Spurring economic growth through human development: research results and guidance for policymakers[1]

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February 2019

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[1] This research was made possible by and developed in conjunction with the Harvard Ministerial Leadership Program. We would like to thank Martin Weese for excellent research assistance.

EXECUTIVE SUMMARY

Education, general health, and reproductive health (RH) are widely understood to be key indicators of human development. Investments in these domains can also promote economic growth by enhancing worker productivity and labor supply, and inducing higher rates of saving, capital accumulation, and technological progress. While substantial evidence supports the impact of human development on economic growth, economic literature does not provide any clear indications with regard to which aspects of human development have the most potent influences on economic growth. The literature also fails to provide a clear comparison of the importance of human development and its components relative to other drivers of growth, such as those related to institutional quality, macroeconomic management, or the nature and density of infrastructure.

This paper seeks to summarize the literature on the returns to different human development strategies and to provide original empirical evidence on the relative impact of improvements in different aspects of human development on subsequent economic growth. It also offers guidance on prioritizing expenditures within sector by reviewing literature on the social and private returns to different education, health, and reproductive health interventions.

Cross-country Differences in Economic Performance

Most countries classified as low- or middle-income in the mid-20th century experienced substantial economic growth over the last 70 years, but average incomes have improved considerably more in some countries than others. These growth discrepancies are most evident when one contrasts the economic growth experience of East Asia with that of sub-Saharan Africa. In 1960, both regions had comparable per capita GDP. But real income in East Asia grew to more than 800% of its 1960 value by 2017, whereas income per capita in sub-Saharan Africa grew by only 50% over the same period (see Figure ES1).

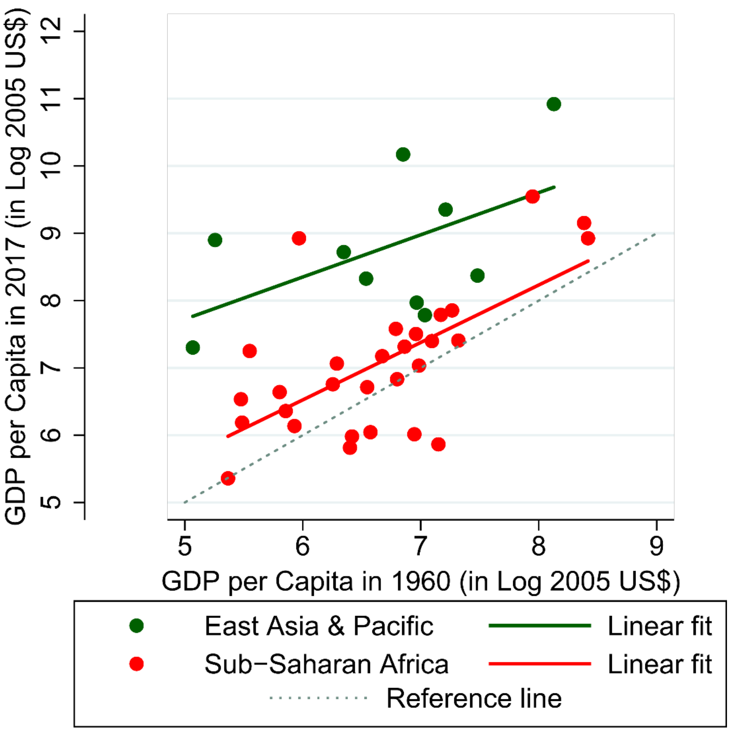

Figure ES1. Real GDP per capita of LMICs in 1960 and 2017[2] with linear projections by region

Cross-country differences in rates of income growth have been accompanied by corresponding differences in trajectories of human development, especially in education, life expectancy, and fertility (see Table ES1).

Table ES1. Income and Indicators of Human Development by Current Income Grouping

Variable	1990 Value	2017 Value	Change (%)
Low-Income Countries			
Income p.c. (in 2010 US$)	567	720	27
Life Expectancy at Birth	51	63	24
Literacy Rate (Age 15+)	46	61	33
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Upper-Middle-Income Countries			
Income p.c. (in 2010 US$)	3,148	8,225	161
Life Expectancy at Birth	69	75	9
Literacy Rate (Age 15+)	82	95	16
Total Fertility Rate (TFR)	2.6	1.8	-31

[2] The general patterns shown in this chart also hold for purchasing power parity (PPP) adjusted GDP, although PPP-adjusted data are only available from 1990 onward.

The association between these human development outcomes and economic growth is consistent with economic theory and presumably reflects a bi-causal relationship: (i) the extent to which increased income allows individuals and governments to invest more heavily in human development, and (ii) the impact of improvements in general health, reproductive health, and education on economic growth.

Variation in Resource Allocation

Expenditures on health and education, as well as those on infrastructure, vary appreciably across LMICs. Across the entire LMIC group, health expenditures range from less than 3% of GDP in Bangladesh, Pakistan, and Angola to more than 9% in Uruguay, Malawi, and Serbia. Education expenditures range from below 3% of GDP in South Sudan, Sri Lanka, and Kazakhstan to more than 7% in Costa Rica, Senegal and Bhutan.[3] The lowest-income countries have tended to increase expenditures on health, education, and infrastructure more rapidly in recent years than upper-middle income countries [see Table A4]. Increases in these expenditures are all associated with more rapid GDP growth in subsequent years [see Figures A5-A7].

Literature on Drivers of Economic Growth

Theoretical considerations and empirical evidence strongly support the conclusion that the positive association between expenditures on human development and the pace of economic growth reflects at least partially, a causal impact of improved general health, reproductive health, and education on economic growth. By contrast, evidence that infrastructure investments drive economic growth is less clear cut.

There are several pathways through which education can contribute to increased economic growth. Better educated workers: (i) are more productive, (ii) are more likely to participate in the labor force, (iii) tend to have longer working lives, (iv) are more likely to establish successful and productive firms, (v) more readily adopt and more efficiently assimilate technologies from abroad, and (vi) enhance the productivity of their co-workers through beneficial synergies and spillovers.

Results suggest that, on average, individual income is 10% higher for each additional year of schooling received. Some results estimate even higher returns for low-income countries. Average private rates of return to schooling are highest in Latin America and the Caribbean and for sub-Saharan Africa, and lowest for Europe and the Middle East and Northern Africa. Recent literature suggests that the rate of return to education increases considerably (from 11% to 16%) if the impacts of education on mortality are taken into account. Furthermore, a large body of macroeconomic literature finds education to be a key determinant of economic growth and suggests that the impact of education on individual productivity aggregates up to greater total productivity at the country level – perhaps because of beneficial spillovers among a more

[3] Even among settings in which expenditures are comparable as a share of GDP, per capita expenditures vary substantially. For example, 9% of GDP per capita is roughly US$530 in Serbia but only US$30 in Malawi.

educated workforce and because such a workforce attracts more foreign direct investment. In general, the literature suggests that a one-year increase in average educational attainment is associated with between a 0.5 and 1.2 percentage point (pp) increase in the annual growth rate of GDP per capita. A 25 point improvement in PISA score,[4] a measure of educational quality, is similarly associated with a 0.5 pp increase in annual GDP per capita growth.

A substantial body of literature finds consistent patterns in the returns to different types of educational investment. Investments in primary education generally offer higher returns than those in secondary education and tertiary education (see Table ES2). Investing in high quality pre-primary education can also have huge positive returns, even in very low-income settings. Returns to girls' education are generally higher than those for boys' education and have important economically beneficial spillover effects through reducing the TFR and promoting stronger families and communities. This is particularly the case in settings with large gender gaps in educational attainment.

[4] This 25 point improvement in PISA score is relative to a normalized mean of 500 and standard deviation of 100.

Table ES2. Social returns to investments in education, 1960-2014

	Low income	Middle income
Primary	22.08%	17.10%
Secondary	18.10%	12.79%
Tertiary	13.18%	11.44%

Source: Meta-study of *Psacharopoulos and Patrinos (2018)*

Investments in health also enhance productivity and economic growth through several channels: (i) healthier workers tend to be more consistently working and more productive when working; (ii) healthier children tend to perform better in school, attend school for more years, and accumulate more human capital in the process, which tends to enhance their productivity and incomes in adulthood, (iii) healthier individuals have greater incentive to pursue education and save for retirement, (iv) healthy populations are more powerful attractors of foreign direct investment, and (v) health investments that cure or prevent infectious diseases (such as vaccination) have positive spillovers to other individuals.

Here, too, the positive effects of improved health on individual productivity are consistent with macro-level evidence suggesting that health is an important determinant of economic growth. Estimates from the literature suggest that a 10% increase in the adult survival rate leads to a 6.7% increase in productivity per worker and a 4.4% increase in GDP per worker. Other research estimates that, on average, a one-year increase in life expectancy at birth causes a 4% increase GDP per capita.

In addition to enhancing productivity, investments in education and health facilitate escape from the often crushing burden of youth dependency. Poor countries tend to have much higher youth dependency rates than wealthier countries. Supporting the basic needs of a relatively large child population imposes a substantial resource burden, necessitating the diversion of resources from other productive investments and impeding, for decades, the pace of measured economic growth. As child survival improves, and as women become healthier, more educated, and more empowered, desired fertility tends to decline. Major drops in fertility initiate a period of lower youth dependency, during which resources are freed up for other productive investments. If properly harnessed, this fertility transition can result in a sizable boost to economic growth, known as the "demographic dividend".

Results from the literature imply that a fall in the TFR by one child leads to an economic growth rate that is 0.45 pp higher. Other analyses suggest that one-third of East Asia's "growth miracle" is due to the demographic dividend that followed the strong decline in fertility in China, South Korea, Hong Kong, Singapore, and Taiwan. This one-third figure corresponds to a 0.66 pp increase in the growth rate of per capita GDP for each one-child reduction in the TFR.

Results from the literature are mixed with respect to infrastructure spending. Some results suggest that government consumption, particularly in the form of spending on infrastructure, serves to enhance economic development and growth. Other studies find no effect, which may reflect the fact that private investment is crowded out by spending on public infrastructure.

Empirical Analyses

This report presents original empirical analysis in the form of single and multiple equilibria cross-sectional and panel growth regressions. Multiple equilibria models are able to account for the fact that the variables of interest may have distinct effects on economic growth in developing and developed countries (defined both in terms of income group and timing of demographic transition). Whereas the cross-section threshold growth regressions focus on the long-run effects, dynamic panel threshold regressions allow us to instrument the independent variables and perform an improved causal inference over shorter (i.e., five-year) intervals from 1980 through 2015. The aim is to estimate the impact of different health, fertility, education, and infrastructure indicators on GDP per capita growth simultaneously and under an internally consistent methodological framework.

We contrast these results with those summarized from the extant literature , which are typically based on a variety of sources that make use of different country samples, time frames, controls, and datasets (of varying quality). Earlier studies also utilize different econometric methods and take different types of costs and benefits into account. While these results are helpful for discerning the general economic impacts of improvements in specific outcomes, they do not lend themselves easily to straightforward comparisons of impacts of different types of outcomes on economic growth.

Taken as a whole, our empirical analyses suggest four main findings relevant to policymakers in LMIC settings:[5]

(1) A sustained one-child decrease in the TFR corresponds to a 2 pp increase in annual GDP per capita growth in the short-run (5 years) and 0.5 pp higher annual growth in the medium- to long-run (35 years).

(2) A 10 percent increase in life expectancy at birth[6] corresponds to a 1 pp increase in annual GDP per capita growth in the short-run and 0.4 pp higher growth in the medium- to long-run.

(3) A one-year increase in average educational attainment corresponds to a 0.7 pp increase in annual growth in the short-run and 0.3 pp higher growth in the medium- to long-run.

(4) Infrastructure proxies were not significantly associated with subsequent growth in any of the models whose parameters we estimated.

[5] The relationships between these variables likely vary with contextual factors. As such, the results presented should be understood as average, at-the-margin, estimates. Additionally, as mentioned above and described in the main body of this manuscript, different methodologies are used to estimate short-run and mid- to long-run effects, so conclusions about the timeline of the return on benefits should be made cautiously.

[6] This is equal to a 6.3-year increase in life expectancy at birth for the average low-income country, a 6.8-year increase for the average lower-middle-income country, and a 7.5-year increase for the average upper-middle-income country.

Given that per capita GDP growth in LMICs generally averages between 2 and 4 pp, the estimated changes in annual growth provided above are appreciable. In interpreting these results, it is important to consider the compounding effect of a persistent change in growth over several years. For example, a 1 pp increase in average annual economic growth from 3% to 4% cumulates to GDP per capita that is 3.9 times higher after a period of 35-years rather than 2.8 times higher.

Prioritizing Expenditures within Sector: Copenhagen Consensus Findings

Additional results from the literature offer guidance on prioritizing expenditures within given sectors (for example, on the highest return health investments). The Copenhagen Consensus (CC) Center's Post-2015 Consensus Project brought together economists and experts from the UN, NGOs, the private sector, and the academic community to produce over 100 literature- and evidence-informed reports on the effectiveness of the development targets proposed by the UN's Open Working Group. The group of reports were reviewed by an expert panel that prioritized the goals according to the value offered per dollar spent attaining them. The aggregated research results of the Post-2015 Consensus priorities rank the returns to one US dollar spent from 2015 to 2030 on meeting the UN-proposed development targets. The list of top-ranked outcomes, provided in Table ES3, highlights specific targets within general health, reproductive health, education, and other domains that merit particular focus.[7] It is worth noting that these recommended targets are highly consistent with our empirical findings; improving access to reproductive health tops the list and the majority of other outcomes are health-related. Many of the CC's recommendations have proven fairly stable over time: increasing availability of family planning, reducing under-nutrition among preschoolers, expanding access to tuberculosis treatment, promoting malaria prevention and treatment, and providing aspirin to reduce heart attack risk all ranked among the top 20 interventions in the previous two lists of CC recommendations released in 2008 and 2012.

[7] For the health-focused studies mentioned below, the returns refer to the discounted value of gains in disability-adjusted life years relative to the actual costs of the intervention.

Table ES3. Top 10 post-2015 Consensus priorities

Category	Sub-category	Ratio of Returns to Investment
Reproductive health	Universal access to sexual and reproductive health (SRH)	120
Nutrition	Reduce by 40 per cent the number of children under 5 who are stunted	60
Illicit financial flows	Reduce to zero	49
Population and Demography	Reduce barriers to migration within low- and middle-income countries, as well as between low- and middle-income countries and high-income countries	45
Health	Reduce Tuberculosis deaths by 95% and TB incidence by 90%	43
Health	Delay artemisinin resistance and reduce malaria incidence using bed nets by 50%	36
Food security	Increase investment in agricultural R&D by 160%	34
Education	Increase the preschool enrollment ratio in sub-Saharan Africa from the present 18% to 59%	33
Health	Aspirin therapy at the onset of AMI (75% coverage)	31
Health	In hyper-endemic countries, attain circumcision coverage of at least 90% amongst HIV-negative adult men	28

Conclusions

Taken as a whole, economic theory, empirical literature on returns to spending on interventions aimed at promoting different aspects of human development, and new evidence on the drivers of economic growth suggest the following 3 conclusions:

1. **Reducing fertility has considerable potential to boost the rate of economic growth, especially in settings in which fertility remains well above replacement.** Reduced fertility offers very large economic returns over the short- and medium-long-run that are highly robust to different estimation and measurement methodologies.

(2) **Improving general health and education also promote economic growth.** Improvements in health will have a more appreciable impact on economic growth in settings in which health is initially very poor, while education is relatively more potent in settings characterized by moderately good health.
(3) **Infrastructure gains do not show a consistent relationship with economic growth in the literature and are not significantly associated with economic growth in our analyses.**[8] This suggests that the capacity of infrastructure projects to improve economic growth should be evaluated on a case-by-case basis.

Concluding Caveats:

The results presented herein refer to average effects associated with improvements in different human development indicators, with little attention to the distribution of benefits across settings and interventions. For example, a program to expand access to birth control may be highly successful in reducing fertility in a locality where unmet need for contraceptives is high, but completely ineffective in another environment where individuals desire a large number of offspring. As such, policymakers must consider the specific binding constraints to development in their settings, as well as the relative cost of the options available for achieving improvements in health, education, fertility, and infrastructure, in order to make sound assessments of their relative returns on investment (ROIs). Ultimately, the rational allocation of resources to different interventions remains highly contextual, and will also be driven by whether decision-making exercises are aimed at allocating fixed sectoral budgets, or at determining the socially optimal size of a sectoral budget as well. Evidence-based resource allocation decisions seem advisable, but it should also be noted that the evidence is very thin with respect to (a) whether, for example, doubling the improvement in some human development indicator more than or less than or exactly doubles the ensuing boost to economic growth; (b) the likely existence of positive and negative interactions among different interventions (presumably because they are so difficult to tease out from existing data); and (c) the time frames in which income benefits are realized, which will naturally vary according to the nature of the human development investment, with the most immediate benefits coming from fertility decline and the most delayed benefits being associated with improvements in child health.

[8] While the absence of a significant relationship is to some extent consistent with the theory of poverty traps, it could also be explained as a result of lack of impact of the projects themselves, the inadequacy of indicators used to proxy infrastructure quality, or the possibility that infrastructure financing effectively crowds out equally-beneficial private sector investments.

Prioritizing governmental expenditures: research results and guidance for policymakers

1. Introduction

Most countries classified as low- and middle-income at the mid-20th century experienced substantial economic growth over the last 70 years but this rising tide has lifted some countries far higher than others. These growth discrepancies are exemplified by contrasting the experience of East Asia, where real per capita income grew to more than 8 times its 1960 value by 2017, with that of sub-Saharan Africa, where income increased by only around 50% over the same period (See Figure 1). This divergence in income has been accompanied by a divergence in human development, notably through stark differences in education, life expectancy, and fertility (see Table 1).

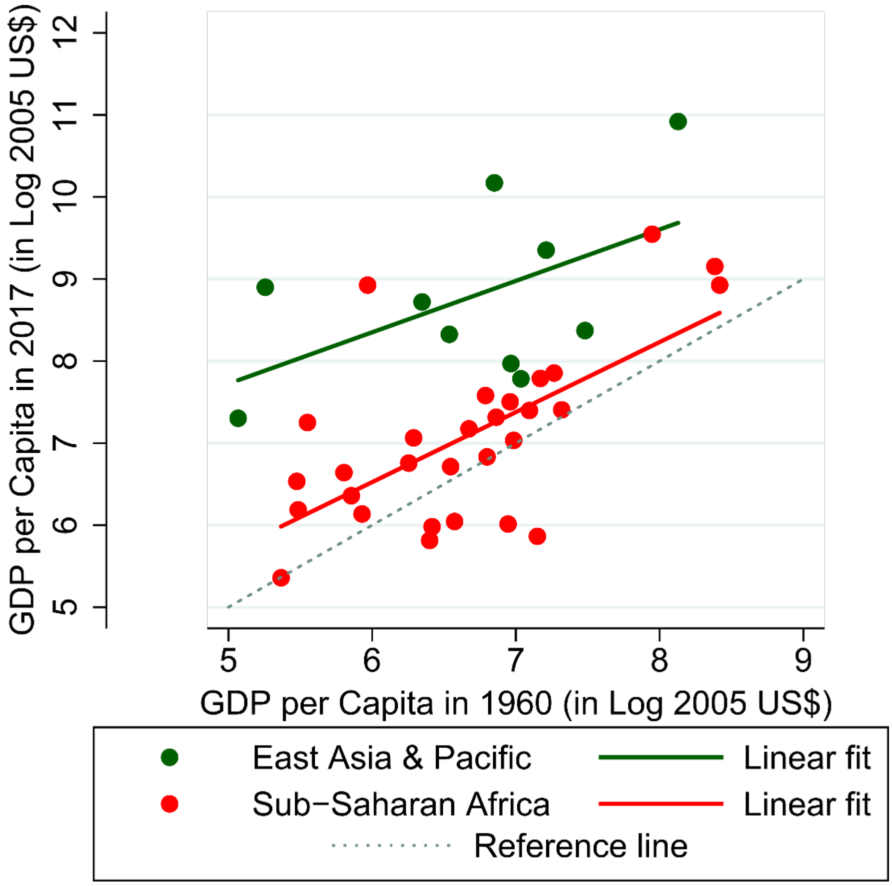

Figure 1. Real GDP per capita of LMICs in 1960 and 2017 with Regional Projections
Source: World Bank (2018)

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An abundance of evidence supports the notion that different aspects of human development are strongly and reliably associated with economic growth (Ranis, 2004; Suri et al., 2011; Deaton, 2008). Although economic growth does not guarantee improved living conditions—if, for example, additional income is distributed in a highly disparate fashion or misdirected—an expansion of resources allows both individuals and governments the opportunity to invest more heavily in areas that directly impact wellbeing. International experience suggests that growth is vital to aiming beyond "low-bar" development goals, related to eliminating extreme poverty, towards achieving higher standards of well-being (Pritchett & Kenny, 2013). As such, policymakers and other stakeholders interested in promoting human development would benefit from a better understanding of the factors that have contributed to the divergent growth of LMICs in the last century, especially those factors that they can influence. Economic prioritization could subsequently offer an additional guideline for international organizations focused on providing foreign aid.[9]

Furthermore, much of the evidence regarding the relationship between economic growth and human development points to the importance of human capital, technology, and demographic variables as drivers of growth (Barro, 2001; Hanushek, 2013; Bloom & Canning, 2000; Malecki, 1997; Bloom, Canning, & Malaney, 2000; Lee & Mason, 2010). Accordingly, it is now widely appreciated that efforts to improve health, education, and access to family planning are, in fact, supportive of economic growth.

However, the relative prioritization of health, education, and infrastructure varies considerably across LMICs, as reflected by cross-country differences in spending on these sectors. Health expenditures, for example, range from less than 3% of GDP in Bangladesh, Pakistan, and

[9] Analysts offer a wide range of opinions on the effects of foreign aid: from little to no effects (Burnside and Dollar, 2000 and Easterly et al. 2004) to the transformational impulse of the big push (see Sachs, 2005).

Angola to more than 9% in Uruguay, Malawi, and Serbia. Education expenditures range from below 3% of GDP in South Sudan, Sri Lanka, and Kazakhstan to more than 7% in Costa Rica, Senegal and Bhutan. While the variation between countries is substantial, the average levels of spending (as a percentage of GDP) are actually fairly consistent across income groups; on average, upper-middle income countries spend only a modest share more on health and education than the lowest-income countries [see Table A3].[10] Nonetheless, increases in these expenditures at the country-level are associated with more rapid GDP growth in subsequent years [see Figures A5-A7].

Substantial theory and evidence suggests that the association between these increased expenditures and faster economic growth reflects, at least partially, the causal impact of improved health and education on economic growth. Nonetheless, the information available in the literature does not yield an immediate conclusion as to which of these investments convey the biggest boost to economic growth. It also does not provide a clear comparison of the importance of these variables relative to other drivers of growth, such as trade, institutions, macroeconomic policy, or infrastructure.

This paper offers a basis for prioritizing different forms of development expenditure by drawing on evidence from low- and middle income countries (LMICs) on the association between different investment strategies and subsequent growth trajectories. It also offers guidance on prioritizing expenditures within sector by presenting information from the literature on which education, health, and reproductive health interventions have the biggest impacts on economic growth and development. A review of existing literature is used to inform priority setting within and across sectors and original empirical analysis is used to provide additional information on priority setting across sectors. In this analysis, we deliberately abstract from the other beneficial effects offered by health, education, and lower fertility rates.[11] As such, the impacts on economic growth described in the paper should be considered in complement with the various other benefits resulting from spending in a given domain or on a specific program.

The manuscript is organized as follows: Section 2 describes a theoretical framework motivating the importance of large-scale investment in physical or human capital to escaping national poverty traps. Section 3 provides a literature review on the causal pathways from health, education, and fertility to economic growth, and the evidence supporting these mechanisms. Section 4 describes the methodological approach taken in this paper to assess the impacts of health, education, and demographic variables on economic growth, and presents the results of these analyses. Section 5 provides guidance on economic prioritization between and within sectors, Section 6 offers information on prioritization with respect to the Copenhagen Consensus, and Section 7 concludes.

2. Theoretical Analysis

[10] Even among settings in which expenditures are comparable as a share of GDP, per capita expenditures vary substantially. For example, 9% of GDP per capita is roughly US$530 in Serbia but only US$30 in Malawi.
[11] For example, we do not consider the direct impact of increased life expectancy on improving welfare, which greatly exceeds the indirect effects of health on economic growth (Kuhn and Prettner, 2016; Baldanzi et al. 2019; Fan et al., 2018).

To illustrate the differential effects of investments in infrastructure, health, education, and fertility reduction from a qualitative point of view, we consider an economy in which time $t = 1,2 \ldots$ evolves discretely. Aggregate output Y_t depends on the stocks of physical capital K_t and human capital H_t employed in the production process. These two accumulable production factors can be combined to produce aggregate output according to the overall productivity level A_t. The production function that translates factor inputs and productivity into output has the general form

$$Y_t = F(A_t, K_t, H_t),$$

where $F(\ldots)$ has positive first partial derivatives and negative second partial derivatives with respect to the accumulable production factors K_t and H_t. Physical capital comprises private production capital such as machines, production halls, and office buildings, but also public capital such as railroads, highways, electricity grids, and ports. In contrast to physical capital, human capital is embodied in the workers of an economy and is mainly determined by the average health status and education level of the workforce. Productivity A_t consists of two parts: the technological state of the economy determining the location of the production possibility frontier, and the efficiency of input use determining whether the economy produces at its production possibility frontier (is efficient) or below its production possibility frontier (is inefficient).

2.1 The case of a unique steady-state equilibrium

In a perfectly competitive economy with full information and without externalities, the investment decisions of all agents are efficient. The private rate of return and social rate of return coincide for each investment such that the equilibrium outcome is optimal and does not require governmental intervention. In this case, the economy develops according to the well-known dynamics of standard economic growth models with exogenously increasing technology (cf. Solow, 1956; Diamond, 1965). We illustrate the development process of such an economy in Figure 2. The horizontal axis depicts the physical capital stock at time t, while the vertical axis refers to the physical capital stock at time $t + 1$. The capital stock in each period is carried over from the previous period net of the depreciation of old capital, as given by $\delta * K_t$ (where δ is the depreciation rate). The capital stock rises because of gross investment $I_t = s * F(A_t, K_t, H_t)$ (where s is the saving rate).. For this illustration, we assume that productivity and human capital stay constant at the levels $\bar{A}$ and $\bar{H}$ and that the function $F(\bar{A}, K_t, \bar{H})$ is concave in K_t because the marginal product of physical capital is diminishing. Thus, at some point, capital accumulation stops because additional gross investment is only sufficient to replace additional depreciation. If this is the case, the capital stock at time t and the capital stock at time $t + 1$ coincide and the economy is at its steady state. In Figure 2, this point is the intersection of the K_{t+1}-curve and the 45° line at the corresponding steady-state capital stock K^*. At this steady state, the economy is comparatively rich. Output growth at the long-run steady state depends mainly on technological progress that shifts the production possibility frontier outwards (Romer, 1990). In empirical analyses of long-run growth processes in developed countries, the determinants of technological progress are the main regressors of interest, and the specifications of the growth regressions are typically standard linear models of either a cross-country or panel data structure.

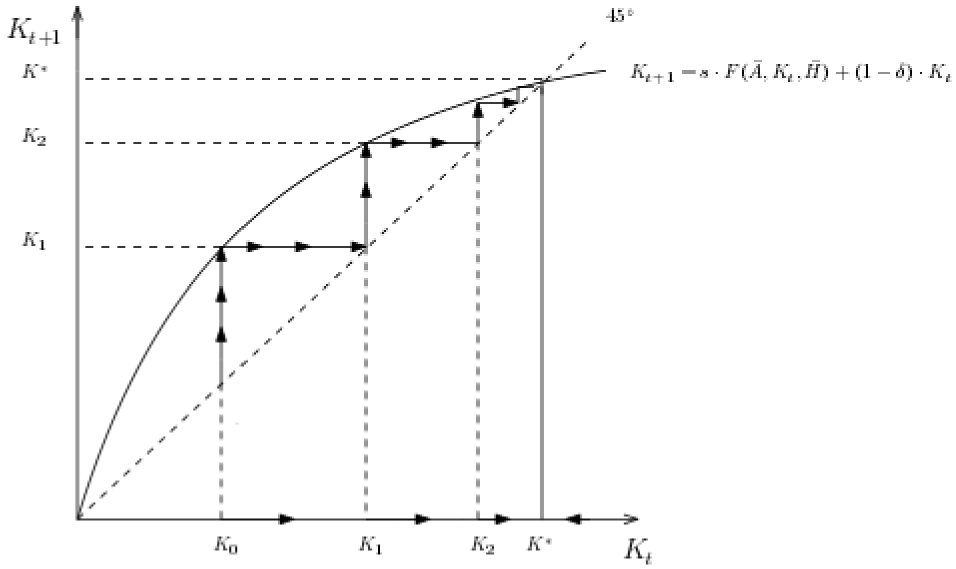

Figure 2. Economic development based on capital accumulation without a poverty trap. The figure illustrates the growth process as described by a discrete-time version of the Solow (1956) model with a constant human capital stock and constant technology.

2.2 The case of multiple equilibria and poverty traps

In contrast to the case of a unique steady-state equilibrium in high-income countries, market imperfections, externalities, and coordination failures between different agents might imply the presence of multiple steady-state equilibria in low-income countries. The multiplicity of equilibria means that some economies will be caught in a poverty trap. In such a poverty trap, income is much lower than it could be at the high-income steady state (described in the previous paragraph) because endogenous forces push the economy back into a low-income equilibrium.

Two potential mechanisms that sustain poverty traps are:

(i) **Health:** The general health status of the population could be very low due to widespread infectious diseases. Consequently, life expectancy might be so low that private investments in education do not pay off (Ben-Porath, 1967; Cervellati and Sunde, 2005, 2013). In this situation, building schools is not an effective development strategy because there is simply no investment return on education.

(ii) **Population growth:** In a country in which the majority of the population lives close to subsistence levels, an increase in income (e.g., by a technological improvement or by foreign aid inflows) primarily leads to a higher net rate of reproduction over the subsequent periods. The associated faster population growth puts additional strain on private and public investments, resulting in declines of physical and human capital whereby the economy remains trapped in the low-income equilibrium.

For an overview of different mechanisms that lead to the emergence of poverty traps see, for example, Galor and Weil (2000), Bloom et al. (2003a), Azariadis and Stachursky (2005), Galor (2005, 2011), Strulik et al. (2013), and Bloom et al. (2017).

Straightforward extensions of the baseline arguments of Solow (1956) and Diamond (1965) allow for a qualitative analysis of the dynamics of poverty traps. This analysis helps clarify why physical capital accumulation alone might not lift an economy out of poverty and why investments in human capital and fertility reduction are more promising. The canonical case of the dynamics of economic development in the presence of a poverty trap is shown in Figure 3. There are three intersections between the K_{t+1}-curve and the 45° line such that three qualitatively different steady-state equilibria emerge. One steady-state equilibrium is at the origin, where the capital stock K'^* is low and the economy is poor. Another equilibrium is at the capital stock K^*, which corresponds to the prosperity equilibrium shown in Figure 2. In between these two equilibria, there is an unstable steady-state equilibrium, where the vertical red line intersects the K_{t+1}-curve. If the economy starts with a capital stock that is lower than the capital stock corresponding to the level indicated by the vertical red line, the economy is caught in the basin of attraction of the poverty trap, and converges to the low-income steady-state (as indicated by the arrows in the diagram). Any policy that fails to raise the capital stock to a value above the vertical red line is insufficient to catalyze sustained growth.

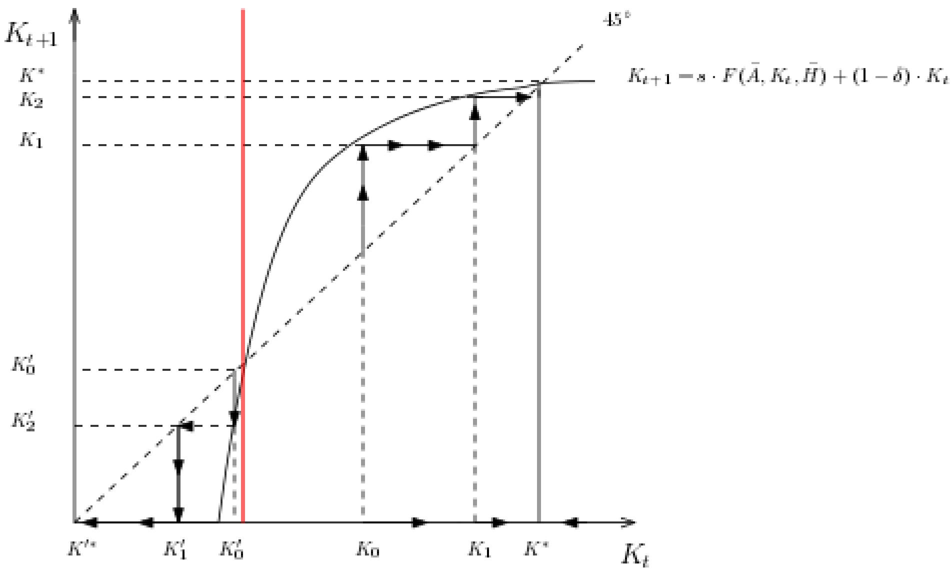

Figure 3. Illustration of a possible poverty trap. If the initial stock of capital is located to the left of the vertical red line, the capital stock decreases over time and the economy shrinks towards the origin that represents the poverty trap.

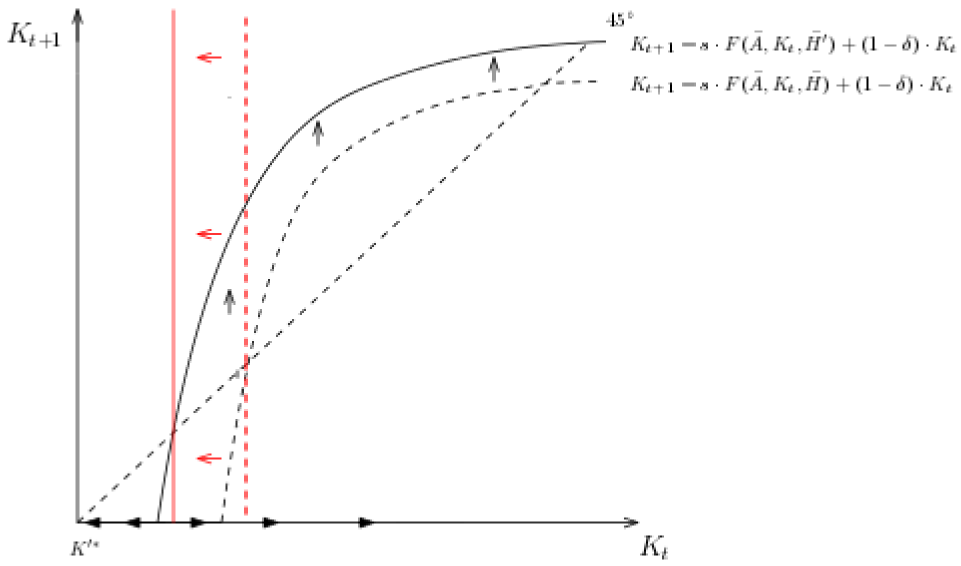

Figure 4. Illustration of the effects of a policy that raises $\overline{H}$ in case of the presence of a poverty trap. The K_{t+1}-curve shifts upwards such that the basin of attraction of the poverty trap shrinks as compared to Figure 3.

There are two fundamentally different approaches to escaping such a poverty trap. The first is to invest massively in the accumulation of physical capital, whereby the economy ends up with a capital stock to the right of the vertical red line and in the basin of attraction of the high-income steady state. This "big push" strategy has been used as an argument in favor of immense foreign aid packages and expenditures on large infrastructure projects (cf. Murphy et al. 1989). The second way to overcome the poverty trap is represented by policies targeted at increasing productivity $\bar{A}$ and/or human capital $\overline{H}$ to shift the K_{t+1}-curve upwards. This shift leads to a shrinking basin of attraction of the poverty trap, as illustrated in Figure 4 in which $\overline{H}$ increases to $\overline{H'}$. Such an upward shift could be caused by investments in education, health, or fertility reduction. The next section discusses the particular pathways by which enhancing human capital may foster economic growth and reviews the empirical evidence in support of these mechanisms.

3. Literature Overview on the Qualitative and Quantitative Results of Different Investments

3.1. Pathways and Qualitative Findings

The following pathways have been suggested in the literature as explanations of the growth effects of education investments: better educated individuals i) are more productive and, therefore, contribute more to aggregate output (Psacharopoulos, 1994; Hall and Jones, 1999; Bils and Klenow, 2000; Psacharopoulos and Patrinos, 2004, 2011); ii) more readily embrace the adoption of productivity-enhancing technologies from abroad (Nelson and Phelps, 1966; Bloom et al., 2015); iii) are more likely to establish successful and productive firms (Cabral and Mata, 2003; Bhattacharya et al., 2013; Gennaioli et al., 2013); and iv) increase the productivity of their team members through spill-over effects (Lucas, 1988; Battu et al., 2003). Furthermore, a substantial body of macroeconomic literature finds education to be a key determinant of economic growth, suggesting that the education's impacts on individual productivity aggregate up to greater total productivity at the country level (see, for example, Barro 1991; Sala-i-Martin, 1997; Hanushek and Kinko, 2000; Krueger and Lindahl, 2001; Sala-i-Martin et al. 2004; de la Fuente and Domenech, 2006; Cohen and Soto, 2007; Hanushek and Woessmann 2012, 2015).

Similar pathways suggest that investments in health pay off over and above the increases in longevity and reductions in morbidity that are beneficial at the individual level. The following channels receive particular attention in the literature: i) healthier workers are more productive and contribute more to aggregate output (Fogel, 1994, 1997; Shastry and Weil 2003; Weil, 2007; Bloom et al, 2018); ii) healthier children tend to perform better in school, which enhances their potential for human capital accumulation (Miguel and Kremer, 2004; Bleakley and Lange, 2009; Field et al., 2009; Bleakley, 2010, 2011; Baldanzi et al., 2017; Bloom et al., 2017); iii) healthier individuals are more inclined to educate themselves and to invest (Ben-Porath, 1967; Kalemli-Ozcan, 2000; Bloom et al., 2003c, 2007, 2014; Cervellati and Sunde, 2005, 2013; Prettner, 2013); and iv) health investments that cure or prevent infectious diseases (such as vaccination) have positive spillovers to other individuals (Luca et al., 2018). Here, too, the positive effect found in micro-based studies is consistent with the macro-based evidence that health is an important determinant of economic growth (Barro 1991; Sala-i-Martin, 1997; Sala-i-Martin et al. 2004; Lorentzen et al., 2008; Suhrcke and Urban, 2010; Aghion et al., 2011; Cervellati and Sunde, 2011; Bloom et al., 2014; Bloom et al., 2018).

In addition to enhancing productivity, investments in education and health facilitate escape from fertility-induced poverty traps. Poor countries tend to have much higher youth dependency rates than wealthier countries. Supporting the basic needs of a relatively large child population imposes a substantial resource burden, necessitating the diversion of resources from other productive investments and ultimately impeding economic growth. While this high youth dependency partly reflects high infant and child mortality, it is primarily driven by the high fertility rates in these settings. As women become healthier, more educated, and more empowered, and as their expectations regarding child mortality improve, they tend to have fewer children, which helps to escape fertility-induced poverty traps and to converge onto a development path with low fertility and sustained economic growth (see Becker et al., 1990; Galor and Weil, 2000; Galor, 2005, 2011; Diebold and Perrin, 2013a, 2013b; Bloom et al. 2015; Prettner and Strulik, 2017 for the theoretical mechanisms and Brander and Dowrick, 1994; Ahituv, 2001; Li and Zhang, 2007; Herzer et al., 2012 for empirical evidence). The economic gains from lowering fertility (known as the "demographic dividend") can be sizable (Bloom and Williamson, 1998; Bloom et al., 2003b, 2017, Golley and Tyers, 2015 and Misra, 2015). In addition, published research has revealed a second demographic dividend due to ageing (Mason and Lee, 2007), wherein persons expecting to live longer accumulate more assets in order to smooth consumption in old age.

3.2. Quantitative Results from the Literature

Quantitative assessments of the return on investment (ROI) in health, education, and fertility show that their impacts on productivity are sizeable. Psacharopoulos (1994), Hall and Jones (1999), Bils and Klenow (2000), and Montenegro and Patrinos (2014) demonstrate that, on average, income is 10% higher for each additional year of schooling. Psacharopoulos and Patrinos (2018) estimate even higher returns for low-income countries. In particular, average private rates of return to schooling are highest in Latin America and the Caribbean and for sub-Saharan Africa and lowest for Europe, the Middle East, and Northern Africa. Table 2 illustrates the findings of four prominent studies regarding education and growth of per capita GDP. The relation between schooling and growth is positive and ranges from 0.2 to 12.5% per each additional year of schooling with most of the estimates clustering in the rage of 0.5% to 1.2%. A 25 point improvement in PISA score, a measure of educational quality, is similarly associated with a 0.5 percentage point (pp) increase in annual GDP per capita growth. These improvements in education may have a positive spillover effect on health as well (Pradhan et al., 2017, p. 424).

Table 2. Selected prominent studies on the relation between one-year increases in schooling and per capita GDP growth in percentage points

Sources	Relation with per capita GDP growth	Time frame	Coverage
de la Fuente and Domenech (2006, p. 28)	0.574 - 1.151% per schooling year	1960-1990	World
Cohen and Soto (2007)	1.05 - 1.26% per schooling year	1960-1990	World
Lutz et al. (2008, Fig. S1, Supplements)	0.2-12.5% per schooling year	1970-2000	World
Hanushek and Woessmann (2012)	0.5% per 25 PISA test score points	1960-1990	World

The effects of health improvements on economic growth are quantified by Fogel (1997), Shastry and Weil (2003), and Weil (2007). Fogel (1997) provides historical evidence that improved nutrition (as observed over the period from 1780 to 1980 in Great Britain) raised the productivity of the workforce by 95%. Weil (2007) estimates that a 10% increase in the adult survival rate leads to a 6.7% increase in productivity per worker and a 4.4% increase in GDP per worker. The results of Shastry and Weil (2003) imply that differences in adult survival rates can explain even one third of cross-country variation in GDP per worker. The macroeconomic estimates of Bloom et al. (2018) lie in between the results derived by Shastry and Weil (2003) and Weil (2007) based on the aggregation of microeconomic effects. Bloom et al.'s results indicate that a 10% increase in the adult survival rate leads to a 9.1% higher productivity per worker. Measuring the causal impact of health on economic growth is a difficult task that requires tackling measurement and endogeneity issues. The results of selected studies that address these problems are included in Table 3.

Table 3. Selected prominent studies on the relation between increases in life expectancy and GDP per capita (or income) growth

Sources	Effect on growth	Time frame	Region
Bloom et al. (2014, p. 1364)	A 1-year increase in life expectancy raises per capita income between 5 and 15%over a 60- year period	1940-2000	World
Bloom et al. (2004)	A 1-year increase in life expectancy is associated with a 4% increase in long-run per capita output	1960-1990	World
Aghion et al. (2011, Table 5)	A 1% increase in life expectancy at birth is associated with 2.88-9.46% higher growth	1960-2000	OECD
Cervellati and Sunde (2011, p. 130)	A 1% increase in life expectancy at birth in post demographic transition countries is associated with a 1.94-4.14% higher growth rate	1940-2000	World
Bloom et al. (2018, p. 16)	A 10% increase in adult survival rates is associated with an increase in labor productivity of 9.1%	1960-2010	World
Weil (2007, p. 1291)	A 10% increase in adult survival rates is associated with an increase in labor productivity of 6.7%and thus GDP per worker of 4.4%	-	Australia, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden and the UK
Shastry and Weil (2003, p. 394)	Changes in health can explain 19% of cross-country differences in per capita income	-	World

Ashraf et al. (2013) simulate output trajectories for different demographic scenarios and show that a reduction in the total fertility rate (TFR) of 0.5 children per woman raises per capita GDP by 11.9% after 50 years. Assuming linearity in the dependence between economic growth and fertility reduction, this implies that a fall of the TFR by one child leads to an economic growth rate that is 0.45 pp higher (see also Bloom et al., 2017). For Asian countries, the results of Bloom and Williamson (1998) and Bloom and Finlay (2009) suggest that one-third of East Asia's "growth miracle" is due to the demographic dividend that followed the strong decline in fertility in these countries. This corresponds to an increase in GDP per capita growth by about 0.66% for each one-child reduction in the TFR. Even small changes in infant mortality, wherein lower fertility rates follow increased survival rates, may lead to a substantial rise in growth (see effects from the selected studies in Table 4).

Table 4. Demographic dividends

Sources	Effects found	Time frame	Region
Bloom and Williamson (1998, p. 435-437)	A 1% higher growth rate of the working-age population is associated with an increase of 1.37-1.46% in the growth rate of GDP per capita	1960-1990	East and Southeast Asia
Bloom and Finlay (2009, p. 58)	A 1% higher growth rate of the labor force is associated with an increase of 1.665% in the growth rate of GDP per capita	1965-2005	World

We also analyzed literature that studied the relationship between infrastructure spending and economic growth. Influential works of Barro (1990) and Canning and Pedroni (2008) suggest that government spending—and infrastructure spending in particular—may enhance economic development and growth. Other findings (Crafts, 2009) suggest that the effect is heterogeneous and that other countereffects may outweigh the positive ones.

4. Empirical Analysis

The estimates presented in the previous section are drawn from a variety of sources that make use of different country samples, time frames, controls, and datasets (of varying quality). Furthermore, these studies utilize different econometric methods and take different types of costs and benefits into account. As such, these results are helpful for discerning the general impacts of different types of expenditures but do not lend themselves easily to straightforward comparisons of the relative ROI across sectors.

One main virtue of the original empirical analyses presented in this paper, is that they estimate the impact of health, fertility, education, and infrastructure on GDP per capita simultaneously and under an internally consistent methodological framework. These analyses are able to better isolate the different relationships of interest and estimate their magnitudes in fully comparable manner. Our empirical strategy[12] is based on growth regressions in both cross-country and panel data settings. Cross-sectional analyses are used to capture cumulative relationships over a relatively long time horizon. Here we use initial levels of explanatory variables to explain economic growth over the following time period as a means of addressing issues of reverse causality. However, this does not control for confounding factors that may influence both initial levels of explanatory variables and subsequent growth, and thus does not fully address endogeneity concerns. As such, dynamic panel data methods are used to better infer about causal impacts over a five-year interval.

The cross-country regressions explain annual per capita GDP growth rates between 1980 and 2015 as a function of initial income, share of equipment investments, initial levels of life

[12] An alternative strategy would be a micro-simulation using a general equilibrium model as in Kabajulizi et al. (2017) and Mohammed (2018), where the causal impact of expenditures are modelled for Uganda and Algeria, respectively. However, due to calibration issues, these simulations are generally better suited for specific countries, rather than for large cross-country samples. Thus, in order to provide a broader analysis, we base our empirical approach on the well-established growth regression framework.

expectancy, mean years of schooling, total fertility rate, electricity usage per capita (a proxy for infrastructure), share of the population working aged (i.e., age 15-64) to control for the initial demographic structure, and political rights (a proxy for institutions).[13] In order to be consistent with the presence of poverty traps (described above) our data should exhibit multiple equilibria. As such, before we proceed to the formulation of the empirical strategy, we test the income data for the presence of multiple equilibria, or thresholds.

Three well-established modality tests are applied: the original Silverman (1981) test; the improved Hall and York (2001) test, specifically tuned for unimodality testing; and the Fisher and Marron (2001) test, which is superior in handling outliers. These tests reveal mixed evidence in favor of unimodality for GDP per capita analyses of 1960: the Hall and York (2001) test does not reject unimodality, whereas the Fisher and Marron test does. However, both tests reject unimodality in favor of bimodality for 1980 and 2015 numbers. From Figure 5, it follows that the 1980 modes are located in proximity to 8.02 and 10.2, corresponding to the low- and high-income equilibria respectively. The antimode of 8.8 for 1980 serves as a virtual borderline between these two regimes. Notably, the threshold test for the multiple equilibria analysis points at 8.38, close to the antimode in 1980. For 2015, the modes are located in proximity to 8.21 and 10.71. This indicates that the income distribution has shifted higher, but maintained bimodality, making the threshold analysis valid throughout the period.

Another interesting observation is the increase in dispersion among LMICs: reflecting the fact that countries like China, Indonesia, and South Korea moved to upper quartiles within LMIC group, while other countries experienced very little growth. Strikingly, only South Korea managed the transition from the low-income equilibria in 1980 to the high-income equilibria in 2015. Understanding the modality and the implications of the presence of different income regimes is crucial for the estimation strategy, since the effects may have different magnitudes for different regimes (and may even offset each other).

Table 5. Testing income modality

log GDP p.c.	Hall and York (2001) / Silverman (1981)	Fisher and Marron (2001)
	H0: Unimodality	
1960	0.08	0.044
1980	0.042	0.039
2015	0.043	0.028
	H0: Bimodality	
1980	0.96	0.662
2015	0.486	0.243

Note: for all tests 1000 bootstrapping rounds are conducted; support is derived from the range of the sample

[13] More attention is due to nonlinearities in these relationships (e.g., the diminishing returns to education) and interaction terms between variables (e.g., that investments in education may increase productivity to a greater extent when a population is healthy). However, inclusion of these extra terms did not improve the predictive power of the models developed in this paper, possibly due to the relatively small sample of countries.

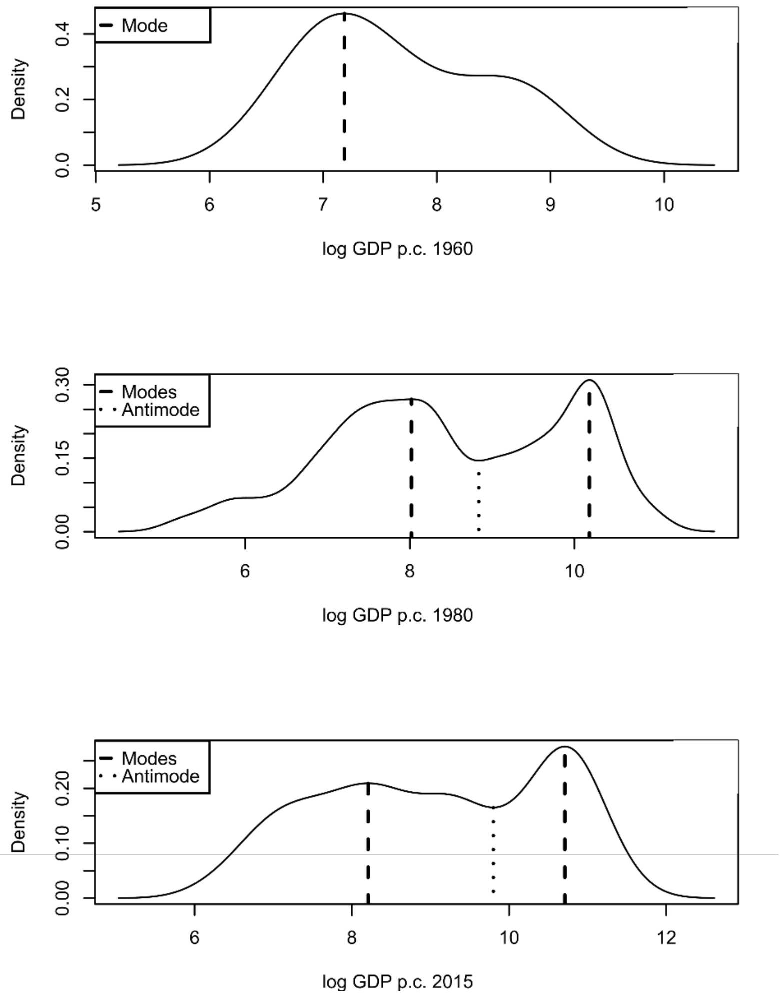

Figure 5. Evolution of the log of GDP p.c. distribution from 1960 to 2015; same sample of 69 countries used for the estimation; critical bandwidths used from 1960, 1980 and 2015: 0.41, 0.26 and 0.4.

In order to address the problem of poverty traps, we apply single and multiple equilibria empirical strategy. The equation for the single equilibrium approach allows for one single set of coefficients:

$$\bar{y}_{i,T-t_0} = \beta_0 + \beta_1 y_{i,t_0} + \beta_x X_{i,t_0} + u_{i,T-t_0},$$

whereas the multiple equilibria approach, as in Hansen (2000), allows for multiple (in this case, two) sets of coefficients:

$$\bar{y}_{i,T-t_0} = \begin{cases} \theta_{10} + \theta_{11} y_{i,t_0} + \theta_{1x} X_{i,t_0} + u_{i,T-t_0} & q_i \leq \gamma \\ \theta_{20} + \theta_{21} y_{i,t_0} + \theta_{2x} X_{i,t_0} + u_{i,T-t_0} & q_i > \gamma \end{cases}$$

where $\bar{y}$ is the annual growth rate of GDP per capita between time t_0 and T, y is income at time t_0, X is a matrix of growth determinants at time t_0, u is the error term, i are the country subscripts, and β and θ denote the coefficients of interest, whereas γ and q_i denote the threshold and the threshold variable. We use the initial levels of the selected growth determinants (i.e., their values at t_0) to limit the influence of endogeneity and reverse causality on the estimated coefficients. For the threshold variable, we use logarithm of initial income in order to distinguish between countries around the low- and high-income equilibria.

In the single equilibrium estimations (Table 6, column 1), fertility was the most powerful predictor of growth. In this specification the only other significant effects were the convergence effects and the share of equipment investments. However, the single equilibrium approach may be problematic due to the fact that effects may vary in magnitude and sign across different segments of the data; the multiple equilibria analysis in Table 6 (columns 2 and 3) separately estimates effect magnitudes for low- and high-income countries (for the list of countries, see Appendix, A1). The threshold between low- and high-income countries, γ, is determined during the estimation.[14] This reflects bimodality of income persistent during the period of our analysis (as shown above).[15] For the countries in the low-income equilibrium, the following variables were significant: initial income, share of equipment investments, life expectancy, fertility, working age population share, and the share of rural population. A 10% increase in life expectancy for the low-income countries is linked to a 0.39 pp increase in average annual per capita GDP growth over the following 35 years. Increasing mean years of schooling by one year is in turn linked to a 0.27 pp increase in annual growth. Decreasing TFR by one child per female is associated with a 0.5 pp and 1 pp increase in growth for low- and high-income countries, respectively. No empirical evidence of heteroscedasticity was found and standard errors were used for both estimation strategies.

[14] The multiple equilibria analysis presented in Table 6 assumes two regimes, reflecting the bimodal income distribution evidenced above.

[15] Implementing these analyses assuming a larger number of regimes would be problematic due to the sample size.

Table 6. Single (1) and multiple equilibria (2 and 3) analysis; annual GDP p.c. growth rates during 1980-2015

Variables	(1) Overall	(2) Low	(3) High
log of GDP p.c., 1980	-0.0128***	-0.0169***	-0.0143**
	(0.00285)	(0.00424)	(0.00600)
log of GDP p.c., 1960	-0.00435	-0.00268	-0.00832
	(0.00318)	(0.00487)	(0.00525)
equipment investments share (DeLong and Summers, 1991)	0.101*	0.184*	0.108
	(0.0505)	(0.0992)	(0.0693)
log of life expectancy, 1980	0.00927	0.0390**	-0.0470
	(0.0176)	(0.0193)	(0.0470)
mean years of schooling, 1980	0.00105	-0.000953	0.00273***
	(0.000744)	(0.00115)	(0.00105)
fertility, 1980	-0.00992***	-0.00521*	-0.0103**
	(0.00229)	(0.00304)	(0.00511)
log of electricity usage p.c., 1980	0.000483	0.00144	0.00359
	(0.00178)	(0.00185)	(0.00442)
working age population share, 1980	-0.000412	0.00203**	-0.00106
	(0.000564)	(0.000934)	(0.000916)
rural population share, 1980	-2.60e-05	-0.000292*	2.78e-05
	(7.72e-05)	(0.000169)	(9.68e-05)
political rights (Gentil, 1987 and Barro, 1991)	0.00123	0.00177	0.00145
	(0.000990)	(0.00118)	(0.00186)
Constant	0.168*	-0.0752	0.458*
	(0.0992)	(0.129)	(0.249)
Observations	69	69	69
R-squared	0.679		
R-squared adj.	0.624		
Breusch-Pagan test (p value)	0.884		
Threshold (log of GDP p.c., 1980)		8.38	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Initial income is an intuitive variable for determining thresholds in the multiple equilibria analysis. However, other variables can be used to delineate thresholds as well: for example, Bloom and Canning (2007) focused on mortality traps and distinguish equilibria using life expectancy data. The state of the country with respect to the demographic transition can also be used to differentiate equilibria. Although correlated with income, the timing of a country's demographic transition can provide additional perspective regarding variation in the determinants of economic growth among demographic transition forerunners, followers, trailers, and latecomers (Reher, 2004). Bimodality of fertility transitions is plausible and the Hall and York (2001) and Fisher and Marron (2001) tests both reject unimodality, with p-values of 0.022 and 0.0002, respectively. According to the threshold analysis, forerunners and followers belong to one regime, whereas trailers and latecomers belong to the other. Table 7 shows that using thresholds based on the timing of the demographic transition produces effect estimates that correspond reasonably well to those produced using initial income: for trailers and latecomers, life expectancy is significant and positive, and for forerunners and followers, mean years of schooling is the most significant determinant. Once again, fertility is significant and negative for both regimes, whereas life expectancy shows a negative effect for forerunners and followers.

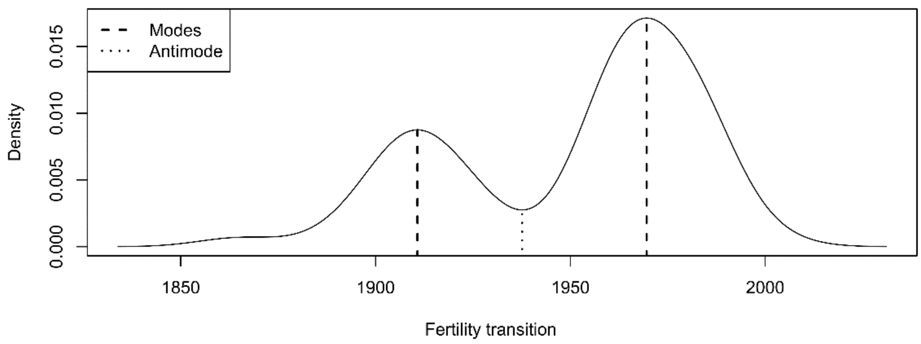

Figure 6. Fertility transition years as in Reher (2004); sample of 58 countries; critical bandwidth: 10.35.

Table 7. Multiple equilibria analysis; annual GDP p.c. growth rates during 1980-2015

	Transition after 1960	Transition before 1960
	(4)	(5)
Variables	Trailers and latecommers	Forerunners and followers
log of GDP p.c., 1980	-0.0176***	-0.0125***
	(0.00362)	(0.00473)
log of GDP p.c., 1960	0.00217	-0.00788*
	(0.00381)	(0.00464)
equipment investments share (DeLong and Summers, 1991)	0.186**	0.0825
	(0.0886)	(0.0598)
log of life expectancy, 1980	0.0379**	-0.123***
	(0.0175)	(0.0410)
mean years of schooling, 1980	0.000251	0.00287***
	(0.00103)	(0.000804)
fertility, 1980	-0.00822***	-0.0192***
	(0.00245)	(0.00466)
log of electricity p.c. usage, 1980	-4.28e-05	0.00113
	(0.00172)	(0.00327)
working age population share, 1980	0.000436	-0.000851
	(0.000799)	(0.000764)
rural population share, 1980	-0.000152	-6.42e-05
	(9.46e-05)	(0.000108)
political rights (Gentil, 1987 and Barro, 1991)	0.00126	0.00222
	(0.00101)	(0.00145)
constant	-0.00114	0.788***
	(0.109)	(0.199)
Observations	58	58
Threshold (fertility transition)	1960	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To further minimize endogeneity bias and overcome other problems typical to cross-country growth regressions, we also construct a strongly balanced panel dataset encompassing 55 countries for the time span 1990-2015. In this estimation, we include the lag of GDP per capita to control for the convergence process and use five-year averages of the explanatory variables to smooth out business-cycle fluctuations,[16] alleviate measurement errors, and focus on short-run effects. Panel data growth equations are estimated using the system generalized method of moments (SGMM) estimator (Blundell and Bond, 1998), treating all explanatory variables as endogenous. Explanatory variables are all lagged by one 5-year time period and time fixed effect are included.[17] The dynamic threshold panel model from Dang et al. (2012) is used to apply the single and multiple equilibria approach for the panel data. This model is superior to non-dynamic threshold panel models, such as Hansen (1999), because it enables the usage of dynamic instruments for potentially endogenous regression, including the autoregressive term.

[16] As noted in Durlauf et. al (2005), 5-year aggregation is a well-established practice in dynamic panel data estimation of growth regressions.
[17] Due to collinearity, it was possible to control for the 2010-2015 period for both estimation models.

The latter is a crucial control for the convergence effect. We use the same set of variables as in the cross-country regressions with an exception of fixed capital investments share, which is not available for the given time span and country sample. Controlling for the lagged income should at least partly account for the stock of physical capital and therefore the absence of the latter control should not pose a major issue. The dynamic threshold panel model from Dang et al. (2012) takes the following form:

$$y_{i,t} = (\rho_1 y_{i,t-1} + \pi_1 X_{i,t-1}) I_{\{q_{i,t} \leq c\}} + (\rho_2 y_{i,t-1} + \pi_2 X_{i,t-1}) I_{\{q_{i,t} > c\}} + v_{i,t}$$

where i and t are country and time indices with 5-year periods, y is log of GDP per capita, X is a matrix of determinants and controls, I is the indicator function for the regime attribution below or above the threshold, c (1 for low-income and 2 for high-income), ρ and π are coefficients and $v_{i,t}$ is the composite error term.

In the single equilibrium dynamic panel data estimation, fertility is the only significant predictor of economic growth: a one-unit decrease in TFR in the current 5-year period is associated with a 4.46% increase in GDP per capita in the next. Thus, the annualized effect of fertility is to increase per capita GDP growth by roughly 0.89 pp. Under the multiple equilibria specification, the dynamic threshold panel model estimates significant effects for multiple variables: for the low-income equilibrium, the annualized effects of TFR, life expectancy and schooling are all significant. A one child decrease in the TFR is associated with a 2.1 pp increase in GDP per capita growth, an additional year of schooling with a 0.7 pp increase, and a ten percent increase in life expectancy with a 1.1 pp increase. Notably, the threshold[18] for the given estimation lies close to 7.142, which is lower than in the cross-section threshold growth regressions and, therefore, these effects can be interpreted as best applying to very low-income cases.[19] In general, the short-run effects using the dynamic threshold panel model confirm the importance of health, education, and fertility in these settings.[20]

[18] The Hansen (1999) model estimates similar values validating these results.

[19] At least 12 countries from our sample would fall in this category at different time periods: Bangladesh, Benin, Cameroon, China, Congo (Dem. Rep.), Cote d'Ivoire, Ghana, India, Kenya, Myanmar, Nicaragua, and Nigeria. For the list of countries see Appendix, A2.

[20] In addition, we conducted an impulse-response analysis [see Figure A8] using panel vector autoregressions to cross validate the effects in the short run using 3-year periods and explicitly address the impact of health and education expenditures on economic growth. The orthogonal cumulative impulse-response functions suggest that after 15 periods (45 years) the impact of health expenditures would prevail.

Table 8. Single (6) and multiple (7 and 8) equilibria SGMM estimation; 5-year log GDP p.c. levels, 1990-2015

Variables	(6) Overall	(7) Low	(8) High
log GDP pc (t-1)	0.939***	0.913***	0.860***
	(0.0329)	(0.230)	(0.0629)
log life expectancy (t-1)	0.111	0.583*	0.125
	(0.107)	(0.317)	(0.120)
years of schooling (t-1)	0.00337	0.0360**	-0.00257
	(0.00503)	(0.0179)	(0.0105)
fertility (t-1)	-0.0446*	-0.103***	-0.0312
	(0.0250)	(0.0369)	(0.0345)
working age population share (t-1)	0.00764	0.000382	0.00786
	(0.00634)	(0.0154)	(0.00740)
log of electricity p.c. usage (t-1)	-0.0203	-0.199	0.0647
	(0.0371)	(0.235)	(0.0813)
rural population share (t-1)	-0.000134	-0.00697	0.000413
	(0.00136)	(0.00474)	(0.00124)
political rights (t-1)	-0.0100	-0.0205	-0.0164
	(0.00880)	(0.0229)	(0.0186)
Time dummies	x	x	
Observations	275	275	
Countries	55	55	
Arellano-Bond test for AR(2)	0.117	0.838	
Hansen test p-value	0.999	0.999	
Threshold (log of GDP p.c.)		7.142	
Difference-in-Hansen tests			
GMM levels, exclusion		0.997	
GMM levels, difference		0.888	
IV instruments, exclusion		0.999	
IV instruments, difference		0.188	

Robust two-step corrected errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To summarize, health and demography are again the most powerful predictors for economic growth and, thus, should be considered as priorities in policymaking. Schooling follows in terms of magnitude and robustness. Altogether, these results are consistent with the theoretical model suggesting that policies to reduce fertility, increase health, and bolster education are effective in helping an economy to escape from a poverty trap. The results are also consistent with the literature discussed in section 3.

5. Sub-sector Prioritization

The literature suggests that returns to education differ by education level and income setting. The Psacharopoulos and Patrinos (2018) meta-analysis shows that primary education is associated with a particularly high ROI in LMICs. The social return on investment in primary education is 22% in low- and 17% in middle-income countries, while the return on investment is substantially lower for secondary and tertiary education (see Table 9). This is consistent with the findings of Mingat and Tan (1996) and Petrakis and Stamatakis (2002), who show that low-income countries benefit most from investments in primary education. Investing in high quality pre-primary education can also have huge positive returns, even in very low-income settings (Lomborg, 2018). Returns to girls' education are generally higher than those for boys' education and have important spillover effects through reducing TFR (Fink and Peet, 2016).

Table 9. Social returns to investments in education, 1960-2014

	Low income	Middle income
	Public	
Primary	22.08%	17.10%
Secondary	18.10%	12.79%
Tertiary	13.18%	11.44%

Source: Meta-study of *Psacharopoulos and Patrinos (2018)*

In general, policies aimed at reducing gender inequality could be highly effective in boosting growth. Table 10 lists multiple studies suggesting that eliminating gender-based education gaps could yield approximately a 1% increase in economic growth. In addition, improvements in female education are associated with decreasing fertility, which has demonstrable effects on economic growth.

Table 10. Impacts of improving outcomes for women and girls

Source	Effects found	Time frame	Region
Bhalotra and Rawlings (2011)	Significant negative relationship between mothers' health and neonatal infant and child mortality, low body weight of the newborn, and stunting	1970-2000	38 developing countries
Albanesi and Olivetti (2016)	Improvements in maternal mortality and infant feeding substantially increased female labor force participation and decreases years lost due to disability	1920-1990	US
Klasen (2018, pp. 292-294)	Eliminating gender gaps in education would boost economic growth at least by 0.8-1%	1960-2000	South and East Asia
Abu-Ghaida and Klasen (2004, p. 1082)	A one-year increase in female years of schooling reduces fertility by 8-13%	1975-2015	45 developing countries
Klasen (2004, p. 370)	Closing gender gaps in education would increase economic growth by at least 0.9%	1960-1992	World

Altogether, particularly successful strategies for low-income countries would be targeted investments in women's education, such as ensuring the universal primary education of girls (see also Bloom et al. 2017b, 2018b), targeted interventions in women's health, such as iodine supplementation and HPV vaccination (Field et al., 2009; Bloom et al., 2015; Luca et al. 2018), and other female-targeted health and education investments, which tend to have substantial knock-on effects in the form of fertility reduction.

The clearest, most up-to-date, and comprehensive results informing prioritization of health interventions come from the non-sector-specific findings of the Copenhagen Consensus, which are discussed in the next section.

6. Copenhagen Consensus Findings

The Copenhagen Consensus[21] (CC) Center's Post-2015 Consensus Project brought together economists and experts from the UN, NGOs, and the private sector to produce over 100 literature-informed reports on the effectiveness of the development targets proposed by the UN's Open Working Group. The group of reports were reviewed by an expert panel that prioritized the interventions according to their value offered per dollar spent, including the value of discounted[22] disability-adjusted life years. The aggregated research results of the Post-2015 Consensus priorities rank the returns to one US dollar spent from 2015 to 2030 on meeting these targets (Lomberg, 2018). The list of top ranked interventions, provided in Table 11, highlights targets within general health, reproductive health, education, and other domains that merit particular focus. It is worth noting that many of the CC's recommended interventions have proven fairly stable over time: increasing availability of family planning, reducing under-nutrition among preschoolers, expanding access to tuberculosis treatment, promoting malaria prevention and treatment, and providing aspirin to reduce heart attack risk all ranked among the top 20 interventions in the previous two lists of CC recommendations released in 2008 and 2012.

Certain measures in the health sector can be listed as top priorities according to their returns: Nugent and Brouwer (2018) note that aspirin therapy at the onset of acute myocardial infarction can yield up to a 31 US dollar return, mainly due to extremely low costs; reducing salt content in manufactured foods by at least 30% would yield 19 US dollars; increasing tobacco prices by 125% through taxation would return around 10 US dollars; chronic hypertension management for medium- to high-risk patients with at least 50% coverage could yield up to 7 US dollars; and secondary prevention measures for cardiovascular diseases with at least 70% coverage could yield up to 3 US dollars. The above-mentioned returns are related to noncommunicable diseases, yet communicable diseases are also considered a top priority: Raykar (2018) states that reducing malaria incidence by 50% could yield up to a 36 US dollar return; Geldsetzer et al. (2018) report that such measures as increasing circumcision coverage to at least 90% of HIV-negative adult men would yield up to 28 US dollars; and increasing the antiretroviral therapy coverage to at least 90% amongst HIV-infected adults would yield around 10 US dollars of return. In addition, according to Kohler and Behrman (2018), universal access to sexual and reproductive health services and meeting the need for modern contraception could yield up to a 120 US dollar return. With respect to overall returns to decreasing mortality, Jha et al. (2018) indicate that reducing premature mortality by 40% in low-income countries (LICs) could yield at least a 13 US dollar return, whereas a decrease in premature mortality by the same magnitude

[21] The Copenhagen Consensus was established in Denmark in 2004 to respond to various global challenges and is now run by the U.S. non-profit Copenhagen Consensus Center. The 2015 conference focused on establishing sustainable development goals for the following 15 years.
[22] In most studies, the discount rate of 3% was used.

in a larger group of lower-middle-income countries (LMIs) would yield at least a 3 US dollar return–a tripling of the invested amount.

Prioritization of expenditures with respect to education is more complicated, yet a list of priorities from the Post-2015 Consensus can be derived as well: Psacharopoulos (2018) notes that an increase in preschool enrollment in sub-Saharan Africa from the present 18% to 59% could yield up to a 33 USD return for each dollar spent, whereas an increase in their primary education enrollment from 75% to 100% could yield up to a 7 USD return per dollar. The returns to other spheres of education are more volatile and have a higher uncertainty, though in the latter study, increasing completion rates at other levels of education (e.g. secondary) is also mentioned as a priority.

The above-mentioned priorities related to health and education should be considered in a broader context that also includes measures related to nutrition, food security, and corruption. The values in the table show that all these measures have very high returns above 100%.

Table 11. Top 10 post-2015 Consensus priorities

Category	Sub-category	Return to 1 USD
Reproductive health	Universal access to sexual and reproductive health (SRH)	120
Nutrition	Reduce by 40 per cent the number of children under 5 who are stunted	60
Illicit financial flows	Reduce to zero the legal persons and arrangements for which beneficial ownership info is not publicly available	49
Population and Demography	Reduce barriers to migration within low- and middle-income countries, as well as between low- and middle-income countries and high-income countries	45
Health	Reduce Tuberculosis deaths by 95% and TB incidence by 90%	43
Health	Delay artemisinin resistance greater than 1% and reduce malaria incidence using bed nets by 50%	36
Food security	Increase investment in agricultural R&D by 160%	34
Education	Increase the preschool enrollment ratio in sub-Saharan Africa from the present 18% to 59%	33
Health	Aspirin therapy at the onset of AMI (75% coverage)	31
Health	In hyper-endemic countries, attain circumcision coverage of at least 90% amongst HIV-negative adult men	28

7. Conclusions

During the last seventy years, many LMICs have experienced transformational economic growth while others experienced moderate to non-existent development gains. Governments of developing countries that have made substantial progress can take advantage of the resource expansion that came with their past growth experiences and invest in health, education, and infrastructure to promote further economic growth. Countries that have made only modest improvements can draw lessons from these disparate growth outcomes, in order to improve their growth trajectory going forward.

Using an intuitively accessible Solow model in discrete time, we show that i) investments in physical capital (e.g., infrastructure investments) could help a country escape a poverty trap and develop along a balanced growth trajectory only in the case of a “big push” scenario, while ii) investments in health and human capital would change the dynamic system and lift the balanced growth trajectory upwards, reducing the basin of attraction of the poverty trap, and making the transition to sustained growth easier.

We carry out our empirical analysis based on cross-sectional and dynamic panel data threshold regressions during the overall time frames from 1980 to 2015. Empirical analyses across multiple data sets, time frames, controls, and econometric estimators yields four main findings relevant to policymakers in LMIC settings:[23]

(1) **A one-child decrease in TFR** corresponds to a 2 pp increase in annual GDP per capita growth in the short-run (5 years) and 0.5 pp higher annual growth in the mid- to long-run (35 years).

(2) **A ten percent increase in life expectancy at birth** corresponds to a 1 pp increase in annual GDP per capita growth in the short-run and 0.4 pp higher growth in the mid- to long-run.

(3) **A one-year increase in average educational attainment** corresponds to a 0.7 pp increase in annual growth in the short-run and 0.3 pp higher growth in the mid- to long-run.

(4) **Infrastructure** proxies were not significantly associated with subsequent growth in any of the models estimated.

Given that per capita GDP growth in LMICs generally averages between 2% and 4%, the estimated changes in annual growth provided above are appreciable.[24] The findings of these analyses are generally consistent with the theoretical and empirical literature.

[23] The relationships between these variables likely vary with contextual factors. As such, the results presented should be understood as average, at-the-margin estimates. Additionally, as mentioned above and described in the manuscript, different methodologies are used to estimate short-run and mid- to long-run effects, so conclusions about the timeline of the return on benefits should be made cautiously.

[24] In interpreting these results, it is important to consider the compounding effect of a persistent change in growth over several years. For example, a 1 pp increase in average annual economic growth from 3% to 4% cumulates to GDP per capita that is 3.9 times higher after a period of 35-years rather than 2.8 times higher.

Decisions on prioritizing governmental expenditures for economic growth should consider several factors alongside the average effects of the outcome variables on growth: the effectiveness of spending in improving the outcome variables, the timeline over which the effects of the spending will be realized, and validation using context-specific findings. Applying these metrics, reproductive health and fertility reduction tend to predominate as growth determinants. Policy measures related to this sector are most effective in the short- and medium-term time domains (5-15 years). Improving general health can be particularly effective in the medium term as well;[25] however, most of the returns would be expected in the long run. Education features a longer maturity horizon, although for low-income countries, some effects can be seen even in the middle term. Infrastructure projects have the broadest range in terms of findings and time domain. Our analyses suggest that this category showed less transformative potential than the others, but this does not suggest that a positive relationship between infrastructure spending and economic growth should be completely ruled out.

Priority setting within sectors is equally important: within health and education, investments in decreasing the burden of diseases, HIV and AIDS treatment and prevention, and preschool and primary education (especially for the low-income countries) show the most potential for growth. Growth spending priorities are not limited to these two sectors, as investments in improving gender equality can reduce fertility, increase the stock of human capital, and result in health improvements, all of which promote sustained economic growth.

It is important to consider that all of the results presented in this manuscript represent the average costs or benefits of different interventions and improvements in outcomes across countries, with the original empirical results excluding costs altogether. In reality, both the costs and benefits of achieving improvements in outcomes will vary substantially across settings and within the context of different programs. For example, a program to expand access to birth control may be highly successful in reducing fertility in a locality where unmet need for contraceptives is high, but completely ineffective in another environment where individuals desire a large number of offspring. As such, policymakers must consider the specific binding constraints to development in their settings, as well as the relative cost of the options available for achieving improvements in health, education, fertility, and infrastructure, in order to make sound assessments of their relative ROIs. Ultimately, the decision over which interventions will best promote economic growth remains highly contextual but well-informed decisionmakers should benchmark their expectations relative to the cross-country development experience of the last several decades.

[25] See Table 8 for the panel data results and the related middle-term effects.

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Appendix

A1. List of countries for Table 5

Cross-section	
Low-income equilibria	High-income equilibria
Algeria	Argentina
Bangladesh	Australia
Benin	Austria
Bolivia	Belgium
Cameroon	Brazil
Colombia	Canada
Congo, Rep.	Chile
Cote d'Ivoire	Costa Rica
Dominican Republic	Cyprus
Ecuador	Denmark
El Salvador	Finland
Ghana	France
Guatemala	Germany
Honduras	Greece
India	Hong Kong
Jamaica	Ireland
Jordan	Israel
Kenya	Italy
Korea, Rep.	Japan
Malaysia	Mexico
Mauritius	Netherlands
Morocco	Norway
Mozambique	Panama
Nepal	Portugal
Nicaragua	Singapore
Pakistan	Spain
Paraguay	Sweden
Peru	Switzerland
Philippines	Trinidad and Tobago
Senegal	Turkey
Sri Lanka	United Kingdom
Thailand	United States
Tunisia	Uruguay
Zambia	Venezuela
Zimbabwe	

A2. List of countries for Table 7

Panel data	
Low-income equilibria	High-income equilibria
Bangladesh	Algeria
Benin	Argentina
Cameroon	Australia
China	Austria
Congo (Dem. Rep.)	Belgium
Cote d'Ivoire	Bolivia
Ghana	Brazil
India	Canada
Kenya	Chile
Myanmar	Colombia
Nicaragua	Congo, Rep.
Nigeria	Costa Rica
	Cuba
	Cyprus
	Denmark
	Dominican Republic
	Ecuador
	Egypt
	El Salvador
	Finland
	France
	Gabon
	Germany
	Guatemala
	Honduras
	Hong Kong
	Iceland
	Indonesia
	Iraq
	Ireland
	Israel
	Italy
	Jamaica
	Japan
	Jordan
	Korea, Rep.
	Luxembourg
	Malaysia
	Malta

Mexico
Morocco
Netherlands
New Zealand

Table A3. Descriptive statistics for expenditure levels by quartiles of initial income

Levels of expenditures		
Variable	Average, %	Coefficient of variation, %
A. First quartile based on initial income		
GDP p.c. growth rates	4.595	0.4488
Health expenditures	10.013	0.2861
Education expenditures	3.794	0.3206
Infrastructure expenditures	0.860	1.8053
B. Second quartile based on initial income		
GDP p.c. growth rates	3.351	0.2965
Health expenditures	11.712	0.2818
Education expenditures	4.254	0.1842
Infrastructure expenditures	0.464	0.5925
C. Third quartile based on initial income		
GDP p.c. growth rates	1.767	0.4095
Health expenditures	13.930	0.1727
Education expenditures	5.045	0.1837
Infrastructure expenditures	0.665	0.5416
D. Fourth quartile based on initial income		
GDP p.c. growth rates	1.414	0.2859
Health expenditures	14.027	0.1430
Education expenditures	5.411	0.2529
Infrastructure expenditures	0.756	0.5136

Note: initial income is measured in 1995 in logarithms; GDP p.c. growth rates are measured during 2005-2015; expenditure levels are measured as share of GDP in 1995-2005.

Table A4. Descriptive statistics for expenditure growth rates by quartiles of initial income

Growth rates of expenditures		
Variable	Average, %	Coefficient of variation, %
A. First quartile based on initial income		
GDP p.c. growth rates	4.595	0.4488
Health expenditures	9.450	0.7100
Education expenditures	7.187	0.6691
Infrastructure expenditures	29.582	1.1028
B. Second quartile based on initial income		
GDP p.c. growth rates	3.351	0.2965
Health expenditures	5.362	0.5202
Education expenditures	4.522	0.4745
Infrastructure expenditures	30.800	1.0902
C. Third quartile based on initial income		
GDP p.c. growth rates	1.767	0.4095
Health expenditures	2.900	0.3624
Education expenditures	2.671	0.8032
Infrastructure expenditures	22.825	1.6432
D. Fourth quartile based on initial income		
GDP p.c. growth rates	1.414	0.2859
Health expenditures	2.319	0.4375
Education expenditures	2.779	0.7172
Infrastructure expenditures	10.142	0.6191

Note: initial income is measured in 1995 in logarithms; GDP p.c. growth rates are measured during 2005-2015; expenditure growth rates are measured in 1995-2005

Figure A5. Health Expenditures vs. per capita GDP Growth (outliers removed)

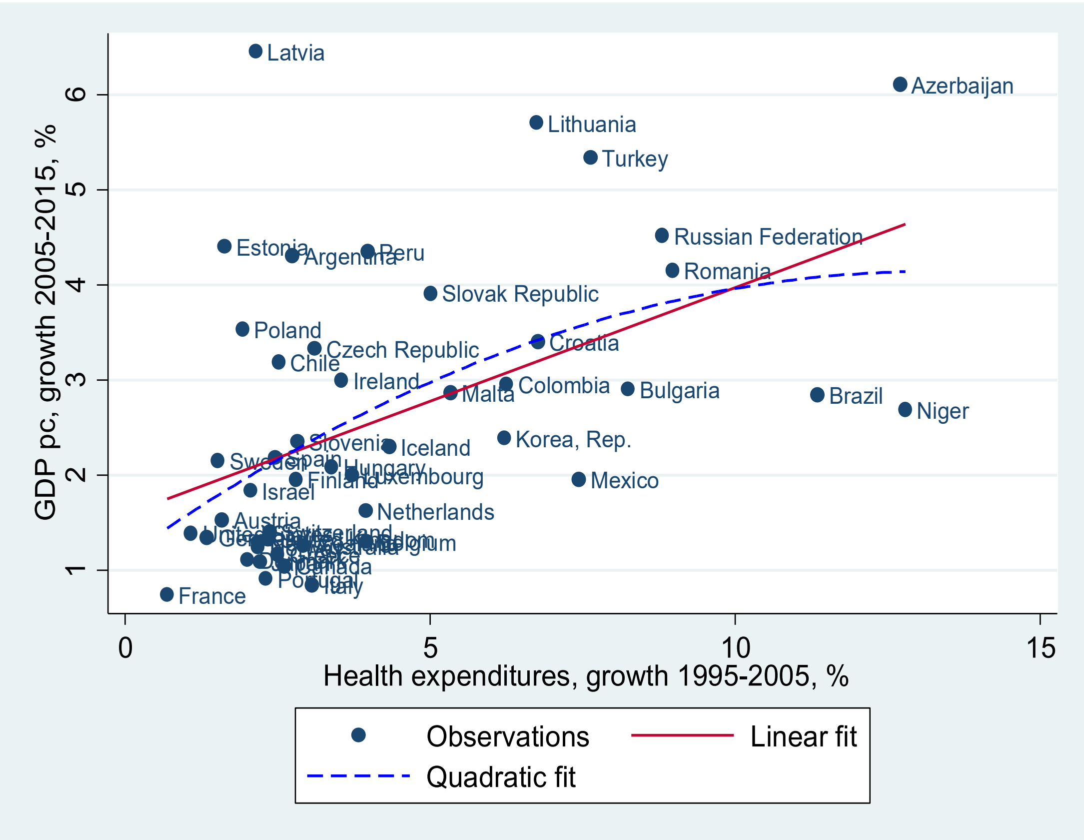

Figure A6. Education Expenditures vs. per capita GDP Growth (outliers removed)

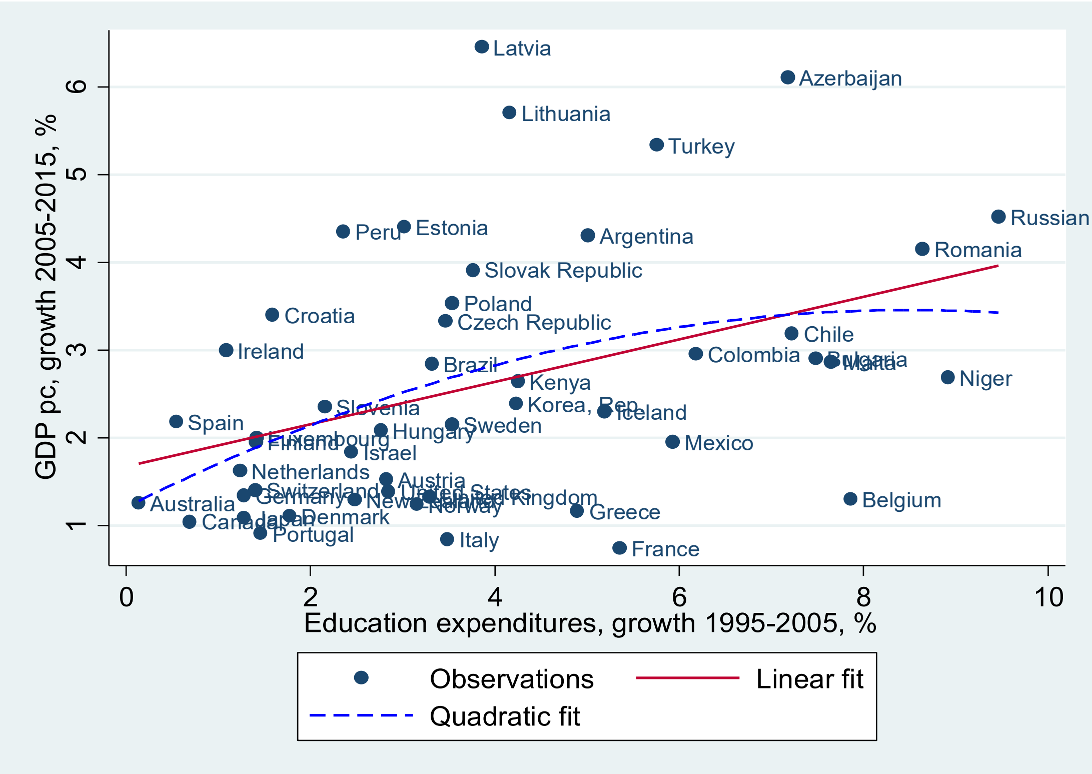

Figure A7. Infrastructural Expenditures vs. per capita GDP Growth (outliers removed)

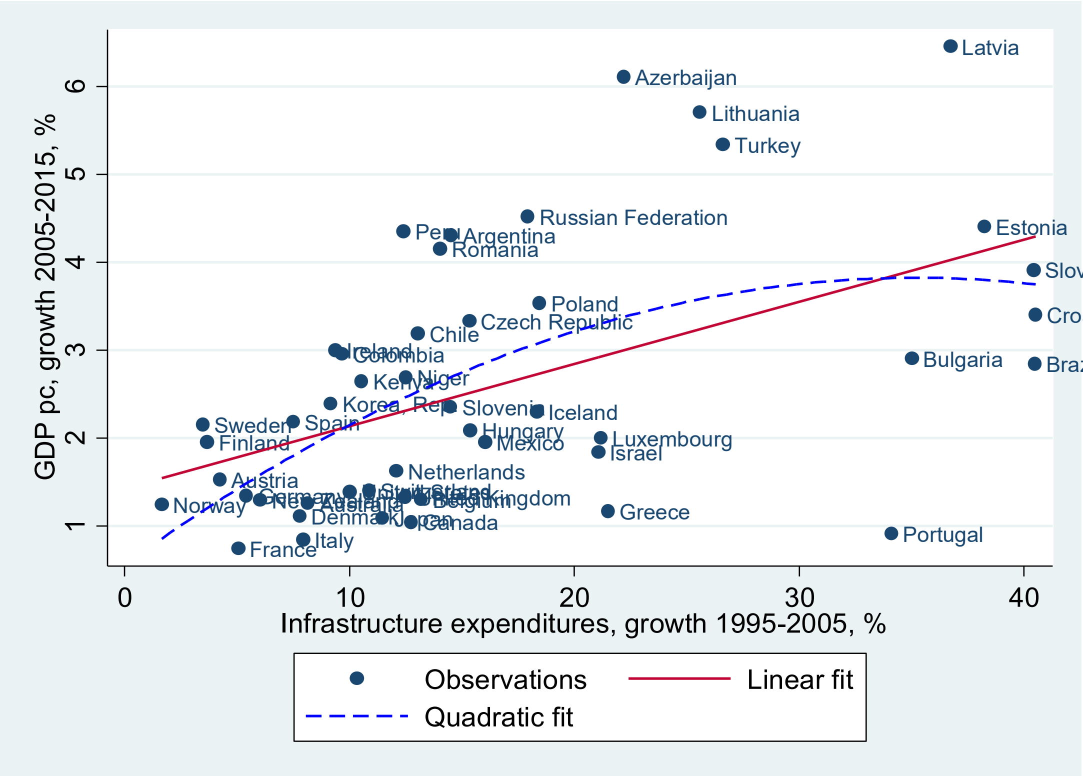

Figure A8. Panel VAR cumulative impulse-response functions for health and education expenditures using 3-year periods