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South Asia/Frontier Health Gaps and Long-Term Income Dynamics

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By

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Abstract

We first use the catch-up index to examine the dynamics of South Asian (SA) countries' growth since 1951 using PWT 9.0 and compare it to earlier results. Only one-third of SA countries experienced catch-up in relative income over the US for at least one ten-year period that was not a growth recovery, as compared about 85% for peer countries; they do not clearly experience the stable growth phase (meaning neither catching-up nor falling back) experienced by other countries; they show catch-up/growth reversals every two decades; they do not experience acceleration-of-growth episodes, and income gaps from the US of even the "hills" (Pritchett (2000)) increased from 1960-1992. The SA countries exhibit poorer and more volatile catching-up than rest of the world and the conclusions using PWT 9.0 differ from those using the earlier generation PWTs.

Turning to health measures, we show there is very large variation in stillbirth rate among South Asian countries – with Pakistan's rate about nine times that of Sri Lanka's. Overtime, its rate of decrease is smaller than neonatal mortality's, its dispersion among SA countries increases and that in life expectancy decreases. Neonatal mortality decrease by itself "explains" only about 19% of life expectancy increase, but when the stillbirth rate is added to it, the said percentage rises to 31%. We define catch-up indexes for life expectancy, and stillbirth and neonatal mortality rates. Although the catch-up rates are positive, they are not related strongly to the initial levels. Relating the catch up rates in income and health, we find a better performance in income is associated with a worse performance in early-child mortality and is only weakly related to better performance in life expectancy.

Key Words: Long-term income dynamics of South Asian countries
Early-child mortality and life expectancy trends
Catch-up indexes for health measures
Relationship between health catch up and income catch up

JEL Codes: O10, O47, I15

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South Asia/Frontier Health Gaps and Long-Term Income Dynamics

1. Introduction

We first discuss dynamics of long-term economic development of South Asian countries. We then examine trends in their various health measures and define catch up indexes for them. Finally, we examine the relationship between income and health catch up.

Dynamics of long-term economic development has recently received considerable attention by economists. See, Jones and Olken (2008), Jerzmanowski, (2006), Easterly et al. (1993), Hausmann et al. (2005), and Pritchett (2000). Jones and Olken (2008) show growth "miracles" and "failures" are ubiquitous at ten- and fifteen-year periods, and almost all countries have experienced higher growth than the US over at least one ten-year period that was not recovery from previous ten-year or longer lower growth rates. Jerzmanowski, (2006) finds most of the 89 countries studied by him switch overtime among four growth regimes, stable growth, "miracle" catch-up, stagnation, and crisis. Easterly et al. (1993) find poor persistence of growth rates across decades. Hausmann et al. (2005) classify growth acceleration-episodes (above average growth for eight years) by whether they had negative, poor, or above average growth in the preceding eight and the following 10 years, and identify these episodes for countries using PWT 6.1. Pritchett (2000) finds six distinct patterns of within-country growth experience over time based on growth rate before and after a break-point for each country.

The dominant method to empirically study long-term comparative development has been β-convergence regressions. Under this approach, cross-section growth rates over a long period are regressed on initial per capita income levels. If the coefficient β is statistically significant and of the right sign, it is taken as evidence that poor countries tend to grow faster. See, Barro and Sala-i-Martin, (1992), Sala-i-Martin (1996), Galor (1996), and Barro (2015), for example. Such regressions are not well-suited to examine income dynamics - in explaining turning points, ubiquitous “miracles” and “failures” of economic development experience, within-country regime changes, and variety of “states” of developing countries. On the other hand, the catch-up index, see Kant (2017a), is calculated year by year and so it helps in understanding within country/region variation over time.

Turning to health measures, late-fetal and early-child (newborn and infant) mortality are considered among the best indicators of health-status and future human capital of a country since they depend the least on environmental factors like pollution and public sanitation, and life-style choices like smoking, and eating and exercise habits. See, Gonzalez and Gilleskie (2017) for a similar statement, and Bozolli et al. (2009) who find strong inverse relationship between early-child mortality rates and mean height of adults. The slower decline in neonatal mortality (mortality within 28 complete days of live birth) as compared to post-neonatal child mortality has recently been recognized. Shiffman (2016) highlights this fact; and also reports neonatal mortality constitutes 44% of child mortality and equals 2.9m. globally. For South Asian countries, Khan (2012), Rubayet et al. (2012) and Pradhan et al. (2012) similarly find neonatal mortality declined at a slower rate than 1-59-month mortality from in Pakistan, Bangladesh and Nepal, respectively.[1]

Shiffman (2016) ascribes the lower decline in neonatal mortality to attention to it only recently (as compared to that to overall infant mortality). Another mortality with still less recognition and attention is late-fetal mortality or stillbirths; a relatively new and evolving topic. Defining stillbirths as fetal death at 28 or more completed weeks of gestation (after which

[1]The former respectively declined at 0.9%, 4%, and 3.6% annual rates while the 1-59-mortality declined faster – for Bangladesh and Nepal, at more than twice higher rate. Further, Pradhan et al. (2012) report two-thirds of child mortality in Nepal is neonatal.

voluntary abortions are very dangerous and extremely rare), Blencowe et al. (2016) highlight 2.6 m. stillbirths occur each year. That is, the number stillborn roughly equals both neonatal and 1-59-month mortality.

This paper first uses the catch-up index to examine the dynamics of South Asian (SA) countries' growth and catching-up experience since 1951. It finds only one-third of SA countries experienced higher growth than the US over at least one ten-year period that was not a growth recovery, a proportion lower than 84% for the poorest 1/3 countries and 86% for all countries found by Jones and Olken (2008). SA countries also do not experience the stable growth phase (meaning neither catching-up nor falling back) even though we consider a long period of 64 years. They either fall back (for most of this period), or catch-up (for rest of the period); and exhibit more volatility than 89 countries in Jerzmanowski, (2006). Rather than a mere poor growth persistence across decades as Easterly et al. (1993) find for 115 (total) and 67 (non-oil producing developing) countries, SA countries show catch-up and growth reversals every two decades. None of the South Asian acceleration-episodes that Hausmann et al. (2005) identify meet their criteria for acceleration-episode using our data (showing how much the results using the new generation of PWT can differ from those obtained from earlier generation PWT data). Looking at growth relative to the US, income gaps with the US even of the "hills" SA countries identified by Pritchett (2000) (Pakistan and Bangladesh) increased from 1960-1992. SA countries exhibit poorer and more volatile catching-up and growth than rest of the world.

Turning to health measures, stillbirth rate is defined either as a proportion of total births or of live births. Blencowe et al. (2016) use the former and derive stillbirth rate for 194 countries; Kant (2017b) employs the latter for the same 194 countries. This paper shows there is very large variation in stillbirth rate among South Asian countries – with Pakistan's rate about nine times that of Sri Lanka's. Overtime, its decrease-rate is lower rate than neonatal mortality's, its dispersion increases and that in life expectancy decreases. Neonatal mortality decrease by itself "explains" only about 19% of life expectancy increase, but when the stillbirth rate is added to it, the said percentage rises to 31%. We define catch-up indexes for life expectancy, and stillbirth and neonatal mortality rates. Although the catch-up rates are positive, they are not related strongly to the initial levels. Relating the catch up rates in income and health, we find a better performance in income is associated with a worse performance in early-child mortality and is only weakly related to better performance in life expectancy.

2. Dynamics of Long-Term Economic Development

A. Catching-up/falling-back, β-convergence/divergence, absolute and relative convergence/ divergence, Years for full convergence

We first summarize the definition of the catch-up index and the derivations related to it following Kant (2017a). Let y_{J0} and y_{US0} represent Country J's per-capita RGDP (defined below) for the base year and the US per-capita RGDP for Country J's base year, and R_{J0} Country J's base per capita RGDP ratio. We assume the US is the richer country. Then,

$$R_{J0} = (y_{J0}/y_{US0}) < 1. \quad (1)$$

For each subsequent year, similar ratios of a country's annual per-capita RGDP to that of the US are computed. The catch-up index for Country J for year t is the ratio of its per capita RGDP ratio for year t to its base per capita RGDP ratio. Let I_{Jt} represent this index. Then,

$$I_{Jt} = (R_{Jt}/ R_{J0}) \quad (2)$$

If the value of the catch-up index rises from its initial value (of 100), it indicates catching-up, i.e., an increase in Country J's (poorer country's) income ratio to the frontier's or relative convergence. If it falls, it indicates falling behind or a decrease in Country J's income ratio to the frontier's, or relative divergence. In contrast, absolute convergence/divergence is a reduction/increase in richer-poorer country income-levels gap.

Let y_{Jt} and y_{Kt} and y_{Jt+1} and y_{Kt+1} represent the per capita income levels, of countries J and K, ρ_{Kt} and ρ_{Kt+1} the ratios of Country K's per-capita income to that of Country J, and ΔK_t and ΔK_{t+1} the difference between Country K's and Country J's, per-capita incomes for year t and (t + 1). Assume Country K's per-capita income in period t is higher than Country J's. Then, the income-difference, ΔK_t, is positive, and income ratio, ρ_{Kt}, is greater than one. Let the (initial) income ratio be h. In symbols,

$$\rho_{Kt} = (y_{Kt}/ y_{Jt}) = h > 1 \text{ and } \Delta_{Kt} = (y_{Kt} - y_{Jt}) = y_{Jt}(h - 1) > 0. \qquad (3)$$

Subtracting the income ratio for year t from that for year t + 1, we have

$$(\rho_{Kt+1} - \rho_{Kt}) = (y_{Kt+1}\, y_{Jt} - y_{Jt+1}\, y_{Kt})/\, y_{Jt+1}\, y_{Jt} \qquad (4),$$

$$\text{sign } (\rho_{Kt+1} - \rho_{Kt}) = \text{sign } (y_{Kt+1}\, y_{Jt} - y_{Jt+1}\, y_{Kt}). \qquad (5)$$

The sign of (5) indicates relative convergence or relative divergence. When it is positive, the richer-poorer country income ratio is increasing, and we have relative divergence; negative, the income ratio is decreasing, and relative convergence; zero, the income ratio is not changing and neither relative convergence nor relative divergence.

Let δy_J and δy_K be the change in the two countries income from year t to t + 1. That is,

$$y_{Jt+1} = y_{Jt} + \delta y_J \text{ and } y_{Kt+1} = y_{Kt} + \delta y_K, \qquad (6)$$

Then, Country K's income excess over that for Country J in year t + 1, is

$$\Delta_{Kt+1} = y_{Kt+1} - y_{Jt+1} = \Delta_{Kt} + \delta y_K - \delta y_J$$

Subtracting the income gap for year t from that for year t + 1, we have

$$(\Delta_{Kt+1} - \Delta_{Kt}) = (\delta y_K - \delta y_J), \qquad (7).$$

The sign of (7) indicates absolute convergence or absolute divergence. When it is positive, the richer-poorer country income gap is increasing, and we have absolute divergence; negative, the income gap is decreasing, and absolute convergence; zero, the income gap is not changing and neither absolute convergence nor absolute divergence.

We can prove the following:

Proposition 1: Relative convergence is a necessary but not a sufficient condition for absolute convergence, and relative divergence is a sufficient but not a necessary condition for absolute divergence.

The catch-up index is not a country's income ratio to the frontier's – it is the ratio of the said ratio for a year to a similar ratio for the base year. Using it, we can derive the equation for the number for years for full convergence or for a country's income to equal the frontier's.

Let r_I represent the annual (proportionate) catch-up rate of Country J to the US (defined by (2)) since the base year 0, and r_J and r_{US} the corresponding (proportionate) growth rates in per capita income of Country J and the US. Then, it can be shown that

$$r_I = r_J - r_{US.} \tag{8}$$

That is, the annual catch-up rate of Country 's income to that of the US is the difference between Country J's per capita income growth rate and that for the US. When it is positive (negative), we have relative convergence (divergence), and when it is zero, neither relative convergence nor relative divergence.

Let n be the year Country J's income becomes equal to the frontier's. From (1) and (2),

$$R_{J,n} = 1 \qquad (1')$$

$$I_{J,n} = (1/R_{J,0}) \qquad (2').$$

Using the compound growth expression and solving for n,

$$I_{J,n} = I_{J,0} (1 + r_I)^n = (1 + r_I)^n$$

$$n = \log (1/R_{J,0}) / \log(1 + r_I) \qquad (9)$$

(9) is stated as

Proposition 2: The number of years for full convergence (for income to equal the frontier's) depends not only on the catch-up (relative growth) rate(s) but also on the initial conditions.

It can be seen that since the reference country (the US) is the same for all countries, the comparison of catch-up rates of different countries, in fact, compares the growth rates of different countries. When the comparison is done with reference to initial per capita income levels, we would, in fact be examining β-convergence. Further, β-convergence measures rich-poor country income ratio reduction (relative convergence), not income gap reduction (absolute convergence). No simple algebraic expression (like we have derived for years for full convergence) can be derived for the number of years of relative convergence it would take for absolute income gap to starts decreasing. A heuristic exercise shows if the US initial income is \$30,000, Country J's \$,1000, and the catch-up rate is 2%, it will take 141 years of relative convergence (at 2% annual rate) for absolute convergence to start – income levels will be diverging for 140 years. On the other hand, if Country J's initial income is \$2,000 and the catch-up rate is 4%, it will take 43 years of relative convergence (at 4% annual rate) for absolute convergence to start. Faster growth is consistent with absolute divergence.

B. South Asian Countries' Income Dynamics

Kant (2017a) examines South Asian and Sub-Saharan countries' catching-up between the end-points of 1951 and 2013, 1972 and 2013, and 1992-2013 periods, respectively. This paper studies South Asian countries' catch-up dynamics with annual data and relates it to what other authors have found either for them or their peers.

Starting with version 8.0 (the new generation), PWT gives two versions of real GDP: using prices that are constant across countries but depend on the current year, CGDP; and using prices that are constant across countries and are also constant over time, RGDP. The R variables are well-suited for comparisons across countries and over time. See, Feenstra et al. (2015). Following them, we employ the RGDP numbers, and use the recent PWT 9.0 data since the first year the data is available for a country.[2] The US per-capita RGDP is taken as the frontier. PWT 9.0 (available at http://www.rug.nl/ggdc/productivity/pwt) gives country data from 1950 to 2014. Annual catch-up index shows sharp changes in some years/countries. These swings are explained by a country's business cycle not synchronizing with the US, fluctuations in GDP caused by fluctuations in FDI and capital flows to some countries, sudden primary products' price changes, political upheavals and civil-wars in a country/group of countries in a year. For example, Kant (2016) reports annual FDI as a proportion of GDP varies from -0.1 to 6.2 for South Asian countries during 2000s. Thus, a three-year moving average of a country's index is used. That gives us observations from 1951, or the data availability year plus one, to 2013.

The numerical values of the index for each year are presented in Supplementary Table 1. We first perform cusum-of-squares test for linearity. This test is based on recursive least squares in which the equation is estimated repeatedly using ever larger subsets of the data. The first equation is run on the number of observations that equals the number of regressors. The equation is then re-run with the next observations added one-by-one until all the observations have been used. At each step, the estimated coefficients are used to predict the next value of the

[2]RGDP data for Maldives with 1990 population of 0.22 m. is considered too unreliable and is not used. In addition, RGDP is not available for Afghanistan (1990 population = 12.1m).

dependent variable yielding one-step ahead forecast errors called recursive residuals. Cusum-of-squares is the cumulative sum of squared residuals. The test involves plotting it (as a fraction of the sum summed over all observations) and examining whether it goes outside, say, 5% critical lines. See, Galpin and Hawkins (1984), Harvey and Collier (1977) and Brown, Durbin, and Evans (1975).

Catch-up index for none of the countries passes the cusum-of-squares test of stability of parameters and of linearity. We focus on long-term catching-up/falling-back and ignore ups and downs in the index that last less than 10 years. With that perspective, Bhutan's catch-up index generally increases. Other countries show break(s) in trend lasting ten years or more. Recursive residuals can also be used to identify a break-point: It is the year these residuals go outside the critical values. See, the references cited above. Figure 1 shows the annual catch-up index for the six countries. Table 1 summarizes the Supplementary Table 1 and the information shown by Figure 1; and identifies break-years. The break-points are confirmed by Chow test in both its equal error variances for the two parts (*F* statistic) and unequal variances (Wald test and log likelihood ratio test) versions.[3]

The index for India increases from 1951 to 1963, decreases from 1963 to 1986, and increases after 1986. We ignore the first slight increase (to 104 in 12 years), and consider it decreasing for the whole 1951-1986 period.[4] With this interpretation, countries other than Bhutan show declining index and relative divergence (RD) from the start year. Since RD is

[3]All break-points shown meet each of the three tests.

[4]Similarly, we ignore first slight increase and then slight decrease in Nepal's catch-up index from 1980 to 2006.

sufficient for absolute divergence, their income gap from the U.S. increases initially. The falling behind period varies from 29 years for Nepal (from 1961 to 1980) to 51 years for Pakistan (from 1951 to 2002). The worst extent of falling behind is Bangladesh. By 2003, its catch-up index fell by 63.9% from its 1960 start year. US income increased by 190.9% for this period, implying US-Bangladesh income gap was about three and one-half times in 2003 of what it was in 1960.

Falling behind and absolute divergence may continue even after a country's catch-up index starts increasing (i.e., relative convergence starts) since relative convergence (RC) is not sufficient for absolute convergence. Kant (2017a) finds that 21 of the 28 countries exhibiting catching-up during 1992-2013 show falling behind over either 1971-2013 or over 1951-2013 (or both), and suggests that to project to the future, we should consider the growth experience of a period longer than 20 years. RC of Bangladesh and Pakistan is over too short a period to predict a long-term RC. Four countries, Bhutan, India, Nepal, and Sri Lanka, exhibit RC for at least 27 years. Their annual catch-up rates since the start of RC and years for full convergence with the US are also shown in Table 1. By this performance, they are projected to reach income equality with the US in 84 to 272 years. Table 1 also gives the catch-up rate since the start year and years for full convergence based on it. Based on that information and Figure 1, of the four countries, Bhutan has the steadiest catching-up, Sri Lanka the least. Even though Sri Lanka and India have been catching-up for 27 and 33 years, respectively, their overall performance since 1951 creates some doubt whether they will be able to sustain it.

Jones and Olken (2008) mean by convergence and divergence higher or lower average growth in PCY than average US growth over the same ten-year period. By our definitions, it means relative convergence and relative convergence (increase and decrease in the catch-up index) over a ten-year period. Using PWT 6.1 data (that is for 1950-2000) for 125 countries (excluding countries with less than 20 years of data), and excluding catching-up episodes that follow ten-year or longer periods of falling-back (to eliminate possible growth recoveries) they find 86% of all and 84% of poorest one-third countries in 1960, a group to which South Asian countries belonged in 1960 (and still do), experienced at least one relative convergence episode.

Our PWT 9.0 data is for 1950-2014. Even after considering the relative convergence periods (shown in Table 1), one country falls-behind (Bangladesh) and three (Nepal, Pakistan, and Sri Lanka) barely recover the income relative to the US they had 52 to 62 years back. Their single relative convergence periods follow four or five times longer relative divergence periods and are excludable as growth recoveries. That is, only one-third of countries in South Asia (Bhutan and India) show relative convergence that are not growth recoveries. Fewer South Asian countries exhibit catching-up than their peers (poorest one-third countries).

Using PWT 6.1 data for 89 countries, Jerzmanowski (2006) finds countries switch overtime among four growth regimes summarized as stable growth (growth of 2% and low volatility), "miracle" catch-up (growth of 6%), stagnation (no growth overall and large volatility) and crisis (non-persistent booms and busts). Assuming US growth rate of 2%, regimes other than crisis can be translated in terms of the catch-up index/rate as follows: stable growth = no relative convergence or relative divergence (i.e., no change in the catch-up index), "miracle" catch-up = relative convergence at 4% rate, stagnation = relative divergence at 2% rate. Jerzmanowski (2006) states most countries visit these regimes overtime. Nevertheless, South Asian countries exhibit either relative divergence or relative convergence; they do not exhibit stable growth even though we consider a long period of 64 years. The only country that can be said to have stable growth is by breaking up Pakistan's relative divergence into three sub-periods; relative divergence from 1951 to 1960, stable growth from 1960 to 1993, and relative divergence from 1993 to 2003. South Asian countries' growth experience is more volatile than the sample of 89 countries studied by Jerzmanowski (2006).

Easterly et al. (1993) find poor correlations between growth rates across decades. They use per capita income data from PWT 5 for 115 countries for 1960-88 and compute least squares growth rates for 1960-69, 1970-79, and 1980-88. For 67 non-oil producing developing countries, the sample most comparable to South Asia, they find correlation coefficients between 60s and 70s and 70s and 80s to be .099 and .332, respectively. Dividing our 64-year data into five 11-year periods, 1950-60, 1961-71, 1972-82, 1983-93, and 1994-2004, and one ten-year period, 2005-2014, and denoting these periods as D_t, t = 1, . . . 6; we obtain least squares growth rates of the catch-up index for each of them.

The correlation coefficients between the catch-up rate between D_1 and D_2, D_2 and D_3, D_3 and D_4, D_4 and D_5, and D_5 and D_6 are -.488, .298, -.517, .575, and -.419, respectively. Although absolute values are higher, the sign-reversal between every two correlation coefficients shows catch-up reversals. On average, the South Asian country that caught-up fastest during decades D_t and D_{t+1}, caught-up slowest during decade D_{t+2}. Recalling that comparing catch-up rates in effect compares growth rates - since from each country's growth rate, the same US growth rate is being subtracted, this means on average the South Asian country that grew fastest during decades D_t and D_{t+1}, grew slowest during decade D_{t+2}.[5] Easterly et al. (1993) find weak persistence of growth. For South Asian countries, we find a more serious problem; it is reversal of (growth)

[5]For example, Pakistan caught-up at the fastest rates of 0.98% and 0.07% during D2 and D3, and slowest in D4 (falling back at -0.39%); and Bangladesh caught-up least/fell back at -.02% and -2.73% in D4 and D5, but caught-up the fastest (at 7.84%) in D6.

fortunes every two decades. This reinforces the conclusion that to evaluate comparative development, we should look at growth experience over more than 20 years.

Hausmann et al. (2005) define a growth acceleration-episode as where i) per capita growth increases by two percentage points or more (from its average of previous eight years) that itself is sustained for at least eight years, ii) the annual growth of least 3.5% during these eight years, and iii) post-episode output exceeds the pre-episode peak level of income. Using data from PWT 6.1, they find Pakistan starting in 1962 and 1979, Sri Lanka in 1979, and India in 1982 experienced growth accelerations. None of the acceleration-episodes that Hausmann et al. (2005) identify for South Asian countries meet their criteria for acceleration-episode using our data (that is from PWT 9.0). Eight-year moving average of per capita growth rate increases by 0.5 (from -0.2 to 0.3), 0.2 (from 1.1 to 1.3), and 0.2 (from -2.1 to -1.9) percentage points, for Pakistan in 1962, Pakistan in 1979, and India in 1982; and falls by 1.8 percentage points (from -2.1 to -3.9) for Sri Lanka in 1979; and per capita growth exceeds 3.5% in only five, zero, four, and four years, in the growth episode of eight years that Hausmann et al. (2005) identify.

Why are our results so different? The answer most likely depends on the generation of PWT used. Johnson et al. (2013) point out updates of PWT for different years (available up to that time) do not successfully give incomes that are comparable away from the bench mark year. It had been the practice at PWT to simply discard earlier benchmark prices when prices for a different benchmark year became available. The new generation of PWT, i.e., those starting from 8/8.1, link different benchmark years' prices by chained indices. The real GDP numbers then become comparable not only across countries for one benchmark year but also over time and over different benchmark years. See, Feenstra et al. (2015) who also explain that the new generation of PWT real GDP numbers (rather than of versions before 8.0) are well-suited for comparisons across countries and over time. Our results are different because we use PWT version that successfully give incomes that are comparable away from the bench mark year.[6]

Using PWT 5.6 data for 1960-1992 for 111 countries, Pritchett (2000) identifies six distinct patterns (giving them topological names) of per capita income growth based on growth rate before and after a beak-point for each country. These are steep hills (growth rates higher than 3% in either period), hills (higher than 1.5% in either period), plateaus (higher than 1.5% in the first period, but lower in the second), mountains (higher than 1.5% in the first period, but negative in the second), plains (less than 1.5% in either period), and accelerators (growth rates less than 1.5% in the first period, but greater than 1.5% in the second). He finds Pakistan and Bangladesh in the hills category, Nepal in plains, and India and Sri Lanka among the accelerators. Considering the whole 1960-92 period, by PWT 9.1 data, US per capita income grew 2.3% annually – a growth rate exceeding those of all five South Asian countries for 1960-92. South Asian countries diverged both relatively and absolutely from the US: Their income

[6]PWT 8.0/8.1 was based on purchasing power parities (PPPs) data from the 2005 International Comparison Program (ICP). PWT 9.0 is instead based on ICP 2011, released by the World Bank in 2014, and changes the reference year from 2005 to 2011. Certain methodological problems with ICP 2005 (e.g., inclusion in ICP 2005 of many products typical in the consumption baskets of high-income countries that are high-priced luxury items in low-income countries) were identified (see World Bank, 2013) soon after its release. This caused ICP prices of many low-income countries to be overstated and their real GDP understated. Inklaar and Rao (2017) demonstrate this bias was present in ICP 2005 but not in ICP 2011. PWT 9.0 corrects these prices fully and is the most sophisticated and reliable PWT so far.

gaps from the US – even of the “hills” countries - increased from 1960-1992.[7] This comparison highlights difference of the catch-up approach. Just looking at growth ignores inter-country inequality; a “success” in growth is consistent with widening income gap from the frontier.

3. Stillbirth Rates and Life Expectancy Measures for South Asian Countries

A. Stillbirth Rates and Life Expectancy Measures

We now turn to two basic health measures: a) late-fetal and neonatal mortality (*NM*), and b) life expectancy at birth. For the former, we first focus on late-fetal mortality or stillbirths.

The most complete data on stillbirths (for a total of 195 countries) is by Blencowe et al. (2016). They provide 2015 data and trends since 2000 for stillbirths as a proportion of total births. Following Kant (2017b), let *STBR* represent stillbirths expressed as a proportion of total (= live + still) births and *SLBR* represent stillbirths expressed as a proportion of live births, and let *LB*, *SB*, and *TB* denote the number of live, still, and total births in a year. Then, the equations for the two stillbirth rates are:

$$STBR = SB \times 1000/(LB + SB) > 0. \qquad (10),$$

and

$$SLBR = SB \times 1000/LB > 0 \qquad (11).$$

[7]As indicated above, Pritchett (2000) finds Bangladesh grew by more than 1.5% annually throughout 1960-1992. Nevertheless, we find its growth rate to be only 0.22% for this period. Similarly, Jerzmanowski (2006) finds India grew at a slightly higher rate than US (2.10% v. 2.04%) over 1962–1994, while we find (using PWT 9.1) the respective rates to be 1.26% and 2.44%, respectively (for the same period). These data again illustrate the results can be quite different when the new generation of PWT is used instead of an earlier generation version.

Multiplying and dividing the right-hand side of (10) by *LB*, we have

$$STBR = SLBR \times LB/(LB + SB) \qquad (10́)$$

And the difference between the two rates is

$$SLBR - STBR = SLBR \times STBR/1000 > 0. \qquad (12).$$

(12) confirms that *SLBR* is always greater than *STBR*. It also tells us the greater is the *SLBR*, the greater is its excess over *STBR*. For richer countries where the still birth rates are low, *SLBR* and *STBR* will be quite close to one another; but for poorer countries where they are high, the excess of *SLBR* over *STBR* will be significant.

It can be algebraically shown the two rates either both decrease or both increase. When they are falling, the rate of fall in *SLBR* must be greater than that in *STBR*.

Turning to life expectancies, the traditional life expectancy applies to all live births and measures the number of years a live new-born can be expected to live. We call it life expectancy of live-births (*LELB*). On grounds i) almost as many live births that do not survive their first day as intra-partum stillbirths, ii) how stillbirths are distinguished from live births varies across countries, states of a country (e.g., states of the U.S.), and localities with some registering only those new-borns as live births that survive for a specified period beyond birth, iii) the separation of the stillborn from neonatal mortality is not exact and suffers from considerable errors and misclassifications – an error that is compounded when births that take place at home as is common in rural areas of South Asia, misreporting of female losses occurring very early in life simply as stillborn, and millions of stillborn, who, by definition, are after 28 weeks of gestation are simply ignored in the traditional life expectancy measure, Kant (2017b) proposes a parallel life expectancy at birth measure, life expectancy of a total birth, *LETB*, that includes stillbirths.

Total life expectancy of 1000 live births is 1000 × *LELB*. Dividing this product by 1000 plus the still live-birth rate, *SLBR*, gives us the life expectancy of a total (= live + still) births. That is,

$$LETB = (1000 * LELB)/(1000 + SLBR) \qquad (13),$$

and

$$LELB - LETB = |LETB - LELB| = SLBR \times LELB/(1000 + SLBR) > 0 \qquad (14),$$

viz., greater is the *SLBR* and/or greater is the *LELB*, ceteris paribus, greater is *LELB*'s excess over *LETB* (or, greater is *LETB*'s shortfall from *LELB).*

The difference between the two life expectancies measures the disability-adjusted life-years for stillbirth for every live birth, or simply stillbirths-caused loss of life years per live birth. The total stillbirths-caused loss of life years, *TSCLLY*, is obtained by multiplying loss per live birth by the number of live births. That is,

$$TSCLLY = |LETB - LELBI| \times LB. \qquad (15).$$

B. South Asian Countries

Table 2 gives the two stillbirth rates for 2000 and 2015, and their annual rate of change, for the six South Asian countries. It confirms that i) *SLBR* is always greater than *STBR*, ii) greater is the *SLBR*, the greater is its excess over *STBR*, iii) the two rates both decrease, and iv) the rate of fall in *SLBR is* greater than that in *STBR.* We prefer *SLBR*, and discuss it further. Table 2 shows its great variation among South Asian countries – with Pakistan's rate (in 2015) about nine times that of Sri Lanka's and that of Bangladesh and India being about five times Sri Lanka's. Standard deviation of *STBR* is about 60% of mean. Defining it with respect to live births, i.e. considering *SLBR*, increases every country's stillbirth rate – for Pakistan the increase is about three in 2000 and about two in 2015. Stillbirth and neonatal mortality data are not available by sex while 36% of neonatal deaths occur on the day of birth. See, Lawn et al. (2012).

The a) high stillborn rates for Pakistan and Bangladesh coupled with Bongaarts and Guilmoto (2015)'s observation that these countries had long been reported to have excess female infant mortality (but little prenatal sex selection); and b) the near normal, viz. 105 males to 100 females, sex ratio at birth (SRB) in the most populous but among the poorest Indian states of Uttar Pradesh and Bihar, despite desired SRB of as much as 150 as found by Bongaarts (2013), are consistent with misreporting of immediate neonatal mortality as stillbirths and such mortality substituting for prenatal sex selection.

For comparison overtime, we also give in Table 2 the percentage rate of change in the neonatal mortality rate (*NMR*). We have reported above findings of Khan (2012), Rubayet et al. (2012) and Pradhan et al. (2012) that neonatal mortality declined at a slower rate than 1-59-month mortality from 2000 to 2010 in Pakistan, Bangladesh and Nepal, respectively.[8] Table 2 shows while the rate of decline in *SLBR is* greater than that in *STBR*, *SLBR* decreases less than *NMR* for every South Asian country. As a result, *SLBR:NMR* = *SB:NM* has increased for every country and now almost equals one for most countries, and exceeds one for one country (Bangladesh).[9] The lower decrease apparently is due to the lack of attention and resources to stillbirths. For example, it was only in 2014 that the first international goal on stillbirths was adopted, and child mortality data is developed by the UN Inter-Agency Group for Child Mortality Estimation while WHO is the lonely agency involved with developing stillborn information. See, WHO, UNICEF (2014).

Performing multivariate hazard and logistic analyses on for Derbyshire, England for the early twentieth century, Reid (2001) finds the stillborn and neonatal mortality are subject to similar

[8]The annual rate of decline in *NMR* for Pakistan between 2000 to 2015 is 1.89% while Khan (2012) found it to be only 0.9% between 2000 and 2010.

[9]It may be noted *SB:NM* ratio does not equal *STBR:NMR* but is greater than it.

social, environmental, and demographic factors. Using the 1974 Bangladesh famine as a natural experiment, Hernandez-Julian, Mansour, and Peters (2014) show that women who were pregnant during the famine had a higher number of the stillborn; and their live births had a 32% greater probability of neonatal mortality. We add a cross-country analysis to these results and show South Asia has achieved partial success on the stillbirth front. The success is its fall (and of neonatal mortality rates) for each country; the failure is increase in within region dispersion - measured by standard deviation/mean. Stillbirths rates decline less and dispersion of their decline (scaled by the mean decrease) is more than that of neonatal mortality. It indicates great scope of improvement in stillbirths that exists by the laggard countries emulating their more successful neighbors.

Table 3 gives the two life expectancies for 2000 and 2015, their trend since 2000, difference between the two for 2015, and total life years lost in 2015. As expected, the loss of life years per live birth due to stillbirths, given by the difference between the two life expectancies, is strongly and positively related to the stillbirth rate (with correlation of almost one). It is as much as three years for Pakistan, about two years for Bangladesh, for India about 1.6 years, and for Sri Lanka, as little as 0.4 years. Although the effect of *LELB* on the difference is not so obvious from the table, the correlation between the two (at 0.8) is strong. Overtime, the two life expectancies increase for all countries and at very different rates; and there is within-group convergence in life expectancies, with its dispersion decreasing between 2000 to 2015.

Tables 2 and 3 can also be used to relate neonatal and late-fetal mortality to life expectancy. The three South Asian countries with the largest decrease in neonatal mortality rate (listed in order) are Sri Lanka, Bangladesh, and Bhutan; and the three with the largest increase in *LELB* are Bhutan, Nepal, and Bangladesh indicating weak relationship between reduction in *NMR* and *LELB.* The coefficient of determination obtained by regressing the growth rate in

LELB on that in *NMR* is only 18.5 percent. On the other hand, if we include stillbirths, then the coefficient of determination obtained by regressing the growth rate in *LETB* on that in *NMR* plus *SLBR* is about 27 percent and that with *LELB* as the regressand is about 31 percent. Including stillbirths increases the power of early-child mortality in explaining life expectancy.

4. Trends in Health Gaps from the Frontier

We now consider gaps in health of South Asian countries from the frontier. Although in measures of health, a greater number of rich countries surpass the US, we use it as the frontier in health too to maintain the same benchmark. Three inter-related health measures will be considered: stillbirths, neonatal mortality and life expectancy at birth. As noted above, stillbirth data are available for 2000 and some later years. On the other hand, neonatal mortality data have been available since 1990, and information on life expectancy at birth has been available since 1960. See, World Development Indicators.

We follow the method in Section 2A to construct catch-up indexes in life expectancy and in stillbirths and neonatal mortality. The method for life expectancy follows exactly, since the countries catch up to higher US life expectancy will be studied. That for stillbirths and neonatal mortality will slightly differ, since the objective is to reach the *lower* stillbirths and neonatal mortality in the US.

Letting LE_{J0} and LE_{US0} represent life expectancy in Country J and the US in the base year, and $LE\text{-}R_{J0}$ Country J's base life expectancy ratio.

$$LE\text{-}R_{J0} = (LE_{J0}/LE_{US0}) < 1. \tag{16}$$

The life-expectancy catch-up index for Country J for year *t* is the ratio of its life expectancy ratio for year *t* to its base life expectancy ratio. Let $LE\text{-}I_{Jt}$ represent this index. Then,

$$LE\text{-}I_{Jt} = (LE\text{-}R_{Jt}/LE\text{-}R_{J0}) \tag{17}$$

Consider now the catch up index for stillbirths and neonatal mortality. Let child mortality rate, *CMR*, stand for any of the following mortality rates: late-fetal mortality or stillbirths rate, neonatal mortality rate, infant mortality rate, and child mortality rate. Let CMR_{J0} and CMR_{US0} represent child mortality rate in Country J and the US in the base year, and $CMR\text{-}R_{J0}$ Country J's base life expectancy ratio. Then,

$$CMR\text{-}R_{J0} = (CMR_{US0}/CMR_{J0}) < 1. \tag{18}$$

That is, to get child mortality rate ratio for Country J, we divide US child mortality rate by Country J's child mortality rate. To emphasize the difference, for life-expectancy ratio, we divide Country J's life-expectancy by the US life-expectancy; for the child-mortality rate ratio, we divide US child-mortality rate by Country J's child-mortality rate.

The child mortality rate catch-up index for Country J for year *t*, $CMR\text{-}I_{Jt,}$ is similarly defined as before - the ratio of its child mortality rate ratio for year *t* to its base child mortality rate ratio. That is,

$$CMR\text{ -}I_{Jt} = (CMR\text{ -}R_{Jt}/\ CMR\text{ -}R_{J0}) \tag{19}$$

With the health ratios and indexes so defined, everything else is the same as before. If the index rises, it indicates catching-up or relative convergence. If it falls, it indicates falling-behind or relative divergence. In contrast, absolute convergence/divergence is a reduction/ increase in poorer country's health-levels gap from the richer. As before, relative convergence is a necessary but not a sufficient condition for absolute convergence, relative divergence is a sufficient but not a necessary condition for absolute divergence, and the catch-up rate is the excess of a Country J's rate over that of the US.

Table 4, Panel A presents the various health catch-up indexes and Panel B the catch up rates. We focus on those with base 2000 since they are available for all four measures - stillbirths live birth rate, neonatal mortality rate, and life expectancy of live births and life expectancy of total births. All the catch-up rates are positive, stillbirths and neonatal mortality rates ratios with the US are decreasing and life expectancy ratios with the US are rising, and relative convergence to the frontier in health is taking place. To find whether the convergence rate is higher for countries that were further behind to start with, we regress the rates on the initial levels. The R^2 are 22% for stillbirth rate, 62% for neonatal mortality rate, and 41% and 37%, for life expectancy of live and total births, respectively. That is, the catch-up rates are weakly explained (except for neonatal mortality) by the initial levels. For example, stillbirth rate in Pakistan shows the lowest catch-up rate (and one-half of Sri Lanka's) even though its level is the highest in 2000 (and is 800% of Sri Lanka's). It indicates how far South Asian countries truly have to travel to capture the perceived low-hanging fruit of catching-up to high income countries' health outcomes.

Relating the catch-up in income (from Table 1 – for the relative convergence period only) to that in health (since 2000), we find the rank correlation between income catch-up and stillbirth or neonatal mortality catch-up rates are negative.[10] Rather than finding that the country catching up faster in income is also catching up faster in early-child mortality, we find a better performance in income is associated with a worse performance in early-child mortality. Although that in income and life expectancy is positive, the coefficient is only .09. There is

[10]Countries with higher catch-up rank in neonatal mortality have a lower rank in life expectancy catch-up. This is consistent with the earlier observation that *NMR* decrease "explains" only 18.5% of *LELB* increase. On the other hand, if we include stillbirths, then the rank correlation between life expectancy and *NMR* plus stillbirths becomes positive. Stillbirths decrease dominates; again showing its importance.

considerable debate in the literature on the relationship between life expectancy and per capita income. Some find a positive effect (e.g., Ebenstein et al. (2015)), others a negative (e.g., Hansen and Lonstrup (2015)). The weak positive association we find above does not clearly favour either side. Clearly, we cannot subsume life expectancy under GDP. We need to go "beyond GDP" to judge the catch-up in economic welfare.

5. Conclusions

Jones and Klenow (2016) propose a summary statistic that goes beyond per capita real GDP as a measure of wellbeing and includes consumption, leisure, mortality, and inequality, with mortality measured by life expectancy at birth. They find their measure's deviations from per capita real GDP are large with mortality explaining the largest difference; and global welfare inequality are greater than income inequality. When life expectancy at birth is defined inclusive of stillbirths, the global welfare inequality will be even greater.

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Figure 1: Catch-up Index 1951-2013

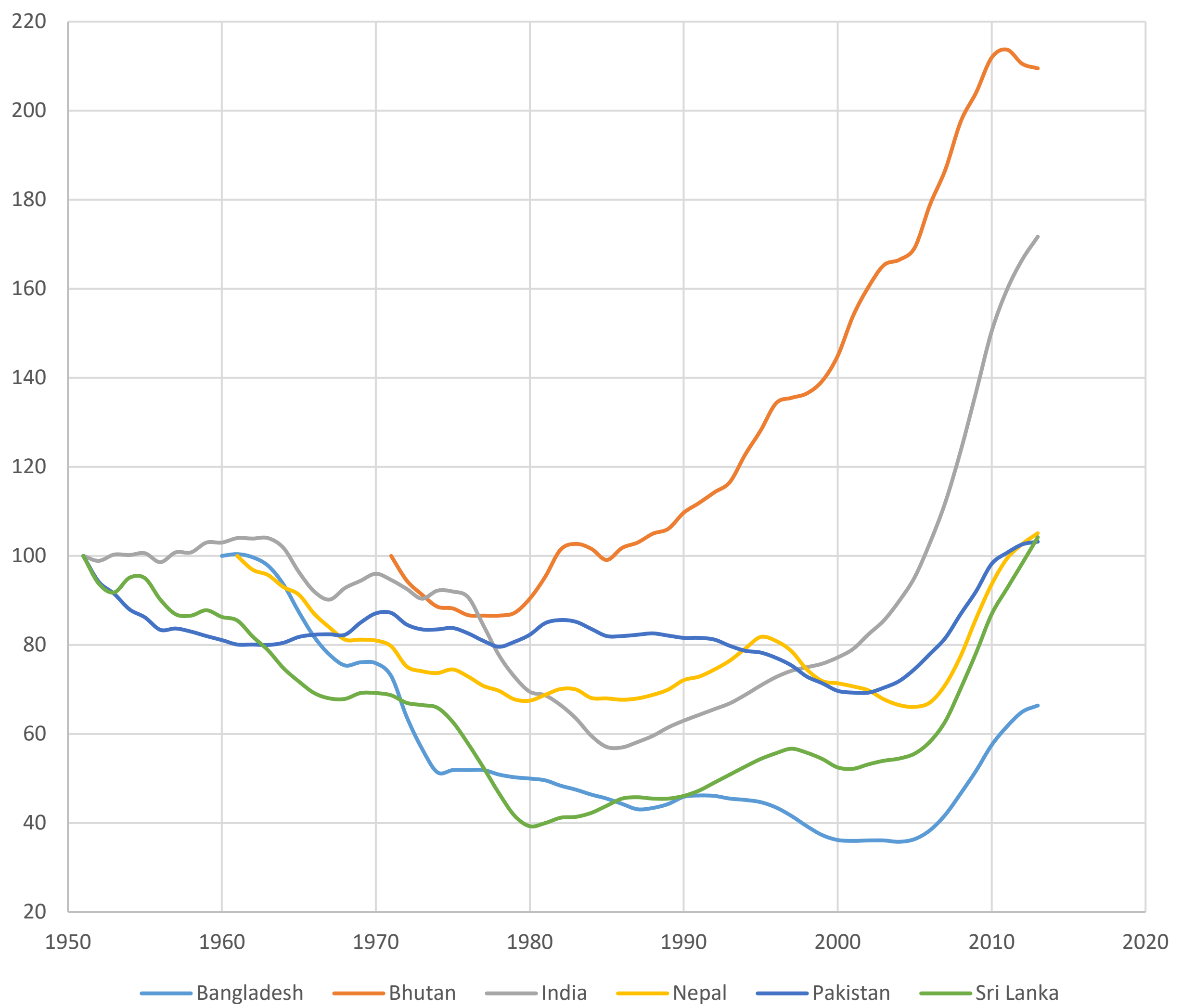

Table 1: Catch-up Index, Relative Divergence and Relative Convergence

	Start Year	R. Divergence Period	Index End of RD	R. Convergence Period	Index 2013	R. Convergence Period CU Rate	Full CYears
Bangladesh	1960	1960-2003	36.1	2003-2013	66.4	6.28	
Bhutan	1971			1971-2013	209.5	1.78	158
India	1951	1951-1986	57.0	1986-2013	171.7	4.17	84
Nepal	1961	1961-1980	67.5	1980-2013	105.1	1.35	272
Pakistan	1951	1951-2002	69.3	2002-2013	103.2	3.69	
Sri Lanka	1951	1951-1980	39.3	1980-2013	104.2	3.00	90

Note: The above table is based on Figure 1 and Supplementary Table 1. R stands for relative, RD for relative divergence, CU for catch-up and CYears for convergence years, respectively. Full convergence years are calculated only for countries with catching-up for at least twenty years.

Table 2: Stillbirth rates and trends since 2000

Country	2000 SLBR	2000 STBR	2015 SLBR	2015 STBR	SLBR-STBR	Ann. % Δ 2000-15 SLBR	Ann. % Δ 2000-15 STBR	Ann. % Δ 2000-15 NMR	SB:NM 2000	SB:NM 2015
Bangladesh	44.22	42.35	26.02	25.36	0.66	-3.5	-3.4	-4.0	103	111.1
Bhutan	27.59	26.85	16.19	15.94	0.25	-3.5	-3.4	-3.8	84	88.2
India	34.46	33.31	23.57	23.03	0.54	-2.5	-2.4	-3.2	75.7	84.6
Nepal	28.77	27.97	18.72	18.38	0.34	-2.8	-2.8	-3.8	72.7	83.9
Pakistan	56.35	53.34	45.09	43.15	1.94	-1.5	-1.4	-1.9	92.1	98.2
Sri Lanka	7.60	7.54	4.91	4.89	0.02	-2.9	-2.8	-4.1	75.3	90.9
StdDev	16.53	15.53	13.32	12.66		0.75	0.74	0.82		
Mean	33.17	31.89	22.42	21.79		-2.77	-2.70	-3.45		
SD/Mean	49.83	48.68	59.43	58.12		-26.88	-27.3	-23.76		

Notes: SLBR and STBR stand for still live birth rates and still total birth rates, SB for the number stillborn and NM for tne number of neonatal mortality. The STBR is from Blencowe et al. (2016), SLBR is derived by using the number stillborn from Blencowe et al. (2016) and number of live births as calculated by using the neonatal mortaility number and rate from World Development Indicators.

Table 3: Life expectancy measures and trends since 2000.

	2000		2015			Total years lost	Ann. % Δ 2000-15	
Country	**LELB**	**LETB**	**LELB**	**LETB**	**|LETB-LELB|**	**(in 100,000)**	**LELB**	**LETB**
Bangladesh	65.35	62.58	72.00	70.17	1.83	58.11	0.65	0.77
Bhutan	60.65	59.02	69.83	68.72	1.11	0.14	0.94	1.02
India	62.63	60.54	68.35	66.78	1.57	392.00	0.58	0.66
Nepal	62.33	60.59	69.97	68.68	1.29	7.08	0.77	0.84
Pakistan	62.77	59.42	66.38	63.52	2.86	152.39	0.37	0.45
Sri Lanka	71.11	70.57	74.95	74.58	0.37	1.15	0.35	0.37
SD	3.73	4.32	2.97	3.67	0.83			
Mean	64.14	62.12	70.25	68.74	1.51			
SD/Mean	5.8	7.0	4.2	5.3	55.1			

Note: LELB and LETB stand for life expectancies of live and total (= live + still) births, respectively. Th difference between the two life expectancies measures stillbirth-adjusted life-years for each live birth.

Table 4: Catch-up in Health

Country	LELB2000	LELB2015	NMR2000	NMR2015	SLBR2015	NMR2015	LELB2015	LETB2015
	(Base 1960)		(Base 1990)			(Base 2000)		
A: Catch-up Index								
Bangladesh	129.8	139.6	118.0	168.9	161.2	143.1	107.6	109.1
Bhutan	160.2	179.2	106.7	149.2	161.7	139.8	111.8	113.3
India	138.4	147.1	100.9	128.6	138.7	127.4	106.3	107.3
Nepal	161.3	176.0	118.1	163.6	145.8	138.5	109.1	110.3
Pakistan	126.2	129.8	84.4	87.7	118.6	103.9	102.9	104.0
Sri Lanka	108.3	111.2	112.3	164.4	146.8	146.4	102.7	102.8
B: Catch-up Rate								
Bangladesh	0.65	0.61	0.41	0.96	3.23	2.42	0.49	0.58
Bhutan	1.19	1.07	0.16	0.73	3.26	2.26	0.75	0.84
India	0.82	0.70	0.02	0.46	2.20	1.63	0.41	0.47
Nepal	1.20	1.03	0.42	0.90	2.55	2.20	0.58	0.66
Pakistan	0.58	0.48	-0.42	-0.24	1.14	0.26	0.19	0.26
Sri Lanka	0.20	0.19	0.29	0.91	2.59	2.57	0.18	0.18
SD	0.38	0.33	0.32	0.46	0.78	0.86	0.22	0.25
Mean	0.77	0.68	0.15	0.62	2.50	1.89	0.43	0.50
SD/Mean	49.7	49.2	216	74.1	31.4	45.5	51.5	49.8

Notes: See above for denition and sources. Data on life expectancy starts from 1960, on neonatal mortality from 1990, and on stillbirths from 2000.

Supplementary Table 1: Yearly Catch-up Index

Year	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
1951			100		100	100
1952			98.9		94.2	93.8
1953			100.3		91.5	91.8
1954			100.2		88	95.1
1955			100.6		86.2	95
1956			98.6		83.4	90.2
1957			100.8		83.7	86.9
1958			100.8		83	86.6
1959			103		82	87.8
1960	100		103		81.1	86.3
1961	100.4		104	100	80.1	85.5
1962	99.7		103.9	96.9	80.1	81.9
1963	97.8		104	95.7	80	78.8
1964	93.6		101.8	93	80.5	74.8
1965	87.4		96.4	91.3	81.8	71.8
1966	81.8		92	87	82.3	69.2
1967	77.8		90.2	83.9	82.4	68
1968	75.4		92.8	81.2	82.3	67.9
1969	76.1		94.4	81.2	85	69.2
1970	75.9		96	81	87.1	69.2
1971	73	100	94.6	79.7	87.2	68.7
1972	63.9	94.5	92.6	75.2	84.6	67
1973	56.7	91.3	90.4	74.1	83.5	66.5
1974	51.4	88.6	92.2	73.7	83.5	65.9
1975	51.9	88.2	92	74.5	83.8	62.7
1976	51.9	86.7	90.7	72.9	82.6	57.8
1977	51.9	86.6	84.3	70.8	80.9	52.4
1978	50.9	86.6	77.7	69.7	79.6	46.7
1979	50.3	87.2	72.9	67.8	80.7	41.7
1980	50	90.4	69.5	67.5	82.3	39.3
1981	49.6	95.3	68.7	68.8	84.9	40
1982	48.4	101.4	66.5	70.1	85.6	41.2
1983	47.5	102.7	63.5	70	85.2	41.4
1984	46.4	101.6	59.6	68.1	83.6	42.3
1985	45.5	99.1	57.1	68	82	43.9
1986	44.3	101.8	57	67.7	82	45.5
1987	43.1	103	58.2	68	82.3	45.8
1988	43.4	105	59.6	68.8	82.6	45.5
1989	44.3	106.1	61.5	70	82.1	45.5
1990	45.9	109.7	63	72.1	81.6	46.1
1991	46.2	111.9	64.3	72.9	81.6	47.3
1992	46.1	114.3	65.6	74.5	81.2	49.1
1993	45.5	116.6	66.9	76.5	79.8	50.9
1994	45.2	122.8	68.8	79.2	78.7	52.7

1995	44.7	128.2	70.9	81.8	78.3	54.4
1996	43.5	134.3	72.8	80.9	77.1	55.7
1997	41.6	135.5	74.2	78.6	75.4	56.7
1998	39.3	136.5	75	74.5	72.9	55.8
1999	37.3	139.3	75.8	71.9	71.4	54.4
2000	36.2	144.9	77.2	71.4	69.7	52.5
2001	36	153.9	79.1	70.7	69.3	52.2
2002	36.1	160.4	82.4	69.8	69.3	53.2
2003	36.1	165.3	85.5	67.8	70.4	54
2004	35.8	166.5	89.9	66.5	71.9	54.5
2005	36.4	169.2	95.2	66.1	74.6	55.6
2006	38.4	178.9	103	67.1	78	58.3
2007	41.9	186.8	112.1	71.1	81.6	62.9
2008	46.7	197.6	123.7	77.6	87	70.3
2009	51.8	204.1	136.9	86	92.1	78.3
2010	57.5	211.9	150.4	93.6	98.2	86.9
2011	61.7	213.7	159.8	99.4	100.7	92.7
2012	65	210.5	166.6	102.7	102.6	98.4
2013	66.4	209.5	171.7	105.1	103.2	104.2