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Government spending and sustainable economic growth: based on first- and second-level COFOG data

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ABSTRACT

The authors look at the effect of the composition of government spending on per capita GDP level using Classification of the Functions of Government (COFOG) data. Government spending on education was found to significantly impact per capita GDP in the short term. R&D spending on education and recreation, culture and religion was found to have a significant long-run GDP effect. This paper suggests that developed countries can successfully promote economic growth by redirecting their total spending portfolio toward education and by increasing their R&D spending on education and recreation, culture and religion.

IMPACT

By examining the effect on GDP of government spending, the authors have discovered a useful idea for the application and utilization of COFOG data. Their findings have policy implications for achieving sustainable economic growth in developed countries. Developed countries can promote economic growth via recomposition of their total spending portfolio toward education and of their R&D spending toward education and recreation, culture and religion.

KEYWORDS

COFOG; economic growth; first- and second-level spending data; government expenditure; panel analysis

Introduction

It is important to examine the effects of government spending on different public services on a country's economy and its citizens' welfare. To do this means we need to separate government spending very precisely into various areas to examine individual effects on the economy.

Many previous studies have embraced this approach and have examined the effects of various types of government spending on economic growth. For example, Barro (1990) and Gemmell, Kneller, and Sanz (2011) divided government spending into two categories: productive and unproductive expenditure. Their research demonstrated that increases in the share of productive spending positively affected the long-term growth rate. Devarajan, Swaroop, and Zou (1996) adopted 10 classification divisions to represent the various functions of government spending, the 'Classification of the Functions of Government' (COFOG), to determine the effect of government spending on economic growth by using the IMF's Government Finance Statistics (GFS) data.

In this paper, we use Devarajan et al.'s first-level, 10-division COFOG. Also, we utilized second-level COFOG data to analyse the effects of various types of R&D spending on per capita GDP. To do this, we constructed panel regression models with the following theoretically cutting-edge factors:

- Considering government budget constraints.
- Incorporating short-term and long-term dynamics as suggested by Kneller, Bleaney, and Gemmell (1999) and Gemmell et al. (2011, 2016).

Our models were a reinterpretation of Devarajan et al. (1996) and were based on a more elaborate regression model that further analysed the GDP effects of various types of R&D spending by using more detailed second-level COFOG data.

The neo-classical endogenous growth models proposed by Barro (1990, 2003, 2015) have argued that we should consider convergence terms (for instance the lagged term of GDP) in empirical analyses in order to capture the initial heterogeneous conditions of the economies being studied. They believe that different initial conditions are crucial to understanding the different impacts of changes in government spending on economic growth. Accepting their ideas, we included a lagged term for per capita GDP. That is, since our dependent variable was the three-year forward moving average of growth rate, we included a per capita GDP at time t . In addition, we included new macro-level state variables in the regression model: for example government expenditure to GDP ratio, and the effect on distortionary and non-distortionary tax revenues on GDP ratio. In this paper, we explain why it is necessary to include initial conditions to properly

explain the effects of government spending on economic growth.

Literature review

In an economic crisis, governments should be spending on areas that will promote economic growth in the long term. Barro (1990) published a study of 98 developed and developing countries (from 1965 to 1985) looking at the relationship between public expenditure and economic growth. He found evidence of a positive relationship between them, but his findings were not statistically significant. Devarajan et al. (1996) investigated how changing the structure of government expenditure could affect long-run growth. Their study focused on 43 developing countries from 1970 to 1990. They showed that changes in the combination of government expenditure could result in higher long-run GDP growth. Their theoretical model predicted that productive expenditures, such as capital, transport and communication and education, would positively affect economic growth. However, they found empirical evidence that, in developing countries, changes in productive expenditure were not positively associated with economic growth. They argued that some developing countries were wrongly allocating public investments and relying more on capital expenditure to the detriment of current expenditure. Using panel data from 22 OECD countries, from 1970 to 1995, Kneller et al. (1999) showed that a rise in productive expenditure financed by non-distortionary taxes promotes economic growth, whereas a rise in unproductive expenditure financed by distortionary taxes hurts economic growth.

Gemmell et al. (2011) found evidence that changes in productive public spending were positively associated with economic growth. However, the largest growth effects of fiscal policy were relatively short run, and the long-run growth (net) effects were small because changes in tax and expenditure have opposite effects on economic growth and these fiscal changes are often made at the same time. Gemmell et al. (2016) examined the long-run GDP effects of changes in total government expenditure and in the shares of different expenditure categories for OECD countries. They found evidence that increasing shares of expenditure on infrastructure and education would enhance the GDP level, but that there was an opposite result for social welfare spending.

Contribution to the academic literature

Following Gemmell et al. (2016), we examined the GDP effects of government expenditure, but we considered more detailed expenditure sub-categories. For example, as shown in Table 1, we divided education expenditure into eight sub-categories: (1) pre-primary and primary education; (2) secondary education; (3) post-secondary non-tertiary education; (4) tertiary education; (5) education undefinable by level; (6) subsidiary services to education; (7) education R&D; (8) education not elsewhere classified. Our focus was on R&D spending. In general, R&D spending can boost economic growth, but the growth effects might differ depending on the expenditure categories. Ours is the first study we are aware of to examine the effects of R&D spending on GDP in terms of the composition of government expenditure.

Table 1. COFOG classifications.

Code	First-level functions (divisions)	Second-level functions (groups)
701	General public services	(1) Executive and legislative, financial and fiscal affairs, external affairs. (2) Foreign economic aid. (3) General services. (4) Basic research. (5) <i>R&D general public services</i> . (6) General public services not elsewhere classified. (7) Public debt transactions. (8) Transfers of a general character between different levels of government.
702	Defence	(1) Military defence. (2) Civil defence. (3) Foreign military aid. (4) R&D defence. (5) Defence not elsewhere classified.
703	Public order and safety	(1) Police services. (2) Fire protection services. (3) Law courts. (4) Prisons. (5) <i>R&D public order and safety</i> . (6) Public order and safety not elsewhere classified.
704	Economic affairs	(1) General economic, commercial and labour affairs. (2) Agriculture, forestry, fishing and hunting. (3) Fuel and energy. (4) Mining, manufacturing and construction. (5) Transport. (6) Communication. (7) Other industries. (8) <i>R&D economic affairs</i> . (9) Economic affairs not elsewhere classified.
705	Environmental protection	(1) Waste management. (2) Waste water management. (3) Pollution abatement. (4) Protection of biodiversity and landscape. (5) <i>R&D environmental protection</i> . (6) Environmental protection not elsewhere classified.
706	Housing and community amenities	(1) Housing development. (2) Community development. (3) Water supply. (4) Street lighting. (5) <i>R&D housing and community amenities</i> . (6) Housing and community amenities not elsewhere classified.
707	Health	(1) Medical products, appliances and equipment. (2) Out-patient services. (3) Hospital services. (4) Public health services. (5) <i>R&D health</i> . (6) Health not elsewhere classified.
708	Recreation, culture and religion	(1) Recreational and sporting services. (2) Cultural services. (3) Broadcasting and publishing services. (4) Religious and other community services. (5) <i>R&D recreation, culture and religion</i> . (6) Recreation, culture and religion not elsewhere classified.
709	Education	(1) Pre-primary and primary education. (2) Secondary education. (3) Post-secondary non-tertiary education. (4) Tertiary education. (5) Education not definable by level. (6) Subsidiary services to education. (7) <i>R&D education</i> . (8) Education not elsewhere classified.
710	Social protection	(1) Sickness and disability. (2) Old age. (3) Survivors. (4) Family and children. (5) Unemployment. (6) Housing. (7) Social exclusion not elsewhere classified. (8) <i>R&D social protection</i> . (9) Social protection not elsewhere classified.

Sources: IMF (2014); Government Finance Statistics Manual (2014), p. 143.

Data description (COFOG)

There are two dominant standard methods of reporting in COFOG: Government Finance Statistics (GFS), which the IMF recommends, and the System of National Accounts (SNA), which has been adopted by the OECD (see Jeong, 2018; IMF, 2014). We focused on the most stable OECD economies and used SNA COFOG data, which is the richest information about OECD countries. Bloch et al. (2016) argued that 'the new OECD Public Finance Dataset is motivated by the need for a detailed breakdown of public expenditure and revenues designed specifically for the analysis of the effect of these spending and revenue items on growth and equity'.

As shown in Table 1 and Figure 1, first-level COFOG has 10 types of government spending: general public services; defence; public order and safety; economic affairs; environmental protection; housing and community amenities; health; recreation, culture and religion; education; and social protection. In terms of average government spending among OECD countries, social protection has the largest share and has been increasing since 1995. Similarly, government spending on health has risen, while general public services spending has been reducing. As government spending by function has varied sufficiently over time, we were able to conduct a panel regression analysis to determine how a specific category of government expenditures affects per capita GDP level.

Each first-level division can be broken down into second-level groups; the total number of second-level groups is 69. One interesting aspect of the second-level COFOG is that government spending on R&D can be broken down into specific areas—see Table 1. So we were able to study the effects of R&D expenditure by function on output growth more precisely and estimate the importance to economic growth. The OECD provides COFOG data in nominal currency units so it had to be standardized in specific real units for the purposes of comparison. Therefore we needed to normalize the COFOG data to real terms 2010 USD. The time range of the COFOG data was 1995 to 2015.

Growth regression (based on first-level COFOG)

We used a fixed-effects panel regression on data on OECD countries from 1995 to 2015. The fixed-effects model excluded the effect of time-invariant factors (for example, country-specific culture) and accounted for the net impact of the explanatory variables on per capita GDP.

The reduced-form specification in equation (1) follows the convergence growth equation constructed by Fournier (2016), and Fournier and Johansson (2016). This is often called the

'autoregressive distributed lag' (ARDL) model.

$$\begin{aligned} \log \frac{GDP}{POP}_{it+1} = & \alpha_1 \log \frac{GDP}{POP}_{it} + \gamma_1 \frac{E_k}{E_{it}} + \gamma_2 \frac{E_k}{E_{it-1}} \\ & + \left(\beta_1 \frac{POP^R}{POP^W}_{it} + \beta_2 \frac{DisTaxRev}{GDP}_{it} + \beta_3 \frac{NonDisTaxRev}{GDP}_{it} \right. \\ & \left. + \beta_4 \frac{E}{GDP}_{it} \right) + \mu_i + \epsilon_{i,t} \end{aligned} \quad (1)$$

Also, equation (1) can be rearranged in the error correction form as equation (2) by substituting:

$$\begin{aligned} \log \frac{GDP}{POP}_{it+1} \text{ with } & \left[\Delta \log \frac{GDP}{POP}_{it+1} + \log \frac{GDP}{POP}_{it} \right] \text{ and } \frac{E_k}{E_{it}} \\ \text{with } & \left[\Delta \frac{E_{kit}}{E_{it}} + \frac{E_k}{E_{it-1}} \right] \text{ in equation (1).} \\ g_{it+1} \left(= \Delta \log \frac{GDP}{POP}_{it+1} \right) \\ = & \varphi_1 \left[\log \frac{GDP}{POP}_{it} + \gamma_k \frac{E_k}{E_{it-1}} \right] + \zeta_k \Delta \frac{E_{kit}}{E_{it}} \\ & + \left(\beta_1 \frac{POP^R}{POP^W}_{it} + \beta_2 \frac{DisTaxRev}{GDP}_{it} \right. \\ & \left. + \beta_3 \frac{NonDisTaxRev}{GDP}_{it} + \beta_4 \frac{E}{GDP}_{it} \right) + \mu_i + \epsilon_{i,t} \end{aligned} \quad (2)$$

Where $\varphi_1 [= -(1 - \alpha_1)]$ captures the error-correcting component, and $\gamma_k \left[= \frac{(\gamma_1 + \gamma_2)}{\varphi_1} \right]$ and $\zeta_k [= r_1]$ captures the long-run effect and the short-run effect of the k th category of government spending on the GDP per capita level (Gemmell, Kneller, & Sanz, 2016; Keele & De Boef, 2004).

However, we encountered problems in this specification of reverse causality and short-term fluctuations in per capita GDP growth rate resulting from changes in public expenditures (Devarajan et al., 1996). To mitigate these problems, following Devarajan et al. (1996), we used the three-year forward moving average of the growth rate as our dependent variable ($g_{it+1, it+3}$). Our modified specification was:

$$\begin{aligned} \overline{g_{it+1, it+3}} = & \varphi_1 \left[\log \frac{GDP}{POP}_{it} + \gamma_k \frac{E_k}{E_{it-1}} \right] + \zeta_k \Delta \frac{E_{kit}}{E_{it}} \\ & + \left(\beta_1 \frac{POP^R}{POP^W}_{it} + \beta_2 \frac{DisTaxRev}{GDP}_{it} \right. \\ & \left. + \beta_3 \frac{NonDisTaxRev}{GDP}_{it} + \beta_4 \frac{E}{GDP}_{it} \right) + \mu_i + \epsilon_{i,t} \end{aligned} \quad (3)$$

Thus, our empirical model can be considered a special case of the ARDL model. As shown in the right-hand side in equation (3), the classical convergence term $\frac{GDP}{POP}$ in the spirit of the work of Barro (1990), accounts for the level of per capita GDP

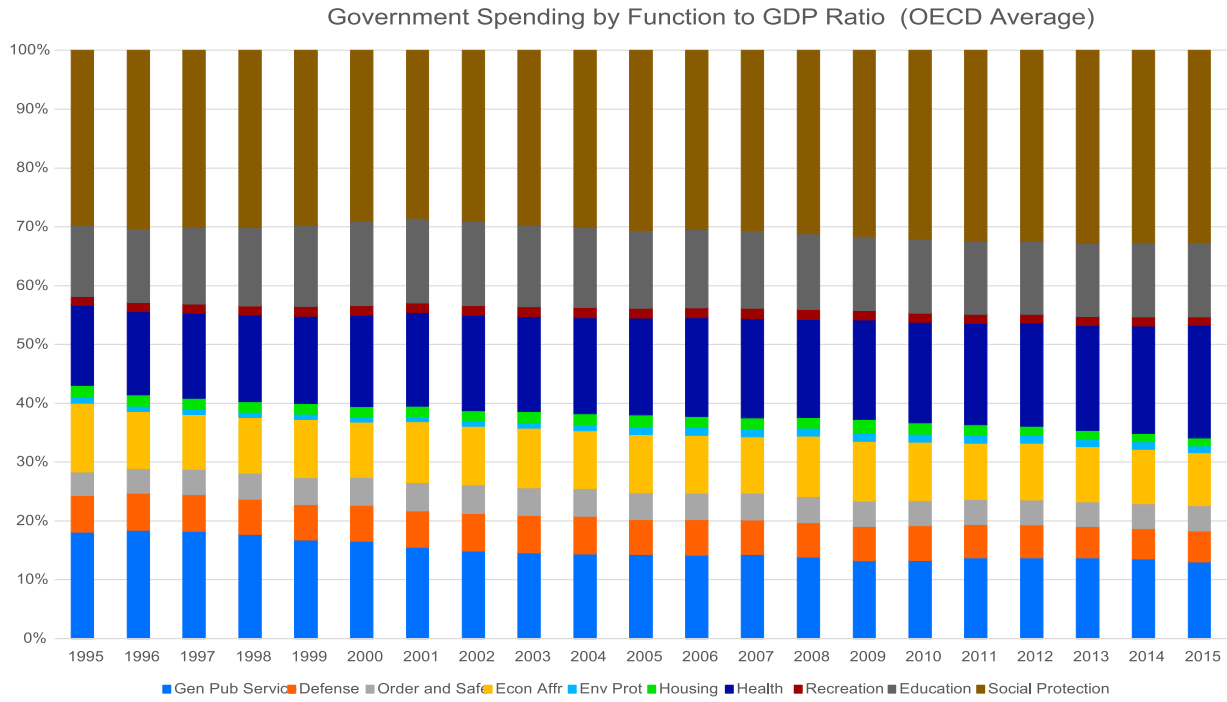


Figure 1. Government spending by function (10 divisions). Source: OECD database, 1995–2015.

Note: We normalized COFOG and GDP data in 2010 USD and calculated government spending shares dedicated to GDP for each country.

at time t : $\frac{POP^R}{POP^W}$ depicts the ratio between retirees (aged 64 and over) and the working population (ages 20 to 64) ratio, which indicates either the level of aging in the population or ages in the workforce. To consider the manner of financing the government budget, as argued in recent studies, we included the distortionary and non-distortionary tax revenues to GDP ratio $\left(\frac{DisTaxRev}{GDP} \text{ and } \frac{NonDisTaxRev}{GDP}\right)$ in our specifications (see Kneller et al., 1999; Gemmell et al., 2011, 2016). Lastly, to control the effects of total expenditures, we added total expenditures to the GDP ratio in our specifications.

Following Gemmell et al. (2016), we included one specific category of the share of expenditures to total government spending (E_k/E) in each regression and repeated this analysis 10 times.

Note that this reduced-form specification is expressed in error correction form, and so we have to interpret the regression to explain the relationship between the independent variable and the per capita GDP level, not the growth rate, even though the dependent variable in the equation is the growth rate (see Gemmell et al., 2016; and D'Agostino, Dunne, & Pieroni, 2017). Summary statistics for our main variables are presented in Table 2.

R&D growth regression (based on second-level COFOG)

It is widely accepted in the economic literature that government R&D spending will help stimulate output

growth (Stokey, 1995). However, since the scope of R&D expenditures is broad, it is necessary to specify the categories of R&D expenditures more precisely and to examine how economic impact varies by the type of R&D expenditure. One novel aspect of COFOG data is that we can use the second-level government spending data regarding R&D in each division. By utilizing this data, we can analyse the effect of each R&D expenditure on economic output. To estimate the GDP effects of government spending for the second-level (group) category regarding R&D, we set the reduced-form specification as follows:

$$\begin{aligned} \overline{g_{it+1,it+3}} = & \varphi_1 \left[\log \frac{GDP}{POP_{it}} + \gamma_k \frac{RnD_k}{RnD_{it-1}} \right] \\ & + \zeta_k \Delta \frac{RnD_{kit}}{RnD_{it}} + \left(\beta_1 \frac{POP^R}{POP^W_{it}} + \beta_2 \frac{DisTaxRev}{GDP_{it}} \right. \\ & \left. + \beta_3 \frac{NonDisTaxRev}{GDP_{it}} + \beta_4 \frac{E}{GDP_{it}} + \beta_5 \frac{RnD}{GDP_{it}} \right) + \mu_i + \epsilon_{i,t} \end{aligned} \quad (4)$$

Where φ_1 captures the error-correcting component, and γ_k and ζ_k capture the long-run effect and the short-run effect of the k th category of R&D expenditures on the GDP per capita level, respectively (Gemmell et al., 2016; Keele & De Boef, 2004).

Results

Table 3 shows the result of the fixed-effects panel regression. In our model, the coefficient of the lagged variable of the expenditure of each category to total

Table 2. Summary statistics and data source.

Variables	No. of observations	Mean	S.E.	Source
Three-year forward moving average of growth rate ($\bar{g}_{t+1,t+3}$)	546	0.020	0.023	National accounts, main aggregates, OECD database
Per capita GDP (million dollars, deflated based on 2010 USD)	648	0.036	0.021	
Distortionary tax revenue/GDP ($\frac{DisTaxRev}{GDP}$)	731	0.224	0.061	Public sector, taxation and market regulation, OECD database
Non-distortionary tax revenue/GDP ($\frac{DisTaxRev}{GDP}$)	732	0.108	0.028	
Ratio between retirees (age 64 and over) and the working population (ages 20-64) ratio ($\frac{POP^R}{POP^W}$)	626	4.609	1.626	Demography and population, OECD database
Total expenditure/GDP ($\frac{E}{GDP}$)	576	0.415	0.094	National accounts, government expenditure by function, OECD database
Expenditure (kth category)/total expenditure ($\frac{E_{kit}}{E_t}$)				
General public service	576	0.148	0.039	National accounts, government expenditure by function, OECD database
Defence	576	0.039	0.031	
Public order and safety	576	0.039	0.013	
Economic affairs	576	0.112	0.041	
Environment protection	576	0.017	0.008	
Housing and community amenities	576	0.018	0.010	
Health	576	0.136	0.030	
Recreation, culture, and religion	576	0.026	0.010	
Education	576	0.124	0.027	
Social protection	576	0.342	0.072	
R&D expenditure/GDP ($\frac{RnD}{GDP}$)	419	0.006	0.003	
R&D expenditure (kth category)/Total R&D expenditure ($\frac{RnD_k}{RnD}$)				
General public service	419	0.066	0.134	National accounts, government expenditure by function, OECD database
Defence	419	0.042	0.061	
Public order and safety	419	0.005	0.008	
Economic affairs	419	0.502	0.233	
Environment protection	419	0.047	0.050	
Housing and community amenities	419	0.007	0.015	
Health	419	0.169	0.128	
Recreation, culture, and religion	419	0.023	0.032	
Education	419	0.123	0.188	
Social protection	419	0.016	0.024	

expenditure ratio ($\frac{E_k}{E_{t-1}}$) shows the long-run effects and the coefficient of its first-differenced variable ($\Delta \frac{E_k}{E_t}$) shows the short-run effects (Gemmell et al., 2016). Each column of Table 2 shows the regression results for the effect of the change in k^{th} expenditure share on the per capita GDP level, holding other factors constant.

Consistent with the earlier endogenous growth studies, the logarithm variable of per capita GDP at time t had a significant and negative coefficient for all specifications, which means that as the initial level of the per capita GDP grew, its future per capita GDP level reduced. The level of aging in the population ($\frac{POP^R}{POP^W}$) had a negative effect on the per capita GDP level, as we expected, and it was statistically significant for all specifications. However, we failed to find a statistically significant relationship between distortionary/non-distortionary tax revenues to GDP ratio and the per capita GDP level ($\frac{DisTaxRev}{GDP}$ and $\frac{NonDisTaxRev}{GDP}$) and the per capita GDP level. On the contrary, the government expenditure to GDP ratio ($\frac{E}{GDP}$) had a significant

negative relationship with the per capita GDP level, which is consistent with previous studies. We can interpret this result to mean that, if the composition of GDP of a country is oriented toward government expenditures (E), there will be a negative impact on the per capita GDP level. Mitchell (2005) explained that this is because 'government spending requires costly financing choices' (extraction cost), and 'government spending is a less effective way to deliver services' (inefficiency cost).

Considering specific government expenditures by function according to first-level COFOG data by the OECD, we found a statistically meaningful relationship between the government expenditure ratio and the per capita GDP level only for environmental protection, housing and community amenities, and education categories. Environmental protection (column 5 in Table 2) had a negative short- and long-run effect on per capita GDP. Second, as shown in column (6), the expenditure on housing and community amenities had a statistically significant negative short-run effect on per capita GDP, but this did not persist in the long run. Finally, column (9) shows that education had a positive and significant short-run effect, but the effect diminished in the long run. Government spending on education increases the level of human capital accumulation in a society, and it results in positive

Table 3. Results of reduced-form regression (first-level COFOG).

Model	(1) ARDL	(2) ARDL	(3) ARDL	(4) ARDL	(5) ARDL	(6) ARDL	(7) ARDL	(8) ARDL	(9) ARDL	(10) ARDL
Estimation method	FE	FE	FE	FE	FE	FE	FE	FE	FE	FE
Dependent variables	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$
Expenditure classification (k)	General public service	Defence	Public order and safety	Economic affairs	Environment protection	Housing and community amenities	Health	Recreation, culture and religion	Education	Social protection
$\left(\frac{POP^R}{POP^W}\right)_t$	−0.015*** (0.005)	−0.016*** (0.005)	−0.016*** (0.004)	−0.016*** (0.004)	−0.014*** (0.004)	−0.014*** (0.004)	−0.016*** (0.004)	−0.016*** (0.004)	−0.016*** (0.004)	−0.016*** (0.004)
$\log \frac{GDP}{POP_t}$	−0.141*** (0.018)	−0.147*** (0.014)	−0.150*** (0.014)	−0.146*** (0.014)	−0.136*** (0.015)	−0.147*** (0.014)	−0.136*** (0.016)	−0.143*** (0.016)	−0.147*** (0.015)	−0.145*** (0.014)
$\frac{DisTaxRev}{GDP}_t$	−0.169* (0.082)	−0.142 (0.085)	−0.139 (0.090)	−0.143 (0.087)	−0.162* (0.089)	−0.148 (0.088)	−0.166* (0.091)	−0.146 (0.090)	−0.144 (0.092)	−0.149 (0.093)
$\frac{NonDisTaxRev}{GDP}_t$	0.044 (0.164)	0.066 (0.192)	0.063 (0.184)	0.069 (0.180)	0.056 (0.162)	0.051 (0.176)	0.017 (0.180)	0.052 (0.172)	0.044 (0.176)	0.058 (0.174)
$\frac{E}{GDP_t}$	−0.049* (0.020)	−0.051*** (0.017)	−0.055*** (0.019)	−0.054** (0.020)	−0.051*** (0.018)	−0.054*** (0.018)	−0.048** (0.018)	−0.048*** (0.017)	−0.044** (0.017)	−0.051*** (0.017)
$\frac{E_k}{E_{t-1}}$	0.058 (0.096)	0.019 (0.298)	0.219 (0.354)	0.039 (0.073)	−1.005* (0.564)	−0.287 (0.201)	−0.178 (0.135)	−0.336 (0.332)	0.193 (0.150)	−0.064 (0.116)
$\Delta \frac{E_k}{E_t}$	0.021 (0.086)	−0.287 (0.283)	−0.628 (0.458)	0.020 (0.034)	−0.530 (0.335)	−0.465** (0.176)	0.040 (0.169)	0.397 (0.445)	0.390*** (0.125)	0.004 (0.127)
Constant	−0.354*** (0.039)	−0.369*** (0.039)	−0.381*** (0.039)	−0.367*** (0.049)	−0.314*** (0.041)	−0.365*** (0.054)	−0.295*** (0.040)	−0.345*** (0.064)	−0.390*** (0.043)	−0.337*** (0.052)
Observations	375	375	375	375	375	375	375	375	375	375
R ²	0.559	0.559	0.563	0.558	0.568	0.564	0.563	0.562	0.564	0.559

Notes: 1. The dependent variable is the three-year moving average growth rate.

2. Cluster-robust standard errors in parentheses and *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 4. Results of reduced-form regression (second-level COFOG).

Model	(1) ARDL	(2) ARDL	(3) ARDL	(4) ARDL	(5) ARDL	(6) ARDL	(7) ARDL	(8) ARDL	(9) ARDL	(10) ARDL
Estimation method	FE	FE	FE	FE	FE	FE	FE	FE	FE	FE
Dependent variables	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$	$\overline{g_{it+1,it+3}}$
Expenditure classification (k)	general public service	defence	public order and safety	economic affairs	environment protection	housing and community amenities	health	recreation, culture and religion	education	Social pProtection
$\left(\frac{POP^R}{POP^W}\right)_t$	-0.022* (0.012)	-0.018 (0.012)	-0.018 (0.012)	-0.017 (0.012)	-0.018 (0.012)	-0.020* (0.011)	-0.020 (0.013)	-0.019* (0.011)	-0.016 (0.011)	-0.018 (0.011)
$\log \frac{GDP}{POP}_t$	-0.150*** (0.018)	-0.152*** (0.019)	-0.153*** (0.019)	-0.155*** (0.017)	-0.151*** (0.019)	-0.151*** (0.018)	-0.151*** (0.020)	-0.153*** (0.018)	-0.164*** (0.015)	-0.152*** (0.018)
$\frac{DisTaxRev}{GDP}_t$	-0.043 (0.091)	-0.040 (0.107)	-0.045 (0.097)	-0.054 (0.095)	-0.047 (0.095)	-0.069 (0.098)	-0.021 (0.100)	-0.059 (0.100)	-0.070 (0.116)	-0.064 (0.102)
$\frac{NonDisTaxRev}{GDP}_t$	0.141 (0.207)	0.026 (0.213)	0.041 (0.225)	0.025 (0.215)	0.022 (0.216)	0.026 (0.226)	0.017 (0.210)	0.029 (0.227)	0.023 (0.210)	0.033 (0.219)
$\frac{E}{GDP}_t$	-0.056* * (0.023)	-0.071** (0.029)	-0.068** (0.029)	-0.070** (0.029)	-0.070** (0.030)	-0.070** (0.030)	-0.076** (0.031)	-0.070** (0.029)	-0.063*** (0.022)	-0.071** (0.028)
$\frac{RnD}{GDP}_t$	0.214 (1.147)	1.354 (1.196)	1.283 (1.220)	1.373 (1.259)	1.284 (1.288)	1.176 (1.225)	1.684 (1.070)	1.342 (1.230)	1.095 (1.224)	1.364 (1.154)
$\frac{RnD}{RnD_k}$	-0.194*** (0.033)	0.003 (0.044)	0.042 (0.158)	-0.019 (0.035)	-0.014 (0.043)	-0.450* (0.222)	-0.065 (0.057)	0.131*** (0.041)	0.120*** (0.036)	-0.002 (0.096)
$\Delta \frac{RnD_{t-1}}{RnD_k}$	-0.032 (0.036)	-0.027 (0.029)	-0.735** (0.323)	0.016 (0.018)	0.004 (0.045)	-0.308 (0.297)	-0.017 (0.024)	-0.017 (0.071)	-0.015 (0.018)	-0.097 (0.096)
Constant	-0.374*** (0.083)	-0.395*** (0.078)	-0.398*** (0.079)	-0.395*** (0.078)	-0.390*** (0.076)	-0.373*** (0.072)	-0.374*** (0.083)	-0.394*** (0.070)	-0.451*** (0.081)	-0.392*** (0.076)
Observations	265	265	265	265	265	265	265	265	265	265
R-squared	0.592	0.542	0.548	0.547	0.541	0.548	0.550	0.545	0.613	0.546

Notes: As Table 3.

externalities, such as knowledge spill-over effects. The endogenous growth literature has argued that, if efficiency gains occur due to an increase in education spending, then their education spending effects persist in the long run. In our study, the coefficient for the education spending variable was positive in the long run, but it was smaller than in the short run and was not statistically significant. Our results imply that, to stimulate per capita GDP, it is important that government spending should be reallocated to increase education's share and spending on environmental protection and the housing and community amenities category should be decreased. However, there would be no or little long-run effects by doing this.

We also examined R&D expenditures by using second-level COFOG data. As shown in Table 4, control variables, such as log per capita GDP, the distortionary and non-distortionary tax revenues to GDP ratio and total government expenditure to GDP ratio, demonstrated similar tendencies to the regression results in Table 3. However, the population aging variable had a similar negative effect and similar sizes of coefficients, but its coefficients were not statistically significant at the 5% level.

Looking at the regression results estimated using second-level R&D spending data, we found evidence of a positive relationship between the total R&D expenditure to GDP ratio and the GDP for all specifications, but was not statistically significant. This may be because per capita GDP will increase only if the positive effects of R&D spending exceed the negative effects of the changes in taxation caused by increasing R&D spending.

Our regression results in Table 4 show that we found a statistically significant relationship between R&D spending and per capita GDP for the following R&D spending categories: general public services, public order and safety, housing and community amenities, recreation, culture and religion, and education. First, as shown in column (1) we found that R&D on general public services had a negative long-run effect on per capita GDP. Second, column (3) shows that R&D spending on public order and safety had a statistically significant negative impact on the per capita GDP in the short run. The long-run effect was positive, but was not statistically significant. This implies that R&D spending on public order and safety may not be productive and effective in the short run, but it could be beneficial in the long run. Third, column (8) shows that R&D spending on recreation, culture, and religion positively and significantly affected per capita GDP in the long run. However, the short-run GDP effect was negative, but was not statistically significant. Lastly, column (9) shows that R&D spending on education was found to have a positive and significant effect on per capita GDP in the long run. However, this positive effect was not observed in the short run.

Our research demonstrated that R&D spending on education and recreation, culture, and religion could have an important impact on long-run per capita GDP. However, we found a long-run negative GDP effect of R&D spending on general public services and housing and community amenities. Also, R&D spending on public order and safety negatively affected per capita GDP in the short run.

Discussion and conclusion

Our main findings were:

- Government spending on *housing and community amenities* had a negative and significant short-run GDP effect.
- Government spending on *environmental protection* had a negative long-run effect on GDP, but only at the 10% significance level.
- Government spending on *education* had a positive and significant short-run effect on GDP.
- R&D spending on *general public services* had a negative and significant long-run effect on GDP.
- R&D spending on *public order and safety* had a negative and significant short-run effect on GDP.
- R&D spending on *housing and community amenities* had a negative long-run GDP effect, but only at the 10% significance level.
- R&D spending on *recreation, culture and religion* and *education* had a positive and significant long-run effect on GDP.

Based on our empirical results, we can suggest a way of restructuring to increase efficiency in government spending. Faced with a limited budget, a government should focus more heavily on education to achieve the targeted per capita GDP level. R&D spending on education was seen to have a long-run positive effect on per capita GDP. In addition, in developed countries, the share of government R&D spending on recreation, culture, and religion should be increased. We believe that developed countries can effectively promote economic growth via recomposition of their total spending portfolio toward education and of their R&D spending toward education and recreation, culture and religion.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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