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The impact of investing in children: assessing the cross-country econometric evidence

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Executive summary

This paper examines the hypothesis that increases in public expenditure which translate into benefits for children have a positive impact on economic growth and a negative impact on inequality. This may be due to the avoidance of irreversible disadvantage to a person's future productivity, mitigation of the intergenerational transfer of poverty, and reduction of future costs to health, education and social welfare systems.

The paper uses two sets of cross-country econometric analysis. The first examines whether government expenditure has a significant positive effect on commonly observed child-welfare indicators, controlling for per capita GDP and certain other factors known to affect child welfare. The second then examines whether increases in child-welfare indicators have a significant impact on economic growth or trends in inequality, controlling for other factors known to affect growth and inequality.

Thirteen child-welfare indicators are included in the analysis, including infant and child survival, pre-primary, primary and secondary school enrolment, primary school completion, immunisation against DPT and measles, births attended by skilled personnel, and access to water and sanitation. In addition, the effects of six different sectors of government expenditure are considered: health, education, housing and community amenities, social protection, agriculture, and transport and communications.

The paper's main findings are as follows:

- Government expenditure on directly relevant sectors has a positive effect on at least some child-welfare indicators. In particular, education expenditure has a positive effect on enrolment in pre-primary school, health expenditure has a positive effect on immunisation against measles and DPT, while housing and community amenities expenditure has a positive effect on access to water.
- Government expenditure on other, less directly relevant sectors also has a positive effect on at least some child-welfare indicators. In particular, health expenditure has a positive effect on primary enrolment, while agriculture expenditure has a positive effect on access to water.
- These effects of government expenditure do not appear to vary according to standard measures of the quality of a country's institutions or governance.
- 'Output-related' child-welfare indicators have a positive effect on 'outcome-related' indicators. In particular, immunisation against DPT and measles, and births attended by skilled personnel have a positive impact on child and infant survival rates.
- Certain child-welfare indicators have positive effects on economic growth. These include child survival, gross primary and secondary enrolment, net secondary enrolment, primary school completion, and births attended by skilled personnel.
- Certain child-welfare indicators also have positive effects on reductions in inequality. These include child survival, gross secondary enrolment and immunisation against DPT.

Overall, the results caution against an overly pessimistic view of the effect of public expenditure. They also make clear that public investment in children is not solely a matter of meeting basic rights; it is also a matter of economic importance. It would be wrong to treat education and health expenditure as purely 'social' and distinct in its effects from 'productive' expenditure such as agriculture. Likewise, it is not only social expenditure which can accelerate human development. These insights can complement more detailed country-specific analysis of policy design and resource allocation at the national-level.

1. Introduction

1.1 Aims and motivation

This paper explores some of the evidence surrounding the links between public expenditure, child welfare, economic growth and inequality in developing countries. The underlying hypothesis is that increases in public expenditure which translate into benefits for children have a positive impact on economic growth and a negative impact on inequality. This may be for various reasons, including the avoidance of irreversible disadvantage to a person's future productivity, mitigation of the intergenerational transfer of poverty, and the reduction of future costs to health, education and social welfare systems.

The paper contributes to the evidence on the links between government spending, child welfare, economic growth and inequality through econometric analysis of cross-country (i.e. national-level) data. Due to the complex and limited nature of intergenerational data, and the general perception of children as either a special interest group or as a sub-group of a homogenous population, many attempts to use empirical analysis to map out this link between investments in children and growth have been limited to looking at specific sectors. These include the many analyses of the returns to education for example. Arguably, there have been far fewer attempts to map out the link at the multi-sectoral or macro-level.

The ultimate aim of the paper is practical: to ensure that the decisions made by aid donors and national governments regarding the allocation of public resources are made on the basis of sound evidence. A secondary aim is to contribute to the extensive debate on what the cross-country econometric evidence says about the links between government spending, child welfare, growth and inequality.

1.2 Methodology

This paper undertakes two main sets of econometric analysis. The first examines whether government expenditure has a significant effect on certain commonly observed child-welfare indicators. This involves regressing the levels of such indicators in a given year on the levels of public expenditure in different sectors in the same year, controlling for levels of per capita GDP and certain other variables known to affect child welfare. The second set of analyses then examines whether increases in child-welfare indicators have a significant impact on economic growth or trends in inequality. This involves first regressing the rate of economic growth over a given period on certain child-welfare indicators, controlling for the various other factors that affect growth. The regression is then repeated using trends in income inequality rather than economic growth as the dependent variable, and controlling for the various other factors thought to affect inequality.

It is important to note that we do not assume that the government expenditures which affect children are only, or even mostly, those that target them directly, such as education. In a similar way, it is accepted that poverty-reducing expenditures are not necessarily limited to the social sectors (Paternostro et al., 2005). Likewise, we do not assume that the so-called 'productive' or 'economic' sectors of government expenditure are the only ones to provide returns to economic growth. Instead, we examine the effects of expenditure in a range of so-called 'economic' and 'social' sectors.

It must be noted at the outset that there are certain caveats to the methods used in the paper, which add to our understanding and interpretation of the results. First, there are numerous significant determinants of children's welfare status, other than government expenditure. These include factors such as gender, mother's health, household incomes and assets, the institutional framework at the sector level, and factors such as conflict and other exogenous shocks.[1] Only a sub-set of these can be observed for a sufficiently large number of countries to be used as control variables in the analysis. This raises problems of omitted variable bias and spurious correlation which the analysis can only partly control for. There is also a possibility that some of the control variables used in the analysis are endogenous: for example, while per capita GDP may be an important determinant of child-welfare indicators, it may also be affected by some of those indicators.

Second, there are various factors which influence the effect of public expenditure on child welfare. For example, the impact of increased public spending on health or education on children's health and education outcomes will often depend on how that spending affects private spending within these two sectors. Another possible mediating factor is the efficiency of public financial management and of the public sector itself. Differences in efficiency in these areas between countries mean that an identical increase in health or education spending need not have the same effect on health or education outcomes. A third potential mediating factor is levels of government spending in complementary areas: for example, infrastructure investments might be needed to realise returns to health expenditure, or education investments might precede breakthroughs in reducing infant mortality (Mehrotra 2004). Finally, there is the possibility that the effectiveness of spending varies according to macro-economic conditions, including the overall state of the economy and fiscal deficit.[2]

The methodology used in this paper can of course be complemented by the wide variety of research that uses microeconomic data or qualitative analysis. One example of this is the Young Lives project (www.younglives.org.uk), which collects longitudinal data from surveys of approximately 8,000 children in four countries (initiated in 2001 to run until 2016), and provides an opportunity to analyse policy change using household panel data. For policy application the methodology in this paper should be complemented by country-specific studies, using either time-series or sub-national level (e.g. district level) data, which can take more account of specific country characteristics than is generally possible with cross-country analysis.

Other methods used to measure returns to investments in children include cost-benefit analysis and specific project impact evaluations. However, many of these approaches are limited by the availability of sufficient qualitative and quantitative panel data. Knowles and Behrman (2005), for instance, take a life-cycle approach to cost-benefit analysis and find that the information available on the returns to various government programmes is insufficient except for only a few investments. The Chronic Poverty Research Centre's work on intergenerational poverty explores a range of methods for analysing the impact of child poverty on future generations. This includes work by Moore (2005) which suggests taking a livelihoods approach to measuring the intergenerational transfer of assets and capital, both positive (i.e. savings, education) and negative (i.e. debts, HIV transmission), through both private and public transfers.

Two final caveats require mentioning. First, it is also acknowledged that there are several reasons for investing in children aside from potential impacts on economic growth or inequality. These include the fact that children represent at least half of the total number of people living in poverty (UNICEF, 2000); that they are disproportionately poor compared to adults (Barrientos and de Jong, 2004); that investing in children has the potential to divert intergenerational poverty transfers (Harper and Marcus, 2003); that investment is needed to ensure fulfilment of child rights (e.g. the UN Convention on the Rights of the Child includes the right to survival and to develop to the fullest); and the moral and ethical motivations of improving the well-being of those who lack adequate power to claim their own rights. Second, we acknowledge that impacts of investing in children on economic growth do not necessarily translate into poverty reduction due to differences in the type of growth that occurs. However, by

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[1] For a detailed theoretical exploration of a wide range of these variables, see the Childhood Poverty Research and Policy Centre; http://www.childhoodpoverty.org/

[2] This is for reasons related to the political nature of national resource allocations, involving bargaining, negotiation and incrementalism: cuts in public spending, for example, tend to be aimed at recurrent inputs such as textbooks or drugs that often account for a sector's level of effectiveness, rather than salaries and big investment projects, which are generally more protected politically or slower to be altered.

focusing also on the impact of increases in child welfare on trends in inequality, we are at least able to say something about the degree to which growth is likely to translate into poverty reduction, and be pro-poor.

1.3 Structure of paper

The remainder of the paper is structured as follows. Section 2 presents the main findings from a literature review. Section 3 then presents the analysis of the impact of government expenditure on child-welfare indicators; section 4 the impact of child-welfare indicators on economic growth, and section 5 the impact of child-welfare indicators on inequality. Finally, section 6 summarises the results contained in sections 3-5 and their relation to previous work, and outlines the implications for policy and for further research in this area.

2. Literature review

Prior to the empirical analysis, a literature review was carried out to examine the scope of existing econometric studies on the links between public expenditure, child outcomes, and growth (Save the Children, 2006). The literature was divided into three parts: that which analyses the effect of investing in early childhood development, that which analyses the impact of government expenditure on child health and education outcomes, and that which assesses the impact of child outcomes on growth and equity. The findings are briefly summarised here.

2.1 Investing in early childhood development

Several studies compare the evidence of returns to investment in different stages of a child's development. The majority conclude that investments at an early stage of a child's life ensure cumulative developmental benefits that would otherwise be irretrievably lost. Returns to investment are therefore high, since deficiencies during childhood in many areas (e.g. nutrition) cannot be adequately compensated for in adulthood. Instead, those deficiencies cause irreversible physical and cognitive defects that impact on a child's ability to contribute productively to the economy as an adult (Harper, 2005). Stunting, for example, is irreversible after a child is two years old; in turn, such children are likely to exhibit reduced working capacity and a higher susceptibility to disease in adulthood, and can have increased complications during childbirth (UNICEF, 2006).

Alderman and King (2006) summarise evidence from several studies that also show that investing in health and nutrition as early as possible in a child's life has significant long-term human capital and economic returns. For example, one study shows that if pre-schoolers in rural Zimbabwe grew at the same rate as children of the same age in a developed country, they would be 3.4 centimetres taller and would have completed an additional 0.85 grades of schooling by adolescence.

The 2006 *World Development Report* (World Bank 2005a) also highlights the high returns to investment in early childhood development. It argues that disadvantages in opportunity transform into reduced access for children to the goods and services required for their progress, thereby impacting on their future productivity and country's development, and that children's unrealised potential translates into a country's lower economic growth. One illustration of the impact that poverty can have on early childhood development is obtained from a survey of Ecuadorian children, which shows that while test scores for vocabulary recognition at the age of three were similar across all socio-economic groups, by the age of five median test scores for children in the bottom quartile had diverged substantially from those of the top quartile (Paxson and Schady, 2005).

2.2 Health and education outcomes

There is a large literature on the determinants of health and education outcomes, much of which includes analysis of the effects of government spending in relevant sectors: for example, the impact of public education spending on education outcomes. Most of these studies regress some measure of child health or education outcomes on levels of public health or education expenditure, GDP per capita, and a range of other variables that are thought to affect children's health or education.

Studies of the determinants of health and education outcomes are not broadly conclusive about the effects of government spending. In particular, few studies are overwhelmingly positive about the impacts of public health spending on health outcomes. One notable study (Filmer and Pritchett, 1999) finds that 95% of the differences in child survival rates across countries can be explained by factors other than public health spending; the latter was only 'very tenuously' linked to improved health outcomes. Regarding the impacts of education spending, Al-Samarrai (2002) finds that public education expenditure generally has no statistically significant effect on primary school enrolment. He argues that differences in private education spending, the effectiveness of the public-expenditure management system, and the composition of public education spending, are the most likely reasons for the absence of a link. Hanmer and Naschold (2000) also find no significant relationship between school expenditure per student and primary enrolment.

2.3 Economic growth and equity outcomes

The literature on the effects of child-welfare outcomes on economic development is more comprehensive. This literature demonstrates that there is strong evidence that a country's level of child survival is positively correlated with its subsequent economic growth (e.g. Barro and Sala-i-Martin, 2005); there is also evidence that higher rates of school enrolment raise growth (e.g. Mankiw et al., 1992). There is also an extensive literature on the links between investing in education and the resulting long-term effects on economic growth through such factors as higher wage rates and reduced fertility, which are still debated (e.g Murrugara, 1999; Schultz, 2003). There is also some evidence that improvements in child outcomes can reduce inequality (Li et al., 1998).

The overall conclusion of the literature review is that further research examining the relationship between government expenditure in a wide range of sectors that may benefit children, and the subsequent impact of increased child welfare on economic growth and inequality, can make a useful contribution to the development literature.

3. Effects of government expenditure on child indicators

This section presents our analysis of the impact of government expenditure on children. Thirteen indicators of child welfare are considered: infant survival, child survival, enrolment in pre-primary school, enrolment in primary school (gross and net), enrolment in secondary school (gross and net), primary school completion, immunisation against DPT, immunisation against measles, births attended by skilled personnel, the proportion of households with access to water, and the proportion of households with access to sanitation (Table 1). These indicators fall into two main groups. The first consists of what might be termed 'final outcome' measures, and includes infant survival and child survival. The second group consists of indicators which are arguably better thought of as outputs rather than outcomes.[3] These include pre-primary, primary and secondary school enrolment, primary school completion, immunisation against DPT and measles, births attended by skilled personnel, and

[3] 'Outputs' refer to the amount of goods and/or services provided by a government and consumed by households, while 'outcomes' refer to the goals that are promoted by providing the good or service. These are the standard definitions of the terms used in public expenditure analysis (see, for example, Foster and Fozzard, 2000: 30-31).

household access to water and sanitation. Note that each child indicator is expressed so that an increase in its value represents either an increase in a final welfare outcome, or an increase in a relevant output.

We also consider the effects of six different sectors of government expenditure: health, education, housing and community amenities, social protection, agriculture, and transport and communications. These correspond to IMF government expenditure categories 706, 707, 709, 710, 7042 and 7045.[4]

Table 1: Variable descriptions, child-welfare indicators

Variable	Description
Infant survival	Children surviving to age 1, proportion of total live births
Child survival	Children surviving to age 5, proportion of all children surviving to age 1
Pre-primary enrolment, gross	Children attending pre-primary school, proportion of relevant age group (0-6)
Primary enrolment, gross	Children attending primary school, proportion of relevant age group (6-11)
Primary enrolment, net	Children of relevant age group (6-11) attending primary school, proportion of total
Primary completion	Children of official graduation age successfully graduating from primary school, proportion of total
Secondary enrolment, gross	Children attending secondary school, proportion of relevant age group (12-17)
Secondary enrolment, net	Children of relevant age group (12-17) attending secondary school, proportion of total
Immunisation, DPT	Children ages 12-23 months who have been vaccinated against diphtheria, pertussis and tetanus, proportion of total
Immunisation, measles	Children ages 12-23 months who have been vaccinated against measles, proportion of total
Births attended by skilled personnel	Deliveries attended by personnel trained to give the necessary supervision, care, and advice, percentage of total
Access to water	Population with reasonable access to an adequate amount of water from an improved source, proportion of total
Access to sanitation	Population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta, proportion of total

Source: World Bank (2005b).

3.1 Specification

Our basic approach is to follow the econometric method used in recent work by Filmer and Pritchett (1999) and various others (e.g. Al-Samarrai, 2002; McGuire, 2006). This involves regressing the level of a child-welfare indicator in a given year on the level of per capita income in that year, the level of public expenditure (typically, or as a share of GDP) on a relevant sector (e.g. health or education) in that year, plus certain other control variables thought to affect children's welfare. The basic hypothesis is that, for any given level of per capita income, a higher level of public expenditure on the relevant sector raises child-welfare indicators.

In algebraic terms, the basic estimating equation is as follows:

$$h_{it} = \alpha + \beta_1 y_{it} + \beta_2 G_{it} + \beta_k Z_{it} + \varepsilon_{it} \quad (1)$$

[4] For information on more disaggregated items of expenditure included within these overall categories, see IMF (2001: 79-110). Of those which are less self-explanatory, housing and community amenities expenditure includes spending on housing development, community development, water supply and street lighting. Social protection expenditure includes spending on sickness and disability payments, old-age and survivors' pensions, family and child allowances, unemployment benefits, housing grants, social inclusion, and payments to victims of natural disasters. These expenditure classifications provided by the IMF have remained constant over the period of analysis.

where h_{it} is the level of some child-welfare indicator in country *i* in year *t*, y_{it} is the level of real per capita GDP in that country and year, G_{it} is the level of government expenditure as a share of GDP on the relevant sector, Z_{it} is a vector of observed control variables, and ε_{it} includes all other unobserved influences on the child-welfare indicator. The main test of interest, for the purposes of this paper, is whether the coefficient β_2 is positive and significant.

We first estimate Equation (1) for each different child-welfare indicator, in each case defining G_{it} to be the most relevant sector of government expenditure in determining that child-welfare indicator (e.g. health expenditure for infant and child survival, education expenditure for primary and secondary school enrolment). The additional control variables are average years of schooling among men and among women in the adult (ages 25+) population, total population size, size of relevant age group (where relevant), and land area. We also include a set of 33 regional/time-period fixed effects (one for each of 11 regions in three points in time).[5]

We then extend this basic approach in two ways. First, we test whether other less directly relevant types of government expenditure affect each child-welfare indicator. For example, government spending on social protection may raise school enrolment levels by relaxing credit constraints among poor households. Second, we test whether the impact of public expenditure on child-welfare indicators varies according to a measure of the quality of a country's governance and institutions, as measured by a rule-of-law index explained in the following section. Baldacci et al. (2004), for example, find in countries with poor governance, the impact of education expenditure on school enrolment is much reduced, while expenditure on health has no impact on under-5 mortality.

3.2 Data

The child-welfare indicators are taken from *World Development Indicators 2005* (World Bank, 2005b). We use observations which are on average at least ten years apart, centred on the years 1980, 1990 and 2000.[6] In order to improve the fit of the regressions, we convert the level of each child-welfare indicator into its equivalent log odds-ratio. For example, if the primary school enrolment rate is 90%, the equivalent odds ratio is 9, and the log odds ratio is 2.2, while if primary school enrolment is 10%, the equivalent odds ratio is 0.11 and the log odds ratio is -2.2.

Estimates of government spending by sector are taken from *Government Financial Statistics* (IMF, 2005). We measure spending in each sector as a proportion of GDP, which we calculate by multiplying estimates of spending as a proportion of total government spending obtained from the IMF data by estimates of government consumption as a share of GDP (in current prices) from the Penn World Tables (Heston et al., 2002: version 6.1). We assume that the most relevant sectors of expenditure in explaining each of our thirteen child-welfare indicators are as follows:

- housing and community amenities expenditure: access to water and sanitation;
- health expenditure: infant and under-5 survival, immunisation against DPT and measles, births attended by skilled personnel;
- education expenditure: school enrolment, school completion.

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[5] The eleven regions are: West Africa, East and Southern Africa, South Asia, East Asia and Pacific, Middle East, North Africa, Eastern Europe and Central Asia, Western Europe, South and Central America, North America, and the Caribbean. The three points in time are 1980, 1990 and 2000.

[6] To increase sample size, we include observations which refer to the years either side of 1980, 1990 and 2000 if data for these exact years is not available. For some of our child-welfare indicators it would have been possible to increase sample size further, by using observations which are at least five years apart. We chose not to expand sample size in this way, in order to keep the differences in the regression samples used for each child-welfare indicator to a minimum. Note also that we are prevented from using annual data since one of our control variables, average years of schooling, is available at five-year intervals only.

The GDP per capita data are taken from the most recent Penn World Tables, the years of schooling data are from Barro and Lee (2001), the age structure of the population data are from UN (2005), and the governance measure we use is the index calculated by Kaufmann et al. (2003). Clearly, no one measure of governance can be truly accurate across all countries but this index is a common measure of governance used by econometricians, mainly because it is available for a large number of countries and is based on information from a variety of different sources (e.g. surveys of business people, scores provided by rating agencies). It is comprised of six dimensions of governance: voice and accountability; political stability and absence of violence; government effectiveness; regulatory quality; rule of law; and control of corruption.

Table 2: Descriptive statistics, effect of government expenditure on child-welfare indicators

Variable name	Units	Mean	St. dev	Min	Max	N
Infant survival	Log odds ratio	3.12	1.11	0.92	5.84	435
Child survival	Log odds ratio	4.23	1.54	1.30	8.11	422
Pre-primary enrolment, gross	Log odds ratio	-0.94	2.04	-6.51	5.09	249
Primary enrolment, gross	Log odds ratio	2.20	1.89	-1.88	7.72	180
Primary enrolment, net	Log odds ratio	2.50	2.04	-1.59	9.77	229
Primary completion	Log odds ratio	1.22	1.62	-2.05	7.01	90
Secondary enrolment, gross	Log odds ratio	-0.02	1.70	-4.48	5.65	311
Secondary enrolment, net	Log odds ratio	0.20	1.53	-3.27	3.72	177
Immunisation, DPT	Log odds ratio	1.28	1.78	-4.60	4.60	251
Immunisation, measles	Log odds ratio	1.21	1.60	-4.60	4.60	231
Births attended by skilled personnel	Log odds ratio	1.06	1.94	-2.53	5.52	56
Access to water	Log odds ratio	1.42	1.07	-0.53	4.60	102
Access to sanitation	Log odds ratio	1.19	1.59	-2.44	4.60	102
Housing and community expenditure	Proportion of GDP (US$ PPP), log units	-5.51	0.87	-7.43	-3.33	160
Health expenditure	Proportion of GDP (US$ PPP), log units	-4.85	0.98	-7.52	-2.55	160
Education expenditure	Proportion of GDP (US$ PPP), log units	-4.03	0.87	-6.18	-2.49	160
Social protection expenditure	Proportion of GDP (US$ PPP), log units	-4.42	1.20	-7.19	-2.07	157
Agriculture expenditure	Proportion of GDP (US$ PPP), log units	-5.08	1.01	-7.39	-2.37	156
Transport and communication expenditure	Proportion of GDP (US$ PPP), log units	-4.79	0.92	-7.49	-2.25	157
Per capita GDP	US$ PPP, log units	8.31	1.04	6.05	10.41	440
Male schooling	Average years of schooling, male (age 25+)	5.22	2.90	0.08	12.45	440
Female schooling	Average years of schooling, female (age 25+)	4.26	3.04	0.00	12.21	440
Population, ages 0-6	Number of persons, log units	14.10	1.54	9.99	18.74	440
Population, ages 6-11	Number of persons, log units	14.02	1.54	10.04	18.85	440
Population, ages 12-17	Number of persons, log units	13.91	1.55	9.85	18.79	440
Population, total	Number of persons, log units	16.02	1.56	12.08	20.96	440
Land area	Square kilometres, log units	16.80	1.99	10.67	20.65	440
Rule-of-law index	z-score, 1998 value	0.20	0.99	-2.09	1.91	440

Notes: Descriptive statistics refer to basic sample of 440 observations for which data on all control variables are available.

Descriptive statistics on all variables used in the analysis are shown in Table 2. Some measures are available for more countries and longer time periods than others. This implies that sample size used in estimating Equation (1) varies according to the child health or education measure being used: between 132 observations (for 75 countries) for the gross secondary school enrolment rate and 31 observations (for 24 countries) for the net secondary school enrolment rate. In all regressions however, the samples include both low and middle-income developing countries (although not always high-income countries), and in most regressions the samples also include countries from each major developing country region (see Appendix Tables A1 and A2). In most cases the samples also include data centred on the years 1980, 1990 and 2000, except for primary completion, births attended by skilled personnel, and access to water and sanitation, where no data centred on 1980 are available.

3.3 Diagnostics and robustness tests

First, we test for heteroskedasticity using the Breusch-Pagan test, and use White-corrected robust standard errors if this test is rejected at the 10% significance level. Second, we test for functional form using the Ramsay regression specification error test. If this test is rejected (at the 10% significance level), we drop observations at each tail of the distribution of the relevant child-welfare indicator until the test is satisfied. Third, we test for outliers by testing the residuals from each regression for normality using the Shapiro-Wilk test. Where this test is not satisfied at the 10% significance level, we exclude from the regression those observations whose standardised regression residual exceeds 2 (in absolute terms).[7] Finally, we test for influential observations by calculating the DF-beta statistics corresponding to the public expenditure variables, and exclude any observations for which the value of this statistic exceeds one in absolute size.[8] We perform the latter two procedures only once, however, so that in some cases the regressions reported below do not satisfy the normality test and/or retain influential observations. These are noted in Tables 3 and 4 and should be treated with more caution than the regressions which do meet the diagnostic tests.

3.4 Results

Table 3 shows the results when estimating Equation (1) for each of our thirteen child-welfare indicators when including in each case only the most directly relevant item of government expenditure in the set of explanatory variables. In ten cases the diagnostic tests for heteroskedasticity, specification error, outliers and influential observations are satisfied (see Appendix Table A1).

For ease of presentation, only the main coefficients of interest are shown (the coefficients on all other variables are shown in Appendix Table A1). However, the regional-time-period fixed effects are in most cases jointly statistically significant at the 5% level or lower, as indicated by the F-test shown in the table. The coefficients on the population and land area variables are also statistically significant in several cases.[9] The results also confirm previous research showing that per capita income has a positive effect on several child-welfare indicators. Of the ten cases meeting the diagnostic tests, its effect is positive and statistically significant at the 1% level in three cases (infant survival, child survival and pre-primary enrolment). The results also confirm previous research showing that, in addition to per capita income, levels of education among adults have a positive effect on several child-welfare

[7] In some cases the Shapiro-Wilk test is satisfied, despite the presence of some large (>3) absolute values of the standardised regression residuals. In such cases we also exclude from the regression those observations whose standardised regression residual exceeds 2 (in absolute terms).

[8] The DF-beta statistic indicates the degree to which a coefficient estimate changes when a particular observation is dropped. It equals the difference between the regression coefficient on an explanatory variable with and without the observation included, divided by the standard error of the coefficient. Defining influential observations as those for which the absolute value of the DF-beta statistic exceeds one is standard practice (e.g. Al Samarrai, 2002).

[9] Land area has a negative and statistically significant effect on infant and child survival and immunisation against DPT, but a positive and significant effect on pre-primary enrolment. The share of children of the relevant age group in total population has a negative impact on infant and child survival, primary school completion, and gross secondary school enrolment.

Table 3: Effects of 'directly relevant' government expenditure on child-welfare indicators

	1 IFS	2 CS	3 PPN	4 PN	5 PNN	6 PCR	7 SN	8 SNN	9 IDPT	10 IMEAS	11 BSKD	12 WTR	13 SAN
Housing and community expenditure	-	-	-	-	-	-	-	-	-	-	-	0.145	-0.150
- p-value												0.13	0.27
Health expenditure	0.002	-0.040	-	-	-	-	-	-	0.249	0.211	0.625	-	-
- p-value	0.97	0.66							0.14	0.03	0.26		
Education expenditure	-	-	0.246	0.148	0.264	-0.429	-0.158	0.218	-	-	-	-	-
- p-value			0.03	0.72	0.00	0.24	0.14	0.42					
No. of observations	107	76	70	74	37	37	132	31	59	49	35	44	38
No. of countries	63	47	45	51	33	29	75	24	45	38	30	29	26
Adjusted R^2	0.91	0.82	0.60	0.24	0.99	0.64	0.84	0.88	0.41	0.66	0.80	0.55	0.72
F-test for region-time period effects	0.00	0.05	0.02	0.92	0.00	0.12	0.00	0.28	0.01	0.00	0.36	0.57	0.03
Diagnostic tests met	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Test for interaction:													
Relevant expenditure, entered separately	0.011	-0.044	0.275	0.147	0.156	-0.727	-0.129	0.266	0.217	0.205	0.629	0.078	-0.217
- p-value	0.81	0.65	0.03	0.73	0.04	0.08	0.23	0.51	0.20	0.05	0.28	0.38	0.17
Interaction with rule of law index	0.008	-0.003	-0.030	0.002	-0.071	-0.161	-0.045	0.012	-0.058	0.011	-0.017	-0.048	-0.049
- p-value	0.53	0.90	0.53	0.99	0.18	0.14	0.18	0.86	0.32	0.74	0.88	0.18	0.36

Notes: Estimation in each case is by ordinary least squares. Other explanatory variables included in each regression are: average years of schooling among men and among women in the adult (ages 25+) population, total population size, the size of relevant age group (except in regressions 12-13), land area, and region and time-period fixed effects. IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PNN=primary enrolment, net; PCR=primary completion; SN=secondary enrolment, gross; SNN=secondary enrolment, net; IDPT=immunisation, DPT; IMEAS=immunisation, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation. For units and descriptive statistics for each variable included in the analysis see Table 2.

Table 4: Effects of six categories of government expenditure on child-welfare indicators

	1	2	3	4	5	6	7	8	9	10	11	12	13
	IFS	CS	PPN	PN	PNN	PCR	SN	SNN	IDPT	IMEAS	BSKD	WTR	SAN
Housing and community expenditure	0.051	0.111	-0.279	0.473	0.251	-0.172	0.031	-0.178	-0.521	0.452	-0.783	0.136	-0.427
- p-value	0.18	0.18	0.00	0.24	0.61	0.60	0.74	0.50	0.01	0.02	0.15	0.39	0.00
Health expenditure	-0.033	-0.086	0.077	0.698	-0.017	0.045	-0.276	0.070	0.448	0.429	0.607	-0.048	0.966
- p-value	0.60	0.53	0.31	0.09	0.90	0.90	0.00	0.79	0.07	0.00	0.35	0.85	0.00
Education expenditure	-0.001	-0.127	0.456	-1.162	0.296	-0.980	-0.039	0.372	-0.270	-0.320	0.928	0.016	-0.461
- p-value	0.98	0.41	0.00	0.09	0.16	0.13	0.78	0.15	0.39	0.05	0.11	0.91	0.02
Social protection expenditure	0.036	0.087	-0.010	0.512	-0.290	-0.043	0.002	-0.165	0.189	0.068	0.311	0.073	-0.416
- p-value	0.28	0.16	0.89	0.26	0.20	0.87	0.98	0.24	0.15	0.41	0.24	0.42	0.01
Agriculture expenditure	-0.028	-0.010	0.006	-0.623	-0.017	1.067	0.116	-0.092	0.006	-0.279	-1.613	0.456	-0.543
- p-value	0.58	0.92	0.95	0.11	0.93	0.04	0.27	0.61	0.97	0.02	0.05	0.15	0.00
Transport and communication expenditure	0.036	0.089	-0.018	-0.133	-0.222	0.025	0.047	-0.580	0.045	-0.159	0.028	-0.230	-0.537
- p-value	0.44	0.36	0.84	0.70	0.31	0.97	0.64	0.06	0.83	0.10	0.94	0.14	0.00
No. of observations	102	71	69	66	36	31	127	32	52	42	33	39	31
No. of countries	62	47	46	47	32	26	74	24	42	34	28	25	23
Adjusted R^2	0.89	0.83	0.65	0.51	0.94	0.87	0.83	0.91	0.52	0.82	0.81	0.65	0.94
Joint test for dummies	0.03	0.07	0.01	0.31	0.06	0.09	0.00	0.26	0.04	0.00	0.39	0.43	0.00
Diagnostic tests met	Yes	Yes	No	Yes	No	No	No	No	No	Yes	No	Yes	No

Notes: Estimation in each case is by ordinary least squares. Other explanatory variables included in each regression are: average years of schooling among men and among women in the adult (ages 25+) population, total population size, the size of relevant age group (except in regressions 12-13), land area, and region and time-period fixed effects. IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PNN=primary enrolment, net; PCR=primary completion; SN=secondary enrolment, gross; SNN=secondary enrolment, net; IDPT=immunisation rate, DPT; IMEAS=immunisation rate, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation. For descriptive statistics on each variable included in the analysis see Table 2.

indicators. In particular, we find that male education has a positive and statistically significant effect on infant survival, pre-primary enrolment and secondary enrolment, while female schooling has a positive and statistically significant effect on immunisation against measles, and access to water and sanitation.

With the effect of government expenditure, the results are mixed. Of the ten cases meeting the diagnostic tests, the coefficient is positive and statistically significant at the 15% level in four cases (pre-primary enrolment, immunisation against DPT, immunisation against measles, and access to water), two of which are also significant at the 5% level (pre-primary enrolment and immunisation against measles). It is also negative and statistically significant at the 15% level in one case (gross secondary enrolment). Nevertheless, although more mixed, there is clear evidence that government expenditure positively affects child-welfare indicators, particularly the output indicators if not the final outcome indicators.

The bottom panel of Table 3 shows the results of testing the hypothesis that the effect of government expenditure on child-welfare indicators varies according to the quality of governance of the country, as measured here by the governance index constructed by Kaufmann et al. (2003). (The regressions are run separately with both the government expenditure variable and its interaction with the rule of law index included. Once again, for ease of presentation only the coefficients on these two variables are shown; the remaining coefficients change little in size.) The main finding to emerge is that there is only one statistically significant relationship between the effect of government expenditure and institutional quality on child-welfare indicators, which is significant at the 15% level only and, contrary to expectation, negative.

Table 4 repeats the regressions in Table 3 but now including all six categories of government expenditure in each regression. Again, for ease of presentation, only the coefficients on the government expenditure variables are shown.[10] The diagnostic tests for heteroskedasticity, specification error and normality are in this case satisfied in much fewer cases, mainly due to the test for influential observations not being satisfied (see Appendix Table A2). For this reason, the results in Table 4 must be treated with caution.

Considering the five regressions in which the diagnostic tests are met (columns 1, 2, 4, 10 and 12), the effect of directly relevant government expenditure on child outcomes is now significant at the 15% level in two cases. The first is the effect of government health expenditure on immunisation against measles (column 10), which is positive, as expected, and similar in size to the effect shown in Table 3. The second is the effect of government education expenditure on gross primary enrolment (column 4), which is negative, contrary to expectation (the effect was not significant in Table 3). The effects of government health expenditure on infant and child survival (columns 1 and 2) are, as in Table 3, generally negative but not statistically significant. The effect of government housing and community expenditure on access to water (column 12) is positive, and similar in size to the effect reported in Table 2, but it is no longer statistically significant.

Table 3 also shows, however, that some categories of government expenditure that are not directly relevant in determining child welfare do, nevertheless, have a statistically significant effect at the 15% level on child-welfare indicators. Considering again the five regressions in which the diagnostic tests are met, three of these significant effects are positive but five are negative. The positive effects are those of housing and community expenditure on immunisation against measles, health expenditure on gross primary enrolment, and agriculture expenditure on access to water. This illustrates the need for policy-makers to consider synergies across sectors and recognise benefits to children that can arise from investment in sectors that might not be considered directly related to child welfare, such as agriculture. The negative effects are those of agriculture expenditure on gross primary enrolment,

[10] The coefficients on per capita income, male and female years of schooling, population size and land area, and on the region-year fixed effects, are in most cases similar in size and statistical significance to those obtained when including only the most directly relevant categories of expenditure (see Appendix Table A2).

transport and communication expenditure on access to water and education, transport and communication, and agriculture expenditure on immunisation against measles. Such negative results might reflect the trade-offs between different expenditure priorities.

3.5 Links between outputs and final child outcomes

As noted above, our child-welfare indicators include both 'final outcome' indicators and 'output' indicators. In this section we investigate the links between these two sets of indicators, focusing on the cases of infant and child survival. Our approach is to re-estimate Equation (1) for infant and child survival, replacing the government expenditure variable with relevant child output indicators. For the latter, we use immunisation against measles and DPT, births attended by skilled personnel and access to clean water and sanitation. All other explanatory variables are left unchanged.[11]

The results are shown in Table 5. Once again only the main coefficients of interest are shown, although the other coefficients are, in most cases, statistically significant (see Appendix Table A3). Note also that the diagnostic tests for heteroskedasticity, specification error, outliers and influential observations are satisfied in all cases (see Appendix Table A3). The main finding to emerge is that three of the child 'output' measures, namely immunisation against DPT and measles, and births attended by skilled personnel, do have positive impacts on infant or child survival, which are statistically significant at the 10% level or lower. By contrast, we do not find any significant impact of access to water or sanitation on infant or child survival.

Table 5: Effects of child 'output' measures on infant and child survival

	1 IFS	2 IFS	3 IFS	4 IFS	5 IFS	6 CS	7 CS	8 CS	9 CS	10 CS
Immunisation, DPT	0.450	-	-	-	-	0.442	-	-	-	-
- p-value	0.00					0.06				
Immunisation, measles	-	0.227	-	-	-	-	0.768	-	-	-
- p-value		0.12					0.00			
Births attended by skilled personnel	-	-	0.719	-	-	-	-	1.351	-	-
- p-value			0.02					0.00		
Access to water	-	-	-	0.058	-	-	-	-	-0.260	-
- p-value				0.85					0.47	
Access to sanitation	-	-	-	-	0.240	-	-	-	-	0.254
- p-value					0.19					0.24
No. of observations	153	167	56	119	116	113	131	54	115	112
No. of countries	66	73	47	75	72	55	59	46	71	69
Adjusted R^2	0.85	0.89	0.93	0.91	0.92	0.79	0.84	0.96	0.95	0.95
Joint test for dummies	0.03	0.00	0.00	0.06	0.05	0.01	0.00	0.00	0.00	0.00
Diagnostic tests met	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Estimation in each case is by ordinary least squares. Other explanatory variables included in each regression are: average years of schooling among men and among women in the adult (ages 25+) population, total population size, population aged 0-6, land area, and region and time-period fixed effects. IFS=infant survival; CS=child survival.

[11] Since these child output measures are now explanatory variables, we enter their unadjusted values rather than their log-odds ratios, but we continue to enter the log-odds ratio of the infant and child survival rates as the dependent variable.

The results in Table 5 are consistent with those of Hanmer et al. (2003), who also find that immunisation rates have a positive and significant impact on infant and child survival.[12] The results are puzzling however: if government spending on health raises immunisation rates (columns 9 and 10 of Tables 3 and 4), and immunisation rates raise infant and child survival rates (Table 5), why does government spending on health have no impact on infant or child survival rates (columns 1 and 2 of Tables 3 and 4)? We discuss this issue in Section 6.

4. Effects of child indicators on economic growth

In this section we analyse the impact of child outcomes on economic growth. We focus on the same thirteen child-welfare indicators analysed in the previous section.

4.1 Specification

To illustrate the effects of infant and child survival on economic growth, we follow the econometric approach used by Barro and Sala-i-Martin (2005). This involves regressing the rate of economic growth over a given period on the infant and child survival rates at the start of the period, and a range of other factors thought to affect growth. Infant and child survival rates are considered to be proxies for a country's stock of human capital.[13] The hypothesis is that the higher a country's initial level of human capital, the higher its rate of economic growth will be over the subsequent period. In algebraic terms, the estimating equation is as follows:

$$g_{it} = \alpha_t + \beta_1 y_{i,t-1} + \beta_2 h_{i,t-1} + \beta_k Z_{it} + \varepsilon_{it} \quad (2)$$

where g_{it} is economic growth in country *i* over the period *t*, $y_{i,t-1}$ is the level of real per capita GDP in country *i* at the start of period *t*, $h_{i,t-1}$ is the proxy (or set of proxies) for the stock of human capital in country *i* at the start of period *t*, Z_{it} is a vector of observed control variables (all measured as averages over the period), and ε_{it} includes all other unobserved influences on growth, including measurement error, and α_i is a set of constant terms for each period *t*. The test of interest is whether the coefficient β_2 is positive and statistically significant.

The set of control variables Z_{it} includes variables which are thought to affect a country's long-run or 'steady-state' level of GDP per capita and which are readily available for a large number of countries and time periods. Following Barro and Sala-i-Martin (2005), these include: savings and investment, openness to international trade, government expenditure, inflation, fertility, the quality of governance or institutions, the extent of democracy, and the terms of trade. Other proxies for the initial stock of human capital are also included when estimating Equation (2); Barro and Sala-i-Martin (2005) include the average years of upper-level (secondary and tertiary) schooling among the adult (25+) male population, and life expectancy and/or survival rates among the adult population.

To illustrate the effects of school enrolment on economic growth, we follow a slightly different econometric approach, namely that used by Mankiw et al. (1992). This involves regressing the rate of

[12] Like Hanmer et al. (2003), we also find that per capita income, education and gender inequality (as indicated here by differences in male and female years of schooling) have significant impacts on infant and child survival. Their results are obtained using robust regression methods, which involve estimating a very large number of regressions (close to half a million), each with a slightly different set of explanatory variables. We do not attempt to repeat this approach here, and it is possible therefore that some of the variables we find to have significant effects on infant or child survival would not be robust if subjected to this type of method. This can only be addressed through further research.

[13] Barro and Sala-i-Martin (2005) in fact use life expectancy, rather than survival or mortality rates, as their preferred proxy for the stock of human capital. Life expectancy is very closely correlated with survival or mortality rates however.

economic growth over a given period on the average school enrolment rate over the same period, and again on a range of other factors thought to affect growth. In this approach, enrolment in school is considered to be a measure of investment in human capital. The hypothesis is that the higher a country's average rate of investment in human capital over a given period, the higher its rate of economic growth will be over that period. In algebraic terms, the estimating equation is:

$$g_{it} = \alpha + \beta_1 y_{i,t-1} + \beta_2 s_{it} + \beta_k Z_{it} + \varepsilon_{it} \qquad (3)$$

where s_{it} is the average level of school enrolment over the period. Here the basic test of interest is whether the coefficient β_2 is positive and statistically significant.

The set of control variables Z_{it} includes the same set of variables as in Equation (2), except that the growth rate of the working-age population is used in place of the fertility rate.[14] Mankiw et al. (1992) include just two control variables; average investment in physical capital and the growth rate of the working-age population, but other more recent studies using the same overall approach have used a broader set of control variables (e.g. Temple, 1998a, 1998b; Milbourne et al., 2003).[15]

We also use this basic approach to illustrate the effects on economic growth of immunisation against DPT and measles, births attended by skilled personnel, and access to water and sanitation. These indicators can also be interpreted as measures of investment in human capital. In each case, the basic hypothesis is that the higher the average level of these indicators over a given period, the higher the rate of economic growth will be over that period, controlling for the set of variables Z_{it}.

4.2 Data

Our measure of economic growth is the annual log change in real GDP per capita between the start and end years of a given period. The GDP per capita data are taken from the most recent Penn World Tables (Heston et al., 2002), and are available for the years 1960-2000. We calculate the rate of growth in each country over three 10-year periods: 1970-80, 1980-90 and 1990-2000. This source is also used for data on investment, government expenditure, and openness to international trade (which is proxied by the ratio of imports and exports to GDP). The data for inflation, terms of trade and fertility are taken from World Bank (2005b); the data on political rights are from Freedom House (www.freedomhouse.org) and Bollen (1990) for earlier years; the data on schooling are from Barro and Lee (2001); and the measure of governance used is the rule-of-law index calculated by Kaufmann et al. (2003). As before, the child-welfare indicators are taken from World Bank (2005b). Descriptive statistics on all the variables used in this stage of the analysis are shown in Table 6.

As in the previous section, the sample size used in the regressions varies according to the child indicators being entered as explanatory variables: between 267 observations (for 120 countries) when entering the gross primary and secondary school enrolment rates and 87 observations (for 87 countries) when entering access to water and sanitation. In all regressions, however, the samples include both low and middle-income developing countries, and countries from each major developing country region (see Appendix Table A4). In most cases, the samples also include data over all three periods, with the exception of immunisation against DPT and measles and births attended by skilled

[14] The main reason is that the population growth rate is treated as an exogenous variable in the neo-classical (or Solow) growth model on which the approach of Mankiw et al. (1992) is based.

[15] A further point to note is that Mankiw *et al.* (1992) measure school enrolment as the number of pupils enrolled in school as a proportion of the working age population. This is considered to be a better measure of a country's investment in human capital, in terms of how much of the potential labour force is refraining from work and instead building up skills for the future. In this paper we have retained the more standard measures of enrolment, number of pupils enrolled as a proportion of relevant age groups. However, we have repeated the regressions with the alternative definition used by Mankiw et al. (1992), so that our results can also be compared directly with theirs if required (details available on request). In addition, Mankiw et al. (1992) look only at the effects of secondary school enrolment on economic growth, but the basic approach is equally valid for primary school enrolment.

personnel, where data over the 1970s are unavailable, and primary school completion and access to water and sanitation, where data over the 1970s and 1980s are unavailable.

Table 6: Descriptive statistics, effect of child-welfare indicators on economic growth

Variable	Units	Mean	St. dev	Min	Max	N
Economic growth	Change in GDP per capita, percent per year	1.27	2.34	-7.58	10.01	304
Per capita GDP	US$ PPP in initial year, log	8.26	1.04	6.09	10.20	304
Government expenditure	Share of GDP (constant prices), average over period	0.20	0.10	0.05	0.64	304
Gross investment	Share of GDP (constant prices), average over period	0.15	0.08	0.02	0.37	304
Openness	Exports and imports as a share of GDP (constant prices), average over period	0.66	0.36	0.08	2.31	304
Inflation	Change in consumer price index, log points per year	0.16	0.24	0.00	2.01	304
Rule-of-law index	z-score, 1998 value	0.08	0.98	-2.09	1.91	304
Political rights	1-7 scale, average over period	3.58	2.03	1.00	7.00	304
Terms of trade	Change in terms of trade index, log points per year	0.04	0.05	-0.16	0.26	304
Fertility rate	Births per woman, average over period, log	1.27	0.56	0.20	2.13	303
Population growth	Log of proportional growth rate of working age population over period +0.05	-2.78	0.14	-3.19	-2.31	303
Male upper-level schooling	Average years of secondary and tertiary level education in the adult (25+) male population	1.68	1.38	0.02	6.65	244
Adult mortality rate	Average of male and female rates over period	257.1	134.2	81.5	648.5	292
Infant survival	Proportion, initial year	0.97	0.04	0.84	1.00	301
Child survival	Proportion, initial year	0.94	0.05	0.79	1.00	301
Pre-primary enrolment, gross	Proportion, average over period	0.36	0.31	0.00	1.14	239
Primary enrolment, gross	Proportion, average over period	0.92	0.23	0.13	1.44	302
Primary enrolment, net	Proportion, average over period	0.81	0.19	0.09	1.00	239
Primary completion	Proportion, average over period	0.75	0.24	0.18	1.17	100
Secondary enrolment, gross	Proportion, average over period	0.52	0.33	0.02	1.37	299
Secondary enrolment, net	Proportion, average over period	0.50	0.30	0.01	0.98	197
Immunisation, DPT	Proportion, average over period	0.70	0.24	0.07	0.99	224
Immunisation, measles	Proportion, average over period	0.69	0.22	0.10	0.99	224
Births attended by skilled personnel	Proportion, average over period	0.69	0.28	0.06	1.00	142
Access to water	Proportion, average over period	0.72	0.26	0.08	1.00	95
Access to sanitation	Proportion, average over period	0.79	0.19	0.25	1.00	101

Notes: There are 304 core observations for which the dependent variable and explanatory variables common to Barro and Sala-i-Martin (2005) and Mankiw et al. (1992) specifications are available. Of these, 78 are from the 1970s, 96 from the 1980s and 130 from the 1990s. By region, 43 are from East and Southern Africa, 46 from West Africa, 33 from East Asia and Pacific, 11 from South Asia, 23 from Eastern Europe/Central Asia, 56 from Western Europe, 11 from the Middle East, 11 from North Africa, 50 from South and Central America, 6 from North America and 13 from the Caribbean.

4.3 Diagnostics and robustness tests

We test for heteroskedasticity, functional form, outliers and influential observations in the same way as in Section 3. We also add dummy variables for eleven country regions to the list of explanatory variables used to estimate Equations (2) and (3), which is one way of controlling for unobserved differences in total factor productivity across countries in growth regressions, which may otherwise bias the remaining coefficients (e.g. Temple, 1998a). We also test for differences in the parameter estimates by levels of countries' GDP per capita, as a way of controlling for possible parameter heterogeneity (ibid). We also test for differences in the parameter estimates across the three different time-periods used in the analysis (1970s, 1980s and 1990s).

4.4 Results

Table 7 shows the results of estimating Equations (2) and (3) by ordinary least squares. Only the main coefficients of interest are shown, but the remaining control variables are, in most cases, signed according to expectation and statistically significant (see Appendix Table A4). In each case the diagnostic tests are satisfied, following, where necessary, the exclusion of certain outliers according to the procedure described above (also see Appendix Table A4). The un-adjusted level of each child indicator is used, but similar results are obtained when entering the log, or (as in Section 3) the log-odds ratio of each indicator.[16]

Column 1 shows the estimates of initial infant and child survival rates on economic growth. The impact of infant survival is not statistically significant, but the impact of child survival is significant at the 5% level and positive as expected. The size of the coefficient on the child survival rate implies that an increase of 5 percentage points in this indicator would, on average, raise economic growth by approximately one percentage point per year. These results are consistent with, and provide further support for, those of Barro and Sala-i-Martin (2005).[17]

Column 2 shows the estimates of gross primary and secondary school enrolment on economic growth. Both estimates are positive, as expected, and the impact of primary school enrolment is statistically significant at the 1% level, while the impact of secondary school enrolment is significant at the 10% level. The size of the coefficients imply that an increase of 20 percentage points in the primary enrolment rate would raise growth by 0.3 percentage points per year, while an equivalent increase in secondary school enrolment would raise growth by 0.2 percentage points per year. These results are consistent with, and provide further support for, those of Mankiw et al. (1992).[18]

Columns 3-5 show variants of the regression in column 2. Column 3 shows the results when using net rather than gross primary and secondary enrolment rates. The coefficient on primary enrolment remains similar in size, but is no longer statistically significant. However, the coefficient on secondary enrolment is now much larger and statistically significant at the 1% level. Column 4 shows the results when adding the gross pre-primary enrolment rate. The effect of this variable is positive as expected, but it is smaller than the effects of primary and secondary enrolment, and not statistically significant. Column 5 shows the results when including the primary completion rate. The effect of this variable is

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[16] The main difference is that levels of statistical significance are lower when entering the log of each child indicator. We also tested for the effect of the average level of immunisation against DPT and measles, and the average level of access to water and sanitation. These effects were both positive and marginally statistically significant at the 15% level when the log of each average rate was entered (details available on request).

[17] In particular, Barro and Sala-i-Martin (2005) find that initial life expectancy at age 1 has a positive and significant impact on future economic growth, but that controlling for this variable the infant mortality rate has no significant impact on subsequent economic growth.

[18] In particular, Mankiw et al. (1992) find that the log of the secondary school enrolment rate (defined as a proportion of the working-age population) has a positive and significant impact on growth. Subsequent work by Temple (1998a) shows that this finding is not robust to the inclusion of regional fixed effects. We, however, obtain a positive and statistically significant effect when entering the log of the combined primary and secondary school enrolment rate, defined as a proportion of the working-age population, even when controlling for regional fixed effects (details available on request).

positive, large and statistically significant at the 1% level, and its inclusion causes the effects of primary and secondary school enrolment to drop in size and become statistically insignificant. This suggests very strongly that simply enrolling children in school is not enough to generate growth.

Table 7: Effects of child-welfare indicators on economic growth, OLS estimates

	1	2	3	4	5	6	7	8
Infant survival	-7.6	-	-	-	-	-	-	-
- p-value	.36							
Child survival	21.0	-	-	-	-	-	-	-
- p-value	.05							
Pre-primary enrolment, gross	-	-	-	0.45	-	-	-	-
- p-value				.35				
Primary enrolment, gross	-	1.45	-	1.16	-0.83	-	-	-
- p-value		.00		.04	.52			
Secondary enrolment, gross	-	1.03	-	1.00	0.72	-	-	-
- p-value		.10		.16	.66			
Primary enrolment, net	-	-	1.19	-	-	-	-	-
- p-value			.21					
Secondary enrolment, net	-	-	2.35	-	-	-	-	-
- p-value			.01					
Primary enrolment	-	-	-	-	4.53	-	-	-
- p-value					.01			
Immunisation, DPT	-	-	-	-	-	1.05	-	-
- p-value						.36		
Immunisation, measles	-	-	-	-	-	-0.40	-	-
- p-value						.73		
Births attended by skilled personnel	-	-	-	-	-	-	1.60	-
- p-value							.05	
Access to water	-	-	-	-	-	-	-	1.78
- p-value								.28
Access to sanitation	-	-	-	-	-	-	-	0.45
- p-value								.60
No. of observations	207	267	181	226	95	210	128	87
No. of countries	88	120	103	119	95	123	101	87
Adjusted R^2	.75	.68	.64	.62	.57	.58	.55	.49
F-test, region effects	.41	.00	.01	.00	.02	.03	.11	.02
F-test, time effects	.00	.00	.00	.08	-	.49	.41	-
Diagnostic tests met	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tests for interaction:								
GDP	No	No	No	No	Yes	No	No	Yes
Time periods	No	Yes	Yes	Yes	-	Yes	No	-

Notes: p-values shown beneath each coefficient. Dependent variable in each case is the growth of GDP per capita in annual percentage points, and estimation is by ordinary least squares. Other explanatory variables included in each regression are initial GDP, inflation, terms of trade, rule of law, political rights and its square, government expenditure, investment, openness to trade, dummy variables for the periods of the 1970s and 1980s and 11 country regions, and either male upper level schooling, adult mortality and fertility (column 1) or population growth (columns 2-8).

Columns 6-8 show the estimates of the remaining child indicators on growth. Column 6 shows the effects of immunisation against DPT and measles. The impact of immunisation against DPT is positive, as expected, but the effect of immunisation against measles is negative, and both effects are statistically insignificant. Column 7 shows the effect of births attended by skilled personnel. This effect is positive, as expected, and statistically significant at the 5% level. Column 8 shows the effects of access to water and sanitation. Both effects are positive, as expected, but neither is statistically significant.

The lower panel of Table 7 shows the results of tests of whether the impacts of the child indicators included in each regression tend to vary, according either to the per capita GDP of the countries concerned or the decade over which growth is measured. Several of these tests generated significant results. Considering first the interactions with per capita GDP, we find some evidence that the impact of secondary enrolment was higher in low-income countries than elsewhere (column 5 but not columns 2-4), and similarly for access to sanitation (column 8).

Considering the interactions with the decade over which growth is measured, we find that the impact of primary enrolment was significantly larger in the 1970s than in the 1980s or 1990s (column 2), while in columns 2-4 we find that the impact of secondary school enrolment was significantly larger in the 1980s and 1990s than in the 1970s. We also find that the impact of immunisation against measles was larger in the 1990s than in the 1980s, but that the impact of immunisation against DPT was smaller in the 1990s than in the 1980s (column 6).

5. Effects of child indicators on trends in inequality

This section presents our analysis of the impact of investing in children on trends in inequality, focusing on the same thirteen child-welfare indicators used in the previous sections. We restrict our attention to inequality in incomes (or consumption, depending on data availability), mainly because fewer estimates of non-income inequalities are available. In addition, we restrict attention to the Gini coefficient measure of income (or consumption) inequality.

5.1 Specification

Our basic approach is the econometric method used in recent work by Ravallion (2003) and Kraay (2006). We regress the rate of change in the Gini coefficient over a given period on the level of each of our thirteen child-welfare indicators, controlling for the level of the Gini coefficient at the start of the period and certain other variables thought to influence countries' steady-state or long-run levels of inequality. In algebraic terms, the basic estimating equation is:

$$r_{it} = \alpha + \beta_1 I_{i,t-1} + \beta_2 h_{it} + \beta_k Z_{it} + \varepsilon_{it}, \quad (4)$$

where r_{it} is the rate of change in the Gini coefficient in country i over the period t, $I_{i,t-1}$ is the level of the Gini coefficient at the start of period t, $h_{i,t}$ is the child-welfare indicator (measured either at the start of the period or as an average over the period), Z_{it} is a vector of observed control variables, and ε_{it} includes all other unobserved influences on the rate of change in the Gini coefficient over the period in question, including measurement error. We multiply changes in the Gini coefficient by minus one, so that a positive rate of change indicates a reduction in inequality, while a negative rate of change indicates a rise in inequality. The main test of interest for the purposes of this paper is therefore whether the coefficient β_2 is positive and statistically significant. This would imply that, controlling for starting levels of inequality, countries which invest more in children see larger reductions, or smaller increases, in inequality than those which invest less or those which do not invest at all.

For the set of control variables Z_{it} we include initial per capita income and its square (to test for the Kuznets hypothesis that there is an inverse U-shaped relationship between long-run levels of inequality and per capita income), institutional quality, a set of eleven regional dummy variables, the initial year of the period over which the change in inequality is measured, and finally a set of three dummy variables for the type of household survey from which the inequality estimates are derived (household or individual, income or consumption, and gross or net income). We also add the child indicators to the regression sequentially, in groups of similar indicators, rather than simultaneously. As in the previous section, this is a means of keeping the number of observations as large as possible.

5.2 Data

The inequality data are obtained from the dataset compiled and made available by Dollar and Kraay (2002). This is an update of the widely-used Deininger and Squire (1996) income inequality database. The periods are chosen so that each is of between 5 and 10 years in length, there is no more than two years of overlap between two periods in the same country, and the type of household survey is the same in the start and end year of each period. This yields a total of 140 periods spanning 72 countries over the period 1960-1998. As in the previous sections, the per capita income data are from Heston et al. (2002) and the governance measure is the index calculated by Kaufmann et al. (2003). Descriptive statistics are shown in Table 8.

Also as in the previous sections, the sample size used in the regressions varies according to the child health or education measures being entered as explanatory variables: between 114 observations (for 58 countries) when entering the gross primary and secondary school enrolment rates and 21 observations (for 18 countries) when including primary school completion rates. In all regressions, however, the samples include both low and middle-income developing countries, and countries from each major developing country region, although the number of observations from sub-Saharan Africa is, in this case, quite low (see Appendix Table A4). The majority of observations are from periods which begin in the 1970s or 1980s.

Table 8: Descriptive statistics, effect of child-welfare indicators on inequality

Variable	Units	Mean	St. dev	Min	Max	N
Reduction in inequality	Reduction in Gini coefficient, percent per year	0.00	0.02	-0.14	0.06	140
Gini coefficient	Gini coefficient in initial year, log	37.3	9.7	17.8	62.5	140
Per capita GDP	US$ PPP, log units, initial year	8.53	0.93	6.30	9.98	121
Rule-of-law index	z-score, 1998 value	0.53	0.89	-1.13	1.85	121
Start year of period	Year	1978	-	1960	1993	140
Infant survival	Proportion, initial year	0.96	0.04	0.84	0.99	119
Child survival	Proportion, initial year	0.98	0.03	0.88	1.00	115
Pre-primary enrolment, gross	Proportion, average over period	0.45	0.31	0.00	1.12	100
Primary enrolment, gross	Proportion, average over period	0.99	0.16	0.38	1.26	124
Primary enrolment, gross	Proportion, average over period	0.89	0.13	0.47	1.00	87
Primary completion	Proportion, average over period	0.86	0.21	0.34	1.36	30
Secondary enrolment, gross	Proportion, average over period	0.62	0.29	0.03	1.27	124
Secondary enrolment, net	Proportion, average over period	0.58	0.27	0.16	0.97	71
Immunisation, DPT	Proportion, average over period	0.73	0.22	0.02	0.99	93
Immunisation, measles	Proportion, average over period	0.69	0.24	0.01	0.99	89
Births attended by skilled personnel	Proportion, average over period	0.73	0.27	0.10	1.00	42
Access to water	Proportion, average over period	0.83	0.17	0.37	1.00	31
Access to sanitation	Proportion, average over period	0.73	0.26	0.16	1.00	30

Notes: There are 140 core observations for which the dependent variable is available. Of these, 3 are from East and Southern Africa, 6 from West Africa, 28 from East Asia and Pacific, 11 from South Asia, 20 from Eastern Europe/Central Asia, 30 from Western Europe, 2 from the Middle East, 4 from North Africa, 21 from South and Central America, 6 from North America and 9 from the Caribbean.

5.3 Diagnostics and robustness tests

We test for heteroskedasticity, functional form, outliers and influential observations in the same way as in the previous sections.

5.4 Results

Table 9 shows the results. The diagnostic tests for heteroskedasticity, functional form, normality and influential observations are met in six out of eight cases (see Appendix Table A5). Again, for ease of presentation, only the main coefficients are shown. However, the other coefficients are, in most cases, signed according to expectation and/or previous research. In particular, we obtain positive and statistically significant coefficients on the initial Gini coefficient, indicating the convergence of inequality levels across countries, and negative and statistically significant coefficients on the start year of the period over which redistribution is measured, indicating that long-run or steady state levels of inequality have been rising (see Appendix Table A5). However, we find, in most cases, insignificant coefficients on per capita income and its square, suggesting little evidence of the Kuznets hypothesis. In addition, we find, in all cases, an insignificant coefficient on the Kaufmann et al. (2003) governance index.

Table 9: Effects of child-welfare indicators on trends in inequality, OLS estimates

	1	2	3	4	5	6	7	8
Infant survival	-12.1	-	-	-	-	-	-	-
	.16							
Child survival	26.1	-	-	-	-	-	-	-
	.07							
Pre-primary enrolment, gross	-	-	-	-0.68	-	-	-	-
				.16				
Primary enrolment, gross	-	-2.35	-	-3.05	15.19	-	-	-
		.02		.01	.34			
Secondary enrolment, gross	-	1.65	-	2.50	-0.16	-	-	-
		.06		.00	.99			
Primary enrolment, net	-	-	0.15	-	-	-	-	-
			.97					
Secondary enrolment, net	-	-	0.85	-	-	-	-	-
			.58					
Primary completion	-	-	-	-	-12.86	-	-	-
					.50			
Immunisation, DPT	-	-	-	-	-	3.09	-	-
						.03		
Immunisation, measles	-	-	-	-	-	-2.08	-	-
						.10		
Births attended by skilled personnel	-	-	-	-	-	-	2.09	-
							.33	
Access to water	-	-	-	-	-	-	-	8.88
								.50
Access to sanitation	-	-	-	-	-	-	-	-2.46
								.86
No. of observations	99	114	65	86	21	79	38	25
No. of countries	54	58	35	47	18	52	32	24
Adjusted R^2	.47	.29	.21	.40	.53	.25	.08	.02
F-test, region effects	.00	.74	.61	.34	.45	.93	.81	.84
F-test, survey effects	.00	.01	.34	.00	.39	.01	.03	.22
Diagnostic tests met	Yes	Yes	Yes	Yes	No	Yes	Yes	No

Notes: p-values are shown beneath each coefficient. Dependent variable in each case is the annual rate of reduction in the Gini coefficient (percentage points per year), and estimation is by ordinary least squares. Other explanatory variables included in each regression are initial Gini coefficient, the start year of the period, rule-of-law index, per capita GDP and its square, and dummy variables for the periods of the 1970s and 1980s, 11 country regions, and 3 household survey types.

Turning to the main coefficients of interest, and considering only the regressions in which the diagnostic tests are met, we find that three of the thirteen child indicators have positive impacts on the rate of reduction in inequality which are statistically significant at the 10% level: child survival, gross secondary enrolment, and immunisation against DPT. We also find, however, that two indicators have negative impacts which are also significant at the 10% level: gross primary enrolment, and immunisation against measles.

Overall, the results in Table 9 suggest that certain, but not all, forms of investment in children can promote reductions in inequality as well as raising economic growth, and can therefore add to their poverty-reducing potential. To take one example, consider the results for secondary enrolment. The results in Table 9 (column 2) suggest that an increase in (gross) secondary enrolment of 20 percentage points would raise the rate of reduction (or reduce the rate of increase) in the Gini coefficient by approximately 0.3 percentage points per year. As noted in the previous section, an increase in secondary enrolment of 20 percentage points would also raise economic growth, by approximately 0.2 percentage points per year. Similarly, the results in Table 9 (column 1) suggest that an increase in the child survival rate of 5 percentage points would raise the rate of reduction (or reduce the rate of increase) in the Gini coefficient by approximately 1.3 percentage points per year. Also as noted in the previous section, an increase in the child survival rate of 5 percentage points would also raise economic growth, by approximately one percentage point per year.

The relative contributions of the above effects to overall poverty reduction will depend on the measure of poverty used, and on the elasticities of the chosen poverty measure with respect to GDP per capita and to the Gini coefficient, which will vary from country to country. To get a sense of the likely magnitudes, Table 10 presents estimates of the likely contributions if increases in secondary enrolment and child survival occurred in Bangladesh, Cambodia and Zambia. The estimates are based on World Bank data on $1-a-day poverty and its elasticity with respect to per capita income and the Gini coefficient. The table shows that a 20 percentage point increase in secondary enrolment would raise the rate of poverty reduction by 0.8 percent per year in Cambodia and Bangladesh, and by 0.2 percent per year in Zambia. Similarly, a 5 percentage point increase in child survival would raise the rate of poverty reduction by 3.5 percent per year in Cambodia and Bangladesh, and by 0.8 percent per year in Zambia. The table also shows that between one-fifth and half of these total effects of increased secondary enrolment and child survival on $1-a-day poverty occur through their effect on inequality, the remaining proportion occurring through their effect on economic growth.

Table 10: Simulated impacts of investment in children on $1-a-day poverty in 3 low-income countries

	Cambodia	Bangladesh	Zambia
Estimated $1-a-day poverty (%)	34	36	65
Estimated Gini coefficient	40	32	53
Year of estimate	1997	2000	1998
Estimated elasticity of $1-a-day poverty with respect to:			
Gini coefficient	1.3	1.1	0.1
Per capita GDP	-1.8	-2.2	-0.7
*Effect of an increase in secondary enrolment on poverty reduction, % per year**			
Via lower inequality	-0.4	-0.3	-0.04
Via economic growth	-0.4	-0.4	-0.1
Total	-0.8	-0.8	-0.2
*Effect of an increase in child survival on poverty reduction, % per year***			
Via lower inequality	-1.7	-1.4	-0.2
Via economic growth	-1.8	-2.2	-0.7
Total	-3.5	-3.5	-0.8

Notes:*An increase of 20 percentage points; ** an increase of 5 percentage points.
Source: World Bank PovcalNet (http://iresearch.worldbank.org/PovcalNet/jsp/index.jsp) and authors' simulations.

6. Summary and relation to previous results

Table 10 summarises the results of the first stage of the analysis, concerning the impact of government expenditure on child-welfare indicators. For the eleven 'output' indicators, there is evidence of government expenditure having a significant impact. We find that government expenditure on directly relevant sectors has a positive and statistically significant effect (at the 15% level) on four such indicators, namely: education expenditure on pre-primary school enrolment rates, health expenditure on immunisation rates against DPT and also measles, and housing and community amenities expenditure on access to water. These findings are to our knowledge new to the literature. In addition, we find that certain output indicators are positively affected by government expenditure on sectors that are not directly related to those indicators, including primary enrolment, which is positively affected by health expenditure, and access to water, which is positively affected by agriculture expenditure.

By contrast, for the two 'final outcome' indicators we find no evidence of a significant impact of government expenditure on either directly relevant sectors or any of the other sectors of expenditure on which we focus. This is in accordance with previous studies (e.g. Filmer and Pritchett, 1999), which have found that public health expenditure has no statistically significant effect on infant or child survival. We also find, like Al-Samarrai (2002), that government expenditure on education has no statistically significant effect on primary school enrolment or completion rates, which might reflect some of the caveats mentioned above, for example the levels of private expenditure or the lack of complementary expenditures such as infrastructure.

In terms of the effect of the output indicators on the final outcome indicators, we find that immunisation against DPT and measles, and births attended by skilled personnel have positive impacts on infant and child survival, which are statistically significant at the 10% level or lower. This is consistent with other recent research which finds a positive relationship between child output and outcome indicators (e.g. Hanmer et al. 2003). Our results also, therefore, identify a puzzle: in particular, a positive and significant effect of government health expenditure on immunisation against DPT and measles, and a positive and significant effect of immunisation against DPT and measles on infant and child survival, but no significant effect of government health expenditure on infant and child survival.

What are the most likely explanations for these results? As explored in Section 1.3, there are a number of possible explanations as to the absence of any significant link between government expenditure on relevant sectors and child output or outcome measures, due to the number of mediating factors within each relationship. Previous studies (e.g. Pritchett and Filmer, 1999; Al-Samarrai, 2002) suggest three main explanations, namely:

- poor data, particularly on the amount of government expenditure on education and health which actually reaches households;
- omission of relevant variables, e.g. the amount of private expenditure by households on health and education, or the role of complementary public expenditures, such as the impact of infrastructure spending on health outcomes;
- low effectiveness of public expenditure management systems in education and health.

Where we find no significant relationship between relevant government expenditure and child output indicators, our results do not shed any more light on which explanation is the most likely. However, neither the first nor the third of the explanations can resolve the puzzle identified above. In particular, poor expenditure data or low expenditure effectiveness cannot be the reason, because we do observe a positive and significant impact of government expenditure on at least some child output indicators. This leads us to suspect that the reason for the lack of an observed relationship between government expenditure on relevant sectors and child health outcomes is therefore the second reason, namely, the omission of relevant variables, with private health expenditure being one such variable. However, although our results are consistent with this hypothesis, we do not provide a direct test.

Tables 11 and 12 summarise the results of the second stage of the analysis, concerning the effects of the child output and outcome measures on economic growth and inequality. First, our results support previous research showing a strong positive correlation between initial levels of child survival and subsequent economic growth (e.g. Barro and Sala-i-Martin, 2005). The existence (i.e. statistical significance) of this effect is, on the whole, not contested in the literature (although for a recent exception see Acemoglu and Johnson, 2006); debate focuses instead on its quantitative importance (e.g. Easterly, 2003). Our results suggest that an exogenous increase in the child survival rate of 5 percentage points would raise economic growth by 1 percentage point per year over the subsequent decade, which clearly is a significant amount.

Table 11: Summary of results – government expenditure and child-welfare indicators

	Effects of directly relevant sectors on:		Effects of all six sectors on:		Effects of outputs on outcomes
	Outcomes	Outputs	Outcomes	Outputs	
Coefficients (no.)	2	11	12	66	10
Diagnostic tests met (no.)	2	8	12	18	10
Positive and significant*	0	4 (PPN, IDPT, IMEAS, WTR)	0	4 (706-IMEAS; 707-PN, IMEAS; 7042-WTR)	6 (IDPT-IFS,CS; IMEAS-IFS, CS; BSKD-IFS,CS)
Negative and significant*	0	1 (SN)	0	6 (709,7042-PN, IMEAS; 7045-IMEAS,WTR)	0
Not significant*	2 (IFS, CS)	3 (PN, PCR, SAN)	12 (All 6-IFS,CS)	8 (706-PN,WTR; 707,709-WTR; 710-PN,IMEAS, WTR; 7045-PN)	4 (WTR-IFS,CS; SAN-IFS,CS)

Notes: For full results, see Tables 3-5. *Statistically significant at the 15% level. IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PCR=primary completion; SN=secondary enrolment, gross; IDPT=immunisation, DPT; IMEAS=immunisation, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation; 706, 707, 709, 710, 7042, 7045=government expenditure on, respectively, housing and community, health, education, social protection, agriculture, forestry and fishing, and transport and communications.

Table 12: Summary of results – effects of child indicators on economic growth

	Effects of outcomes on:		Effects of outputs on:**	
	Economic growth	Trends in inequality#	Economic growth	Trends in inequality#
Coefficients (no.)	2	2	11	11
Diagnostic tests met (no.)	2	2	11	8
Positive and significant*	1 (CS)	1 (CS)	4 (PN,SNN,PCR, BSKD)	2 (SN,IDPT)
Negative and significant*	0	0	0	2 (PN,IMEAS)
Not significant*	1 (IFS)	1 (IFS)	7 (PPN,PNN,SN, IDPT,IMEAS, WTR, SAN)	4 (PPN,PNN,SNN, BSKD)

Notes: For full results, see Tables 7 and 9. *Statistically significant at the 15% level; **Based on results for PN and SN in column (4) of Tables 7 and 9; #Reductions in inequality, so that a positive effect of a child outcome/output indicator implies the indicator reduces inequality, and vice versa for a negative effect. IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PNN=primary enrolment, net; PCR=primary completion; SN=secondary enrolment, gross; SNN=secondary enrolment, net; IDPT=immunisation, DPT; IMEAS=immunisation, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation.

Second, our results also support previous research (e.g. Mankiw et al., 1992) showing a positive effect of school enrolment on economic growth. In contrast to the effect of child survival, however, the existence or statistical significance of this effect is still fairly contested in the literature (see, for example, Temple, 1998a; 1999). Our results will not put an end to this disagreement, mainly because of concerns about potential reverse causation from growth to school enrolment which we have not yet controlled for. However, we do show that one criticism of the original Mankiw et al. (1992) results – that the statistically significant positive effect of school enrolment on economic growth is not robust to the inclusion of regional fixed effects – is no longer valid when using the most up-to-date data.

Third, our results show that certain other measures of human capital investment, such as primary school completion and births attended by skilled personnel, also have a positive impact on economic growth, although at somewhat lower levels of statistical significance. To our knowledge, this finding is also new to the literature.

Finally, our results suggest that certain forms of investment in children, including increasing secondary school enrolment, raising child survival and immunisation against DPT, may also bring about a reduction in inequality. This is also consistent with previous research (e.g. Li et al., 1998). Such an effect will tend to increase the poverty-reducing impact of that investment; some back-of-the-envelope calculations for three low-income countries shown in Section 5 suggest it could potentially double its impact.

Our results also caution against an overly pessimistic view of the effect of public expenditure: that unless accompanied by deep governance reforms, it is unlikely to have much impact. In particular, our results show no correlation between the impact of government expenditure on child-welfare indicators and the level of the country's governance measurement.

In terms of further work, there are various ways in which the empirical approach used in this paper could be usefully extended. One would be to repeat the analyses in Section 3 controlling for estimated private expenditure on education and health. Another would be to control for the possibility of incidental association between per capita GDP or government expenditure on the one hand, and child-welfare indicators on the other (e.g. by estimating the regressions in first-differences rather than in levels, as in Pritchett and Summers, 1996). A third would be to repeat the analyses in Sections 4 and 5 controlling for the likely endogeneity of some of the key explanatory variables of interest.

From a policy perspective, this paper makes it clear that investing in children by governments is not solely a matter of meeting basic rights; it is also a matter of economic importance for the design of national development strategies. Effective investment in children does tend to raise economic growth: those countries with higher child-welfare indicators tend (all else being equal) to have higher economic growth rates. Although there may be other sectors of expenditure to which returns are higher, it would be clearly wrong to treat government expenditure on education and health as simply 'social', given their economic returns, and distinct in its effects from expenditure on 'productive' sectors such as transport. Likewise, the results suggest that it is not just investments in the social sectors that accelerate human development, but also those in productive sectors, such as agriculture. These results can be used to complement detailed country-specific analyses of policy design, public financial management, and related institutional and structural factors.

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Appendix

Table A1: Additional coefficients, diagnostic tests and sample information associated with results in Table 3

	1 IFS	2 CS	3 PPN	4 PN	5 PNN	6 PCR	7 SN	8 SNN	9 IDPT	10 IMEAS	11 BSKD	12 WTR	13 SAN
Additional coefficients													
Per capita GDP	0.379	0.513	0.928	1.358	1.075	0.111	0.239	0.679	0.375	0.084	1.365	-0.057	0.218
(p-value)	0.00	0.00	0.00	0.21	0.00	0.82	0.15	0.04	0.25	0.72	0.11	0.85	0.36
Male schooling	0.064	0.116	0.196	0.134	0.441	0.288	0.303	0.723	0.103	-0.205	0.159	-0.237	-0.544
(p-value)	0.09	0.14	0.04	0.71	0.01	0.37	0.00	0.04	0.49	0.06	0.67	0.16	0.00
Female schooling	0.058	-0.008	-0.080	-0.037	-0.281	0.199	0.057	-0.343	-0.113	0.206	0.055	0.425	0.502
(p-value)	0.13	0.92	0.40	0.93	0.01	0.52	0.53	0.18	0.46	0.06	0.87	0.01	0.00
Population of relevant age group*	-0.369	-0.884	0.329	0.247	2.618	-1.348	-0.620	-1.399	0.334	0.039	-3.821	-	-
(p-value)	0.05	0.06	0.45	0.93	0.00	0.45	0.34	0.23	0.67	0.94	0.05		
Population, total	0.388	0.857	-0.290	-0.101	-2.496	1.525	0.623	1.660	0.006	0.139	3.185	0.203	-0.116
(p-value)	0.04	0.06	0.50	0.97	0.00	0.39	0.34	0.18	0.99	0.78	0.09	0.08	0.31
Land area	-0.082	-0.084	0.131	0.397	0.045	-0.185	-0.051	-0.110	-0.305	-0.102	0.429	-0.029	0.008
(p-value)	0.00	0.10	0.02	0.09	0.24	0.27	0.30	0.33	0.00	0.30	0.18	0.71	0.93
Diagnostic tests													
Heteroskedasticity test	0.49	0.40	0.90	0.58	0.03	0.62	0.12	0.94	0.29	0.48	0.82	0.01	0.22
Functional form test	0.43	0.21	0.37	0.22	0.39	0.46	0.24	0.10	0.35	0.31	0.29	0.48	0.18
Normality test	0.68	0.76	0.75	0.18	0.01	0.25	0.12	0.03	0.95	0.74	0.59	0.93	0.36
Largest standardised residual (abs value)	2.47	2.43	2.72	2.42	1.98	2.75	2.59	1.97	2.38	2.48	2.36	2.49	2.31
Largest DF-beta statistic (absolute value)**	0.586	0.498	0.397	0.630	1.006	0.759	0.377	1.458	0.250	0.556	1.164	0.494	0.665
Observations range	<0.988	<0.994	0.2-0.8	All	<0.9	0.05-0.95	All	<0.75	0.15-0.85	0.2-0.8	All	<0.9	<0.85
Outliers dropped	7	0	6	0	2	0	7	2	0	0	1	1	1

Table A1: cont'd

	1 IFS	2 CS	3 PPN	4 PN	5 PNN	6 PCR	7 SN	8 SNN	9 IDPT	10 IMEAS	11 BSKD	12 WTR	13 SAN
Sample size, by year													
1980	39	27	16	31	16	0	51	7	24	16	0	0	0
1990	40	31	33	29	10	21	52	16	21	23	13	24	20
2000	28	18	21	14	11	16	29	8	13	10	22	20	16
Sample size, by income													
Low-income	32	32	4	23	11	13	29	7	17	14	11	17	16
Middle-income	64	43	32	28	20	24	68	22	27	22	22	27	19
High-income	11	1	34	23	6	0	35	2	14	13	2	0	1
Sample size, by region													
Sub-Saharan Africa	25	24	6	17	10	10	23	6	10	9	8	10	8
East Asia and Pacific	14	10	12	8	2	5	22	4	10	6	5	9	9
South Asia	8	7	1	5	2	2	7	0	4	4	4	5	4
E.Europe and Central Asia	2	0	2	3	1	2	3	0	0	0	0	0	0
Western Europe	8	3	18	17	5	1	21	2	10	12	0	2	0
N.Africa and Middle East	16	12	2	10	5	5	17	6	3	2	6	3	2
Latin America and Caribbean	34	20	23	11	12	13	35	13	21	16	11	15	13
North America	1	0	6	3	0	0	4	0	0	0	1	0	0

Notes: IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PNN=primary enrolment, net; PCR=primary completion; SN=secondary enrolment, gross; SNN=secondary enrolment, net; IDPT=immunisation, DPT; IMEAS=immunisation, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation. *Ages 0-6 for IFS, CS, PPN, IDPT, IMEAS and BSKD; ages 6-11 for PN, PNN and PCR; ages 12-17 for SN and SNN; ** refers to directly relevant sector of government expenditure.

Table A2: Additional coefficients, diagnostic tests and sample information associated with results in Table 4

	1 IFS	2 CS	3 PPN	4 PN	5 PNN	6 PCR	7 SN	8 SNN	9 IDPT	10 IMEAS	11 BSKD	12 WTR	13 SAN
Additional coefficients													
Per capita GDP	0.369	0.497	0.970	0.325	0.733	0.183	0.379	1.148	0.565	-0.057	0.601	0.009	-0.087
(p-value)	0.00	0.00	0.00	0.74	0.35	0.68	0.05	0.06	0.11	0.78	0.47	0.98	0.63
Male schooling	0.080	0.129	0.082	-0.193	0.414	0.212	0.274	0.102	0.225	-0.079	-0.334	-0.410	-0.659
(p-value)	0.08	0.12	0.42	0.54	0.42	0.74	0.01	0.69	0.25	0.50	0.50	0.04	0.01
Female schooling	0.045	-0.009	-0.053	0.414	-0.236	0.398	0.065	-0.111	-0.353	0.027	0.082	0.673	0.681
(p-value)	0.31	0.92	0.60	0.22	0.61	0.40	0.52	0.55	0.09	0.79	0.85	0.00	0.00
Population of relevant age group*	-0.357	-0.650	0.147	2.590	0.401	1.365	-0.417	-3.312	0.408	0.254	-6.395	-	-
(p-value)	0.10	0.31	0.73	0.32	0.86	0.73	0.58	0.19	0.69	0.65	0.01		
Population, total	0.385	0.648	-0.045	-2.607	-0.374	-1.193	0.444	3.281	-0.151	-0.276	6.070	0.196	-0.113
(p-value)	0.07	0.30	0.91	0.31	0.87	0.73	0.56	0.19	0.88	0.60	0.01	0.21	0.21
Land area	-0.091	-0.088	0.118	0.318	0.118	-0.077	-0.075	-0.243	-0.370	0.028	0.108	-0.004	-0.119
(p-value)	0.00	0.11	0.04	0.10	0.31	0.86	0.14	0.14	0.00	0.79	0.75	0.97	0.08
Diagnostic tests													
Heteroskedasticity test	0.94	0.44	0.94	0.20	0.10	0.46	0.38	0.05	0.08	0.31	0.30	0.05	0.05
Functional form test	0.46	0.50	0.88	0.76	.	0.48	0.32	.	0.67	0.47	0.55	0.69	0.30
Normality test	0.51	0.23	0.01	0.28	0.01	0.66	0.05	0.14	0.06	0.15	0.04	0.81	0.21
Largest standardised residual (abs value)	2.43	2.33	2.19	2.32	1.70	1.88	2.67	1.65	2.38	2.59	1.89	2.24	2.03
Largest DF-beta (absolute value)**	0.609	0.961	1.242	1.091	16.032	2.023	0.558	16.309	1.039	0.672	4.090	0.936	1.287
Observations range	<0.988	<0.994	0.2-0.8	All	<0.9	0.05-0.95	All	<0.75	0.15-0.85	0.2-0.8	All	<0.9	<0.85
Outliers dropped	5	0	3	3	0	0	4	0	2	2	0	2	4

Table A2: cont'd

	1	2	3	4	5	6	7	8	9	10	11	12	13
	IFS	CS	PPN	PN	PNN	PCR	SN	SNN	IDPT	IMEAS	BSKD	WTR	SAN
Sample size, by year													
1980	37	26	16	27	16	0	50	7	24	14	0	0	0
1990	38	29	32	26	10	17	51	16	17	20	11	20	17
2000	27	16	21	12	10	14	26	9	11	8	21	16	14
Sample size, by income													
Low-income	28	28	5	20	11	9	25	7	14	11	8	14	11
Middle-income	64	42	31	24	19	22	66	23	16	20	22	22	20
High-income	10	1	33	21	6	0	36	2	12	11	2	0	0
Sample size, by region													
Sub-Saharan Africa	24	23	6	16	10	7	22	6	9	8	7	9	6
East Asia and Pacific	15	10	11	8	2	5	22	4	10	6	5	9	7
South Asia	6	4	2	3	1	1	4	0	3	2	2	2	2
E.Europe and Central Asia	2	0	2	2	1	1	3	0	0	0	0	0	0
Western Europe	7	3	18	15	5	1	22	2	7	10	0	1	0
N.Africa and Middle East	15	12	2	9	5	5	17	6	3	2	6	3	3
Latin America and Caribbean	32	19	22	9	12	11	33	14	20	14	11	12	13
North America	1	0	6	3	0	0	4	0	0	0	1	0	0

Notes: IFS=infant survival; CS=child survival; PPN=pre-primary enrolment, gross; PN=primary enrolment, gross; PNN=primary enrolment, net; PCR=primary completion; SN=secondary enrolment, gross; SNN=secondary enrolment, net; IDPT=immunisation, DPT; IMEAS=immunisation, measles; BSKD=births attended by skilled personnel; WTR=access to water; SAN=access to sanitation. *Ages 0-6 for IFS, CS, PPN, IDPT, IMEAS and BSKD; ages 6-11 for PN, PNN and PCR; ages 12-17 for SN and SNN; ** refers to all six sectors of government expenditure.

Table A3: Additional coefficients, diagnostic tests and sample information associated with results in Table 5

	1 IFS	2 IFS	3 IFS	4 IFS	5 IFS	6 CS	7 CS	8 CS	9 CS	10 CS
Additional coefficients										
Per capita GDP	0.367	0.397	0.383	0.268	0.272	0.499	0.480	0.632	0.633	0.592
(p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Male schooling	0.032	0.031	-0.075	-0.049	-0.044	0.043	-0.010	-0.168	-0.172	-0.161
(p-value)	0.29	0.33	0.17	0.27	0.34	0.39	0.85	0.01	0.00	0.00
Female schooling	0.066	0.076	0.148	0.181	0.168	0.065	0.120	0.167	0.274	0.252
(p-value)	0.05	0.03	0.02	0.00	0.00	0.26	0.06	0.02	0.00	0.00
Population of relevant age group*	-0.149	-0.191	-0.208	-0.600	-0.564	-0.664	-0.401	-0.354	-1.051	-1.098
(p-value)	0.37	0.23	0.56	0.01	0.01	0.07	0.19	0.35	0.00	0.00
Population, total	0.161	0.225	0.229	0.612	0.575	0.586	0.375	0.275	1.016	1.055
(p-value)	0.33	0.16	0.51	0.01	0.01	0.11	0.22	0.46	0.00	0.00
Land area	-0.055	-0.076	-0.118	-0.101	-0.093	-0.007	-0.007	-0.072	-0.087	-0.073
(p-value)	0.01	0.00	0.00	0.00	0.00	0.83	0.85	0.09	0.00	0.01
Diagnostic tests										
Heteroskedasticity test	0.92	0.88	0.76	0.34	0.20	0.93	0.55	0.28	0.86	0.71
Functional form test	0.44	0.33	0.14	0.31	0.25	0.16	0.12	0.17	0.43	0.34
Normality test	0.54	0.81	0.55	0.72	0.80	0.48	0.59	0.91	0.57	0.31
Largest standardised residual (abs value)	2.54	2.74	2.45	2.37	2.45	2.93	2.67	2.36	2.33	2.31
Largest DF-beta (absolute value)**	0.610	0.388	0.846	0.450	0.426	0.682	0.427	0.697	0.460	0.389
Observations range	‹0.98	‹0.99	All	All	All	‹0.99	‹0.995	All	All	All
Outliers dropped	0	0	3	0	0	0	0	4	8	7

Table A3: cont'd

	1	2	3	4	5	6	7	8	9	10
	IFS	IFS	IFS	IFS	IFS	CS	CS	CS	CS	CS
Sample size, by year										
1980	54	49	0	0	0	44	37	0	0	0
1990	58	65	22	60	59	44	55	19	58	57
2000	41	53	34	59	57	25	39	35	56	55
Sample size, by income										
Low-income	71	66	24	44	43	71	66	24	44	43
Middle-income	80	88	26	59	59	42	63	25	51	52
High-income	2	13	6	16	14	0	2	5	19	17
Sample size, by region										
Sub-Saharan Africa	55	55	16	35	34	54	54	16	35	34
East Asia and Pacific	15	14	6	11	11	10	10	6	10	10
South Asia	14	12	7	10	10	13	11	7	10	10
E.Europe and Central Asia	2	4	0	2	2	0	0	0	1	1
Western Europe	1	6	1	12	10	2	4	1	16	13
N.Africa and Middle East	15	17	6	9	9	8	14	6	7	7
Latin America and Caribbean	51	58	19	37	37	26	38	17	33	34
North America	0	1	1	3	3	0	0	1	2	3

Notes: IFS=infant survival; CS=child survival. *Ages 0-6 for IFS, CS, PPN, IDPT, IMEAS and BSKD; ages 6-11 for PN, PNN and PCR; ages 12-17 for SN and SNN; ** refers to child output measure only.

Table A4: Additional coefficients, diagnostic tests and sample information associated with results in Table 7

	1	2	3	4	5	6	7	8
Additional coefficients								
Per capita GDP	-1.72	-1.72	-1.50	-1.63	-1.54	-1.00	-1.15	-0.95
(p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Male upper-level schooling	0.03	-	-	-	-	-	-	-
(p-value)	0.74							
Adult mortality rate	0.00	-	-	-	-	-	-	-
(p-value)	0.26							
Fertility rate	-0.78	-	-	-	-	-	-	-
(p-value)	0.08							
Population growth	-	0.30	-0.76	-0.85	-4.81	-1.17	-1.17	-3.76
(p-value)		0.74	0.50	0.41	0.01	0.29	0.35	0.03
Government expenditure*	-3.06	-0.42	-0.81	-0.49	-0.86	-0.66	-0.08	-0.04
(p-value)	0.01	0.03	0.00	0.05	0.07	0.01	0.81	0.92
Investment*	2.43	0.85	0.96	0.90	0.52	0.94	0.63	0.57
(p-value)	0.09	0.00	0.00	0.00	0.24	0.00	0.03	0.11
Openness	0.21	0.28	0.72	0.23	-1.60	0.30	-0.52	-2.68
(p-value)	0.42	0.21	0.01	0.40	0.01	0.31	0.21	0.00
Inflation	-1.61	-1.98	-1.86	-1.75	-1.91	-1.75	-1.33	-2.26
(p-value)	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.03
Rule-of-law index	0.80	0.94	0.79	0.78	1.95	0.77	1.27	1.21
(p-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Political rights	0.52	0.51	0.56	0.47	1.22	0.92	1.13	0.78
(p-value)	0.03	0.03	0.06	0.09	0.03	0.01	0.01	0.18
Political rights squared	-0.08	-0.06	-0.05	-0.05	-0.13	-0.12	-0.12	-0.09
(p-value)	0.01	0.03	0.17	0.17	0.05	0.00	0.01	0.21
Terms of trade	18.54	13.29	16.00	12.57	1.50	9.92	10.85	8.46
(p-value)	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.01
Diagnostic tests								
Heteroskedasticity test	.75	.68	.41	.77	.42	.64	.75	.64
Functional form test	.88	.73	.42	.43	.82	.19	.75	.33
Normality test	.32	.11	.84	.38	.47	.48	.69	.50
Largest standardised residual (abs value)	2.48	2.32	2.88	2.66	2.35	2.70	2.36	2.62
Largest DF-beta (absolute value)**	.475	.451	.341	.453	.742	.398	.337	.907
Observations range	All	All	All	All	All	All	All	-5% – 5%
Outliers dropped	27	31	11	12	4	12	14	4
Sample size, by period								
1970s	59	69	42	50	0	0	0	0
1980s	69	86	42	62	0	91	32	0
1990s	79	112	97	114	94	119	96	87
Sample size, by income								
Low-income	53	82	39	61	37	69	43	35
Middle-income	84	110	81	100	55	90	64	40
High-income	70	75	61	65	2	51	21	12
Sample size, by region								
Sub-Saharan Africa	44	69	33	48	33	61	38	29
East Asia and Pacific	28	31	21	29	9	22	14	7
South Asia	9	9	3	6	3	8	5	4
E.Europe and Central Asia	4	18	19	22	20	21	13	9
Western Europe	51	56	44	47	0	38	12	8
N.Africa and Middle East	12	19	16	17	8	14	9	7
Latin America and Caribbean	53	59	41	52	21	42	33	21
North America	6	6	4	5	0	4	4	2

Notes: *entered in logarithmic form in columns (2)-(8). **refers to child indicators only.

Table A5: Additional coefficients, diagnostic tests and sample information associated with results in Table 9

	1	2	3	4	5	6	7	8
Additional coefficients								
Gini coefficient	0.12	0.09	0.12	0.11	-0.47	0.04	0.07	0.20
(p-value)	0.00	0.00	0.00	0.00	0.20	0.20	0.29	0.23
Per capita GDP	-7.63	6.53	-5.31	2.78	24.76	1.22	-1.36	-16.85
(p-value)	0.05	0.06	0.47	0.49	0.42	0.84	0.88	0.54
Per capita GDP squared	0.47	-0.37	0.31	-0.17	-1.37	-0.05	0.09	0.92
(p-value)	0.04	0.07	0.46	0.48	0.44	0.88	0.87	0.56
Rule-of-law index	0.08	-0.07	-0.09	0.06	-1.56	-0.15	-0.07	1.00
(p-value)	0.69	0.79	0.82	0.81	0.69	0.61	0.93	0.59
Start year of period	-0.04	-0.05	-0.02	-0.05	-0.27	-0.10	-0.08	0.21
(p-value)	0.02	0.01	0.37	0.01	0.26	0.00	0.41	0.28
Diagnostic tests								
Heteroskedasticity test	.31	.16	.49	.20	.07	.01	.94	.67
Functional form test	.62	.95	.71	.15	.	.66	.73	.14
Normality test	.32	.82	.76	.54	.49	.59	.14	.52
Largest standardised residual (abs value)	2.29	2.75	2.28	2.27	1.38	2.34	2.77	1.86
Largest DF-beta (absolute value)*	.832	.563	.821	.633	3.117	.806	.700	4.243
Observations range	All	All	All	All	All	All	All	All
Outliers dropped	8	0	0	4	4	0	0	5
Sample size, by period								
1970s	53	57	30	35	0	23	2	0
1980s	42	52	32	46	17	51	31	24
1990s	4	5	2	4	3	5	4	1
Sample size, by income								
Low-income	14	17	6	7	8	13	8	5
Middle-income	45	50	25	39	12	36	19	13
High-income	40	47	33	39	0	30	10	7
Sample size, by region								
Sub-Saharan Africa	5	8	1	1	6	7	4	3
East Asia and Pacific	21	24	13	23	5	16	8	7
South Asia	10	11	3	5	2	7	4	1
E.Europe and Central Asia	5	6	4	5	3	6	1	1
Western Europe	25	28	21	21	0	19	6	3
N.Africa and Middle East	6	6	5	4	2	4	2	2
Latin America and Caribbean	21	25	15	21	2	17	10	6
North America	6	6	2	5	0	3	2	2

Notes: Dependent variable in each case is the rate of reduction in the Gini coefficient, percent per year. *refers to child indicators only.