The optimum size of public education spending: panel data evidence

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Abstract

The paper examines the presence of positive effect of public education spending in a panel of 50 developed, developing and transition economies (over the 1980-2012 period) on the level and growth of output, and, provided such effect holds, considers the optimal provision of public education spending. The econometric methodology relies on panel unit root and cross-sectional dependence tests, panel regression with fixed effects, and panel quantile model with fixed effects. It is demonstrated that public education spending is productive at the margin under alternative specifications, and has positive externalities on the private economy, while the factor productivity in the government sector is higher than in the private. For the panel as a whole, the public education tended to be under-provided (the optimal level of 5.05% of GDP compared to the actual average level of 4.14% of GDP); however, the over-provision is observed in the slow-growing economies in the lower quantiles.

JEL Classification: C33, H52, I25

Keywords: Education expenditure; growth; government size, developing countries

Introduction

The relationship between public expenditure and economic and social outcomes has been subject to extensive research in economics and social and political sciences. The literature considered a number of dimensions of the problem, including (but not limited to): the causality between public expenditure and growth, with Keynesian view of expenditure affecting output contrasted with Wagnerian view of the reverse causality (Magazzino, 2012); the non-linearities in the relationship, exemplified by the Armey-Rahn curve that indicates possible negative effects of the expenditure on output beyond some expenditure level (Armey, 1995; Magazzino, Forte, 2010); the (in-)efficiency of government expenditure, i.e. (in-)ability of government expenditure to bring necessary social outcomes (Tanzi, Schuknecht, 1997; Gupta, Verhoeven, 2001), among other issues.

From empirical and policy standpoint, the identification of the optimal size of the government as well as over- or under-provision of the government expenditure is very much a practical task, given the undesirable tendencies that have been observed in recent decades: the rapid size of government expenditure, tax burden and public debt, the imbalance in the growth of public and private sector, the rise and entrenchment of bureaucracy, the growing influence of vested interests (Baumol, 1967; Niskanen, 1971; De Witte, Moesen, 2010: 39; Facchini, Melki, 2011: 2).

As far as the level of (government) education expenditure is concerned, alongside the positive developments, such as growing literacy and school enrollments, reduction of child mortality (Gupta, Verhoeven, 2001), poverty (Grubb, Michelson, 1974), increase in private investment and capital accumulation (Levy, Clements, 1996), offsetting stagnation in labour force growth (Annabi et al, 2011), and enhancement of nation’s human capital (Jurges, Schneider, 2004), brought by sustained public spending on education, the negative

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phenomena are present. These are the over-expansion of education that is not supported by employment opportunities and economic development, particularly in the less developed economies (Mugaju, 1991), the crowding put of private education investment (Dissou et al, 2016: 20), distortion in the composition of education spending (Su, 2004), to name a few.

The purpose of this paper is to provide an empirical estimate of the optimal size of the public expenditure on education, without engaging in the in-depth analysis of the factors responsible for education expenditure growth. The study uses the panel of 50 economies belonging to the high, middle and low income groups in several regions. The study period covers the recent decades, specifically 1981-2012 period. Two econometric techniques are employed: the fixed effects panel OLS estimation of the aggregate production function in growth terms, with marginal productivity of government spending on education and the size of the education expenditure as regressors; and panel quantile model with fixed effects, to capture the heterogeneities in the effect of education expenditure on growth.

The paper is structured as follows. Section 2 provides a literature review of the Armey-Rahn hypothesis, its theoretical base and the relevant empirical studies. Section 2 discusses the methodological issues, describes the model and the data. Section 3 presents empirical results. Section 4 provides the summary of findings.

Literature review

The type of the relationship that exists between government expenditure and output has been subject to extensive theoretical and empirical research that has been conducted in a variety of settings, using a variety of econometric techniques. Two groups of studies can be distinguished.

The first group examines the presence of Armey curve, that represents the non-linear relationship between the government expenditure and the output - positive up until certain point (the so-called 'Scully point'), and negative beyond this point (Scully, 1994; Armey, 1995). The optimum levels of government expenditure at 'Scully point' ranged from as low as 10.8-15.9% of GDP in the East and South-East Asian economies (Chiou-Wei et al, 2010) to as high as 35.4-43.5% of GDP in the EU economies (Magazzino, Forte, 2010). The estimates likewise varied a lot depending on the type of the economy (developed, transition or developing), the historical period, specification of the models and other factors, thereby precluding the making of generalisations in relation to the 'typical' optimal level of expenditure or elevating the Armey curve hypothesis to the level of economic law. On the other hand, the optimum levels of expenditure in the developed economies are likely to be lower than those in the developing economies and respectively the over-provision of the actual government expenditure beyond the optimal level in the former group of economies is also likely to be common (Magazzino, Forte, 2010: 38-39).

The studies typically focused on the total expenditure as a regressor, however, some of the authors considered disaggregated expenditure (Vedder, Gallaway, 1998, and Miller, 2008). The models included GDP and expenditure in levels or in logarithms, used GDP growth or GDP per capita as dependent variable, introduced lags of the dependent variable, and experimented with a range of control variables (openness, consumption and investment share of GDP, population, tax rates, employment, among others).

Regarding adopted econometric methods, the studies used time series models (Facchini, Melki, 2011 for France during 1871-2008 period, and Magazzino, 2008 for Italy during

1862-1998 period); threshold panel models (Hajamini, Ali Falahi, 2014); dynamic smooth transition autoregressive (STAR) model (Chiou-Wei et al, 2010); data envelopment analysis (De Witte, Moesen, 2010); (panel) Granger causality (Wu et al, 2010); panel OLS and 2SLS (Angelopoulos et al, 2008); panel cointegration (Ghose, Das, 2013); instrumental variable estimations (Afonso, Furseri, 2010); panel models with fixed and random effects (Romero-Avila, Strauch, 2008; Folster, Henrekson, 2001); constrained non-linear regression (Chao, Grubel, 1998).

The second group of studies (that are used as methodological template in this paper) did not attempt to detect non-linearities in the output-expenditure relationship, but instead concerned with the marginal product and output elasticity of government services (Karras, 1996, 1997), the externality effects of government spending, and the factor productivity differentials between government- and non-government sectors (Ram, 1986). These issues were examined using the aggregate production function framework for the total economy (in Karras and the subsequent research), or using the production function for the economy partitioned into the government- and non-government sector, the former having externality effect on the latter (the studies that followed the original paper by Ram). The OLS models with one- or two-way fixed effects, generalised least squares, as well as random coefficients models were the econometric techniques used to this end.

The empirical results were as follows.

The early study by Karras (1996), that examined 118 developed and developing economies in five geographical regions (Europe, Asia, Africa, South and North America) over the 1960-85 period, identified significant productivity of government services, over-provision of government services in Africa, under-provision in Asia and optimal provision in other regions, the negative relationship between the marginal productivity of government spending and government size, and the average optimal level of spending at 23% of GDP (ranging from 14% in the high income economies to 33% in South America).

In a sample of 20 European economies over 1950-90 period, Karras (1997) reached similar conclusions regarding productivity of government spending and its relationship to the government size, and similar level of optimal spending - 16% of GDP (+/- 3%), with the actual expenditure levels during the period generally being below that level (with the exception of Denmark, Sweden and the UK).

Aly and Strazicich (2000) considered a group of five Persian Gulf economies (Bahrain, Kuwait, Oman, Saudi Arabia, and United Arab Emirates), individually and as a panel, over the 1970-92 period. The labour inputs and government expenditure were found to be productive, while capital inputs unproductive. While the actual size of government spending during the period was in the 17-29% range, the optimal levels were found to be much lower (9% of GDP for the whole panel, and as low as 0% and 2% in Oman and Saudi Arabia, the figures that warrant further explanation).

Alleyne et al (2004) focused on Caribbean economies, using annual data for the 1975-2002 period. The government services were found to positively affect economic growth in this regional group, while the optimal size of the government stood at 13.0% of GDP for the whole group (well below the average level of 19.3% during the whole period), and 11.9%, 26.4% and 28.0% for Trinidad and Tobago, Barbados, and Belize respectively (reflecting the structural economic and systemic differences in the political economic system across the economies in the same region - social democracy and strong service sector in Barbados, versus liberal democracy and weak services in Trinidad and Tobago).

Zhang and Li (2008) examined the provision of rural (as opposed to purely agricultural) expenditure in China over 1980-2005 period. The results demonstrated positive effect of rural spending on GDP and the significant under-provision of the rural expenditure despite its gradual increase over the years (the optimal level of 13.2% of rural GDP versus the actual expenditure fluctuating between 2% and 6% of rural GDP), indicating the need to upscale rural spending to correct urban-rural imbalances.

The output effects of government spending, the relevant externalities and inter-sectoral productivity differentials based on a two-sector production function were first examined empirically by Ram (1986). Using a sample of 115 market economies during the 1960-80 period, the author unequivocally established positive effects of the spending on output in all periods and in a vast majority of economies in question (but particularly in the low-income economies). The positive externality effects on the rest of the economy were likewise pervasive (increasing over the 1970s), while the inter-sectoral productivity differentials were the most pronounced in the 1960s.

Gunalp and Gur (2002) confirmed Ram's findings in many respects, using the data for the 1979-1997 period; however, a large number of negative relationships were found for the Latin American and African economies, reflecting the macroeconomic and political economic challenges that these countries faced during the period (debt crisis of the 1980s, slack economic reforms and political instability).

The recent study by Saez et al (2017) likewise illustrated the country- and region-specific differences that underpin the government spending effects: the positive relationship between the variables was found on only a handful of European economies during the 1994-2012 period (Portugal and the UK), alongside the negative (Austria, Finland, Italy, and Sweden) or insignificant ones (Belgium, France, Greece, Ireland, Luxembourg, the Netherlands and Spain).

As far as the relationship between education expenditure and output (and its growth), as well as the optimality of this type of expenditure are concerned, the economic theory hypothesizes positive effects of human capital and education for growth, established due to rising marginal productivity in the economy, increase in innovative capacity, and positive spillover benefits (Schultz, 1961; Nelson, Phelps, 1966; Romer, 1990).

As surveyed by Neycheva (2010: 143), methodologically, the empirical studies used literacy rate, the level of educational attainment, the years of schooling, performance at international science tests or national average IQ scores as a proxy for human capital stock (Cohen, Soto, 2007; Jones, Schneider, 2006). An alternative approach is to use of public outlays on education as a proxy for human capital, on the assumption that such outlays are productive (Glomm, Ravikumar, 1998; Neycheva, 2010: 145).

With regard to modelling and estimation methods, the studies used OLS models or extended aggregate production functions with public education expenditure as one of the regressors (Neycheva, 2010); general equilibrium models to examine economic effects of government education expenditure by accounting for structural features of the economy (Jung, Thorbecke, 2003); Granger causality, cointegation, VAR/VECM or simultaneous equations models to establish causality between human capital or education expenditure on one hand

and economic outcomes on the other (Freire-Seren, 2001; Islam et al, 2007; De Meulemeester, Rochat, 1995); overlapping generation models that consider consumption, investment and optimal allocation of resources decisions during human capital formation process (Tran-Nam et al, 1995).

The following results emerge from empirical research. Firstly, the causality between education (expenditure) and human capital on one hand and economic variables on the other is likely to be bi-directional (Francis, Iyare, 2006; Freire-Seren, 2001; Islam et al, 2007). Secondly, the effects on growth are mixed: positive (Behabib, Spiegel, 1994), negative (Pritchett, 2001), or insignificant (Nonnenman, Vanhoudt, 1996). The mixed findings may be attributed to differential quality of schooling; the differences in stock and flow of human capital; the varying effects across education levels (with primary and secondary education, as opposed to tertiary, having the most significant and positive effects on economic outcomes); the influence of other control variables and intermediate variables, such as health, or physical capital; interplay between education outlays and labour productivity; the economic structure, development level, focus and goals of education systems, institutional inertia, among other factors (Neycheva, 2010: 143-4; Islam, 1995; Krueger, Lindhal, 1999; Bosworth, Collins, 2003; Qi, 2016).

We note, that in contrast to studies that attempt to establish the optimal level of aggregate expenditure, the work on the optimal level of education expenditure is lacking, the shortcoming that we try to address in this paper.

Methodology

Model

For the purpose of modelling, we relied on studies by Ram (1986) and Karras (1996, 1997).

The former type of studies examined the sign and significance of government expenditure on GDP growth, the presence of positive (or negative) externalities from the government expenditure and the productivity effects of the government sector vis-a-vis productivity of the non-government sector. The latter type of studies attempts to determine whether the government expenditure is optimally provided (with the marginal product of expenditure equal to unity), or conversely is under- or over-provided.

Ram (1986: 192) divides the total economy into the government (G) and non-government (C) sectors with the following production functions:

$$C = C(L_c, K_c, G) \tag{1}$$

and

$$G = G(L_g, K_g) \tag{2}$$

,where the respective outputs depend on labour and capital inputs, and additionally the government sector having externality effect on the non-government sector. The inputs and outputs on the two sectors add up to make a total economic input and output, i.e. $L_c + L_g = L$, $K_c + K_g = K$, and $Y = C + G$.

It is further assumed that relative factor productivities in the two sectors differ:

$$G_L / C_L = G_K / C_K = 1+\delta \qquad (3)$$

,where $\delta > 0$ is an indicator of higher productivity in the government sector (and $\delta < 0$ in the non-government sector), and the marginal productivites of each factor in each sector are $G_L = \partial G / \partial L$, $C_L = \partial C / \partial L$, $G_K = \partial G / \partial K$, and $C_K = \partial C / \partial K$.

The aggregate growth equation (*Specification 1*) is then given as:

$$\dot{Y} = \alpha\left(I/Y\right) + \beta\dot{L} + \left(\delta' - \theta\right)\dot{G}\left(G/Y\right) + \theta\dot{G} \qquad (4)$$

,where $(\cdot)$ represents growth rate of the respective variable; β, α, θ are parameters to be estimated; $\delta' = \delta/(1+\delta)$ with δ being inter-sectoral productivity differential; I is a proxy for change in the capital stock from year t to year $t+1$; α is the marginal product of K in sector C; β is elasticity of C with respect to L; and $\theta = C_G\left(G/C\right)$ is the elasticity of the non-government sector output with respect to G.

Following Ram (1986), we considered two additional specifications, derived from Equation (4).

In *Specification 2*, $\delta' = \theta$, and Equation (4) reduces to:

$$\dot{Y} = \alpha\left(I/Y\right) + \beta\dot{L} + \theta\dot{G} \qquad (5)$$

,where $\theta > 0$ represents positive externality of the government expenditure on the non-government sector.

In *Specification 3*, G_C is assumed to be a constant parameter, and Equation (4) transforms into:

$$\dot{Y} = \alpha\left(I/Y\right) + \beta\dot{L} + \left(\delta' + C_G\right)\dot{G}\left(G/Y\right) \qquad (6)$$

,where the coefficient of $\dot{G}\left(G/Y\right)$ measures the overall effect of government size on the output growth, as opposed to externality effect in Equation (5).

Following Ram (1986), and Gunalp and Gur (2002), we postulate that government expenditure has positive externality on the other sector, i.e. $\theta > 0$ in Equation (5); the overall effect of government expenditure on growth is positive, i.e. $(\delta' + C_G) > 0$; the coefficient $(\delta' + C_G)$ in Equation (6) is substantially larger than $(\delta' - \theta)$ coefficient in Equation (4) as long as $\theta > 0$; the coefficient $(\delta' + C_G)$ in Equation (6) is larger than θ coefficient in Equation (5) unless $\delta < 0$. To avoid collinearity between $\dot{G}\left(G/Y\right)$ and $\dot{G}$ in Equation (4), the preferred strategy is to estimate Equations (5) and (6) and obtain externality and total effects of government expenditure on growth.

In addition, for comparison purposes, we included *Specification 4* that was advanced by Landau (1983) and occasionally used in the empirical literature (Goel et al, 2008), where G/Y, the government expenditure as a proportion of income, enters as the only regressor representing government expenditure:

$$\dot{Y} = \alpha_K \left(I/_Y \right) + \beta_L \dot{L} + \gamma \left(G/_Y \right) \quad (7)$$

The empirical results tend to counter-intuitively yield negative value of γ.

Regarding under-, over- or optimal provision of government expenditure, Karras (1996: 196-7) considers aggregate production function:

$$Y = f(K, L, G) \quad (8)$$

,where Y is real GDP, K is total public and private capital stock, L is employment, and G is government expenditure. Assuming that function f is homogeneous of degree one in K, L and G and that $f_i > 0$ and $f_{ii} < 0$ for $i = 1,2$, Equation (8) is differentiated with respect to time and re-written with real GDP and government expenditure expressed in per capita terms as:

$$(\Delta Y/Y) = \alpha(\Delta L/L) + MPK(\Delta K/Y) + MPG[(\Delta g/g)(G/Y)] \quad (9)$$

,where $g = G/_N$, with N being population of the country; $\Delta Y/_Y$ is the GDP per capita growth rate; $\alpha = (\partial f/\partial L)(L/Y)$ is the output elasticity of employment; $MPK = \partial f/\partial K$ is the marginal product of capital; and $MPG = \partial f/\partial G$ is the marginal product of government spending. The ratio I/Y is used as approximation of $\Delta K/Y$.

Government expenditure is deemed productive, when $MPG > 0$ and not productive when $MPG = 0$. The level of government expenditure is considered optimal, when $MPG = 1$. The expenditure is under-provided, when $MPG > 1$, and over-provided, when $MPG < 1$.

Assuming that $MPG = \gamma/s$, where $\gamma = (\partial f/\partial G)(G/Y)$ is the output elasticity of expenditure, and $s = G/Y$ is the size of government expenditure as proportion of GDP, the optimal government size is given as $MPG^* = 1$ and $s^* = \gamma$. The Equation (8) is differentiated one more time and the estimate of the optimal level of expenditure, γ, is obtained from:

$$(\Delta Y/Y) = \alpha(\Delta L/L) + MPK(\Delta K/Y) + \gamma(\Delta g/g) \quad (10)$$

In both types of functions proposed by Ram (1986) and Karras (1996, 1997) we replace the total government expenditure with expenditure on education, an approach that was previously adopted in Goel et al, 2008 (R&D expenditure in the US), and Zhang and Li, 2008 (rural fiscal expenditure in China).

Data

The public expenditure on education data is obtained from the International Food Policy Research Institute (IFPRI) 'Statistics of Public Expenditure for Economic Development (SPEED)' database (IFPRI, 2015).[i] The database covers 1980-2012 period and includes 147 economies falling into eight regional groups (East Asia and Pacific, Eastern Europe and Central Asia, Euro Zone, High Income Economies, Latin America and Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa). The complete and consistent education expenditure time series with 33 observations are not available for each individual economy in IFPRI database, and therefore the sample was curtailed to include 50 economies (listed in the Appendix), belonging principally to the Eurozone and high-income economic groups, and to much smaller extend to the developing economies groups. The number of observations was reduced by one and the study period is trimmed to 1981-2012, given that estimates in growth rates are performed. The expenditures are valued in national currencies at 2005 constant prices, converted to the US dollars using purchasing power parity (PPP) exchange rates, and expressed as a proportion of GDP. The primary sources of government expenditure data are IMF *Government Financial Statistics (GFC)* Yearbook, IMF *Statistical Appendix*, IMF *Selected Issues* publications, and the World Bank's *Public Expenditure Reviews*, supplemented by data from the countries' government agencies and central banks, and international and multilateral organisations (Yu et al, 2015: 7).

The GDP figures together with gross fixed capital formation data were obtained from the *UN National Accounts - Analysis of Main Aggregates* database,[ii] and investment share of GDP was respectively calculated (the investment share was used as a proxy for the capital stock data, as in Ram, 1986, and Gunalp and Gur, 2002).

The population figures were based on the *World Population Prospects: The 2018 Revision* document published by the UN Population Division (United Nations, 2019). The labour force data was obtained from the Penn World Table Version 8.1 (PWT 8.1) and was defined as the number of persons engaged in millions (*emp* indicator).

In few rare cases, the outlier observations (that could potentially distort the results) were eliminated and replaced with interpolated data (cubic spline interpolation being the respective method): GDP growth in Botswana (1989), Kuwait (1990-93), and Nigeria (2002), and investment share as proportion of GDP in Switzerland (1981-82, 1984, 1986-89 and 1998-2000).

The paper focuses explicitly on the public expenditures on education, therefore the empirical results based on total (or private expenditure) may differ from those provided in this paper. The public expenditure is defined based on the Classification of the Functions of Government, COFOG, and includes (at the second level of classification) expenditures on pre-primary and primary education, secondary education, post-secondary non-tertiary education, tertiary education, education not defined by level, subsidiary services to education, R&D pertaining to education, and education not elsewhere classified (OECD, 2011: Annex B).

Econometric method

Three complementary techniques were used. Firstly, to obtain efficient estimates, properly model error term and given that same sample is used along all periods, the panel OLS with country- and time-specific effects is used (as in Karras, 1996: 198):

$$y_{it} = (\alpha + u_i + \lambda_t) + \beta X'_{it} + v_{it} \tag{11}$$

,where y_{it} is dependent variable ($\Delta Y/Y$), X'_{it} is the vector of regressors, u_i and λ_t are unobserved individual- and time-specific effects, and v_{it} is independently and identically distributed error term with variance σ_v^2 (Park, 2011:9).

Secondly, given the presence of outliers and long-tail distribution in education expenditure (as proportion of GDP) and the heterogeneities in the effect of expenditure on growth, a panel quantile model was applied (Koenker, Bassett, 1978).

For a set of regressors X_{it}, the $\tau-$th quantile is represented as the conditional distribution of the economic growth rate ($\Delta Y/Y$):

$$Q_{\tau}(\Delta Y/Y) = \alpha_{\tau} + \beta_{\tau} X_{it} + \alpha_{\tau} \mu_{it} \quad (12)$$

,where $0 < \tau < 1$, and μ_{it} represents unobservable factors (Gozgor et al, 2018: 30-1).

The estimates of coefficients in Equation (12) are obtained as a result of minimization of the absolute value of residuals as follows:

$$Q_{\tau}(\beta_{\tau}) = \min_{\beta} \sum_{i=1}^{n} \left[\left| \ln(\Delta Y/Y) - \beta_{\tau} X_{it} \right| \right] =$$

$$= \min_{\beta} \left[\sum_{i:(\Delta Y/Y)_{it} \geq \beta X_i}^{n} \tau \left| (\Delta Y/Y)_{it} - \beta_{\tau} X_{it} \right| + \sum_{i:(\Delta Y/Y)_{it} \geq \beta X_{it}}^{n} (1-\tau) \left| (\Delta Y/Y)_{it} - \beta_{\tau} X_{it} \right| \right] \quad (13)$$

Thirdly, the method of moments panel quantile regression (MM-QR) proposed by Machado and Silva (2019) was used. The advantages of the method are the following: 1). In contrast to Koenker method (Koenker, Bassett, 1978; Koenker, 2005), that accounts for different fixed effect at each quantile (quantile-by-quantile approach) and yields unbiased estimates of β only when T is sufficiently large and greater than N, MM-QR method estimates quantiles from the estimates of the conditional mean and the conditional scale function, while also providing information on the dependent variables affecting the whole conditional distribution (Galan, 2020: 14-15; Haylock, 2020: 15). 2). It is computationally simpler than methods that include a large number of individual intercepts in the quantile regression, and eliminates to inflation effect problem (the introduction of large number of individual effects increasing the variability of other covariate effects' estimates, Koenker, 2004).

Empirical results

As a first step we examine the statistical properties of the series (Table 1, and Table 7 in the Appendix). The variables are represented as growth rates and therefore a number of outliers in the data appear. The observations above the 95th and below the 5th percentile were removed using the trimming procedure.

All variables had positive means and medians before and after the trimming. The trimming reduced the range (the difference between the maximum and minimum observation values) as well as standard deviation, skewness and kurtosis for all variables. Following trimming, all variables were symmetric around the mean, with the exception of the investment share of GDP and the marginal product of education spending, $\dot{G}\left(G/Y\right)$, that were moderately skewed to the right. Following trimming, the labour force growth rate, (per capita) GDP growth rate, education spending as proportion of GDP and the marginal product of education spending were platykurtic (kurtosis smaller than three), while all other variables were leptokurtic (kurtosis greater than three). The null hypothesis of the normal distribution of the data in the Jarque-Bera test was rejected in all cases except for the GDP per capita growth rate. The growth rates of the dependent variable were positive in all countries, except United Arab Emirates that has experienced rapid migration-driven population growth as a result of the initially insufficient labour force (hence negative growth rate of GDP per capita over 1981-2012). The countries with the lowest GDP growth rates were Czech Republic, Denmark, Germany, Greece, Italy, and Romania (and with the lowest GDP per capita growth rates Czech Republic, Greece, Guatemala, Jordan, Kenya, Philippines and the United Arab Emirates).

Table 1 - Descriptive statistics

Statistics	$\dot{Y}$	$\Delta Y/Y$	I/Y	$\dot{L}$	G/Y	$\dot{G}(G/Y)$	$\dot{G}$	$\Delta g/g$	$(\Delta g/g)(G/Y)$
Mean	3.793	2.295	21.818	1.983	4.019	0.161	4.251	2.836	0.099
Median	3.658	2.327	21.161	1.923	4.037	0.118	3.506	2.186	0.065
Maximum	9.837	7.780	37.713	6.370	8.121	0.783	25.916	24.840	0.873
Minimum	-2.066	-3.919	12.503	-1.825	0.652	-0.264	-13.917	-16.297	-0.469
Std. Dev.	2.579	2.389	4.870	1.784	1.837	0.220	7.513	7.466	0.231
Skewness	0.197	-0.107	0.808	0.259	0.072	0.603	0.432	0.377	0.538
Kurtosis	2.537	2.822	3.698	2.502	2.036	2.887	3.285	3.372	3.783
Jarque-Bera	22.152	4.474	185.883	30.920	56.979	79.281	49.621	42.400	106.237
J-B prob.	0.000	0.107	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note. $\Delta Y/Y$ and $\Delta g/g$ are growth rates of GDP per capita and education expenditure per capita.

Secondly, we check for the presence of unit roots in series using the panel unit root tests with constant and no deterministic trend, given the nature of the growth data (Im-Pesaran-Shin/IPS, Levin-Lin-Chu/LLC, ADF-Fisher χ^2, PP-Fisher χ^2 and cross-sectionally augmented IPS / CIPS tests).[iii] We also use the Pesaran (2004) cross-sectional dependence test to detect the possible presence of spatial autocorrelation (cross-sectional dependence).

According to Pesaran (2004) test, the cross-sectional dependence is observed in all series (with the null of cross-sectional independence rejected), the plausible result in light of the globalisation and economic integration processes that were underway during the study period. The unit root tests (Table 2) indicate that all series, except education expenditure / GDP ratio (EDU), are stationary in levels, and (by definition of cointegration) no long-term equilibrium relationship may exist among them. The use of econometric techniques for the stationary panel data (e.g. models with fixed or random effects of the variables in levels) is therefore appropriate. The EDU variable likely contains unit root according to IPS and ADF-Fisher χ^2 tests, therefore its inclusion in the growth regression alongside stationary variables, as suggested by Landau (1984) may lead to spurious results.

Table 2 - Panel unit root tests' results

Statistics	$\dot{Y}$	$\Delta Y/Y$	I/Y	$\dot{L}$	G/Y	$\dot{G}(G/Y)$	$\dot{G}$	$\Delta g/g$	$(\Delta g/g)(G/Y)$

LLC	-15.231	-13.850	-4.399	-10.064	-1.545	-6.947	-17.967	-17.604	-14.467
	(0.000)	(0.000)	(0.000)	(0.000)	(0.061)	(0.000)	(0.000)	(0.000)	(0.000)
IPS	-16.306	-15.378	-4.644	-14.459	-1.075	-11.362	-19.776	-19.677	-19.067
	(0.000)	(0.000)	(0.000)	(0.000)	(0.141)	(0.000)	(0.000)	(0.000)	(0.000)
ADF	466.097	432.968	201.258	416.527	117.228	343.295	567.048	563.910	546.186
	(0.000)	(0.000)	(0.000)	(0.000)	(0.115)	(0.000)	(0.000)	(0.000)	(0.000)
PP	570.851	611.733	163.092	499.641	143.921	831.798	989.569	1004.600	1020.080
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
Pesaran	28.666	27.931	5.050	9.216	16.277	4.072	3.993	3.698	10.725
	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)

Note. p-values are indicated in the parentheses.

Table 3 presents the estimates of the four specifications proposed by Ram and Landau (Equations 4 to 7). Each equation was estimated with cross-section and period fixed effects and Driscoll-Kraay heteroscedasticity consistent standard errors that are robust to the general forms of spatial and temporary dependence (Hoechle, 2007: 2). The table contains the Hausman test results (that could justify the selection of the model with fixed as opposed to random effects), and the panel serial correlation, heteroscedasticity and cross-sectional dependence tests' outcomes (that could indicate the appropriateness of using the Driscoll-Kraay errors).

Table 3 - Panel regression with fixed effects estimates

Variables	Specification 1	Specification 2	Specification 3	Specification 4
$\dot{L}$	0.230	0.189	0.228	0.196
	(0.004)	(0.030)	(0.006)	(0.016)
I/Y	0.053	0.027	0.025	0.034
	(0.132)	(0.502)	(0.444)	(0.384)
$\dot{G}$	0.052	0.062		
	(0.044)	(0.048)		
$\dot{G}(G/Y)$	-0.045		1.884	
	(0.944)		(0.001)	
G/Y				-0.097
				(0.589)
Constant	6.205	7.429	7.609	8.118
	(0.001)	(0.000)	(0.000)	(0.000)
Period FE	179.770	4.610	186.900	122.530
	(0.000)	(0.000)	(0.000)	(0.000)
Cross-sectional FE	217.700	158.040	293.040	176.900
	(0.000)	(0.000)	(0.000)	(0.000)
Serial correlation	35.843	34.843	22.412	9.401
	(0.000)	(0.000)	(0.000)	(0.004)
Heteroscedasticity	7437.330	11110.940	7602.130	17739.930
	(0.000)	(0.000)	(0.000)	(0.000)
Hausman	58.303	25.477	21.827	16.812
	(0.000)	(0.000)	(0.000)	(0.001)

Note. p-values are indicated in the parentheses. FE represents fixed effects.

In every specification, the coefficient of the labour force growth variable was positive and significant at the 1% significance level, while the coefficient of the investment share was positive but not significant.

In Specification 1 that indicates both the inter-sectoral factor productivity difference and the elasticity of the private sector output with respect to G, the coefficients of $\dot{G}\left(G/Y\right)$ and $\dot{G}$ were negative and positive respectively. Given that $\delta' - \theta = -0.045$ and $\theta = 0.052$, $\delta' = -0.047$. Since $\delta' = \delta/(1+\delta)$, the inter-sectoral factor productivity differential is estimated to be equal to 0.049, suggesting that higher marginal factor productivities are experienced in the public sector. The result is in line with the findings by Ram (1986: 196) for the expenditure effects in the 1960s in the developed and the least developed countries; it, however, contravenes the findings by Gunalp and Gur (2002: 323) who established, in the case of developing economies during the 1979-1997 period, the higher marginal factor productivity in the private sector.

In Specification 2, that includes the estimate of the externality effect of the education expenditure, the relevant coefficient is positive and significant at the 1% significance level ($\theta = 0.062$), pointing to the positive spill-overs from education on private economy.

In Specification 3, that examines the overall economic impact of education irrespective of the sign of the inter-sectoral productivity differential, the coefficient of $\dot{G}\left(G/Y\right)$ is positive and significant at the 1% significance level with $\left(\delta' + C_G\right) = 1.8843$, in line with the previous research, confirming the positive and likely large effect of education expenditure on the economic growth. We also note that the coefficient of $\dot{G}\left(G/Y\right)$ in Specification 1 is substantially smaller than in Specification 3 (-0.045 < 1.884) and the coefficient of $\dot{G}\left(G/Y\right)$ in Specification 3 is substantially larger than the coefficient of $\dot{G}$ in Specification 2 (1.884 > 0.062), implying that value of θ is positive, and the value of δ is not a large negative number.

Specification 4, proposed by Landau (1984) is put for comparative purpose, despite the well known problems with the equation functional form due to the inclusion of G/Y as a regressor (Ram, 1986: 197). While Landau's equation may appear more appropriate for the analysis of the Wagner's hypothesis of the scale of the government growing faster than the economy (not for the analysis of the impacts of expenditure growth on economic growth), it nonetheless ignores the causality that runs from the economic level variable to the expenditure variable (e.g. $Y \rightarrow G/Y$). In Landau's specification, the value of the G/Y coefficient is negative and insignificant, similar to the findings by Ram (1986) and Gunalp and Gur (2002). In light of the above this negative value cannot be construed to indicate the perverse effects of the expanding government on the economy (as hypothesized in the public choice and political economy literature).

To examine the impact of education expenditure across the distribution of the GDP growth, we estimated the panel quantile model with fixed effects (Equations 12 and 13) based on Specifications 2 and 3. The results reported in Table 4 indicate that in Specification 2 the coefficient of education expenditure growth rate were positive for all quantiles, but significant for quantiles 5 to 9 (in particular at 1% significance level for quantiles 6 to 9), i.e.

for economies that experienced higher economic growth rates.[iv] The positive externalities of education expenditure on the private economy were thus present. The coefficients for labour inputs were positive and significant in Specification 3 (and positive and insignificant in Specification 2, with the exception of quantiles 6 and 7), while for investment share positive but insignificant in each quantile. Regarding Specification 3, the similar pattern is observed, except for the first quantile, where the coefficient of $\dot{G}\left(G/Y\right)$ was negative, pointing to the negative growth effects of education in slow-growing economies (Czech Republic, Greece, Denmark, Germany, Italy and Romania).

Table 4 - Panel quantile regression with fixed effects estimates

Specification 2									
Variables	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
$\dot{L}$	0.373	0.305	0.264	0.231	0.202	0.171	0.142	0.106	0.047
	(0.295)	(0.243)	(0.198)	(0.154)	(0.111)	(0.072)	(0.068)	(0.212)	(0.746)
I/Y	0.003	0.006	0.008	0.010	0.011	0.013	0.015	0.016	0.019
	(0.972)	(0.916)	(0.858)	(0.786)	(0.692)	(0.547)	(0.411)	(0.399)	(0.558)
$\dot{G}$	0.013	0.031	0.042	0.050	0.058	0.066	0.074	0.083	0.099
	(0.892)	(0.658)	(0.445)	(0.244)	(0.089)	(0.009)	(0.000)	(0.000)	(0.011)

Note. p-values are indicated in the parentheses.

Specification 3									
Variables	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
$\dot{L}$	0.392	0.327	0.283	0.249	0.221	0.191	0.160	0.123	0.066
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.074)	(0.467)
I/Y	0.002	0.005	0.007	0.009	0.010	0.012	0.013	0.015	0.018
	(0.933)	(0.761)	(0.593)	(0.450)	(0.353)	(0.296)	(0.284)	(0.305)	(0.358)
$\dot{G}(G/Y)$	-0.095	0.353	0.651	0.881	1.075	1.277	1.489	1.741	2.128
	(0.930)	(0.659)	(0.313)	(0.116)	(0.041)	(0.017)	(0.011)	(0.013)	(0.021)

Note. p-values are indicated in the parentheses.

Having established that education expenditure has positive effect on economic growth (with certain exceptions in the lowest quantile), we consider the issue of over-, under-, or optimal provision of education services and the marginal productivity of education spending.

We consider the issue based on Karras specification (Equations 9 and 10), with two key variables (education spending and economic growth) being represented in per capita terms, i.e. growth rate of GDP per capita and the growth rate of education spending per capita (Karras, 1997: 283-4). The model is run with cross-section fixed and period fixed effects and with the other two production function variables (labour input growth rate and investment share). Results reported in Table 5 indicate that marginal product of the government education expenditure is positive and therefore public education spending is productive at the margin. The respective coefficient is greater than one ($MPG = 1.8993$), suggesting that education is under-provided for a whole sample of 50 economies. The values of α and MPK are also positive (but, in the case of investment share variable, insignificant) indicating the adequate productivity of labour and less so of capital inputs. The direct estimation of the optimal expenditure size, γ, in Equation 10 confirms the above finding: the coefficient value is equal to 0.0505, i.e. the optimal expenditure is 5.05% of GDP compared to the actual average expenditure over the 1981-2012 period of 4.14% of GDP.

Table 5 - Panel regression with fixed effects estimates (Karras specifications)

Variables	Equation (9)	Equation (10)
$\dot{L}$	0.130	0.166
	(0.095)	(0.032)
I/Y	0.041	0.018
	(0.326)	(0.615)
$\Delta g/g$		0.051
		(0.007)
$(\Delta g/g)(G/Y)$	1.899	
	(0.000)	
Constant	7.364	6.223
	(0.000)	(0.001)
Period FE	179.79	183.26
	(0.000)	(0.000)
Cross-sectional FE	254.21	232.82
	(0.000)	(0.000)
Serial correlation	32.882	37.492
	(0.000)	(0.000)
Heteroscedasticity	15686.84	7315.55
	(0.000)	(0.000)
Hausman	30.737	70.335
	(0.000)	(0.000)

Note. p-values are indicated in the parentheses. FE represents fixed effects.

The estimation of the panel quantile regression with fixed effects (Table 6) is performed for Equations 9 and 10. For both equations, the marginal productivity of labour is positive in all quantiles (except the highest quantile in Equation 9) and significant in all quantiles (except quantiles 7 to 9 in Equation 9 and quantile 9 in Equation 10). The investment share coefficient is positive in quantiles eight and nine in Equation 9, and in quantiles four to nine in Equation 10. It is, however, statistically insignificant in all instances. Based on the size of MPG coefficient, the public education expenditure is overprovided in quantiles one to five, is optimally provided in quantile 6, and is underprovided in the higher quantiles. The coefficient is significant in all quantiles except for the first two. Based on Equation 10, the optimal size of the public education expenditure is below 4.14% of GDP (the average level across the economies for the study period) in quantiles 1 to 4,[v] is close to the actual level in quantile 5 (4.11% of GDP) and is above the actual average level in quantiles 6 to 9.[vi] Overall, the results suggest that public education is overprovided in lower quantiles (economies with slow GDP per capita growth), and is underprovided in the the higher quantiles (fast growing economies).

Table 6 - Panel quantile regression with fixed effects estimates (Karras specifications)

Equation (9)									
Variables	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
$\dot{L}$	0.346	0.263	0.216	0.171	0.139	0.107	0.071	0.033	-0.026
	(0.003)	(0.001)	(0.001)	(0.003)	(0.011)	(0.056)	(0.254)	(0.654)	(0.783)
I/Y	-0.058	-0.040	-0.030	-0.021	-0.014	-0.008	0.000	0.008	0.020
	(0.472)	(0.483)	(0.515)	(0.601)	(0.708)	(0.844)	(0.997)	(0.878)	(0.760)
$(\Delta g/g)(G/Y)$	0.573	0.724	0.809	0.893	0.950	1.008	1.073	1.143	1.250
	(0.360)	(0.106)	(0.027)	(0.004)	(0.001)	(0.001)	(0.002)	(0.004)	(0.015)

Note. p-values are indicated in the parentheses.

Equation (10)									
Variables	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
$\dot{L}$	0.347	0.282	0.249	0.216	0.187	0.165	0.139	0.108	0.061
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.012)	(0.098)	(0.476)
I/Y	-0.006	-0.002	0.000	0.002	0.004	0.005	0.007	0.009	0.012
	(0.935)	(0.969)	(1.000)	(0.956)	(0.911)	(0.881)	(0.856)	(0.843)	(0.840)
$\Delta g/g$	0.029	0.034	0.037	0.039	0.041	0.043	0.045	0.047	0.050
	(0.375)	(0.149)	(0.062)	(0.019)	(0.007)	(0.006)	(0.008)	(0.018)	(0.052)

Note. p-values are indicated in the parentheses.

Conclusion

The paper examined the two aspects of the relationship between public spending on education and the economic outcomes: the sign and significance of the effects of the former variable on the growth rate of (per capita) GDP and its optimal level as proportion of GDP. This research objective is warranted given that empirical literature tended to focus on the economic effects of the aggregate public spending and on only one of the aspects. Given diversity of economies in terms of level of development and public spending on education, we applied panel quantile model with fixed effects in addition to the conventional panel data methods. The use of the models was justified by the outcomes of the panel unit root and cross-sectional dependence tests.

The paper established positive effects of labour force growth rate and investment share of GDP on the GDP growth, in line with empirical research on economic growth determinants. The overall effect of the public education spending on the level of GDP as well as spillovers on the private economy output were both positive, while the marginal productivity of the private education spending was smaller than marginal productivity of public spending, confirming the earlier findings by Ram (1986). The negative effects of public education spending were observed in the economies with slow economic growth (certain transition economies that experienced slump in the 1990s or some of the developed economies with stagnating GDP). This, however, does not necessarily provides support for the public choice or the new political economy theses on the negative economic effects of over-spending and 'bloated' government, given the possibility of bilateral causality between GDP and spending and the powerful role of education and human capital investment in overcoming stagnation and accelerating growth. The estimates from the specification with GDP per capita as a dependent variable delivered similar results: the positive effects of labour force and marginal productivites of capital and public education spending. Across the whole sample, the education spending (as proportion of GDP) was underprovided, with optimal and actual spending standing at 5.05% and 4.14%. This was not the case of the economies with slow GDP per capita growth. Overall, further research is needed to establish whether the level of education spending in the slow-growing economies is the evidence of optimal (sufficient) provision in a slack and stagnating economy, or excessive spending in the economy that reached its growth limits. The future research may likewise consider the public education spending effects at sub-national level or at the greater level of disaggregation, the possible crowding out effects of public on private spending, as well as the quality and efficiency of public education spending.

Appendix

The sample included 50 economies in the following regions: East Asia and Pacific (P. R. China, Malaysia, Philippines, Singapore, Thailand, Tonga), Europe and Central Asia (Romania), Eurozone (Austria, Belgium, Cyprus, Denmark, Finland, Germany, Greece, Iceland, Italy, Luxembourg, Malta, Netherlands, Norway, Sweden, Czech Republic), other high income economies (Australia, Japan, Israel, South Korea, New Zealand, the UK, the USA), Latin America (Chile, Costa Rica, El Salvador, Guatemala, Panama), Middle East and North Africa (Egypt, Jordan, Kuwait, Oman, Tunisia, Turkey, United Arab Emirates), South Asia (Nepal, Pakistan), Sub-Saharan Africa (Botswana, Kenya, Lesotho, Mauritius, Nigeria, Swaziland/Eswatini, Uganda).

Table 7 - The average growth rates in GDP and GDP per capita for the individual economies

GDP growth (%)						GDP per capita growth (%)					
Country	Mean	SD	Country	Mean	SD	Country	Mean	SD	Country	Mean	SD
ARE	3.576	6.906	LSO	4.074	2.047	ARE	**-3.153**	7.196	LSO	2.746	2.028
AUS	3.218	1.629	LUX	4.071	3.533	AUS	1.792	1.704	LUX	2.965	3.688
AUT	2.114	1.560	MLT	3.678	2.411	AUT	1.833	1.551	MLT	2.853	2.393
BEL	1.900	1.520	MUS	5.037	2.119	BEL	1.590	1.556	MUS	4.160	2.131
BWA	7.038	6.343	MYS	5.903	3.865	BWA	4.400	5.938	MYS	3.450	3.774
CHE	**1.755**	1.691	NGA	4.576	5.165	CHE	**0.979**	1.766	NGA	2.090	5.010
CHL	4.651	4.601	NLD	2.171	1.955	CHL	3.184	4.571	NLD	1.718	1.861
CHN	10.013	2.766	NOR	2.550	1.796	CHN	9.067	2.667	NOR	1.914	1.947
CRI	4.093	3.517	NPL	4.573	2.358	CRI	2.170	3.408	NPL	2.481	2.250
CYP	4.291	3.048	NZL	2.487	2.056	CYP	2.611	3.272	NZL	1.305	1.914
DEU	**1.772**	2.068	OMN	5.336	4.949	DEU	1.708	2.024	OMN	1.398	4.297
DNK	**1.752**	2.095	PAK	4.686	2.023	DNK	1.547	2.136	PAK	1.986	1.797
EGY	5.507	2.729	PAN	4.869	4.315	EGY	3.351	2.572	PAN	2.688	4.333
FIN	2.309	3.245	PHL	3.286	3.463	FIN	1.941	3.331	PHL	**1.052**	3.640
GBR	2.291	1.986	ROU	**1.349**	5.308	GBR	1.990	2.048	ROU	1.825	5.534
GRC	**1.048**	3.714	SGP	6.830	4.198	GRC	**0.687**	3.622	SGP	4.099	4.084
GTM	2.840	2.199	SLV	2.185	3.184	GTM	**0.474**	2.215	SLV	1.645	2.568
ISL	2.675	3.458	SWE	2.111	2.357	ISL	1.509	3.446	SWE	1.716	2.487
ISR	4.356	2.427	SWZ	3.971	2.984	ISR	1.985	2.164	SWZ	1.662	2.341
ITA	**1.306**	1.910	THA	5.634	4.158	ITA	1.139	1.994	THA	4.505	4.055
JOR	4.312	4.856	TON	2.683	3.863	JOR	**0.331**	4.275	TON	2.008	3.388
JPN	2.098	2.560	TUN	4.059	2.382	JPN	1.750	2.473	TUN	2.325	2.574
KEN	3.631	2.359	TUR	4.411	4.403	KEN	**0.587**	2.366	TUR	2.691	4.385
KOR	6.878	3.885	UGA	6.253	3.127	KOR	5.951	3.709	UGA	2.930	3.046
KWT	4.574	19.806	USA	2.770	1.994	KWT	2.744	21.785	USA	1.764	1.968
All	3.791	4.640				All	2.243	4.708			

Note. The economies with the slowest growth are highlighted in bold.

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[i] The database is available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/INZ3QK, accessed on 5 February 2020.

[ii] The database is available at https://unstats.un.org/unsd/snaama/Downloads,
Accessed on 1 July 2020.

[iii] Maddala, Wu, 1999; Choi, 2001; Levin et al, 2002; Im et al, 2003; Pesaran, 2007. The null hypothesis is the presence of common unit root, while the alternative hypothesis is (trend) stationarity for all panel members in LLC test, and in some of the panel members in other tests.

[iv] The Table 7 in the Appendix contains the average GDP and GDP per capita growth rates for the 50 economies in the panel over the 1981-2012 period. The countries belonging to the Quantile 1 (countries with the slowest growth rates) are highlighted in bold.

[v] Ranging from 2.94% to 3.89% of GDP.

[vi] Ranging from 4.27% to 5.04% of GDP.