Finding Winners on National Preston Curve Trajectories. The myth of exemplary progress meets the data

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For submission to:
PAA Annual Meeting, Austin, TX, April 11-13, 2019
Session 425: Gains and Gaps in Life Expectancy
Session 415: Social and Economic Determinants of Health and Mortality

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Short abstract

This paper aims to assess the promise and pitfalls of scouring the world's picture album of country trajectories along their own Preston Curves to find high-performing countries. We categorize the various possible trajectories that 189 countries had between 1950-2009 into one-of-five typologies: i) Preston-behavior (Health growth + Economic growth); ii) Health growth + Economic recession; iii) Health decline + Economic growth; iv) Health decline + Economic recession; and v) Suspiciously Linear. Over the 9,450 country-years analyzed, 66% of them exhibited Preston-behavior. Contrary to assumptions, the input-output relationship where both life expectancy and GDP per capita are simultaneously growing fails to hold up much of the time. Once countries were categorized by typology, we assessed the rapidity of the Preston curve decade by decade across countries at various stages of population health. We find that the list of the top-five exemplary countries was neither consistent across decades nor across LEB stratum.

Abstract

Background: The goal of this paper is to assess the promise and pitfalls of scouring the world's picture album of country trajectories along their own Preston Curves to find high performing countries. We present a global typology that classifies countries into five typologies based on their decadal gains in GDP per capita and life expectancy at birth (LEB) for the last 50-years, and we identify the top five exemplary countries with celebratory progress in both their economy and health by decade and level of LEB.

Methods: We categorize the various possible trajectories that 189 countries had between 1950-2009 along their sojourn through the space of progress in LEB and GDP per capita into one-of-five typologies: i) Preston-behavior (Health growth + Economic growth); ii) Health growth + Economic recession; iii) Health decline + Economic growth; iv) Health decline + Economic recession; and v) Suspiciously Linear. Every decade, countries with positive gains in their economy and health were ranked by their ability to increase their LEB given their level of GDP per capita using a linear regression. To adjust for each country's starting point of LEB, the analysis was performed by LEB strata: LEB < 51, 51 ≤ LEB < 61, 61 ≤ LEB < 71, and LEB ≥ 71.

Results: Over the 9,450 country-years analyzed, 66% of them exhibited Preston-behavior. As life expectancy at birth increases, the greater the percentage of countries with Preston-behavior. In the lowest LEB stratum (LEB < 51), 50.7% had Preston-behavior, while this proportion was 77.3% in the highest LEB stratum (LEB ≥ 71). The list of the top five exemplary countries was neither consistent across decades nor across LEB stratum. There were some exceptions in the bottom three strata, where countries such as Nepal and Mali made the list more than twice. In the 1960s Nepal was in the lowest strata (LEB<51) and gained 1.648 (SE 0.350) years in their LEB given a one dollar increase in their GDP per capita (P<0.01).

Conclusions: Contrary to assumptions, the input-output relationship where both life expectancy and GDP per capita are simultaneously growing fails to hold up much of the time. The list of best performing countries is still limited because it is often the case that a country looks like it is deriving a high health output from minimal economic growth simply because it has had a prolonged spell of economic stagnation and health improvements that are simply occurring from improving technology.

1. Background

The goal of this paper is to assess the promise and pitfalls of scouring the world's picture album of country trajectories along their own Preston Curves to find high performing countries. There have been many efforts to view the progress of national development indicators as a way of finding "best" practices and policies. For example, "Asian Tigers" were identified by observing extremely high rates of GDP per capita growth during the 1980s and 90s. Similarly in health, there have been a handful of exemplary countries who have had made celebratory progress in indicators of population health. These countries have been interrogated for lessons in how countries can achieve better than expected results in population health given their limited resources in order to find routes that could be followed by other limited populations [1–3].

The Preston Curve (1975) summarizes the accepted stylized fact that improvements in the economy are typically accompanied by improvements in population health [4]. The curve shows that for countries with low levels of income, a relatively small increase in income is associated with larger gains in life expectancy than for countries with high levels of income. Economists see the Preston Curve as an input-output relationship where countries can input economic resources and receive an output of better population health. From this viewpoint, countries that are obtaining higher than average health outputs from a given input would seem to be investors worth imitating.

However, previous studies found that over the past 60-years the average pace of improvement in the decadal gains of life expectancy at birth has slowed around the world. The slowdown was not explained by a longevity ceiling effect because it is happening in countries with low levels of life expectancy [5]. Thus, finding a set of countries with constant increases in population health is hard to imagine no matter how high their economy becomes. In this study, we first analyze how often the input-output relationship holds – where both life expectancy and GDP per capita are simultaneously growing – by categorizing the various possible trajectories that countries can take along their sojourn through the space of progress in life expectancy and GDP per capita. For instance, there are countries where health is trending up and prosperity is trending down for prolonged periods that few would want to emulate.

Once countries are classified by their progress in life expectancy and GDP per capita we carefully assess the rapidity of the Preston curve decade by decade across countries at various stages of population health. We confine our search for exemplary performance to those countries that are having both economic growth and health improvements. When we undertake a detailed analysis of these spells in the world's database we are able to find a list of best performing countries.

This analysis tries to explain the typology that countries go through their trajectories, where economic recessions and epidemics occurs as well as economic and health growth, and empirically identify exemplary countries achieving good health at low cost or "punching above their weight".

2. Methodology

This section describes a global classification of countries that delineates the mechanisms by which a country's economic growth enables improvements of population health. Countries with positive gains in life expectancy and economic growth were ranked by decade based on their ability to increase their Life Expectancy at Birth (LEB) given increases of their GDP per capita.

To compare countries with similar starting points of LEB, countries were divided into four strata: LEB<51, 51≤LEB<61, 61≤LEB<71, and LEB≥71. This stratification was done previously by Cardona and Bishai [5]. The analysis allowed each country to be reclassified into a new stratum whenever its life expectancy crossed a specific age-threshold. Between 1960 and 2009, most countries left a lower stratum to join a higher one. Many countries crossed 2-3 life expectancy strata, contributing country-years of observation in multiple strata.

2.1. Data

Data were obtained for a set of 189 countries on Life Expectancy at Birth and Gross Domestic Product (GDP) per capita over a 50-year period, 1960-2009, from publicly available databases.

Country data for Gross Domestic Product (GDP) per capita by Purchasing Power Parities (PPPs) (in international dollars, fixed 2011 prices) were obtained from Gapminder compilation [6]. The inflation and differences in the cost of living between countries were taken into account by adjusting for PPPs as calculated in the 2011 round of International Comparison Program (ICP). Data between 1990 and 2009 comes from World Development Indicators [7] and prior to 1990 most data comes from The Maddison Project – Maddison Historical Statistics for the World Economy from the University of Groningen [8]. For a detail explanation by country please refer to Gapminder Documentation 001 (GD001) [9].

Life Expectancy at Birth were also obtained from Gapminder [10]. Data from 1990-2009 was retrieved from the Global Burden of Disease Study 2015, from the Institute for Health Metrics and Evaluation (IHME), University of Washington, Seattle [10]. Data prior to 1990 uses Gapminder Historic Life Expectancy data, whose main sources are the Human Mortality Database [11], and World Population

Prospects – the 2010 revision [12]. See Gapminder Documentation 004 (GD004) [13] for a detail explanation of sources by country and year.

2.2. Criteria for Typology

Countries were classified into five typologies according to the 3-year Moving Average (MA) of the *k*-year-gains in the log of Life Expectancy at Birth (LEB), and to the 3-year Moving Average (MA) of the *k*-year-gains in the log of GDP per capita. To distinguish countries, we tried different *k*-year intervals to define LEB and GDP gains, $k = 1, 3, 5,$ and 10. Gains were defined as the difference between the current observation in t and the observation in t-k for every i^{th} country, $i = 1, \ldots, 189$, in t years, $t = 1960, 1961, \ldots, 2009$. For example, LEB-*10*-year-gains$_i$ were defined as the difference between $LEB_{i,t}$ and $LEB_{i,t-10}$. We identified five typologies, their thresholds are as follows:

i) Preston-Behavior:
   a. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} \geq 0$, and
   b. 3-year MA of the *k*-year-gains in the log of $GDP_{i,t} \geq 0$;
ii) Health growth + Economic recession:
   a. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} \geq 0$, and
   b. 3-year MA of the *k*-year-gains in the log of $GDP_{i,t} < 0$;
iii) Health decline + Economic growth:
   a. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} < 0$, and
   b. 3-year MA of the *k*-year-gains in the log of $GDP_{i,t} \geq 0$;
iv) Health decline + Economic recession:
   a. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} < 0$, and
   b. 3-year MA of the *k*-year-gains in the log of $GDP_{i,t} < 0$;
v) Suspiciously Linear:
   a. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} \leq 1.01$*3-year MA of the *k*-year-gains in the log of $LEB_{i,t-1}$, and
   b. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} \geq .99$*3-year MA of the *k*-year-gains in the log of $LEB_{i,t-1}$, and
   c. 3-year MA of the *k*-year-gains in the log of $LEB_{i,t} \neq 0$.

The percentage of country-years with Preston-Behavior on the 3-year MA of the log of LEB and GDP per capita by all *k*-year intervals and LEB stratum, showed no significant differences across strata – except for the highest stratum. Given the typology definitions, using a 3-year MA of the 5-year-gains and the decadal-

gains in the log of LEB and GDP, the 9,450 country-years of observation were respectively distributed as follows: 66.0% and 65.8% have Preston-behavior, 16.3% and 15.3% have LEB Growth & Economic Recession, 4.8% and 3.5% have Epidemic & Economic Growth, 3.8% and 3.9% have Epidemic & Economic Recession, and 9.1% and 11.5% have suspiciously linear data. For this study, we considered decadal-gains to define the typology of the countries.

Figure 1 shows a pseudo Preston curve that maps the trajectory of a typical country in life expectancy and economic growth. Countries cannot have constant economic growth nor constant improvements in their life expectancy across years, epidemics and economic recessions happen, evidencing that countries cannot have Preston-behavior all the time. Figure 2 shows the typology of various trajectories in the LEB-GDP plane for a typical country using the 3-year MA of the decadal-gains in the log of LEB and the 3-year MA of the decadal-gains in the log of GDP per capita. Quadrant I groups country-years of observations with Preston-Behavior – both the 3-year MA of the decadal-gains in the log of LEB and the log of GDP per capita are positive. While quadrant II, III, and IV groups country-years with positive decadal-gains in the log of LEB and an economic recession, country-years with health decline and an economic recession, and country-years with health decline and economic growth, respectively. Over the 50-years of analysis, most countries went back and forth between quadrants, contributing country-years of observation in multiple typologies.

2.3. Good-performance definition

We define good performance as the slope of the relationship between the 3-year moving average of the log of LEB and the 3-year moving average of the log of GDP per capita. The analysis was performed separately for each country, by decade, and by LEB stratum to confine comparisons of countries with similar LEB starting points in a given decade. Only countries with Preston-behavior were included. The slope was defined using an OLS model of the following equation:

[Eq. 1] $$E[MA(\log \text{ of } LEB_{i,t})] = \beta_0 + \beta_1 * MA(\log \text{ of } GDP_{i,t}) + \varepsilon_i$$

where β_0 is the unknown intercept for each country *i* in one of the four LEB stratum and in one of the five decades, β_1 is our coefficient of interest that captures the association between GDP per capita and LEB, and ε_i is the error term. In the analysis, countries had to be in the stratum at least for three years in a given decade to be included.

3. Results

Most countries had positive decadal-gains in their life expectancy and GDP per capita, however the proportion of countries with this typology varies considerably across life expectancy levels. Figure 3 shows the distribution of country-years across typologies by LEB stratum. The results show that as life expectancy at birth increases, the greater the percentage of countries with Preston-Behavior. Among countries from the lowest LEB stratum (LEB < 51), 50.7% had Preston-Behavior, while this proportion was 77.3% among countries from the highest LEB stratum (LEB ≥ 71).

Between the 1960s and 1990s, the proportion of countries with Preston-Behavior decreased across decades within each LEB stratum, and increased back in the 2000s. In the 1960s, the proportion of country-years with Preston-Behavior in the lowest and highest LEB stratum was 67.2% and 93.5%, respectively. This proportion decreased to 9.3% and 64.3% in the 1990s for countries in the lowest and highest LEB stratum, respectively. This is likely to happen because many countries transitioned to a higher stratum across time.

Figure 3 also shows that the proportion of countries with positive increases in their decadal-gains in life expectancy while having an economic recession was higher among countries from the lowest LEB (LEB< 51) and among countries from the second stratum (51<=LEB<61).

Over the 9,450 country-years analyzed (189 countries assessed over 5-decades), 6,218 country-years – more than half of those examined – exhibited positive decadal-gains in their life expectancy and economic growth. These countries were ranked by decade and LEB stratum based on their ability to increase their level of Life Expectancy at Birth given an increase on their GDP per capita. Figure 4 displays the top five countries with the greatest increase – the list only includes countries with Preston-Behavior. We were expecting to find the list of the top five countries to be consistent across decades by LEB stratum. However, the majority of top performers changed across decade and LEB stratum. There were some exceptions in the bottom three strata, where countries made the list more than twice, but no country made the list more than twice in the highest LEB stratum.

Countries with an outstanding progress in the bottom three strata were Mali and Nepal, they achieved high life-expectancy growth during periods of minimal economic growth. Mali was in the lowest LEB stratum (LEB<51) from the 1960s to the mid-1990s. In this stratum, it ranked third during the 1970s and 1980s, and first during the 1990s. Mali's greatest decadal-gains in LEB and GDP per capita were in the 1980s, they were able to increase an average of 8.13 (SD 0.15) years in their LEB given an average increase of 117 (SD 112) (international) dollars in their GDP per capita. Mali transitioned to the second LEB stratum

(51<=LEB<61) in the mid-1990s and remained there in the 2000s. The country ranked second in the 1990s and fifth in the 2000s, with an average increase of 0.218 (SE 0.047) and 0.534 (SE 0.052) years in their life expectancy given a one (international) dollar increase in their GDP per capita, ($P < 0.01$). Nepal made the top five list four times between the 1960s-2000s. It ranked fifth in the 1960s (LEB<51), second in the 1980s (51<=LEB<61), and second and fifth in the 1990s and 2000s (61<=LEB<71). For Nepal, the greatest gain was 1.648 (SE 0.350) years in their LEB given a one (international) dollar increase in their GDP per capita in the 1960s when it had a LEB<51, ($P<0.01$).

4. Conclusion

We show that contrary to assumptions, the input-output relationship where both life expectancy and GDP per capita are simultaneously growing fails to hold up much of the time. An examination of country specific data on Life Expectancy at Birth and GDP per capita between 1960 and 2009 finds that simultaneous increases in health and wealth only occur in less than 70% of observations.

The list of best performing countries is still limited because it is often the case that a country looks like it is deriving a high health output from minimal economic growth simply because it has had a prolonged spell of economic stagnation and health improvements that are simply occurring from improving technology. What appear to be “top-performing” countries on climbing the Preston curve often appear this way because of stagnant barely positive economic growth. The project of empirically identifying exemplary countries achieving good health at low cost or “punching above their weight” needs to re-examine the weakness of the international observations at its foundation. The list of top-performers seems to be circumstantial to a given period of time.

5. References

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6. Figures

Figure 1: Trajectory in life expectancy and GDP per capita for a typical country, Zambia

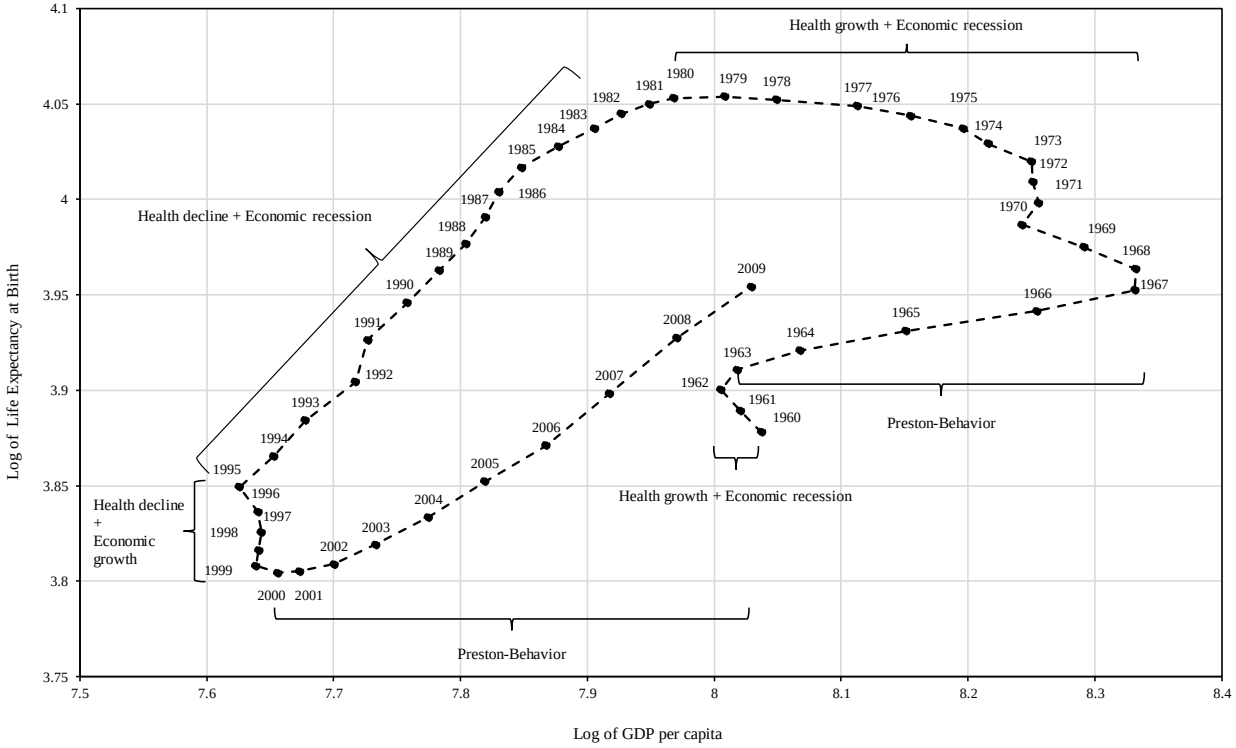


Figure 2: Typology of various trajectories in the progress in life expectancy and GDP per capita plane for a typical country, Zambia

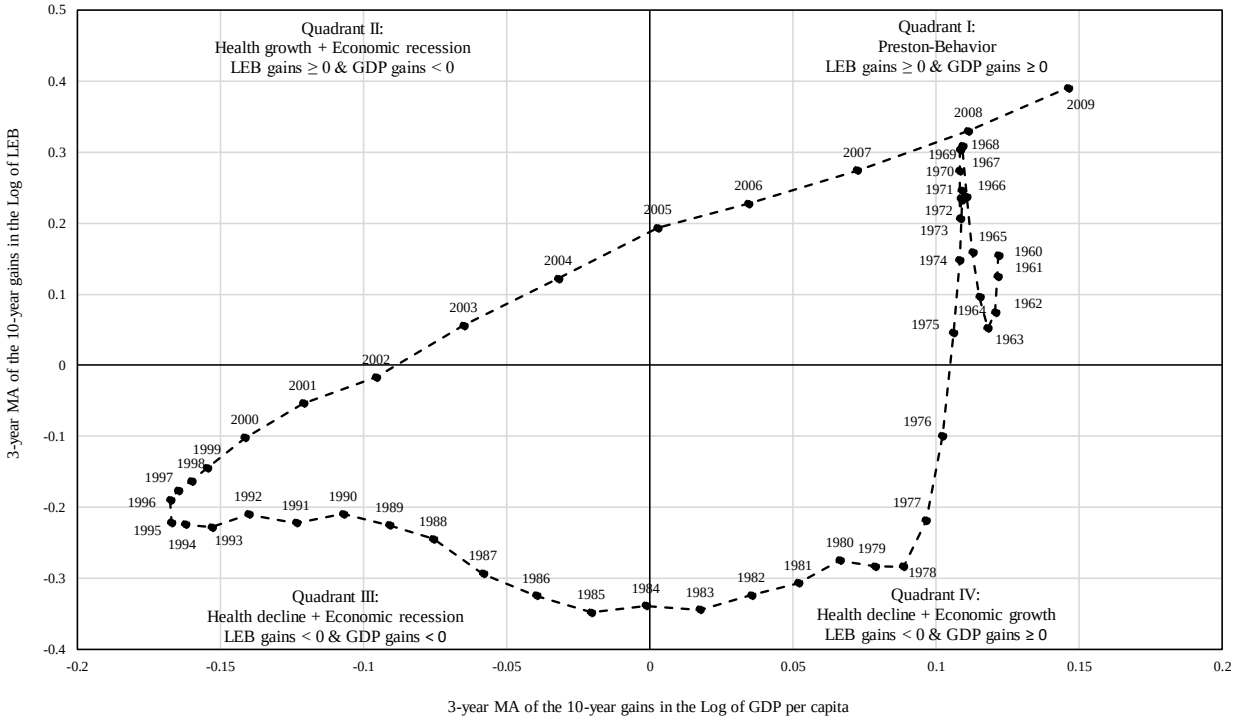


Figure 3: Typology distribution of country-years by LEB stratum

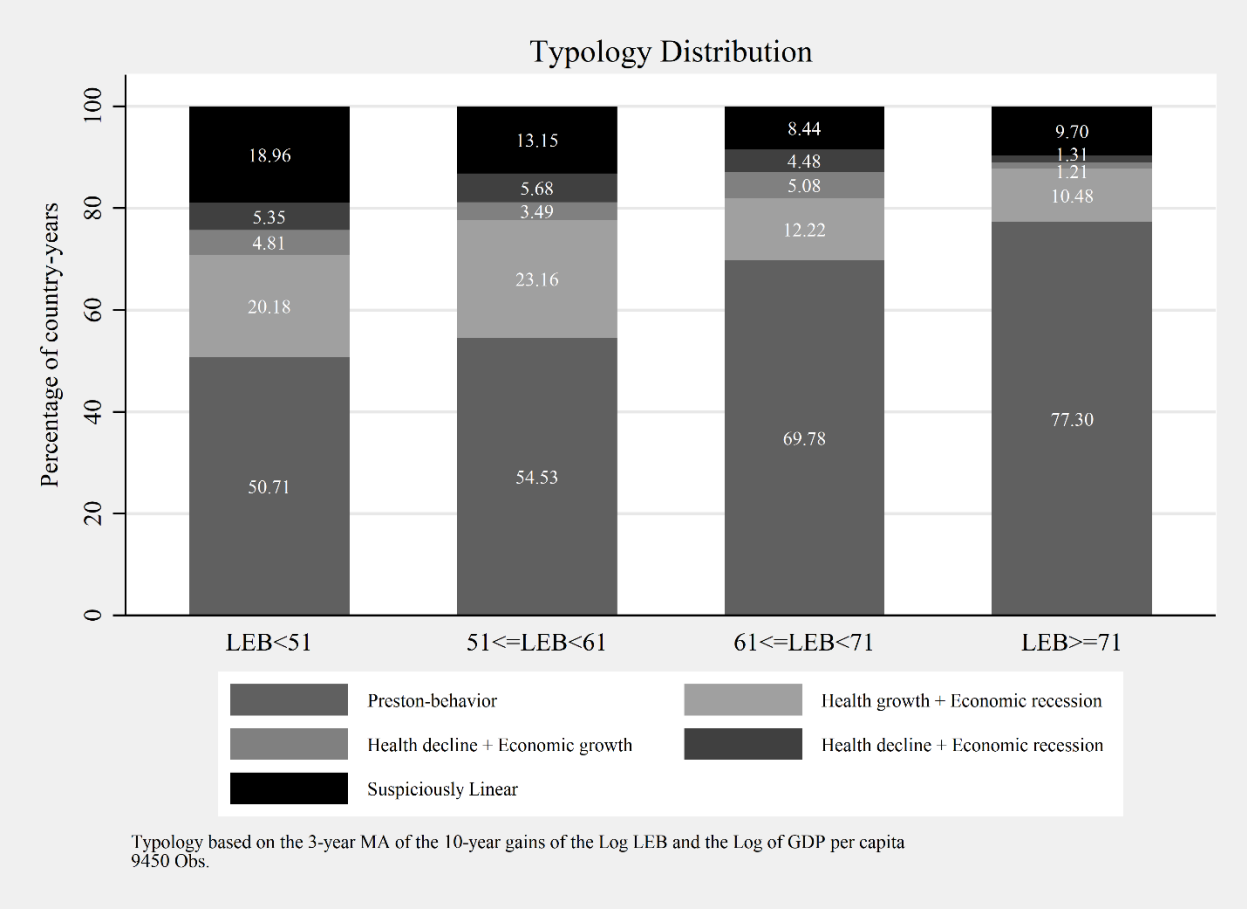
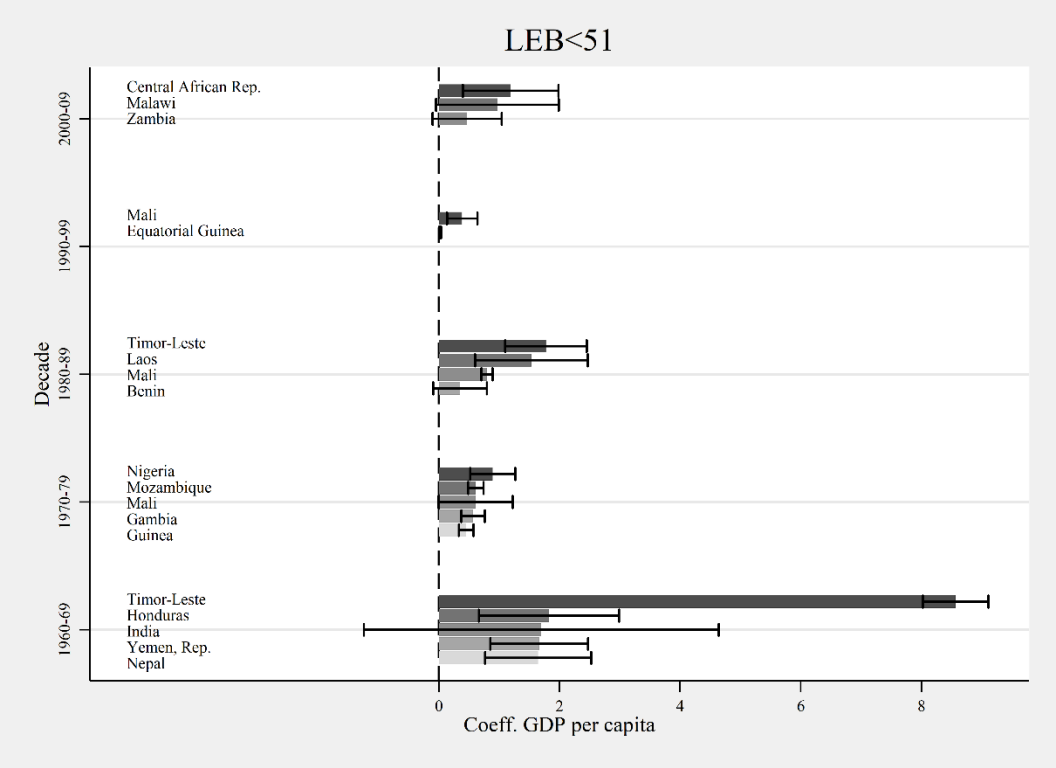
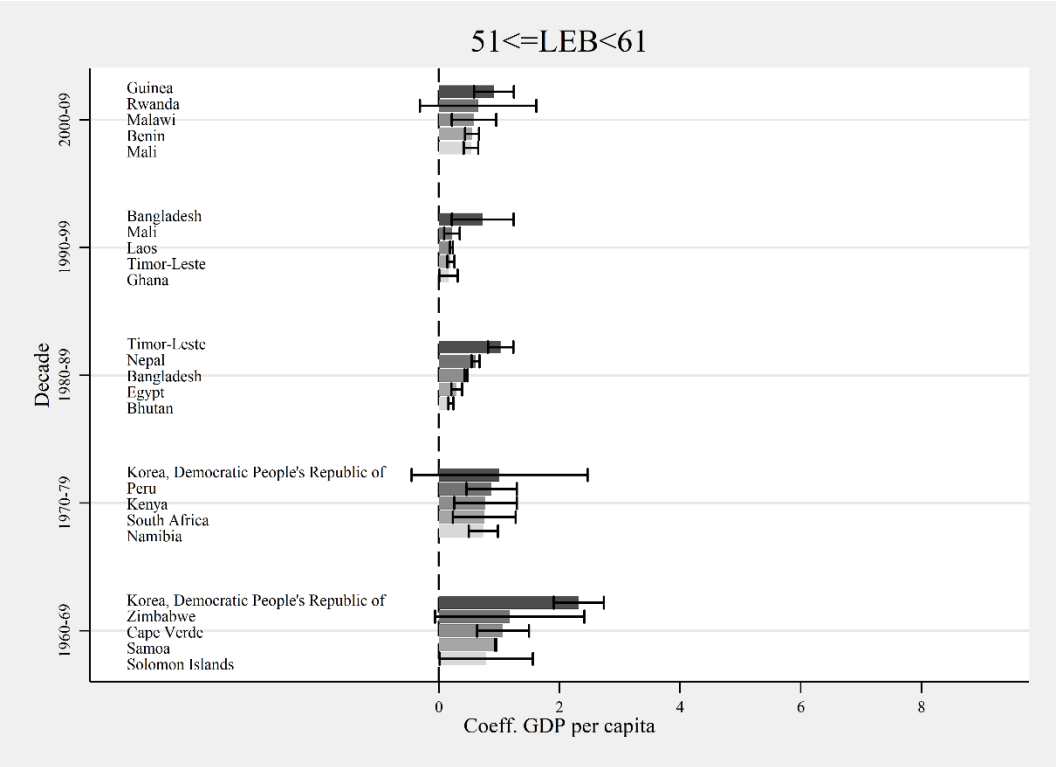
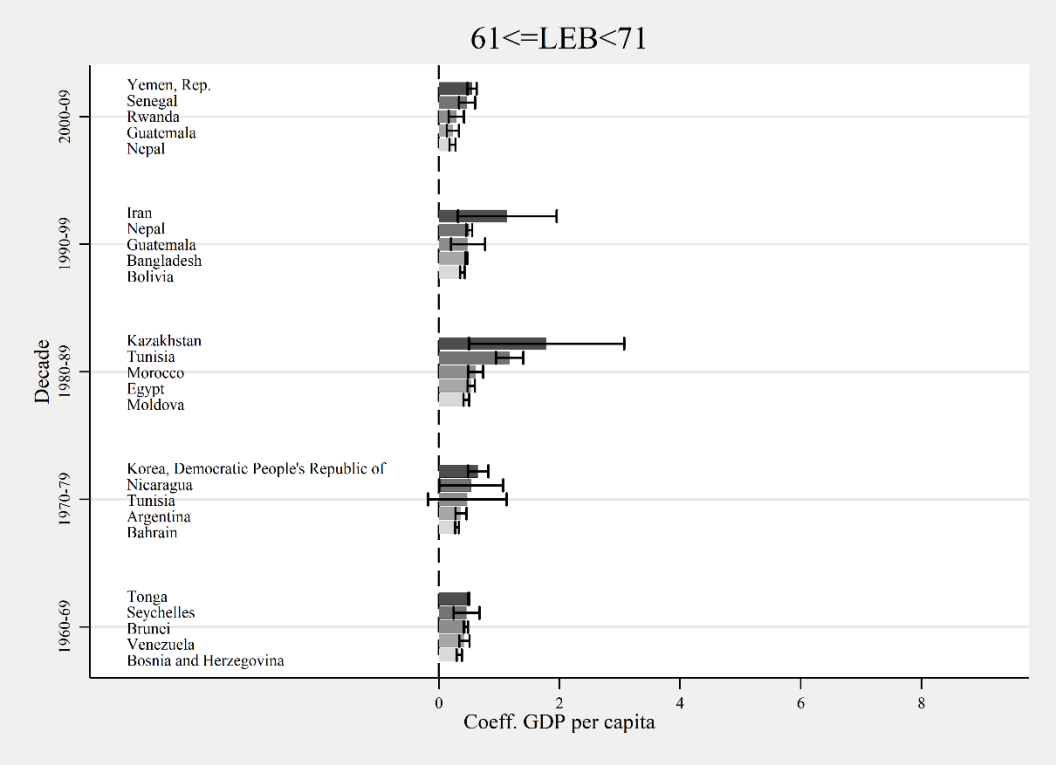
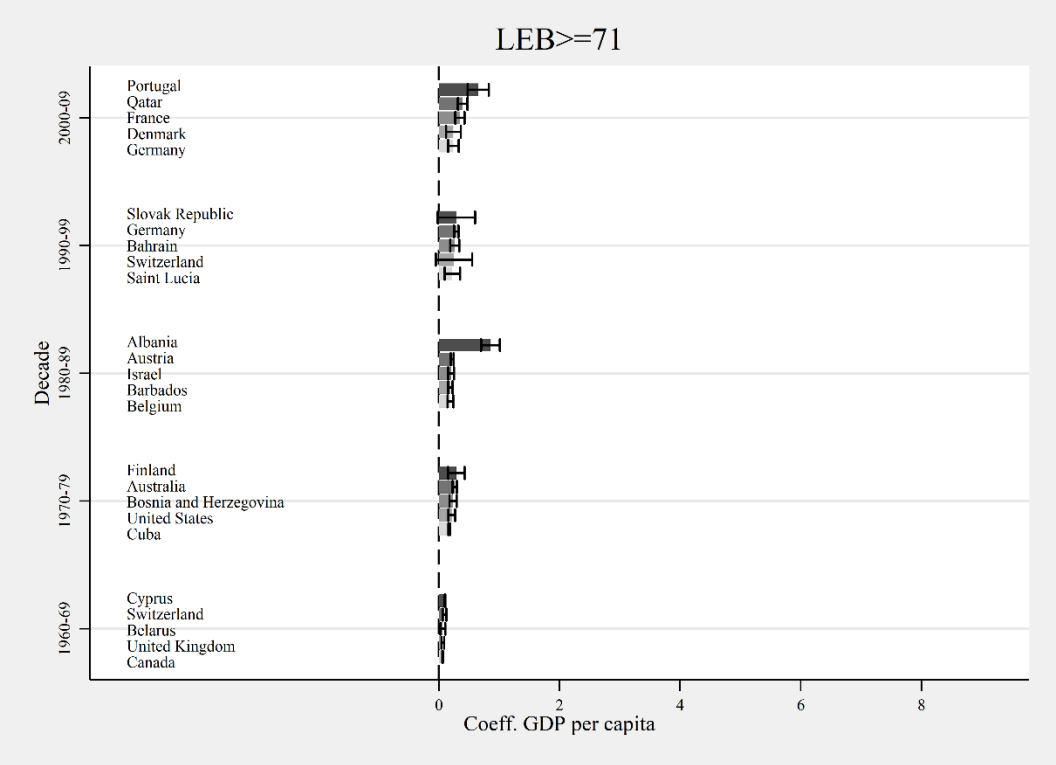


Figure 4: Top five economies with Preston-Behavior by strata and decade






61<=LEB<71
Decade
2000-09
1990-99
1980-89
1970-79
1960-69
Yemen, Rep.
Senegal
Rwanda
Guatemala
Nepal
Iran
Nepal
Guatemala
Bangladesh
Bolivia
Kazakhstan
Tunisia
Morocco
Egypt
Moldova
Korea, Democratic People's Republic of
Nicaragua
Tunisia
Argentina
Bahrain
Tonga
Seychelles
Brunei
Venezuela
Bosnia and Herzegovina
0
2
4
6
8
Coeff. GDP per capita


LEB>=71
Decade
2000-09
1990-99
1980-89
1970-79
1960-69
Portugal
Qatar
France
Denmark
Germany
Slovak Republic
Germany
Bahrain
Switzerland
Saint Lucia
Albania
Austria
Israel
Barbados
Belgium
Finland
Australia
Bosnia and Herzegovina
United States
Cuba
Cyprus
Switzerland
Belarus
United Kingdom
Canada
0
2
4
6
8
Coeff. GDP per capita