covariance decomposition of log input with log output on all years of data. The second is the covariance decomposition of log input with log output for each decade separately, and then averaged over all years. The next column is the covariance decomposition of log input with log output, but with inputs restricted to human capital and physical capital intensity on all years. The fourth column in this heading repeats the cross sectional covariance decomposition of log input with log output, with inputs restricted to human capital and physical capital intensity, and then averaged across the years. The final two columns in this group are average BDT decompositions, first over all years simultaneously, and the next column contains the average BDT decomposition by region for all years and then averaged. Ignoring the restricted input measures to start, we find that log level input variations explain between three-fifths and over three-fourths of log level output variations. Even in the restricted input case, we find that log level input variations explain at least half of the log level output variations 16 times out of 26. In no case does it fail to explain at least 40 percent of the log level variations.

The final column of Table 7 is an arithmetic average of all columns. In 12 out of 13 cases the average exceeds two thirds, and in the one case below two thirds, it explains over five-eighths. The spread for the twelve cases is very small, ranging between 67.5% to 69.6%. Thus we believe that our results are robust, variations in input growth or log levels explain more than seventy percent of output growth variations, and over three-fifths of log level variations, respectively.[39]

6.3 First Half & Second Half

In this section we examine how well the model works for early years and later years. For each country we found the midpoint year observation, hereafter referred to as midyear, and split the country's time series

[38] This allows us to see if some regions are driving the results and if the specification succeeds or fails spectacularly in some regions.

[39] In computations not shown, we eliminate from consideration all parameter specifications with $\beta > .55$. Essentially for all values of $\beta > .55$ the level of TFP in many regions exceeds that of the Western Countries, Southern European countries and the N.I.C.'s for most of the twentieth century. We consider this result to be implausible, and exclude these parameter specifications from the rest of the analysis.

into two parts. We examine how the models fit the data when comparing the period from the first year of observation until the midyear, and then from the midyear to 2007. If the human capital calculations are robust, then they should fit each of these periods as well as the overall period, absent innovations to the underlying structure of the economy. Tables 8 - 11 contain the results of both the growth accounting and the variance decompositions for both the original model, and the new human capital model both with and without spillovers. Tables 8 and 9 present growth accounting for each period, and Tables 10 and 11 present the variance decomposition results for the original model. We concentrate on the results contained in the top third of Tables 8 and 9, those arising from *population-duration* weights. There is a noticeable acceleration in growth rates between the first half and the second half, from 0.61% per year to 1.79% per year. Growth rates accelerate in every region except for *Sub-Saharan Africa* and the *Middle East*. It is all the more remarkable since for all of these regions, except for *Sub-Saharan Africa*, the second half of the data include both World Wars, and the Great Depression! The base model explains three-fifths of growth in the first half and two-thirds of growth in the second half. The intergenerational model of human capital accumulation without spillovers explains ninety percent of the growth in the first half, but only four-sevenths of growth in the second half. With spillovers the intergenerational human capital model captures 95% of growth in the first half and 80% of growth in the second half. While the intergenerational model overestimates growth in some regions in the first half, *Southern Europe*, *Central & Eastern Europe*, *NIC* and *Asia*, and underestimates growth in these regions in the second half, the model does capture the acceleration in growth rates well. For example in *Asia* growth is predicted in the first half of 0.185 (compared with .16 actual), and 1.34 in the second half (compared with 1.89 actual). In three regions the intergenerational model over predicts second half growth. In *Latin America* first half growth is predicted 0.53 (compared with 1.09 actual), and second half growth is predicted 1.94 (compared with 1.53 actual).

Recall that in the variance decomposition of growth rates, the base model explained about half of the variance of growth, see Table 2. When the data is split, the base model explains 60 percent of the variation of growth in the first half of the data, before falling to slightly less than a third of the variation in the second half,(based on using the covariance share and average BDT share). The decline is pretty uniform across the different regions, with the largest decline in the *Western Countries* and the *non OPEC Middle East* regions. In the *Western Countries*, the model's explanatory power drops from 70 percent to only 17 percent, and for the *non OPEC Middle East* the base model suffers a decline from 60 percent to 9 percent. The decline is evident for the larger regions as well. Whereas in the first half of the data the model explains anywhere from 56 percent to 67 percent of the variation in growth, in the second half the model is only capable of explaining between thirty percent and forty percent of the variation.

The intergenerational human capital model improves the ability to explain the cross sectional variation in growth rates. Without spillovers the model explains two thirds of the variation in growth rates in the first half, and slightly less than half in the second half. While explaining less than half of the cross sectional variation in growth rates in the second half, this is still a large change compared to the one third share of growth variations explained in the base model over the same period. In the first half the intergenerational model explains no less than half the growth rate variations in each region, and in the larger regions it explains between two-thirds to four-fifths of the growth rate variations. In the second half the model can explain only about one seventh of the growth variations in the *Western Countries*, one third of the growth variations amongst the *NIC*, and between four-ninths and three-fifths in all the other regions. In the larger regions the model explains somewhere between 40 percent and slightly more than half of the growth rate variations.

Like the previous results on growth rates over the entire horizon, in examining the behavior in two separate time periods the spillover model implies that substantially more output growth is associated with the growth of aggregate input. The change is most dramatic for the *Western Countries* and *Southern Europe* regions. For the full time period, the intergenerational model without spillovers explains between half and three-fifths of the cross sectional variation in growth rates; the addition of spillovers increases the explanatory power to over 95 percent. In Tables 10 and 11 the change arising from spillovers is smaller. In the first half the spillover model explains 70 percent of the growth rate variations in the world compared with two-thirds without spillovers. The fit ranges from half in *North Africa* to ninety percent in *Southern Europe* and the *NIC*. In the larger regions, the spillover model explains between two thirds and ninety percent of the growth rate variations. In the second half, the spillover model improves the explanatory power of the intergenerational model from 49 percent to 51 percent. Most of the gain comes from the Western Countries, going from 14 percent to 24 percent, and Southern Europe, going from 54 percent to 65 percent. In the larger regions the spillover model explains between 45 percent and 57 percent of the growth rate variations.

The results obtained by splitting the sample into equal length time periods suggest that both the base model and the intergenerational human capital model's results are robust. While there is a lessening of both models' ability to explain growth rate variations in the second half of the data, they both are reasonable characterizations of the data.

Table 7: Robustness Analysis

Model	Growth Variance Decomposition Average Input Share				Development Variance Decomposition Average Input Share						
(β, ρ)	$\frac{\sigma_{g_x, g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}, g_y}}{\sigma^2_{g_y}}$	Avg BDT World	Avg BDT Region	$\frac{\sigma_{\ln x, \ln y}}{\sigma^2_{\ln y}}$	$\overline{\frac{\sigma_{\ln x, \ln y}}{\sigma^2_{\ln y}}}$	$\frac{\sigma_{\ln \hat{x}, \ln y}}{\sigma^2_{\ln y}}$	$\overline{\frac{\sigma_{\ln \hat{x}, \ln y}}{\sigma^2_{\ln y}}}$	Avg BDT World	Avg BDT Region	Mean
(.05, .65)	87.8	81.8	90.0	79.4	63.9	60.5	46.2	41.1	71.1	62.8	68.5
(.15, .55)	86.1	79.3	88.5	79.5	65.0	61.9	47.8	43.1	71.9	63.7	68.7
(.20, .50)	85.2	78.0	87.5	79.9	65.5	62.6	48.5	44.2	72.3	64.2	68.8
(.25, .45)	85.0	77.6	86.0	80.7	67.2	64.0	51.0	46.3	72.9	64.8	69.6
(.30, .40)	82.6	74.0	84.1	81.4	67.3	64.1	51.2	46.4	73.5	65.2	69.0
(.35, .35)	81.4	72.2	82.5	81.9	68.1	65.0	52.4	47.8	74.0	65.8	69.1
(.40, .30)	79.9	69.9	80.5	81.1	68.9	65.8	53.6	48.9	74.6	66.2	68.9
(.45, .25)	78.4	67.7	78.8	79.0	69.9	66.5	55.0	50.0	74.1	66.7	68.6
(.50, .20)	77.3	66.1	77.4	77.6	70.9	67.7	56.6	51.8	75.8	67.5	68.9
(.55, .15)	76.0	64.2	74.8	74.2	71.6	69.8	57.6	54.9	76.5	68.8	68.8
(.60, .10)	73.6	60.6	72.3	72.3	72.6	70.7	59.2	56.3	77.0	69.3	68.4
(.70, .00)	67.9	52.1	67.3	68.5	74.3	73.7	61.7	60.8	78.0	70.9	67.5
(.80, .20)	63.7	45.8	66.3	65.9	71.9	67.7	58.1	51.8	75.5	66.9	63.4

Table 8: Growth Accounting First Half: Base & New Human Capital $\beta = .35$ & $.35 \geq \rho > 0$

		Annualized Growth Rates							
Region	N	g_y	g_k	g_{hc}^{base}	$g_{hc}^{\rho=0}$	$g_{hc}^{\rho\geq0}$	share^{base}	share$^{\rho=0}$	share$^{\rho\geq0}$
Population-Duration Weights									
World	168	0.61%	0.59%	0.24%	0.50%	0.55%	0.605	0.885	0.947
Western Countries	18	1.11	1.04	0.45	0.70	0.84	0.584	0.734	0.815
Southern Europe	7	0.81	0.80	0.28	0.88	0.97	0.557	1.051	1.121
Central and Eastern Europe	24	0.89	0.76	0.36	1.17	1.26	0.542	1.148	1.218
Newly Industrialized Countries	5	0.67	0.99	0.25	0.71	0.79	0.745	1.203	1.280
Asia	20	0.16	0.17	0.08	0.18	0.20	0.679	1.073	1.160
Sub-Saharan Africa	48	1.42	1.68	0.65	0.66	0.73	0.798	0.819	0.849
Latin America	28	1.09	0.75	0.29	0.39	0.43	0.406	0.468	0.489
Middle East	13	1.88	1.74	0.26	1.12	1.17	0.563	0.760	0.772
North Africa	5	1.01	0.90	0.09	0.84	0.84	0.460	0.911	0.914
Population Weights									
World	168	0.77%	0.75%	0.33%	0.55%	0.61%	0.642	0.833	0.886
WC	18	1.11	1.04	0.45	0.71	0.84	0.580	0.736	0.816
SE	7	0.86	0.89	0.29	0.90	1.00	0.571	1.043	1.116
CEE	24	0.86	0.52	0.49	0.93	1.02	0.536	0.874	0.945
NIC	5	0.66	0.98	0.25	0.71	0.79	0.744	1.204	1.281
Asia	20	0.30	0.34	0.14	0.31	0.34	0.685	1.069	1.132
SSA	48	1.43	1.72	0.68	0.63	0.69	0.820	0.812	0.843
LA	28	1.36	1.01	0.41	0.48	0.54	0.449	0.483	0.515
ME	13	2.81	2.62	0.43	1.13	1.21	0.577	0.686	0.700
NA	5	1.46	1.29	0.19	0.85	0.85	0.512	0.792	0.794
Unweighted									
World	168	1.47%	1.61%	0.59%	0.88%	1.03%	0.647	0.775	0.839
WC	18	1.46	1.80	0.45	0.88	1.08	0.613	0.808	0.901
SE	7	2.38	3.61	0.59	1.53	1.86	0.672	0.936	1.030
CEE	24	0.74	0.17	0.68	0.97	1.11	0.626	0.875	0.998
NIC	5	0.61	0.68	0.12	1.03	1.07	0.508	1.503	1.546
Asia	20	1.03	2.16	0.42	0.76	0.85	0.971	1.192	1.256
SSA	48	1.67	1.72	0.72	0.82	0.97	0.648	0.693	0.751
LA	28	1.75	1.66	0.61	0.69	0.85	0.549	0.578	0.638
ME	13	1.89	1.90	0.58	1.18	1.27	0.657	0.798	0.821
NA	5	1.98	1.76	0.32	0.86	0.87	0.552	0.722	0.724

Table 9: Growth Accounting Second Half: Base & New Human Capital $\beta = .35$ & $.35 \geq \rho > 0$

Region	N	Annualized Growth Rates g_y	g_k	g_{hc}^{base}	$g_{hc}^{\rho=0}$	$g_{hc}^{\rho\geq 0}$	share^{base}	share$^{\rho=0}$	share$^{\rho\geq 0}$
Population-Duration Weights									
World	168	1.79%	1.70%	0.86%	0.58%	1.22%	0.671	0.573	0.806
Western Countries	18	1.67	1.86	0.65	0.70	1.31	0.629	0.647	0.891
Southern Europe	7	2.08	2.33	0.94	0.82	1.37	0.671	0.633	0.811
Central and Eastern Europe	24	1.74	1.77	1.09	0.58	1.04	0.759	0.572	0.740
Newly Industrialized Countries	5	2.98	3.86	0.96	1.09	1.77	0.645	0.675	0.827
Asia	20	1.89	1.61	0.83	0.53	1.21	0.575	0.470	0.709
Sub-Saharan Africa	48	0.74	0.67	0.96	0.46	0.73	1.107	0.713	1.270
Latin America	28	1.53	1.58	1.03	0.26	0.84	1.317	1.037	1.268
Middle East	13	1.10	1.06	1.03	0.78	1.40	0.956	0.848	1.108
North Africa	5	1.51	1.49	0.96	0.97	1.36	0.760	0.770	0.924
Population Weights									
World	168	1.67%	1.68%	0.90%	0.52%	1.20%	0.721	0.579	0.839
WC	18	1.91	2.06	0.72	0.74	1.31	0.611	0.616	0.891
SE	7	2.10	2.34	0.93	0.82	1.38	0.669	0.633	0.811
CEE	24	1.16	1.89	0.96	-0.19	0.68	1.114	0.484	0.957
NIC	5	2.98	3.85	0.96	1.09	1.77	0.645	0.675	0.827
Asia	20	1.98	1.77	0.87	0.53	1.21	0.591	0.477	0.705
SSA	48	0.64	0.62	0.98	0.49	1.20	1.264	0.827	1.507
LA	28	1.36	1.45	1.05	0.25	0.87	1.329	0.985	1.266
ME	13	0.66	0.97	1.25	0.89	1.71	1.637	1.376	1.940
NA	5	1.35	1.41	0.98	0.94	1.36	0.819	0.814	0.993
Unweighted									
World	168	1.20%	1.68%	1.00%	0.48%	1.32%	1.022	0.755	1.197
WC	18	2.08	2.33	0.94	0.81	1.44	0.671	0.633	0.861
SE	7	2.80	3.19	0.90	1.20	1.95	0.594	0.664	0.843
CEE	24	1.03	2.30	0.85	-0.72	0.63	1.329	0.356	1.190
NIC	5	3.10	4.11	0.97	1.06	1.70	0.650	0.668	0.806
Asia	20	1.98	1.98	1.01	0.82	1.49	0.674	0.612	0.836
SSA	48	0.95	1.41	1.05	0.73	1.48	1.221	1.006	1.520
LA	28	0.75	1.08	1.03	0.23	1.01	1.645	0.957	1.635
ME	13	-0.03	0.32	1.35	1.71	1.27	-	-	-
NA	5	0.38	0.94	1.13	0.75	1.38	2.354	1.980	2.803

Table 10: Growth Variance Decomposition: First Half, Base, New Human Capital $\beta = .35, \rho = 0$, $\beta = .35, .35 \geq \rho > 0$

Region	N	$\frac{\sigma_{g_x, g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}, g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{base}$	$\frac{\sigma_{g_x^{\rho=0}, g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}^{\rho=0}, g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{\rho=0}$	$\frac{\sigma_{g_x^{\rho\geq 0}, g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}^{\rho\geq 0}, g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{\rho\geq 0}$
World	168	.6119	.3030	.6077	.6707	.4003	.6666	.7202	.4767	.7088
WC	18	.7002	.5448	.6991	.7467	.6146	.7171	.8725	.8033	.7901
SE	7	.7116	.5617	.6343	.7977	.6909	.7490	.9017	.8469	.9008
CEE	24	.4892	.2072	.4894	.6403	.4308	.6223	.6059	.3792	.5853
NIC	5	.6860	.5255	.6790	.9365	.9012	.8553	.9981	.9937	.8922
Asia	20	1.3087	1.4450	.8072	1.6891	2.0157	.7101	1.7551	2.1146	.6986
SSA	48	.4250	.1239	.4337	.5047	.2410	.5046	.5678	.3366	.5670
LA	28	.6770	.5113	.6565	.5822	.3692	.5696	.6981	.5431	.6928
ME	13	.5732	-.0241	.5419	.6350	.1251	.6047	.6481	.1530	.6158
ME not OPEC	4	.7257	.5850	.5718	.7859	.6753	.7640	.8441	.7626	.8418
ME OPEC	9	.5592	-.0804	.5327	.6211	.0743	.5894	.6301	.0968	.5940
NA	5	.6288	.1536	.5007	.5221	-.0440	.5001	.5214	-.0450	.5001
larger regions										
(1): WC & SE	25	.7133	.5643	.6754	.8115	.7116	.8094	.9190	.8727	.9046
(2): (1) & NIC	30	.7126	.5634	.6706	.7895	.6787	.7850	.8981	.8416	.8911
(3): (2) & NA	35	.6843	.4290	.6227	.7050	.4495	.6853	.7778	.5587	.7752
(4): (3) & SSA	83	.5679	.2924	.5560	.6126	.3524	.6084	.6808	.4552	.6798
(5): (4) & Asia	103	.6344	.3963	.6339	.7139	.5094	.6956	.7819	.6118	.7466
(6); (5) & CEE	127	.6175	.3704	.6166	.7057	.4966	.6890	.7562	.5725	.7246
(7): (6) & LA	155	.6204	.3832	.6187	.6773	.4633	.6677	.7367	.5526	.7143
(8); (7) & ME not OPEC	159	.6216	.3860	.6196	.6788	.4668	.6696	.7377	..5553	.7160

Table 11: Growth Variance Decomposition: Second Half, Base, New Human Capital $\beta = .35, \rho = 0$, $\beta = .35, .35 \geq \rho > 0$

Region	N	$\frac{\sigma_{g_x,g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}},g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{base}$	$\frac{\sigma_{g_x^{\rho=0},g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}^{\rho=0},g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{\rho=0}$	$\frac{\sigma_{g_x^{\rho\geq 0},g_y}}{\sigma^2_{g_y}}$	$\frac{\sigma_{g_{\hat{x}}^{\rho\geq 0},g_y}}{\sigma^2_{g_y}}$ k/y	$\overline{S}_x^{\rho\geq 0}$
World	168	.3098	-.0886	.3270	.4855	.1945	.4871	.5080	.2119	.5072
WC	18	.1260	-.3062	.1742	.1083	-.3328	.1450	.2278	-.1536	.2430
SE	7	.2286	-.1562	.3000	.5449	.3183	.5396	.6522	.4792	.6521
CEE	24	.2181	-.1742	.3124	.4005	.0942	.4436	.3869	.0797	.4486
NIC	5	.5325	.2997	.5324	.3480	.0228	.3533	.3158	-.0254	.3302
Asia	20	.2118	-.1784	.2120	.4633	.1988	.4778	.5529	.3332	.5409
SSA	48	.4657	.1840	.4727	.6014	.3918	.5962	.6583	.4708	.6572
LA	28	.3441	-.3651	.3796	.5555	-.0901	.5417	.6405	.0577	.6123
ME	13	.4055	-.1573	.4065	.5298	.1694	.5288	.5625	.1827	.5623
ME not OPEC	4	-.0949	-.6382	.0940	.3231	-.0114	.4774	.3851	.0816	.3906
ME OPEC	9	.4429	-.0943	.4433	.5890	.2709	.5879	.5931	.2813	.5931
NA	5	.2455	-.3869	.4727	.3625	-.0733	.4887	.3070	-.2620	.4768
larger regions										
(1): WC & SE	25	.2385	-.1401	.2951	.3991	.1008	.4073	.5010	.2535	.5010
(2): (1) & NIC	30	.3071	-.0384	.3409	.4436	.1663	.4491	.5242	.2872	.5235
(3): (2) & NA	35	.2768	-.2152	.3768	.4143	.0667	.4485	.4350	.0358	.4511
(4): (3) & SSA	83	.3899	.0415	.4157	.5314	.2758	.5276	.5710	.3150	.5677
(5): (4) & Asia	103	.3558	-.0018	.3773	.5138	.2539	.5117	.5606	.3070	.5567
(6); (5) & CEE	127	.3028	-.0675	.3358	.4839	.2151	.4868	.5019	.2323	.5016
(7): (6) & LA	155	.3000	-.0785	.3181	.4855	.2084	.4871	.5069	.2325	.5062
(7); (6) & ME not OPEC	159	..2980	-.0815	.3158	.4851	.2077	.4867	.5061	.2314	.5055

7 Evidence from Micro Literature

Our work produces human capital across countries. How would one get an independent measure of human capital, separate from the macro approach here? This is exactly answered in the work of Hendricks (2002) and Schoellman (2011). In their works these authors attempt to measure relative human capital of individuals educated from different countries working in the same labor market and having the same observable characteristics, i.e. years of schooling, years of work experience, marital status, sex, etc. We can compare our values of human capital relative to those in Hendricks and Schoellman to see if the human capital measures that are produced here are consistent with micro evidence.

In this section we take our estimates of human capital in 1990 & 2000 and compare them with micro evidence from Hendricks and Schoellman. Table 12 presents comparisons of our relative human capital and those from Hendricks (2002) and Schoellman (2012). We have much more in common with Schoellman than with Hendricks. In the first column we regressed log relative human capital by Hendricks (Schoellman) against our log relative human capital for 15 to 24 year olds.[40] We add regional dummies and find the same results. We also ran regressions in the levels, and those are reported in Table 14 as well. Again we see that our measures of human capital are highly positively correlated with both Hendricks and Schoellman. The model human capital is more closely related to Schoellman's estimates of relative human capital, than Hendricks.

Our new estimates are much closer to those of Schoellman than Hendricks. While Hendricks typically reports human capital in many countries greater than that in the US, we find no country with human capital in excess of the US. Schoellman only finds one country, Netherlands, to have higher human capital than the US. Furthermore our human capital estimates of *Asia*, *Sub-Saharan Africa* and *Latin America* are on average only about one quarter of the US, one sixth of the US and thirty percent of the US, respectively. Our *Middle East* countries typically have only a fifth of the US human capital per worker.

Hendricks finds that relative human capital of those educated outside of the United States had attained 92 percent of the US human capital level in 1990. Our measure of relative human capital in 1990 ranges from 22 percent for 35 to 44 year olds and 31 percent for 15 to 24 year olds. In comparison the same countries have relative output per worker of 22 percent. So our measure of relative human capital is much closer to the relative output of those countries' workers.

We are much more closely correlated with Schoellman (2011). He finds 2000 relative human capital of 37 percent, compared with ours of 30 percent for 15 to 24 year olds and 22 percent for 35 to 44 year olds. Output per worker for these countries relative to the US worker is 18.5 percent. So again we are closer to the relative productivity on average than Hendricks was in 1990.

Table A5 takes from Hendricks (2002), and contains the 1990 values of relative earnings of immigrants

[40] We do this with and without population weights. The results do not vary much with population weights, so we only report the unweighted regressions.

to the US, controlling for age, education and sex. The first column lists the country of origin. The second column presents his adjusted relative earnings (100 base), and the third column presents the human capital from this paper relative to the US in 1990. We present three different relative human capital values for each country, those for ages 15-24, 25-34 and 35-44. We examine these three groups as they are the most likely immigrant population age groups, who are educated in the origination country. The final four columns present the year 2000 relative human capital of countries from Schoellman (2011) and our relative human capital for these countries.

8 Conclusion

The paper presents a simple model of human capital accumulation and physical capital accumulation within the framework of a standard Cobb-Douglas aggregate production function. We use the new data created here to estimate new values of country specific human capital. Using a method standard in the labor literature we allow for Mincerian age-earnings relationships to hold within each country, but allow for human capital to accumulate across generations. This accumulation technology is similar to Bils and Klenow (2000), Lucas (1988), Tamura (1991,2002,2006). We allow human capital to build on the shoulders of the previous generation. We find that this model can explain all of the long term growth of output per worker, and between 70 and 80 percent of the cross sectional variation in output per worker growth. The results of the development accounting show that the new human capital model is capable of explaining between 50 percent and generally closer to 70 and 80 percent of the differences in log output per worker.

The plausibility of the estimates can be determined by examining other predictions that can be made with the data. Our construction produces a distribution of human capital for every country. Theories that consider the inequality of human capital (usually without an age distribution) and their effects on growth can be tested with our measures of the distribution of human capital, for example Banerjee and Newman (1993), Barro (2000), Chen (2003), Benabou (1996a,b), Benhabib and Spiegal (1994), Galor and Tsiddon (1997), Persson and Tabelllini (1994), etc. Additionally we can combine our data with that contained in Tamura (2006), to examine the connection between mortality risk and human capital accumulation. Finally the data augmented with fertility provides an ability to test long run growth theories of Galor (2005) and his coauthors, Galor and Weil (2000), Galor and Moav (2004), Galor, Moav and Vollrath (2009).

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Table 12: Regressions with Model Relative Human Capital: $\beta = .35, .35 \geq \rho > 0$

	Hendricks				Schoellman			
Variable	ln(H)	ln(H)	H	H	ln(H)	ln(H)	H	H
ln(relative hc)	0.2556***	0.1084**			0.8282***	0.7799***		
	(0.0372)	(0.0480)			(0.0303)	(0.0485)		
relative hc			0.7579***	0.2393			0.9949***	0.9935***
			(0.0940)	(0.1513)			(0.0389)	(0.0698)
constant	0.2198***	0.1070	0.6752***	0.8881***	0.0587	0.1551	0.0945***	(0.1480)
	(0.0.0424)	(0.1400)	(0.0407)	(0.1191)	(0.0436)	(0.1254)	(0.0147)	(0.0400)
N	73	73	73	73	166	166	166	166
$\overline{R}^2$	.3993	.6831	.4780	.6921	.8201	.8495	.7993	.8909
region dummies	no	yes	no	yes	no	yes	no	yes

9 Appendix

Appendix Table A1 shows that the data has greatly expanded in depth of coverage relative to BDT. We list each country by geographic region, as in BDT. We also list the first year of observation for each country and the additional years of information in this data set compared to BDT.[41] In region 1, the *Western Countries*, the average initial year of observation is 1827, an increase of 67 years of coverage. We observe these 18 countries for approximately 180 years. In region 2, *Southern Europe*, the initial year of observation is 1859, an increase of 57 years. We now have data for these 7 countries for around 150 years. Although we now observe an initial year of 1940 for region 3, *Central and Eastern Europe*, we have added 39 years of data per country. *Central and Eastern Europe* is predominated by former Soviet republics, now independent. In BDT the initial year of observation was 1990. Now for all of these countries we observe them starting in 1970. Furthermore for the countries that were never Soviet republics, we have an average initial observation year of 1883, and an additional 64 years. All 5 countries in the *Newly Industrialized Countries* group, region 4, have an initial year of observation of 1820. We have extended an average of 113 years for these countries. Our new initial year of observation in *Asia*, region 5, is 1894, an average extension of 75 years. Some of this extension arises from the additional countries added to the sample, Afghanistan, Bhutan, Mongolia, North Korea. However the bulk of the extension arises from the additional years found for previously observed countries. We were able to start observations in 1820 for China (120 additional years), India (88 additional years), Indonesia (133 additional years), Malaysia (147 additional years), Myanmar (128 additional years), Philippines (126 additional years), Sri Lanka (133 additional years), and Thailand (124 additional years). Thus for the overwhelming bulk of Asian population, we have complete data for 187 years! For region 6, *Sub-Saharan Africa*, our average initial year of observation is 1946, an additional 27 years of data. Hence even for the continent with the youngest independent countries, we now observe the typical Sub-Saharan African country for about 6 decades! The new initial year of observation in *Latin America* is 1908, bringing an additional 45 years of observations. Here we added 5 additional countries, Bahamas (1960), Barbados (1960), Belize (1960), Cuba (1930), Suriname (1950). However for the largest Latin American countries, Argentina (1870), Brazil (1820), Chile (1820), Mexico (1820), Uruguay (1870) and Venezuela (1820), we now typically observe them starting in 1837, for an additional 76 years. The *Middle East* has additional 68 years, and an average starting year of 1910. [42] Finally we now observe all *North African* countries, except Libya, starting in 1820. This adds 107 years for the typical North African country.

[41] For all countries, except for the defunct East Germany, we now observe them in 2007, instead of 2000. Thus each country has at least 7 years of additional coverage. All years in excess of 7 indicate either an earlier starting year or countries that were not covered in BDT.

[42] Of all the regions, the *Middle East* is potentially most problematic. This has to do with using modern PPP international dollars to value past output. Most of the oil producing countries of this region in fact were oil producers as early as 1950, as can be seen in Tsui (2011). However the real price of oil in 1950 was very different from today. We often times separate out the oil producers in the Middle East from the rest of the Middle East in the empirical work.

Table A1: First and Last Observations: By Region

Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Australia	1820	48	0.65	0.56	1757	1426	7.75	7.89	173,135	58,219
Austria	1820	67	0.85	0.83	6490	3027	7.55	6.96	196,239	57,260
Belgium	1820	33	0.97	0.95	7627	3488	7.72	8.21	179,936	62,561
Canada	1820	58	1.15	1.13	7182	3335	9.07	9.86	166,382	57,775
Denmark	1820	57	0.95	0.93	11,173	3356	9.40	9.36	178,662	57,829
Finland	1820	37	0.98	0.96	7840	3344	8.42	8.64	167,853	57,453
France	1800	57	1.00	0.98	6354	3198	6.85	6.85	176,903	59,434
Germany	1800	87	1.00	0.98	9440	3166	7.36	7.45	164,963	50,905
Iceland	1950	57	2.30	2.25	43,697	14,604	7.98	8.12	159,533	56,104
Ireland	1820	113	0.68	0.67	2995	2269	7.63	8.28	146,561	67,201
Luxembourg	1950	57	2.30	2.08	12,710	21,635	5.78	6.54	332,333	161,558
Netherlands	1800	56	1.25	1.62	25,088	5644	11.00	11.77	157,053	50,079
New Zealand	1820	98	0.80	0.78	1084	1140	9.37	9.15	134,738	43,217
Norway	1820	42	0.68	0.66	3390	2200	8.38	8.46	189,625	68,134
Sweden	1800	67	1.05	1.03	16,067	4225	7.84	8.12	161,163	56,463
Switzerland	1820	75	0.87	0.85	8364	2957	7.26	7.40	212,377	53,953
United Kingdom	1801	37	1.20	1.18	15,757	4660	8.64	8.60	155,950	57,195
United States	1790	87	1.15	1.13	5323	2931	10.80	13.94	181,769	76,083
Cyprus	1950	7	0.56	0.46	832	2195	3.85	3.69	89,561	46,136
Greece	1820	97	0.50	0.49	7046	2107	7.18	6.81	129,361	43,620
Italy	1820	48	0.80	0.78	5762	2967	7.58	6.89	195,003	57,195
Malta	1960	47	1.40	0.97	2775	4144	5.49	5.29	109,844	46,810
Portugal	1820	36	0.55	0.54	8600	2387	6.28	5.48	114,874	33,554
Spain	1820	44	0.65	0.64	10,240	2794	7.19	6.74	136,684	42,103
Turkey	1820	122	0.55	0.54	3396	1603	3.85	3.85	44,818	18,125
Albania	1950	47	1.25	1.25	5235	2775	3.37	2.95	40,312	10,471
Armenia	1970	27	2.25	2.24	44,038	19,132	3.68	3.48	51,342	28,255
Azerbaijan	1970	27	2.25	2.24	27,228	11,829	4.17	3.77	34,181	18,205
Belarus	1970	27	2.25	2.24	30,839	13,398	4.79	3.92	64,157	26,022
Bulgaria	1870	71	0.45	0.45	5106	1965	4.65	3.74	99,869	25,099

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Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Czech Republic	1820	108	0.65	0.65	8052	2189	5.82	5.82	137,594	30,060
East Germany	1950	-	2.50	2.82	10,837	8892	2.66	3.35	40,844	12,113
Estonia	1970	27	2.18	2.01	46,255	20,095	4.86	3.87	140,428	46,814
Georgia	1970	27	4.50	6.94	36,399	15,813	5.51	5.59	30,606	13,723
Hungary	1869	28	0.70	0.69	8408	3030	6.16	5.46	91,401	26,659
Kazakhstan	1970	27	4.20	3.89	44,417	19,297	5.36	5.35	48,936	24,968
Kyrgyzstan	1970	27	4.20	6.16	23,746	10,316	5.17	4.93	16,916	7311
Latvia	1970	27	2.00	1.82	40,323	17,528	4.81	3.55	90,931	37,751
Lithuania	1970	27	4.50	4.13	42,808	18,598	6.09	5.64	71,336	28,852
Moldova	1970	27	4.50	4.16	29,958	13,015	4.97	5.36	28,385	8133
Poland	1870	68	0.52	0.52	6988	2102	6.28	5.27	80,519	26,448
Romania	1870	67	0.82	0.82	5653	1853	4.20	3.48	51,973	11,804
Russia	1820	104	0.36	0.36	6014	1686	5.27	3.63	48,661	20,465
Slovak Republic	1990	7	2.16	3.20	61,357	20,238	5.05	4.68	105,066	31,841
Tajikistan	1970	27	4.20	6.06	33,208	14,427	5.09	5.20	14,771	5552
Turkmenistan	1970	27	4.20	6.18	70,681	13,781	5.08	5.20	46,457	10,026
Ukraine	1970	27	4.50	7.04	27,229	11,8290	5.78	5.65	37,133	12,492
Uzbekistan	1970	27	4.20	6.17	39,875	17,323	5.08	5.21	41,597	13,539
Yugoslavia	1910	17	0.40	0.40	12,943	2610	2.41	2.39	61,041	16,412
Hong Kong	1820	147	0.38	0.37	1460	1675	5.03	6.05	190,088	73,162
Japan	1820	77	0.85	0.83	2317	1783	7.63	9.12	226,158	54,457
Singapore	1820	150	0.38	0.37	1392	1779	5.54	5.72	193,930	66,158
South Korea	1820	97	0.60	0.59	3022	2176	6.96	6.01	151,921	47,572
Taiwan	1820	113	0.38	0.37	1411	1503	6.00	5.57	111.713	55,657
Afghanistan	1950	57	1.25	1.17	2976	2482	1.25	1.17	2155	2171
Bangladesh	1950	27	1.00	0.93	1608	1190	1.80	1.72	4355	3007
Bhutan	1980	27	0.12	0.12	663	1416	0.76	0.50	7743	7000
Cambodia	1950	37	0.50	0.47	1479	1120	1.76	1.67	4786	4542
China	1820	120	1.00	0.93	5983	2006	3.64	3.39	35,811	14,558
Fiji	1960	7	4.00	3.93	29,742	11,757	4.00	5.07	41,830	9529
India	1820	88	1.00	0.94	4852	1388	3.09	2.84	15,819	8845
Indonesia	1820	138	1.00	0.94	6163	2208	3.62	3.37	25,884	10,597

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Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Laos	1950	37	0.75	0.70	2801	1649	1.64	1.64	11,431	4862
Malaysia	1820	147	1.00	0.94	2611	1991	4.59	4.30	74,354	28,061
Mongolia	1950	57	1.50	1.40	3391	1162	4.00	3.95	18,178	3825
Myanmar	1820	128	1.00	0.94	2440	1103	2.47	2.31	7554	6063
Nepal	1950	17	1.75	1.64	1236	1123	2.21	2.49	7829	3451
North Korea	1820	187	1.00	0.93	1580	1628	3.74	3.51	23,884	3125
Pakistan	1950	8	1.00	0.94	3239	2796	1.28	1.42	12,444	7753
Papua New Guinea	1960	7	2.50	2.45	5024	2655	2.50	3.29	12,367	4792
Philippines	1820	126	1.00	0.94	5878	1875	5.14	4.75	21,174	8032
Sri Lanka	1820	133	1.00	0.94	2470	1717	4.58	4.27	27,570	13,512
Thailand	1820	124	0.75	0.70	4047	1465	4.71	4.35	58,223	18,890
Vietnam	1950	37	0.50	0.49	1846	1370	2.28	1.82	9485	6442
Angola	1950	17	1.00	0.99	6262	2553	1.13	1.34	10,462	4160
Benin	1950	17	0.58	0.58	7648	2485	1.54	1.30	6181	4360
Botswana	1950	17	0.12	0.12	1387	975	2.54	2.07	5,2887	22,499
Burkina Faso	1950	17	0.42	0.42	589	1008	0.74	0.75	4372	3086
Burundi	1950	17	0.85	0.84	422	728	1.07	1.15	867	1229
Cameroon	1950	17	1.22	1.21	1929	1757	2.07	2.24	4345	3811
Cape Verde	1950	57	0.38	0.38	5000	2663	1.95	1.53	15,795	6793
Cent. Afr. Rep.	1950	17	1.50	1.49	2293	1638	1.50	1.82	2411	1832
Chad	1950	17	1.50	1.49	733	1142	1.50	1.77	2456	1622
Comoros	1950	57	1.22	1.21	2737	1512	1.51	1.75	2704	2094
Congo	1950	17	1.40	1.39	4917	3130	2.68	3.14	7982	6817
Djibouti	1950	57	1.50	1.49	2387	3081	1.50	1.80	7252	3483
Equitorial Guinea	57	1950	0.26	0.26	568	1628	1.76	1.67	74,470	31,388
Eritrea	1990	17	0.60	0.56	3862	1410	0.92	0.85	7001	2288
Ethiopia	1950	7	0.46	0.46	405	885	1.06	0.92	1323	2265
Gabon	1950	17	1.50	1.49	14,374	6336	2.69	2.71	27,045	10,763
Gambia	1950	17	1.20	1.19	1296	1424	1.63	1.60	3753	2706
Ghana	1870	97	0.48	0.45	2909	1111	1.88	2.04	4821	4298
Guinea	1950	17	0.67	0.67	470	883	1.10	1.00	863	1523
Guinea-Bissau	1950	17	0.58	0.58	1054	657	1.14	1.07	6631	1962

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Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Ivory Coast	1950	17	1.50	1.49	4590	2925	1.55	1.81	7062	3969
Kenya	1950	19	1.45	1.44	3287	1586	3.01	3.17	4421	3156
Lesotho	1950	17	0.74	0.74	907	975	2.24	2.36	25,000	6920
Liberia	1950	17	1.37	1.36	6233	2829	1.91	1.84	8897	4018
Madagascar	1950	17	1.50	1.49	1637	2254	1.67	1.98	1508	2215
Malawi	1950	17	1.27	1.26	1102	806	2.24	1.96	4480	1907
Mali	1950	17	0.31	0.31	698	993	0.87	0.78	3312	3345
Mauritania	1950	17	0.27	0.27	3837	1201	1.10	0.92	8969	3876
Mauritius	1950	17	1.10	1.09	19,018	10,480	3.67	3.33	49,029	32,824
Mozambique	1950	17	0.56	0.56	2188	2867	1.11	1.08	3033	5417
Namibia	1950	17	1.07	1.06	11,923	6814	2.34	2.15	41,220	18,015
Niger	1950	17	1.50	1.49	1584	1541	1.50	1.73	2429	1541
Nigeria	1950	19	1.10	1.09	2165	2274	1.84	1.71	6455	5360
Reunion	1950	57	1.50	1.49	19,569	4829	3.48	3.64	34,148	10,563
Rwanda	1950	17	0.80	0.79	715	1201	2.09	1.83	1355	2777
Senegal	1950	17	1.26	1.25	2307	3256	1.46	1.59	3833	4805
Seychelles	1950	57	1.50	1.49	16,170	5571	3.47	3.74	86,801	18,317
Sierra Leone	1950	18	1.38	1.37	2079	1949	2.16	1.96	869	1939
Somalia	1950	17	1.50	1.49	9701	2331	1.50	1.74	2988	1207
South Africa	1820	133	0.33	0.31	3005	1162	3.51	3.19	26,433	14,826
Sudan	1950	27	0.64	0.64	4621	2523	1.04	1.06	15,893	5710
Swaziland	1950	57	0.47	0.47	5234	2220	2.59	2.39	29,453	12,671
Tanzania	1950	17	0.74	0.74	1581	924	1.36	1.42	2498	1812
Togo	1950	17	1.50	1.49	3940	1522	2.27	2.44	6113	1924
Uganda	1950	16	1.00	0.99	7135	1589	1.74	1.60	11,104	2756
Zaire	1950	7	1.50	1.49	1565	1306	1.81	2.18	645	746
Zambia	1950	7	1.50	1.49	4062	1730	2.14	2.45	6882	2271
Zimbabwe	1950	7	1.50	1.49	3561	1839	2.81	3.13	9313	2424
Argentina	1870	32	1.45	1.42	6246	2996	5.51	4.35	58,792	26,444
Bahamas	1960	47	3.50	3.43	53,482	38,359	4.67	5.05	97,789	31,675
Barbados	1960	47	1.55	1.51	18,214	10,464	4.80	3.97	56,083	30,966
Belize	1960	47	3.50	3.43	14,017	7913	3.75	4.39	40,524	14,582

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Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Bolivia	1880	77	1.45	1.41	2460	1570	4.19	2.98	16,964	7622
Brazil	1820	59	1.20	1.17	8528	2387	3.68	3.12	36,529	15,845
Chile	1820	82	1.20	1.17	3323	2468	4.80	4.14	93,929	39,093
Colombia	1890	34	1.45	1.41	30,268	4797	2.79	2.64	33,022	15,420
Costa Rica	1920	38	0.90	0.88	10,389	5118	2.88	2.89	42,301	20,274
Cuba	1930	77	1.60	1.56	34,064	5218	3.76	3.44	13,162	7367
Dominican Republic	1950	7	1.25	1.23	4116	3362	3.25	3.03	29,455	13,422
Ecuador	1940	17	2.30	2.26	10,766	4413	3.54	3.73	31,188	9797
El Salvador	1920	37	1.50	1.47	8484	3419	3.76	3.34	18,147	8754
Guatemala	1921	36	0.75	0.74	9271	4969	2.01	1.83	29,777	15,905
Guyana	1946	7	1.80	1.76	20,753	3905	3.28	3.47	30,498	7705
Haiti	1940	12	3.00	2.94	5806	2362	3.00	4.10	4705	2012
Honduras	1920	17	3.50	3.44	8282	4667	3.50	4.40	19,910	6430
Jamaica	1820	140	1.20	1.17	14,535	2149	4.03	3.63	44,589	10,589
Mexico	1820	82	1.20	1.17	8484	1906	3.40	3.05	74,071	24,467
Nicaragua	1920	37	3.50	3.44	10,594	4240	3.50	4.32	17,523	5341
Panama	1940	12	1.50	1.47	20,090	7089	3.89	3.67	50,700	19,612
Paraguay	1939	7	3.50	3.43	27,434	7627	3.56	4.49	22,835	8460
Peru	1900	15	0.63	1.32	3523	2106	3.37	3.10	34,070	12,785
Puerto Rico	1950	17	1.55	1.52	10,904	8654	4.68	4.58	104,931	43,086
Surname	1950	57	1.10	1.03	20,931	6724	3.02	2.68	55,968	19,929
Trinidad	1946	21	1.15	1.13	6801	10,455	3.61	3.53	104,148	61,656
Uruguay	1870	76	1.50	1.46	25,151	6938	4.64	3.65	53,557	23,364
Venezuela	1820	123	1.20	1.22	4706	1761	3.15	2.99	65,331	25,453
Bahrain	1950	57	0.95	0.93	15,774	6001	4.05	3.50	34,722	16,357
Iran	1820	143	0.26	0.25	8333	2312	2.73	2.28	67,896	19,484
Iraq	1820	137	0.20	0.20	9114	2685	2.24	2.28	11,337	9831
Israel	1948	7	1.95	1.41	13,570	10,409	5.79	4.69	139,324	53,057
Jordan	1950	17	2.35	2.35	20,830	11,026	4.24	3.83	40,833	18,840
Kuwait	1950	37	2.50	2.50	101,042	69,625	3.04	3.72	35,718	23,238
Lebanon	1820	187	1.10	1.07	10,090	2823	4.04	3.53	41,330	11,852
Oman	1950	27	0.20	0.20	2994	2860	1.69	1.42	30,761	26,662

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Country	1^{st} yr	add'l yrs	h_{15-24}	hc	k	y	h_{15-24}	hc	k	y
Qatar	1950	57	2.50	2.45	151,261	102,853	4.19	4.27	78,955	36,275
Saudi Arabia	1950	17	0.75	0.74	13,689	9157	2.28	1.95	55,706	31,330
Syria	1820	140	0.42	0.41	7528	3347	2.52	2.62	42,497	24,550
UAE	1950	37	2.50	2.45	159,188	81,144	3.40	3.80	97,567	40,150
Yemen	1950	27	0.45	0.44	3306	2636	2.04	1.64	17,455	11,789
Algeria	1820	135	0.36	0.35	4253	1312	3.54	3.03	38,066	10,294
Egypt	1820	104	0.36	0.35	2723	1394	3.78	2.98	20,631	13,809
Libya	1950	17	2.20	2.16	11,285	3760	5.22	4.30	41,136	8838
Morocco	1820	138	0.35	0.35	3729	1539	1.92	2.01	25,483	11,100
Tunisia	1820	143	0.35	0.35	3264	1565	3.77	3.06	47,400	19,014

Table A2: Growth Variance Decomposition: Plausible Bounds

Region	N	$\bar{s}_x$	$\bar{S}_x$	$\bar{s}_{tfp}$	$\bar{S}_{tfp}$	avg S_x	avg S_{tfp}	BDT_x	BDT_{tfp}
World	168	.210	.790	.210	.790	.500	.500	.22	.78
(WC) W. Countries	18	.112	.957	.043	.888	.535	.465	.46	.54
(SE) S. Europe	7	.006	.998	.002	.994	.502	.498	.50	.50
(CEE) C. & E. Europe	24	.110	.713	.287	.890	.412	.588	.28	.72
(NIC) N. I. C.	5	.063	.502	.498	.937	.283	.717	.64	.36
(Asia) Asia	20	.196	.802	.198	.804	.499	.501	.40	.60
(SSA) Sub-Saharan Africa	48	.172	.862	.138	.828	.517	.483	.37	.63
(LA) Latin America	28	.401	.591	.409	.599	.496	.504	.22	.78
(ME) Middle East	13	.137	.919	.081	.863	.528	.472	.44	.56
(ME) ME not OPEC	4	.398	.803	.197	.602	.601	.399		
(ME) ME OPEC	9	.110	.938	.062	.890	.524	.476		
(NA) North Africa	5	.512	.704	.296	.488	.608	.392	.84	.16
larger regions									
(1): WC & SE	25	.032	.991	.009	.968	.512	.488		
(2): (1) & NIC	30	.037	.990	.010	.963	.513	.487		
(3): (2) & NA	35	.255	.904	.096	.745	.580	.420		
(4); (3) & SSA	83	.208	.845	.155	.792	.526	.474		
(5): (4) & Asia	103	.206	.835	.165	.794	.520	.480		
(6); (5) & CEE	127	.183	.804	.196	.817	.493	.507		
(7): (6) & LA	155	.207	.778	.222	.793	.492	.508		
(8): (7) & ME no OPEC	159	.209	.778	.222	.791	.494	.506		

Table A3: Growth Variance Decomposition: Plausible Bounds, New Human Capital $\beta = .35$, $\rho = 0$

Region	N	$\bar{s}_x$	$\bar{S}_x$	$\bar{s}_{tfp}$	$\bar{S}_{tfp}$	avg S_x	avg S_{tfp}
World	168	.586	.885	.115	.414	.736	.264
(WC) W. Countries	18	.240	.970	.030	.760	.605	.395
(SE) S. Europe	7	.030	.999	.001	.970	.514	.486
(CEE) C. & E. Europe	24	.619	.836	.164	.381	.727	.273
(NIC) N. I. C.	5	.906	.966	.034	.094	.936	.064
(Asia) Asia	20	.8874	.9200	.0800	.1126	.9037	.0963
(SSA) Sub-Saharan Africa	48	.4854	.9283	.0717	.5146	.7068	.2932
(LA) Latin America	28	.4462	.6504	.3496	.5538	.5483	.4517
(ME) Middle East	13	.2261	.9433	.0567	.7739	.5847	.4153
(ME) ME not OPEC	4	.0373	.9967	.0033	.9627	.5170	.4830
(ME) ME OPEC	9	.1640	.9652	.0348	.8360	.5646	.4354
(NA) North Africa	5	.7227	.9520	.0480	.2773	.8374	.1626
larger regions							
(1): WC & SE	25	.2566	.9902	.0098	.7434	.6234	.3766
(2): (1) & NIC	30	.3248	.9863	.0137	.6752	.6556	.3444
(3): (2) & NA	35	.4241	.9708	.0292	.5759	.6974	.3026
(4): (3) & SSA	83	.4595	.9416	.0584	.5405	.7006	.2994
(5): (4) & Asia	103	.6199	.9221	.0779	.3801	.7710	.2290
(6); (5) & CEE	127	.6493	.9058	.0942	.3507	.7775	.2225
(7): (6) & LA	155	.6415	.8842	.1158	.3585	.7629	.2371
(7); (6) & ME no OPEC	159	.6386	.8852	.1148	.3614	.7619	.2381

Table A4: Growth Variance Decomposition: Plausible Bounds, New Human Capital $\beta = .35$, $.35 \geq \rho > 0$

Region	N	$\bar{s}_x$	$\bar{S}_x$	$\bar{s}_{tfp}$	$\bar{S}_{tfp}$	avg S_x	avg S_{tfp}
World	168	.743	.907	.093	.257	.825	.175
(WC) W. Countries	18	.977	.994	.006	.023	.986	.014
(SE) S. Europe	7	.913	1.000	.000	.087	.956	.044
(CEE) C. & E. Europe	24	.477	.880	.120	.523	.678	.322
(NIC) N. I. C.	5	.914	.949	.051	.086	.932	.068
(Asia) Asia	20	.916	.999	.001	.084	.958	.042
(SSA) Sub-Saharan Africa	48	.742	.952	.048	.258	.847	.153
(LA) Latin America	28	.720	.822	.178	.280	.771	.229
(ME) Middle East	13	.306	.946	.054	.694	.626	.374
ME not OPEC	4	.990	.995	.005	.010	.993	.007
ME OPEC	9	.228	.961	.039	.772	.594	.406
(NA) North Africa	5	.501	.825	.175	.499	.663	.337
larger regions							
(1): WC & SE	25	.959	.998	.002	.041	.979	.021
(2): (1) & NIC	30	.974	.998	.002	.026	.986	.014
(3): (2) & NA	35	.981	.998	.002	.019	.993	.007
(4): (3) & SSA	83	.794	.959	.041	.206	.876	.124
(5): (4) & Asia	103	.896	.946	.054	.104	.921	.079
(6); (5) & CEE	127	.787	.928	.072	.213	.858	.142
(7): (6) & LA	155	.807	.909	.091	.193	.858	.142
(7); (6) & ME no OPEC	159	.809	.910	.090	.191	.860	.140

Table A5: Relative Output per Worker, Human Capital, and School Quality Measures

Country	y	Hendricks	r^{15-24}_{1990}	r^{25-34}_{1990}	r^{35-44}_{1990}	y	Schoellman	r^{15-24}_{2000}	r^{25-34}_{2000}	r^{35-44}_{2000}
Australia	84.2	131.3	60.6	62.0	52.1	75.2	67.6	63.0	56.7	59.3
Austria	77.0	126.3	56.5	45.9	38.6	80.0	70.2	63.6	55.0	43.8
Belgium	96.0	126.5	64.2	64.5	51.0	87.6	70.3	68.1	62.4	62.9
Canada	75.9	125.8	81.6	67.3	54.1	75.6	89.9	92.6	81.8	65.7
Denmark	69.4	131.4	74.7	68.5	55.0	74.4	79.4	75.5	74.3	67.3
Finland	76.9		66.0	65.5	51.2	69.2	84.3	72.9	64.8	64.6
France	98.6	126.5	56.7	50.5	39.6	84.3	65.5	61.4	53.1	48.1
Germany	86.9	117.0	61.8	54.3	38.8	68.6	69.3	66.0	60.9	52.7
Iceland*	70.8		63.5	63.1	47.2	65.4	68.7	62.9	62.2	62.0
Ireland	67.8	119.3	66.2	61.8	52.5	91.8	69.5	66.1	64.7	59.9
Luxembourg*	113.4		57.0	46.2	46.9	163.5	56.0	53.0	54.9	43.6
Netherlands	83.7	110.2	89.3	85.9	73.7	82.8	104.9	95.5	90.1	86.1
New Zealand	69.4	126.2	69.8	68.0	62.2	58.0	77.4	71.9	66.2	65.4
Norway	78.6	131.0	64.5	66.0	51.0	88.9	69.0	70.8	62.9	64.4
Sweden	71.0	129.2	63.4	65.1	50.4	68.2	63.8	65.0	61.8	63.7
Switzerland	78.7	131.4	56.9	54.7	47.4	73.8	56.8	64.8	54.7	52.2
United Kingdom	74.9	130.5	66.9	65.5	57.5	71.6	71.5	66.2	65.1	63.9
average	84.1	124.4	65.1	59.9	48.1	75.4	72.7	69.3	63.6	58.4
Cyprus	34.2		28.9	28.0	21.2	56.2	45.7	29.7	27.2	26.7
Greece	56.1	102.6	54.5	51.4	39.2	49.8	59.0	59.0	52.3	49.2
Italy	91.8	119.1	54.3	52.8	37.4	75.2	69.2	57.8	52.4	50.9
Malta*	50.5		43.5	37.3	25.2	60.8	55.4	48.1	41.5	35.4
Portugal	48.1	109.4	42.3	41.8	32.0	48.5	47.9	46.2	39.9	39.7
Spain	68.9	105.5	59.3	45.4	32.2	64.1	77.3	61.4	58.3	43.2
Turkey	26.1	107.0	30.8	31.2	20.4	24.7	37.4	34.3	28.2	28.9
average	60.7	110.6	47.1	43.4	30.5	51.9	57.8	49.5	44.3	40.6
Albania*	11.0		22.4	21.8	19.1	10.0	40.2	30.9	12.5	10.5
Armenia*	26.6		30.2	31.1	32.5	14.6	56.9	37.3	16.8	13.9
Azerbaijan	23.3		32.1	33.2	33.3	9.7	71.0	42.4	18.7	14.6
Belarus	28.6		31.9	32.7	33.1	21.4	71.5	45.2	18.5	14.4
Bulgaria	23.6		33.0	37.0	33.0	17.6	60.7	39.8	19.1	16.3
Czech Republic	36.5	100.5	36.1	40.9	43.6	28.9	61.4	54.9	34.6	38.8
East Germany	20.8		31.5	33.6	33.0					
Estonia*	44.7		31.0	31.5	32.1	39.0	66.2	43.4	17.8	13.9
Georgia	43.4		53.2	62.0	66.8	11.6	71.9	56.1	31.2	27.2
Hungary	24.4	100.4	34.1	38.6	37.2	25.8	54.9	48.2	32.8	37.4
Kazakhstan*	32.7		49.7	57.6	61.8	23.1	75.1	54.4	28.8	25.4
Kyrgyzstan*	18.1		49.7	54.7	56.1	8.5	39.9	37.2	27.7	26.0
Latvia	38.0		29.9	30.9	29.5	25.4	64.0	39.5	17.2	13.6

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Country	y	Hendricks	r^{15-24}_{1990}	r^{25-34}_{1990}	r^{35-44}_{1990}	y	Schoellman	r^{15-24}_{2000}	r^{25-34}_{2000}	r^{35-44}_{2000}
Lithuania	35.1		53.2	62.3	67.4	21.5	68.5	52.6	31.3	27.1
Moldova*	27.1		53.2	61.0	64.8	7.8	65.1	50.5	30.1	27.4
Poland	27.1	92.3	32.5	35.4	30.2	25.0	63.1	51.0	31.5	34.3
Romania	17.8	97.8	31.3	33.0	31.8	11.2	52.3	34.8	17.7	14.9
Russia	29.2	93.0	37.2	38.8	34.5	17.7	80.3	27.0	23.2	17.1
Slovak Republic	34.8		25.5	28.9	30.8	26.7	57.6	48.9	24.6	27.9
Tajikistan*	17.4		49.7	57.8	62.2	4.2	75.4	51.8	29.0	25.4
Turkmenistan*	23.9		49.7	57.8	62.2	8.1	73.7	51.7	29.0	25.4
Ukraine	5.5		53.2	62.0	66.8	9.6	70.8	56.1	31.2	27.2
Uzbekistan	22.9		49.7	57.6	61.8	14.7	74.6	51.7	28.8	25.4
Yugoslavia	33.2	111.3	24.1	22.9	19.2	15.3	45.5	24.3	13.4	10.9
average	28.8	94.8	35.5	37.3	33.4	17.0	70.5	40.4	25.5	22.1
Hong Kong	70.3	98.3	48.1	40.9	35.5	82.3	47.3	50.5	45.8	38.3
Japan	80.7	136.4	71.2	75.7	58.4	69.6	71.1	69.3	69.8	74.8
Singapore	62.4		43.6	39.3	34.0	83.4	49.2	46.1	41.4	34.0
South Korea	43.6	77.6	45.8	36.6	28.2	48.9	61.4	52.5	43.8	34.8
Taiwan	51.4	99.4	42.2	40.8	31.8	68.2	49.8	44.9	39.7	38.5
average	69.1	118.3	61.8	62.3	48.2	65.4	65.3	61.8	59.2	59.8
Afghanistan	3.0		14.8	11.2	9.3	2.3	10.7	12.4	9.4	8.3
Bangladesh	2.8	78.8	12.9	14.2	14.0	2.9	18.2	12.3	13.0	12.3
Bhutan*	3.7		3.8	1.7	1.1	4.1	8.8	3.6	3.7	1.4
Cambodia	2.7		15.0	11.4	9.4	3.9	22.2	17.3	13.0	11.6
China	6.6	77.3	25.0	19.0	15.7	10.2	30.0	22.4	16.9	15.0
Fiji	28.3	81.4	47.3	51.7	53.7	31.1	37.8	39.7	40.6	47.5
India	6.6	97.5	26.3	19.9	16.5	7.6	27.8	28.3	21.3	18.9
Indonesia	12.3	96.7	30.1	22.9	18.9	12.9	34.3	31.2	23.5	20.9
Laos	3.3		15.0	12.1	9.8	4.7	21.2	13.7	14.2	10.5
Malaysia	26.9	93.5	32.3	24.5	20.3	33.1	35.0	37.8	28.5	25.3
Mongolia*	5.6		36.3	32.9	22.6	3.6	58.1	38.7	28.9	31.7
Myanmar	3.0		21.6	16.4	13.6	4.6	21.4	22.1	16.6	14.8
Nepal	3.3		20.7	24.3	23.0	4.1	19.4	19.6	20.9	20.7
North Korea*	11.4		39.5	30.0	24.8	3.6	40.1	38.0	28.6	25.4
Pakistan	10.2	81.9	11.8	14.2	12.6	8.9	14.7	9.9	11.4	12.3
Papua New Guinea*	6.3		29.6	35.5	34.9	6.3	18.5	24.8	29.0	31.4
Philippines	12.9	76.4	48.1	36.5	30.2	11.0	54.4	48.0	36.2	32.2
Sri Lanka	15.5	100.0	42.5	32.3	26.7	14.7	47.3	42.0	31.7	28.2
Thailand	17.8	83.0	35.8	27.2	22.5	19.0	34.6	33.7	25.4	22.6
Vietnam	3.5		16.7	10.3	8.1	6.3	26.5	14.2	14.9	8.9
average	7.6	86.0	25.6	19.9	16.6	9.2	28.9	24.8	19.2	17.1
Angola*	3.8		13.5	12.3	11.0	2.3	18.2	11.3	11.9	10.7

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Country	y	Hendricks	r_{1990}^{15-24}	r_{1990}^{25-34}	r_{1990}^{35-44}	y	Schoellman	r_{2000}^{15-24}	r_{2000}^{25-34}	r_{2000}^{35-44}
Benin*	5.3		10.9	8.6	7.0	5.2	17.2	9.4	9.7	7.4
Botswana*	16.4		15.0	8.3	5.2	17.1	38.0	17.5	13.8	7.4
Burkina Faso*	3.3		6.8	6.3	5.4	3.5	10.6	6.8	5.7	5.3
Burundi*	2.8		10.1	10.2	9.6	1.4	14.1	10.6	8.5	8.8
Cameroon	6.4		20.1	17.5	14.9	4.9	27.8	19.5	18.4	15.8
Cape Verde	7.1		13.7	8.8	7.3	7.1	27.3	13.8	12.4	7.7
Central African Republic*	2.7		17.7	18.6	17.2	2.0	17.6	14.9	15.7	16.3
Chad*	1.8		17.7	18.0	16.8	1.7	13.3	14.9	15.1	15.4
Comoros*	3.2		17.9	14.7	13.6	2.3	20.9	15.0	16.2	12.6
Congo*	12.3		32.3	22.1	17.5	8.4	42.2	27.2	30.8	20.3
Djibouti*	5.1		17.7	18.1	17.1	4.6	12.1	14.9	15.2	15.5
Equitorial Guinea*	8.8		15.7	12.5	6.9	36.5	25.8	13.2	14.5	11.4
Eritrea	2.4		7.1	5.4	4.5	2.2	11.1	6.5	7.0	4.6
Ethiopia	2.7	73.8	7.8	6.7	5.5	2.5	11.2	7.0	6.6	5.7
Gabon*	24.6		21.9	21.8	19.4	13.8	32.1	22.4	20.0	20.0
Gambia*	3.5		14.2	14.4	13.4	3.1	15.0	12.7	12.3	12.3
Ghana	4.8	70.4	18.4	15.7	12.5	4.8	30.0	16.4	16.6	14.1
Guinea*	2.2		8.8	8.7	7.5	2.2	12.0	7.5	7.5	7.5
Guinea-Bissau*	3.3		10.0	8.7	6.7	2.6	14.1	8.5	8.7	7.4
Ivory Coast*	7.7		17.7	18.5	17.5	6.0	18.9	14.9	15.7	16.1
Kenya	5.2	99.0	28.1	23.1	18.4	3.6	36.7	25.4	26.4	21.3
Lesotho*	6.6		20.5	16.5	14.4	7.1	35.2	21.2	18.9	15.0
Liberia	5.4		16.2	16.4	15.7	4.4	15.5	13.6	14.2	14.0
Madagascar*	3.6		19.1	19.0	17.7	2.7	19.9	16.8	17.2	17.0
Malawi*	2.9		15.0	15.5	15.1	2.4	20.2	13.8	13.3	13.5
Mali*	3.1		6.9	6.4	4.9	3.2	10.1	6.1	5.9	5.4
Mauritania*	4.1		7.4	5.9	4.6	4.0	13.4	7.5	6.3	5.0
Mauritius*	40.3		26.1	21.8	19.3	54.9	44.0	26.2	24.4	20.1
Mozambique*	4.9		10.4	8.0	7.6	5.1	14.6	8.7	9.1	6.9
Namibia*	17.0		12.7	13.3	12.9	6.4	40.7	21.9	11.0	11.7
Niger*	2.3		17.7	17.8	16.4	.7	10.4	14.9	15.0	14.9
Nigeria	6.3	67.1	14.5	13.7	12.2	5.5	21.1	12.7	12.9	12.2
Reunion*	18.1		31.5	27.0	21.9	14.9	43.8	34.8	29.8	25.2
Rwanda*	3.6		13.5	14.5	10.6	2.3	22.3	13.7	12.0	13.0
Senegal	6.1		14.9	15.4	14.4	5.7	16.1	12.5	12.9	13.4
Seychelles*	25.5		35.0	25.6	26.1	27.5	46.9	30.8	33.3	23.8
Sierra Leone	6.0		16.3	16.8	15.7	2.0	16.9	13.7	14.3	14.5
Somalia	5.0		17.7	17.7	16.4	2.7	10.6	14.9	15.1	14.8
South Africa	23.4	135.9	23.0	24.7	22.4	18.1	42.2	32.2	21.1	22.8
Sudan	4.4		9.6	9.0	7.3	5.0	15.2	9.1	8.3	7.8
Swaziland*	15.0		20.4	15.2	9.2	12.8	41.9	21.4	19.1	14.0

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Country	y	Hendricks	r_{1990}^{15-24}	r_{1990}^{25-34}	r_{1990}^{35-44}	y	Schoellman	r_{2000}^{15-24}	r_{2000}^{25-34}	r_{2000}^{35-44}
Tanzania	2.0		14.8	9.0	8.4	1.9	18.3	12.4	13.3	7.7
Togo*	4.2		23.6	18.7	17.6	2.9	29.2	19.8	21.8	16.6
Uganda	2.5		11.8	12.2	12.1	3.0	19.5	13.2	10.3	10.6
Zaire*	2.4		21.7	20.0	18.2	1.0	25.0	18.2	19.8	18.2
Zambia*	4.0		21.6	23.7	18.6	2.6	46.5	21.1	19.6	21.9
Zimbabwe	6.4		28.7	19.2	19.6	4.6	46.5	28.5	26.9	17.4
average	8.3	84.1	16.3	15.3	13.2	4.8	22.1	14.9	14.2	12.9
Argentina	34.6	78.6	41.5	31.8	26.5	37.6	58.2	43.9	32.3	30.2
Bahamas	65.8		51.4	43.2	45.9	50.7	54.9	47.4	40.0	40.4
Barbados	34.9	95.5	35.3	28.3	22.8	30.2	56.3	36.8	28.3	26.9
Belize	26.3	84.6	41.4	43.2	45.6	22.0	41.3	34.7	35.3	40.4
Bolivia	12.6	78.6	25.7	20.0	16.0	11.0	136.7	23.8	22.0	18.5
Brazil	24.9	94.1	29.0	23.4	16.8	21.5	40.0	27.6	24.1	21.7
Chile	39.6	90.7	36.8	30.9	24.7	45.0	59.5	41.0	29.3	29.6
Colombia	22.7	83.9	22.8	20.7	18.1	19.5	34.4	22.9	20.4	18.9
Costa Rica	29.4	86.4	27.5	22.3	18.3	28.1	41.9	25.4	23.2	20.8
Cuba	13.7		33.3	23.1	21.8	8.6	44.2	31.2	27.3	21.1
Dominican Republic	19.7	79.1	27.0	23.1	18.9	15.3	42.0	26.5	23.0	21.3
Ecuador	26.3	82.2	40.3	28.9	26.8	15.1	47.6	33.8	32.3	26.8
El Salvador	11.7	74.7	25.8	26.7	25.2	11.2	34.3	24.8	22.8	25.0
Guatemala	29.5	75.9	14.5	13.1	11.0	24.3	24.2	14.7	14.0	11.6
Guyana	8.5	88.7	32.0	30.0	28.6	14.6	38.9	26.8	26.9	28.2
Haiti	4.8	72.7	35.5	35.3	37.7	2.9	17.7	29.8	41.6	30.7
Honduras	14.1	73.0	41.4	46.8	42.3	10.7	32.6	34.7	37.4	42.4
Jamaica	20.2	90.4	33.2	27.3	21.0	12.5	51.0	30.0	27.0	25.7
Mexico	43.3	76.5	28.1	23.2	18.2	32.4	44.0	27.2	23.6	21.5
Nicaragua	12.7	66.5	41.4	47.5	47.0	6.5	37.4	34.7	35.9	42.8
Panama	28.7	90.6	34.9	27.9	23.9	24.5	51.4	32.6	28.2	26.2
Paraguay	16.1		41.4	44.7	43.5	14.6	33.9	34.7	36.0	41.3
Peru	18.5	77.3	27.5	21.0	16.9	9.0	48.2	30.8	23.0	19.6
Puerto Rico	69.2	85.3	45.0	35.3	30.7	65.7	68.3	43.6	34.3	34.3
Surname*	17.0		22.0	18.5	15.5	12.7	68.3	24.0	19.5	16.7
Trinidad	48.6		33.9	27.8	22.2	49.5	53.4	33.3	27.5	26.3
Uruguay	33.8	96.3	33.0	25.5	21.3	31.5	54.6	39.0	27.1	24.0
Venezuela	46.5	89.2	27.0	23.3	20.8	35.7	39.8	25.3	23.1	21.6
average	29.8	85.2	29.8	24.7	19.8	24.9	42.5	29.1	25.1	23.0
Bahrain*	19.5		27.3	23.3	16.4	20.0	36.7	37.2	22.7	21.8
Iran	29.6	91.2	17.8	14.5	9.6	28.3	37.1	19.3	15.9	13.1
Iraq	20.4	88.3	18.9	17.9	10.7	7.6	40.7	21.4	17.0	16.2
Israel	67.7	109.7	45.0	33.8	27.6	62.4	62.4	45.9	34.3	32.8
Jordan	29.0	91.3	29.6	31.8	32.2	24.1	32.3	24.8	26.0	28.7

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Country	y	Hendricks	r_{1990}^{15-24}	r_{1990}^{25-34}	r_{1990}^{35-44}	y	Schoellman	r_{2000}^{15-24}	r_{2000}^{25-34}	r_{2000}^{35-44}
Kuwait	33.1		35.9	31.6	33.7	44.9	29.9	30.1	30.0	29.4
Lebanon	13.1		31.1	24.5	19.8	17.3	50.9	33.2	25.3	23.0
Oman*	48.8		8.4	6.1	4.8	48.3	21.7	15.7	8.5	5.1
Qatar*	25.1		39.4	31.5	35.2	34.1	25.7	41.0	32.2	29.3
Saudi Arabia	62.5		13.3	11.8	9.7	44.0	21.4	17.3	12.9	10.3
Syria	48.5	106.2	27.0	20.1	14.0	41.9	44.6	25.2	21.3	18.4
UAE	48.1		33.7	32.7	34.8	50.0	18.1	34.5	28.8	29.9
Yemen	14.0		10.8	8.9	6.9	14.7	22.1	15.0	10.7	7.6
average	32.3	93.6	21.0	17.4	12.1	29.0	35.1	21.4	17.2	14.9
Algeria	17.7		22.8	15.0	10.9	17.3	43.6	25.6	19.2	13.7
Egypt	16.1	93.7	20.4	16.6	14.0	15.5	48.6	29.9	18.2	15.2
Libya*	22.8		34.8	28.8	31.1	14.1	45.0	32.0	29.1	26.3
Morocco	16.0		13.7	11.2	10.5	12.4	20.6	12.3	13.0	9.7
Tunisia*	19.8		20.3	17.6	15.5	20.6	38.9	23.6	17.9	16.3
average	16.1	93.7	20.4	16.6	14.0	15.5	40.9	25.0	17.7	14.2
overall relative hc average	22.3	91.8	31.4	27.1	22.2	18.5	37.4	29.7	24.2	22.0

Notes: * Not in Schoellman (2012) sample.