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Emanuele Baldacci, Maria Teresa Guin-Siu, Luiz R. de Mello

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MORE ON THE EFFECTIVENESS OF PUBLIC SPENDING ON HEALTH CARE AND EDUCATION: A COVARIANCE STRUCTURE MODEL

EMANUELE BALDACCI,* MARIA TERESA GUIN-SIU* and LUIZ DE MELLO*
International Monetary Fund, Washington, DC, USA

Abstract: Using data for a sample of developing countries and transition economies, this paper estimates the relationship between government spending on health care and education and selected social indicators. Unlike previous studies, where social indicators are used as proxies for the unobservable health and education status of the population, this paper estimates a latent variable model. The findings suggest that public spending is an important determinant of social outcomes, particularly in the education sector. Overall, the latent variable approach yields better estimates of a social production function than the traditional approach, with higher elasticities of social indicators with respect to income and spending, therefore providing stronger evidence that increases in public spending do have a positive impact on social outcomes. Copyright © 2003 John Wiley & Sons, Ltd.

1 INTRODUCTION

Social programmes such as health care and education are generally believed to have a bearing on human development, and, consequently, increased government spending in those programmes is expected to result in better social outcomes. However, recent empirical studies have noted that the impact on outcome indicators of government spending on social programmes is weak, both in developed and developing countries. In general, income per capita is a more powerful determinant of school enrollment and immunization rates, for instance, than the resources spent by the government on programs aimed at improving social outcomes.

In the case of health care, many studies using data for both developed and developing countries show that income is the major determinant of the population's health status, while the ratio to GDP of public spending on health care, as well as the share of public outlays in total health care spending, are relatively poor predictors of cross-country

*Correspondence to: E. Baldacci, M. T. Guin-Siu and L. de Mello, Suite 3-700, Fiscal Affairs Department, International Monetary Fund, 700 19th Street, Washington, DC, 20431, USA. E-mail: ebaldacci@imf.org

differentials in health indicators (Filmer and Pritchett, 1999; Filmer *et al.*, 2000; Jack, 1999). Recent research on OECD countries suggests, however, that there is a positive, albeit weak, relationship between public spending on health care and premature mortality (Or, 2000). In education, a stronger relationship is often reported between public spending and social indicators when cross-country differences in socio-demographic and economic indicators are taken into account (Flug *et al.*, 1998). In the same vein, Gupta *et al.* (2003) show that both the level and the composition of spending on education, proxying for the efficiency of government spending, are important determinants of enrolment rates, persistence rates through grade 4, and primary school dropout rates. However, as in the case of health care, income tends to dominate the correlation between public spending and outcomes.

The usual culprits for the generally weak estimated relationship between social indicators and public spending are data deficiencies (e.g., exclusion of private and sub-national outlays in total spending data and dearth of disaggregated data on the distribution of indicators by income class) as well as econometric problems (e.g., ill-specified reduced-form estimating equations and poorly defined identification tests). This paper focuses on the latter issue and seeks to address econometric problems by using a latent variable model (covariance structure model), which, to our knowledge, has not been used in the empirical literature. The main argument for using a latent variable model is that the health and education status of the population are unobservable, multi-dimensional concepts and, as such, cannot be measured by a unique social indicator in a social production function.

Based on the latent variable model, we find strong evidence that public spending affects school enrolment positively. Moreover, both real income and the intra-sectoral composition of public spending on education tend to have a higher positive elasticity than in the traditional approach. Another finding of the paper is that unfavourable initial conditions, such as high illiteracy rates, reduce the effectiveness of social spending. On health care, the empirical findings are less clear-cut and, in general, the elasticity of public spending on health outcomes is lower than in the traditional approach. There is, however, a significant non-linear negative relationship between public spending and mortality rates, with the estimated elasticity of spending being higher for a sub-sample of low-income countries. These results are in line with claims that the poor benefit more from public spending on health care, and that the relationship between public spending and the health status of the poor is stronger in low-income countries.[1] In addition, the effect of initial enrolment rates becomes stronger and income elasticities tend to be lower in poorer countries.

This paper is organized as follows. Section 2 briefly describes the methodology for estimating the latent variable (or covariance structure) model. Section 3 presents the data and the estimation results following the traditional approach. Section 4 reports the results of the latent variable model. Section 5 concludes and presents some policy implications of the empirical analysis.

2 COVARIANCE STRUCTURE MODELS

The conventional approach to estimating the relationship between health and education status and government spending is to treat social indicators as outputs and public spending

[1]Gupta *et al.* (2001) and Bidani and Ravallion (1997) find that the poor are affected more favorably by public spending on health care than the non-poor. The authors use disaggregated data on the distribution of indicators by income class to analyse the impact of public health spending on the poor.

on social programs as an input in a social production function. The problem with this approach is that the true outputs in this production function are not observable and, therefore, the use of intermediate health and education indicators as direct proxies for outcomes biases parameter estimates to the extent that these proxies are poor correlates with the unobservable output variable (Jack, 1999). The use of nonparametric estimators in the empirical analysis does not solve this problem, because it does not address the issue of how to correctly measure the dependent variable.[2]

To overcome this problem we argue in this paper that the social production function should be estimated using a latent variable model.[3] In a nutshell, this methodology differs from the traditional approach, because instead of regressing observable social indicators on government spending and control variables, it uses these indicators as determinants of an unobservable, latent variable. Subsequently, the information available in the covariance matrix of both the usual explanatory variables and the social indicators is used to estimate the empirical association between government spending and the unobservable output variable.[4] Covariance structure models are useful statistical tools in the estimation of structural relationships involving unobservable variables, such as well-being, trust, and happiness,[5] and when the relevant variables define multidimensional concepts, such as poverty or, as in the case at hand, the population's health and education status.[6]

In particular, covariance structure models can be interpreted as a synthesis of two different models (Long, 1983b): (i) a measurement or confirmatory factor model, which has been widely used in social sciences; and (ii) a standard structural equation model, where the relevant variables are not affected by measurement errors, as in the standard regression analysis. The factor model assumes that a vector of p observed variables $\boldsymbol{x}$ can be generated by a corresponding vector $\boldsymbol{\xi}$ of q unobserved variables with an error term $\boldsymbol{\delta}$:

$$\boldsymbol{x} = \boldsymbol{\Lambda}\boldsymbol{\xi} + \boldsymbol{\delta} \tag{1}$$

where $\boldsymbol{\Lambda}$ is a matrix of factor loadings in which each $\lambda_{i,j}$ measures the correlation between the latent variable ξ_j and the observed variable x_i, $i = (1, \ldots, p)$ and $j = (1, \ldots, q)$.

For two vectors of observable variables ($\boldsymbol{x}$ and $\boldsymbol{y}$), equation (1) can be defined as a system:

$$\boldsymbol{x} = \boldsymbol{\Lambda}_x\boldsymbol{\xi} + \boldsymbol{\delta} \quad \text{and} \quad \boldsymbol{y} = \boldsymbol{\Lambda}_y\boldsymbol{\eta} + \boldsymbol{\varepsilon} \tag{2}$$

where the observable variables in vectors $\boldsymbol{x}$ and $\boldsymbol{y}$ are defined as deviations from their means and the unobserved variables in vectors $\boldsymbol{\xi}$ and $\boldsymbol{\eta}$ are uncorrelated with the error

[2]For empirical studies on nonparametric estimations of social production functions see, for instance, Tulkens and Van den Eeckaut (1995).
[3]See Alesina and La Ferrara (2000), for a recent example of an application of latent variable methodology to economic problems.
[4]If data are available for a set of observable variables that are known to be associated with the latent variable, covariance structure models allow for estimating the relationship between the unobserved variables and the set of observable regressors. This can be done by decomposing the covariance matrix of the observable variables (or the correlation matrix when the observable variables are standardized) according to a model describing the correlations among the latent factors measured by the observable variables.
[5]Covariance structure models are also useful in dealing with variables measured with error, and in statistical problems involving simultaneity and interdependence among the relevant variables. See Goldenberger and Duncan (1973), for more information.
[6]For a discussion of the multidimensional nature of health status, see for instance Wang et al. (1999).

terms. In addition, the error terms are assumed to be uncorrelated across the equations in the system.

The second part of the covariance structure model (the structural equation model) consists of defining the causal relationships among the latent variables defined in equation (2), the description of the causal effects, and the assignment of the explained and unexplained variances. The structural equation model can be written as:

$$\boldsymbol{\eta} = \boldsymbol{B}\boldsymbol{\eta} + \boldsymbol{\Gamma}\boldsymbol{\xi} + \boldsymbol{\zeta} \tag{3}$$

where η and ξ are the vectors of, respectively, endogenous and exogenous latent variables, defined in equation (2); $\mathbf{B}$ is a matrix of regression coefficients associated with the endogenous latent variables, with zero diagonal elements, and let $\boldsymbol{I} - \boldsymbol{B}$ be non-singular; $\boldsymbol{\Gamma}$ is a matrix of parameters, capturing the effect of the exogenous latent variables on the endogenous latent variables; and $\boldsymbol{\zeta}$ is a vector of random disturbances.

All variables are defined in equation (3) as deviations from their means and the vector of exogenous latent variables is assumed to be uncorrelated with the random error terms. The variance-covariance matrix of $\boldsymbol{x}$ and $\boldsymbol{y}$ can be expressed in terms of all the parameters of the system, given some necessary overall identification restriction (Jöreskog and Sörbom, 1989). The usual identification restrictions for structural equation models apply to equation (3) in the absence of measurement errors.

The covariance structure model (2)–(3) can be estimated for a covariance matrix $\boldsymbol{\Sigma}$ defined as $E\,[zz']$, where $\boldsymbol{z}$ is a vector constructed by stacking the variables in $\boldsymbol{y}$ on the top of those in $\boldsymbol{x}$. The predicted covariance matrix can be defined as:

$$\boldsymbol{\Sigma} = \begin{bmatrix} \boldsymbol{\Lambda}_y\boldsymbol{A}\left(\boldsymbol{\Gamma\Phi\Gamma}' + \boldsymbol{\Psi}\right)\boldsymbol{A}'\boldsymbol{\Lambda}_y' + \boldsymbol{\Theta}_\varepsilon & \boldsymbol{\Lambda}_y\boldsymbol{A\Gamma\Phi\Lambda}_y' \\ \boldsymbol{\Lambda}_x\boldsymbol{\Phi\Gamma}'\boldsymbol{A}'\boldsymbol{\Lambda}_x' & \boldsymbol{\Lambda}_x\boldsymbol{\Phi\Lambda}_x' + \boldsymbol{\Theta}_\delta \end{bmatrix} \tag{4}$$

where $\boldsymbol{A} = \boldsymbol{I} - \boldsymbol{B}$, $\boldsymbol{\Phi}$ is the covariance matrix of $\boldsymbol{\xi}$, $\boldsymbol{\Psi}$ is the covariance matrix of $\boldsymbol{\zeta}$, and $\boldsymbol{\Theta}_\delta$ and $\boldsymbol{\Theta}_\varepsilon$ are the covariance matrices of $\boldsymbol{\delta}$ and $\boldsymbol{\varepsilon}$, respectively.

Assuming that all variables are normally distributed, the parameters in equation (2) can be estimated by maximum likelihood, by minimizing the following expression:

$$tr\left(\boldsymbol{\Sigma}^{-1}\boldsymbol{S}\right) + [\log|\boldsymbol{\Sigma}| - \log|\boldsymbol{S}|] - (r + s), \tag{5}$$

where r and s denote, respectively, the number of endogenous and exogenous latent variables, and $\boldsymbol{S}$ is the observed covariance matrix.

Goodness-of-fit measures include (1) an χ^2 statistic, which can be used to test the estimated model against the alternative that the covariance matrix is unconstrained;[7] (2) an adjusted goodness-of-fit statistic, which measures the share of total variance explained by the model; and (3) the root mean squared error, defined as the average of the fitted residuals, which can be used when the relevant variables are standardized.[8]

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[7]If the probability of the test exceeds classical significance levels, the null hypothesis is accepted and the model is a good representation of the real covariance matrix of the population.

[8]The significance of each parameter can be also tested using a z-statistic distributed as a t-ratio under multivariate normality.

3 DATA AND PRELIMINARY FINDINGS

3.1 The Data

Data on public spending on health care and education, as well as the relevant social indicators, are available for a sample of 94 developing countries and transition economies[9] in the period 1996–98.[10] The dataset contains information on three groups of variables: public social spending, social indicators, and a set of variables that are known to affect the relationship between social spending and outcomes. Health status indicators include infant and child mortality rates, as well as DPT immunization rates (children aged 1 or less).

Education attainment indicators include primary and secondary school enrolment rates, in addition to persistence through grade 5.[11] The control variables comprise socio-demographic factors (i.e., fertility rates, secondary enrolment rates for girls, and adult illiteracy rates), proxies for economic development (urbanization rates and GDP per capita), and sector-specific indicators (pupil-teacher ratios and the ratio of public spending on education per pupil in primary and tertiary education).

The descriptive statistics, reported in Table 1, show that the public spending ratios are on average lower in our sample than those of high-income countries, as expected, but are in line with the middle-income country average (Chu *et al.*, 1995). The standard deviations are high, at almost half of the mean for most of the variables. Also, spending per pupil is much lower for primary than tertiary education, suggesting that the composition of education spending is a factor that could contribute to the large differences in social outcomes in the sample. With regard to social indicators and control variables, gross school enrolment rates are much higher for primary education than for secondary education. The standard deviation of the ratio of public outlays to GDP, measuring government size, is high, reflecting the inclusion of transition economies and higher-income countries in the sample.

Turning to raw correlations, public spending on education is positively correlated with school enrolment rates but the correlation between public spending and persistence through grade 5 is not statistically significant. Public outlays on health care correlate negatively with infant and child mortality, and positively with access to sanitation and DPT immunization rates.[12] As expected, the ratio of public spending per pupil in tertiary education to that in primary education, measuring the intrasectoral composition of

[9]The original dataset of 111 countries exhibited considerable dispersion in many indicators. Principal component analysis and cluster analysis (Bouroche and Saporta, 2002; Morrison, 1990) were used to assess the sources of variance in the data and to identify the potential outliers in the sample. Based on these results, the original sample was reduced to 94 countries, after eliminating 17 outliers.

[10]We used the World Bank's World Development Indicators data base as a source for social indicators and national statistical data for central government spending on health and education.

[11]The choice of indicators used to measure the efficiency of public spending on health care and education was guided by their appropriateness as proxies for education and health care performance and the availability of internationally comparable data for a wide range of countries. See Gupta and others (2000) for more information on international social development goals and performance indicators.

[12]Public outlays on health care are typically positively correlated with life expectancy at birth (Anderson *et al.*, 2000; Or, 2000), although the correlation between public spending and income is much stronger (Pritchett and Summers, 1996; Filmer and Pritchett, 1999). Spending on health care is also usually negatively correlated with malnutrition rates (Peters *et al.*, 1999).

Table 1. Descriptive statistics (In per cent, unless otherwise specified)

Variable	Label	Mean	Median	Standard Deviation	Skewness	Kurtosis
Child mortality rate (per thousand)	CMR	70.3	39.3	60.1	1.0	2.7
Public expenditure on education (in per cent of GDP)	EDY	4.3	4.0	1.9	0.8	3.6
Share of girls in secondary education	GENR	44.3	48.3	10.6	−1.6	6.7
Ratio of health to education expenditure	HED	51.8	50.2	24.7	0.7	3.8
Public expenditure on health care (in per cent of GDP)	HY	2.2	1.9	1.3	0.8	3.3
Illiteracy rate	ILLIT	24.9	17.4	22.7	0.7	2.3
Immunization against DPT[a]	IMM	81.2	88.5	18.4	−1.3	4.1
Infant mortality rate (per thousand)[b]	IMR	47.9	32.0	36.2	0.8	2.4
Gross primary enrolment rate	PENR	95.1	98.8	29.2	−0.8	3.7
Persistence through grade 5	PER5	82.9	85.2	10.6	−1.7	6.4
Pupil–teacher ratio[c]	PUPT	30.7	27.8	11.1	0.8	3.1
Total public spending (in per cent of GDP)	PY	28.8	27.2	10.6	0.7	3.9
Access to sanitation	SANIT	59.9	64.0	27.2	−0.2	1.7
Gross secondary enrolment rate	SENR	55.2	63.0	26.8	−0.2	1.9
Social spending (in per cent of GDP)	SOCY	6.5	6.0	2.8	0.4	2.6
Spending per pupil in primary education[d]	SPPR	15.3	11.4	9.3	2.3	8.3
Spending per pupil in tertiary education[d]	SPTR	105.6	61.6	102.3	1.0	2.2
Total fertility rate (number of children per woman)	TFR	3.6	3.2	1.6	0.4	2.1
Percentage of urban population	URB	49.8	50.4	20.7	0.1	2.4
GDP per capita in US$ (in purchasing power parity terms)	GDP	4615.1	3533.6	3576.7	1.2	3.9

Notes: The sample size is 94.
[a]Children below 1 year of age.
[b]Children below 5 years of age.
[c]In primary schools.
[d]In per cent of per capita GDP.

education spending, correlates negatively with both primary and secondary enrolment rates, and positively with infant and child mortality rates.[13]

3.2 The Conventional Approach: Econometric Results

To motivate the empirical analysis, the relationship between social spending and social indicators was estimated first using the conventional social production function approach in which, as discussed above, health and education indicators are treated as outputs and public spending ratios are treated as inputs. Other exogenous variables, such as per capita income, are included in the equation to control for additional determinants of social

[13]Emphasis on curative health care to the detriment of basic and preventive services would affect mortality rates negatively. Due to data weaknesses, the intra-sectoral composition of public spending on health care is proxied by that in the education sector assuming that, on average, countries that allocate more public funds to tertiary education also tend to allocate more public funds to curative health care services. Correlation coefficients vary between 0.5 and 0.7 and are all statistically significant at the 5 per cent level.

outcomes. The issue of multidimensionality of the outcome indicators is not dealt with explicitly and separate regressions are run for each indicator. The key testable hypothesis is that the government spending coefficient is positive and statistically significant at classical levels.

For a given time period, the conventional cross-sectional estimating equation can be defined as:

$$y_i = \alpha + \beta GDP_i + \gamma S_i + \delta X_i + u_i \tag{6}$$

where y denotes the social indicator (e.g., mortality rates, school enrolment ratios), GDP is defined in real per capita terms, S denotes public social spending (e.g., health care and education as a percent of GDP), X is a vector of control variables, u is a random error term, and i identifies the countries in the sample.[14]

In the education regressions, gross primary and secondary enrolment rates are used as the dependent variables. Explanatory variables include GDP per capita in purchasing power parity (PPP) terms, the share in GDP of public spending on education, the ratio of public spending on tertiary education to public spending on primary education, the pupil-teacher ratio, the adult illiteracy rate, and the share of girls enrolled in secondary education. In the health care regressions, child mortality (0–5 year olds) and infant mortality (0–1 year olds) rates are used as the dependent variables. Explanatory and control variables include GDP per capita in PPP terms, the share in GDP of public spending on health care, the fertility rate, the urbanization rate, the input mix of government spending (proxied by the pupil–teacher ratio), and the intra-sectoral composition of public spending.

The expected signs are consistent with intuition. In both equations, economic development (measured by real GDP per capita and the urbanization rate) and the share of girls attending secondary school are expected to correlate positively with outcomes. On the other hand, the intra-sectoral composition of public spending, the adult illiteracy rate (capturing family background effects and past social policies), the fertility rate, and the pupil–teacher ratio are all expected to correlate negatively with health and education outcomes.[15]

The results of the estimation of equation (6), reported in Table 2, confirm previous findings in the literature. When equation (6) is estimated using the average of primary and secondary school enrollment rates as the dependent variable,[16] per capita income and public spending are found to be important determinants of social indicators. The intra-sectoral composition of social expenditures also matters and, as expected, adult illiteracy is negatively associated with school enrolment, and a higher share of girls enrolled in

[14]The logarithmic transformation of the variables (except for illiteracy rates) is preferred over alternative specifications. We tested this assumption against a linear specification using the RESET and the McKinnon, White and Davidson (MWD) tests and could not reject the hypothesis that the best specification is the one used in the paper. The log-linear specification also yields the highest model fit.

[15]For example, parents will not have strong incentives to send their children to school or women will not be adequately informed about minimal hygienic and nutritional standards during pregnancy, which could affect negatively the health status of the newborn.

[16]The relevant parameters were not found to be statistically significant at classical confidence levels when the primary school enrolment rate was used as the dependent variable in equation (6). Instead, average primary and secondary school enrolment rates were used. Persistence through grade 5 was also found to be weakly correlated with the exogenous variables included in the regression.

Table 2. School enrolment and public spending on education: cross-section regression

	Dependent variable					
	Primary and secondary enrolment				Secondary enrolment	
	(1)	(2)	(3)	(4)	(1)	(2)
Constant	3.69***	3.69***	2.92***	2.90***	3.33***	3.33***
	(8.70)	(8.70)	(8.35)	(8.43)	(5.43)	(5.43)
GDP per capita	0.07**	0.07**	0.11***	0.11***	0.15***	0.15***
	(2.28)	(2.27)	(4.21)	(4.21)	(3.41)	(3.43)
Public expenditure	0.08**	0.09**	0.15***	0.16***	0.21***	0.20***
on education	(2.08)	(2.03)	(4.17)	(4.00)	(3.65)	(3.29)
Spending per pupil	−0.06***	−0.06***	−0.06***	−0.06***	−0.18***	−0.18***
(tertiary/primary)	(−2.82)	(−2.83)	(−2.94)	(−2.92)	(−5.33)	(−5.32)
Pupil–teacher ratio	−0.02	−0.02	0.07	0.07	−0.25**	−0.25**
	(−0.26)	(0.26)	(0.91)	(0.89)	(−2.15)	(−2.15)
Illiteracy rate	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***	−0.01***
	(−5.77)	(−5.76)	(−5.77)	(−5.57)	(−5.45)	(−5.47)
Share of girls in	0.07**	0.07**	0.07**	0.07**	0.10**	0.10**
secondary education	(2.32)	(2.32)	(3.72)	(3.70)	(2.45)	(2.45)
F-statistic	47.40	47.35	45.30	45.34	96.50	96.05
p-value	0.00	0.00	0.00	0.00	0.00	0.00
Adjusted *R*-squared	0.75	0.75	0.99	0.99	0.86	0.86
AIC	−0.60		−0.90		0.14	
Estimation method	OLS	TSLS	WLS[a]	WTSLS[a]	OLS	TSLS

Notes: Variables are defined as means in the period 1996–98. The number of observations is 94. Except for illiteracy, all variables are defined in logs. *t*-ratios are reported in parenthesis. (*), (**), and (***) denote significance at the 10, 5, and 1 per cent levels, respectively. The instruments are public spending, social spending, and infant mortality (all in log form). OLS, WLS, TSLS, and WTSLS, denote, respectively, ordinary least squares, weighted least squares, two-stage least squares, and weighted two-stage least squares. WLS and WTSLS are weighted by the level of public spending in education.
[a]White-consistent standard errors.

secondary education contributes positively to higher enrolment rates for both males and females.[17] These results also hold when equation (6) is estimated using the secondary enrolment rate as the dependent variable and, in this case, the pupil–teacher ratio is statistically significant with the expected sign. The estimated elasticities of government spending are higher when the secondary enrolment rate is used as the dependent variable and the equations are estimated by taking into account cross-country differentials in spending levels (WLS and WTSLS).

The findings of the health regressions, reported in Table 3, are less clear-cut. As discussed in the literature, spending on health care is usually negatively associated with mortality rates, although not always at statistically significant levels, and per capita income is a more important determinant of health indicators than government spending. As expected, a higher fertility rate increases both infant and child mortality rates, but the urbanization rate is weakly correlated with infant mortality rates. The intra-sectoral allocation of spending and the pupil–teacher ratio is not correlated with mortality rates at classical levels of significance. As in the case of education, the estimated elasticities of government spending are higher when cross-country differentials in spending levels are taken into account (WLS and WTSLS).

[17]See Appleton *et al.* (1996) for more information.

Table 3. Mortality indicators and public spending on health care: cross-section regression

	Dependent variable				
	Infant mortality				Child mortality
	(1)	(2)	(3)	(4)	
Constant	4.63***	4.61***	5.72***	5.73***	3.56
	(6.00)	(5.97)	(7.29)	(7.30)	(1.65)
GDP per capita	−0.21**	−0.2**	−0.34***	−0.34***	−0.21**
	(−2.18)	(−2.12)	(−3.21)	(−3.22)	(−2.16)
Public expenditure on health care	−0.13*	−0.15*	−0.22**	−0.22**	−0.04
	(−1.75)	(−2.07)	(−2.24)	(−2.14)	(−0.43)
Total fertility rate	0.82***	0.82***	0.64***	0.64***	0.75**
	(4.85)	(4.80)	(3.41)	(3.42)	(2.25)
Spending per pupil (tertiary/primary)	0.03	0.03	0.04	0.04	
	(0.49)	(0.53)	(0.60)	(0.60)	
Urbanization rate	−0.01*	−0.01*	0.00	0.00	0.00*
	(−1.82)	(−1.83)	(0.44)	(0.44)	(−1.88)
Pupil–teacher ratio					0.47
					(0.74)
F-statistic	36.15	36.34	50.99	50.94	40.67
p-value	0.00	0.00	0.00	0.00	0.00
Adjusted R-squared	0.65	0.65	0.92	0.91	0.69
AIC	1.41		1.39		0.14
Estimation method	OLS	TSLS	WLS[a]	WTSLS[a]	TSLS

Notes: Variables are defined as means in the period 1996–98. The number of observations is 94. Except for illiteracy, all variables are defined in logs. *t*-ratios are reported in parenthesis. (*), (**), and (***) denote significance at the 10, 5, and 1 per cent levels, respectively. The instruments are public spending, social spending, and infant mortality (all in log form). OLS, WLS, TSLS, and WTSLS, denote, respectively, ordinary least squares, weighted least squares, two-stage least squares, and weighted two-stage least squares. WLS and WTSLS are weighted by the level of public spending in education.
[a]White-consistent standard errors.

4 THE LATENT VARIABLE MODELS

The findings discussed above are consistent with those reported in the production-function literature. However, since no single output indicator perfectly captures the multidimensional nature of unobserved variables such as the population's health or education status, our alternative approach takes into account the relationship between the observable social indicators, the unobservable latent variables, and the exogenous determinants in equation (6), using the covariance structure models described in Section 2.

4.1 Estimating Health and Education Status Separately

The model to be estimated below is a Multiple Indicators Multiple Causes model (MIMIC) that can be derived from the general covariance structure model by setting $\boldsymbol{x} \equiv \xi$ and $\boldsymbol{B} = \mathbf{0}$. The MIMIC model equations are defined as:

$$\eta = \boldsymbol{\Gamma x} + \xi \quad \text{and} \quad \boldsymbol{y} = \boldsymbol{\Lambda}\eta + \boldsymbol{\varepsilon}. \tag{7}$$

Table 4. Raw correlation matrix[a]

	CMR	IMR	SENR	PENR	GDP	HY	ILLIT	TFR	EDY	SPTR
CMR	1.00									
IMR	0.94	1.00								
SENR	−0.74	−0.75	1.00							
PENR	−0.43	−0.44	−0.75	1.00						
GDP	−0.69	−0.68	0.73	0.52	1.00					
HY	−0.22	−0.28	0.31	0.25	0.23	1.00				
ILLIT	0.67	0.65	−0.72	−0.41	−0.47	−0.25	1.00			
TFR	0.77	0.76	−0.77	−0.46	−0.62	−0.19	0.77	1.00		
EDY	−0.23	−0.27	0.40	0.28	0.31	0.61	−0.23	−0.16	1.00	
SPTR	0.67	0.65	−0.79	−0.54	−0.62	−0.08	0.68	0.72	−0.12	1.00

[a]See Table 1 for a description of the variables.

The MIMIC model can be estimated separately for health and education indicators, using equation (4) and the input correlation matrix reported in Table 4.

The estimation results are reported in Table 5.[18] Primary and secondary school enrolment rates are used in the estimation of Model 1. Model 2 includes the two school enrolment rates, as well as persistence through grade 5, as indicators of education status, the unobservable latent variable. Control variables include, as in the cross-sectional regressions, per capita income, spending per pupil in tertiary education relative to primary education, and adult illiteracy rate. The parameter estimates suggest a positive and statistically significant association between public spending on education and education status, with an elasticity of 20 per cent. This elasticity is close to the upper range of the estimates based on the traditional approach when secondary education is used as the outcome variable (Table 2). As in most empirical studies, per capita income is also positively signed and statistically significant with an elasticity of 30 per cent. This elasticity is also much

Table 5. School enrolment and public spending on education: LISREL estimates

	Model (1)	Model (2)
Secondary enrolment rate	1.00	1.00
Primary enrolment rate	0.75***	0.75***
Persistence through grade 5		0.03
GDP per capita	0.30***	0.30***
Public expenditures on education	0.20***	0.20***
Spending per pupil in tertiary education	−0.41***	−0.41***
Illiteracy rate	−0.25***	−0.25***
Ψ (education)	0.20***	0.20***
θ (primary enrollment)	0.43***	0.43***
θ (persistence through grade 5)		0.99***
χ^2	9.42	20.50
p-value	0.05	0.02
Goodness of fit	0.97	0.94
Adjusted goodness of fit	0.84	0.82
Root mean-square residual	0.03	0.05
Total coefficient of determination	0.80	0.80

Notes: Maximum Likelihood estimates. (*), (**), and (***) denote significance of the *t*-test at the 10, 5, and 1 per cent level.

[18]Estimates were obtained using LISREL 7 (Jöreskog and Sörbom, 1989).

Table 6. Health status and public spending on health care: LISREL estimates

	Model (1)	Model (2)
Child mortality	1.00	
Infant mortality	0.99***	
DPT immunization		0.80***
Access to sanitation		1.00
GDP per capita	−0.34***	0.50***
Public expenditure on health care	−0.05	−0.03
Illiteracy rate	0.18*	0.01
Total fertility rate	0.41***	−0.37***
Ψ (poor health status)	0.27***	0.14**
θ (child mortality)	0.05**	
θ (infant mortality)	0.06**	
θ (access to sanitation)		0.26***
θ (DPT immunization)		0.53***
χ^2	3.68	11.32
p-value	0.30	0.01
Goodness of fit	0.99	0.96
Adjusted goodness of fit	0.91	0.74
Root mean-square residual	0.01	0.04
Total coefficient of determination	0.97	0.79

Notes: Maximum Likelihood estimates. (*), (**), and (***) denote significance of the *t*-test at the 10, 5, and 1 per cent level.

higher than that estimated using the conventional approach. The factor loadings on the latent variable are positively signed and statistically significant,[19] except for persistence through grade 5.[20] In particular, the primary enrollment rate is positively correlated with education status, even if its estimated impact on the latent factor is weaker in magnitude than that of secondary school enrollment. The overall fit of the model is over 90 per cent and the χ^2 test fails to reject the null hypothesis for both models.

Similar results are reported in Table 6 for the health equations. In Model 1, child and infant mortality rates are used as indicators of the population's health status, whereas Model 2 uses immunization rates and access to sanitation as the determinants of the latent variable. In both cases, public spending on health care is correctly signed but not statistically significant at classical levels. Per capita income is always statistically significant, negatively correlated with mortality rates, and positively correlated with immunization and access to sanitation. The income elasticity is slightly higher than that estimated using the traditional approach, especially in the case of child mortality (Table 3). In fact, the introduction of the latent variable highlights the role of income-related factors in explaining differentials in mortality rates among the countries in the sample. Illiteracy correlates positively with mortality but has a low explanatory power, when immunization rates and access to sanitation are used as the determinants of health status. Finally, as many previous studies have pointed out, fertility is negatively correlated with health status, and the estimated coefficient is statistically significant in both models.

[19]In order to set the metric of the latent variable, the factor loading of one observable indicator has been fixed to unity. The coefficient of secondary enrolment rate has been normalized in the estimate of Models 1 and 2.
[20]Importantly, persistence through grade 5 is supposed to capture the quality dimension of education attainment. According to the results, quality is not adequately reflected in the selected model. Thus, social spending on education and per capita income are more likely to have a considerable effect on the other dimensions of education status, other than attainment.

4.2 Estimating Health and Education Status Simultaneously

The main reason for estimating health and education status simultaneously is that worse education outcomes could have a negative impact on health status, by reducing access to health services, for example, and that health conditions, especially among children, may negatively affect performance at school. As a result, a more general covariance structure model would estimate both health and education status simultaneously, as in equation (2). To this end, the structural relationship between the exogenous variables and the factors is specified as in equation (3) assuming $\boldsymbol{B} = \mathbf{0}$ and that $\boldsymbol{\Psi}$, the covariance matrix of vector $\boldsymbol{\xi}$ (random error), has only non-zero elements. The latter assumption means that the cross-equation relationships (between health and education status) are summarized in the error variance–covariance matrix.

The estimation results, reported in Table 7, show that, as expected, infant and child mortality rates are negatively associated with good health, whereas primary and secondary school enrolment rates are positively associated with education status. Countries with lower per capita income have poorer health and education outcomes. Public spending on education is positively associated with the corresponding latent factor, but health spending does not seem to affect health status significantly, although the coefficient is correctly

Table 7. Health status, school enrolment and social spending: LISREL estimates

	Model (1) latent variable		Model (2) latent variable	
	Poor health	School enrolment	Poor health	School enrolment
Child mortality	1.00		1.00	
Infant mortality	0.99***		0.99***	
DPT immunization			−0.67***	
Access to sanitation			−0.68***	
Secondary enrolment rate		1.00		1.00
Primary enrolment rate		0.75***		0.75***
GDP per capita	−0.35***	0.30***	−0.36***	0.30***
Public expenditure on health care	−0.05		−0.04	
Illiteracy rate	0.19**	−0.26***	0.19**	−0.26***
Total fertility rate	0.38***		0.38***	
Public expenditure on education		0.20***		0.20***
Spending per pupil in tertiary education		−0.41***		−0.40***
Ψ (poor health status)	0.27***	−0.03	0.25***	
Ψ (education)	−0.03	0.20***	−0.04	0.20***
θ (child mortality)	0.06**		0.06***	
θ (infant mortality)	0.06**		0.07***	
θ (DPT immunization)			0.57***	
θ (access to sanitation)			0.54***	
θ (primary enrolment rate)		0.43***	0.43***	
χ^2	27.63		115.37	
p-value	0.07		0.00	
Goodness of fit	0.95		0.83	
Adjusted goodness of fit	0.85		0.65	
Root mean-square residual	0.03		0.08	
Total coefficient of determination	0.88		0.88	

Notes: Maximum Likelihood estimates. (*), (**), and (***) denote significance of the t-test at the 10, 5, and 1 per cent level.

signed. The intra-sectoral composition of education outlays is an important determinant of education status: the higher the share of resources devoted to tertiary education relative to primary education, the lower the primary and secondary school enrolment rates. No significant correlation was found between the latent variables for health and education status once the effect of the other covariates is considered. A possible explanation for this result is that, since income-related variables and the illiteracy rate have a direct significant impact on both mortality and school enrolment, this impact weakens the relationship between health and education status. However, countries that invest effectively in education programs to reduce adult illiteracy can also expect to have a positive impact on health conditions. The model's overall goodness of fit is 95 per cent and the χ^2 test is significant at the 5 per cent level.[21]

The parameter estimates reported above could be affected by the sizeable variability in per capita income levels among countries, as discussed earlier. To take these effects into account, Model 1 was re-estimated for a sub-sample of low-income countries, where low income is defined as per capita income below the sample median. The results, reported in Table 8, are in line with the previous findings. Parameter estimates are of comparable magnitude. The elasticity of per capita income is still significant, but lower in magnitude

Table 8. Health status, school enrolment and social spending: LISREL estimates for a subsample of low-income countries

	Latent variable	
	Poor health	School enrolment
Child mortality	1.00	
Infant mortality	1.03***	
Secondary enrolment rate		1.00
Primary enrolment rate		0.77***
GDP per capita	−0.28***	0.25***
Public expenditure on health care	−0.13	
Illiteracy rate	0.27**	−0.31***
Total fertility rate	0.34**	
Public expenditure on education		0.17**
Spending per pupil in tertiary education		−0.45***
Ψ (poor health status)	0.19***	−0.04
Ψ (education)	−0.04	0.18***
θ (child mortality)	0.15***	
θ (infant mortality)	0.10**	
θ (primary enrolment rate)		0.41***
χ^2	26.15	
p-value	0.10	
Goodness of fit	0.91	
Adjusted goodness of fit	0.72	
Root mean-square residual	0.04	
Total coefficient of determination	0.90	

Notes: Maximum Likelihood estimates. (*), (**), and (***) denote significance of the *t*-test at the 10, 5, and 1 per cent level. The number of observations is 47.

[21]An alternative specification of this model, where health status is measured by immunization and sanitation rates, in addition to child and infant mortality rates, produces similar parameter estimates: public spending on education is positively associated with education status, whereas health expenditures are not correlated with health status at classical levels of significance.

than for the full sample. The elasticity of public spending on education is also slightly lower, but statistically significant. At the same time, the intra-sectoral composition of social spending, as well as adult illiteracy, plays a more important role in explaining education outcomes in the poor-country sample. The overall fit of the model is better than that estimated for the full sample according to the χ^2 test. The coefficient of the health spending variable is negatively signed, as expected, but still not statistically significant.

5 CONCLUSIONS AND POLICY IMPLICATIONS

The empirical literature, focusing predominantly on cross-sectional evidence, has so far provided only partial justification for higher government spending on education and health care. Income alone usually explains the bulk of the cross-country variation in health and education indicators, regardless of estimation technique used and sample size. The main argument in this paper is that applied research on the links between public spending and social indicators has failed to deal with the econometric problems associated with unobservable multidimensional concepts, such as the education and health status of the population, as dependent variables in reduced-form equations. This paper's main contribution is therefore econometric: it argues that using proxies for unobservable outcomes in social production functions is not the best way to estimate the impact of public spending on education and health care on social outcomes.

The estimates of the government spending and income elasticities based on the covariance structure model are in general higher in magnitude than those obtained in the traditional approach. The only exception to these results is government spending on health care, for which the traditional approach tends to yield higher elasticity estimates. Another significant result reported in this paper is that unfavourable initial social conditions, such as illiteracy and gender inequality (as measured by the access of girls to secondary education), tend to worsen social indicators. In the case of education, for which the covariance structure model produces statistically significant elasticities for the public spending variable, our estimates show that the millennium goal (MDG) of universal primary education enrolment by 2015 could be achieved by increasing the current level of such spending, on average 4.3 per cent of GDP in the countries included in the sample, by about one third on average.

These results reinforce some policy prescriptions that have now become standard. First, health status and educational attainment are multidimensional concepts that cannot be directly measured by a single set of indicators. Social outcome should be seen as the result of a complex production process that involves interrelationships among many variables, including institutional factors and individual behavior (Evans *et al.*, 2001; Or, 2000; World Bank, 2000). More importantly, increases in social spending alone do not ensure better social outcomes. Removing unfavorable initial social conditions, such as high illiteracy rates and/or sizable income and gender disparities in the access to basic public services, could accelerate human development. Finally, the intra-sectoral allocation of spending matters: the composition of education outlays between primary and tertiary education is an important determinant of the education status of the population, especially in a sub-sample of poorer countries. In these countries, in particular, investing in basic education can have a positive direct effect on education outcomes through reduced illiteracy and better access to public social services.

The main caveats of our empirical analysis are well documented. Important causal factors could have been omitted from the specification adopted in this paper.

Cross-country equations do not allow for assessing the impact of micro-determinants of social outcomes, such as school management indicators, class sizes, and quality of health services. Data on other important macroeconomic variables, including information on income distribution and the incidence of public social spending, teachers' and physicians' compensation, and private and regional outlays on education and health care, among others, are not readily available across countries. Moreover, we have omitted several institutional factors that could have a direct impact on the link between public social spending and outcomes, including corruption and fiscal decentralization (Duret, 1999). Finally, there could be significant lags between the implementation of social policies in the health and educational sectors and improvement in social indicators. Data deficiencies prevented a more detailed analysis of the lag structure of policy response in our sample. However, even when these lags were adequately taken into account, the structural relationship between social spending and outcomes can shift over time as a result of changes in technology and individuals' preferences, among other factors (Jack, 1999).

APPENDIX. LIST OF COUNTRIES INCLUDED IN THE PAPER

Albania
Algeria
Angola
Argentina
Azerbaijan
Belarus
Belize
Benin
Bhutan
Bolivia
Botswana
Bulgaria
Burundi
Cambodia
Cameroon
Central African Republic
Chad
Chile
Colombia
Costa Rica
Côte d'Ivoire
Cyprus
Dominican Republic
Ecuador
El Salvador
Eritrea
Estonia
Fiji
Gabon
Gambia, The
Georgia
Guatemala
Guinea
Guinea Bissau
Guyana
Honduras
Hungary
Iran, Islamic Republic of
Jamaica
Jordan
Kazakhstan
Kenya
Korea, Republic of
Kuwait
Kyrgyz Republic
Lao P.D.R.
Lebanon
Lesotho
Libya
Lithuania
Madagascar
Malaysia
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Morocco
Mozambique
Myanmar
Namibia
Nepal
Nicaragua
Niger
Nigeria
Oman
Panama
Peru
Philippines
Romania
Russian Federation
Senegal
Seychelles
Slovak Republic
Solomon Islands
South Africa
Sri Lanka
St. Kitts
St. Vincent and the Grenadines
Swaziland
Syrian Arab Republic
Tajikistan
Thailand
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Ukraine
Uruguay
Uzbekistan
Venezuela, República Bolivariana de
Yemen, Republic of
Zambia
Zimbabwe

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