Thammasat Review of Economic and Social Policy
Volume 4, Number 2, July – December 2018

Investigating relationship between Government Spending and Economic Growth: Public Spending and long-run GDP level

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[*] The contents of this article do not reflect the author's affiliation. This article is a part of the author's doctoral thesis submitted to the University of Exeter. The author thanks Professor Gareth D. Myles, Professor Ben Zissimos, Professor Norman Gemmell and Dr. Xiaohui Zhang for their kind advice and support during his doctoral study. Sincere gratitude must also be extended to the Royal Thai Government for the research grant. All remaining errors rest with the author.

ABSTRACT

This study investigates the relationship between public spending and long-run GDP per capita. While most fiscal-growth studies put emphasis on the relationship in the public-policy endogenous growth model, this analysis allows for Solow-type transitional dynamics where the effects of fiscal policy can be persistent. Moreover, the long-run and short-run effects of fiscal changes are identified separately in this analysis using the groups of countries comprising 38 countries (17 developing countries and 21 high-income OECD countries). Our results show that an increase in total spending which is financed by non-distortionary taxes only enhances the level of GDP per capita in high-income OECD countries. With a given level of total spending, increases in the shares of healthcare and general public services spending can improve the levels of GDP per capita in developing countries. On the other hand, increasing the share of education spending in a high-income OECD country is conducive to increasing the level of GDP per capita

Keywords: Fiscal policy, Economic growth, Public expenditure, Government

JEL Classification: E62, H50, O23, O47

1. Introduction

The fiscal-growth studies in a number of studies focus on the public-policy endogenous growth model. In those studies, permanent growth effects of fiscal changes are analysed without transitional dynamics. The analysis of fiscal policy impacts in this study allows for Solow-type transitional dynamics, but the effects of fiscal policy may be persistent according to the framework proposed by Gemmell, Kneller and Sanz (2016).

Gemmell et al.'s (2016) study was motivated by the recent fiscal stimulus enacted after 2009 in order to counteract the global financial crisis. Governments' spending choices in these short-term packages are partially influenced by their ambitions to comply with long-term growth objectives. With this policy design, there are two different questions to be addressed: how forceful is the evidence that long-run income levels or growth rates react to changes in public spending, and if they do, which expenditure types produce most considerable impacts? In the following section, we attempt to respond to these questions similar to Gemmell et al. (2016) by looking at both developing countries and high-income OECD countries.

2. Literature review

In terms of the period of study, recent studies on fiscal policy and long-run size of economy (either level of GDP or rate of growth) include recent data, especially the Acosta-Ormaechea and Morozumi's (2013) study which uses data from 1970 to 2010. Other studies (Afonso & Jalles, 2014; Arnold et al., 2011; Gemmell, Kneller & Sanz, 2011; Gemmell et al., 2016; Xing, 2012) also cover periods from the 1970s until 2010. Ojede and Yamarik (2012) focus on an earlier period; 1967 to 2008.

In terms of the sets of fiscal variables used, these studies either put emphasis on tax policy (Arnold et al., 2011; Ojede & Yamarik, 2012; Xing, 2012), public spending (Gemmell et al., 2016), or both types of variables at once (Afonso & Jalles, 2014; Gemmell et al., 2011). In addition, Afonso and Jalles (2014) look at both functional and economic classes of fiscal variables according to the Government Finance Statistics (GFS) definitions provided by the International Monetary Fund (IMF).

As well as being categorised by their focus (on revenue and/or expenditure), the effects of fiscal changes can be classified by their impact on the size of economy (short-run or long-run impact). Some of these studies focus only on permanent growth effects (Acosta-Ormaechea & Morozumi, 2013; Afonso & Jalles, 2014), while others distinguish between the long-run and short-run impacts of changes in fiscal variables (Arnold et al., 2011; Gemmell et al., 2011; Gemmell et al., 2016; Ojede & Yamarik, 2012; Xing, 2012). Our study pays specific attention to the latter set of studies.

While many studies that differentiate between the long-run and short-run effects of fiscal change capture the size of an economy by using the growth rate of GDP or the growth rate of GDP per capita, Arnold et al. (2011), Xing (2012) and Gemmell et al. (2016) use the level of per capita GDP. Gemmell et al. (2016) claim that using this specification is advantageous since it allows the degree of persistence in GDP growth responses to be identified by the data, rather than by using a functional form incorporating permanent effects. For this reason, our study will focus on the impact on level of GDP per capita.

The three studies (Arnold et al., 2011; Gemmell et al., 2016; Xing, 2012) referred to above use cross-country data, whereas Ojede and Yamarik (2012) evaluate the growth effects of tax policy at state level. Instead of investigating the

growth effects of fiscal policy, Lamartina and Zaghini (2011) test the validity of Wagner's law in high-income OECD countries.

Although there are differences in the model specifications for investigating change in fiscal composition and their effects on either the level of GDP or economic growth, the findings are, to a certain degree, harmoniously aligned. We go on to discuss previous findings, econometric methods, variables included in the model, the role played by budget constraint, and other econometric issues in these studies.

2.1. Previous findings

This strand of literature, like the permanent growth effects of fiscal change studies in endogenous growth model, mainly considers high-income countries and, more specifically, high-income OECD countries (Arnold et al., 2011; Gemmell et al., 2011; Gemmell et al., 2016; Xing, 2012). Other studies, e.g. Acosta-Ormaechea and Morozumi (2013) and Afonso and Jalles (2014), consider a wider set of countries.

Some studies find the reallocation of fiscal composition to be robustly related to long-run growth or GDP level, while others do not. In order to understand this incongruity clearly, we need to take several aspects of the preceding results into consideration. Firstly, there are two different types of fiscal variables being considered, namely public expenditure and public revenue. Secondly, we need to consider the way in which an increase in public expenditure is financed. We previously refer to this as an implicit financing element. For example, Gemmell et al. (2016) find that an increase in total spending enhances GDP per capita level in the long run when financed by non-distortionary taxes. Thirdly, fiscal variable classifications can be interpreted differently when we analyse the impacts of changes in these variables on GDP or growth of

GDP. This depends on the aspect of fiscal change we need to evaluate in order to assess its impact. The following paragraphs summarise the key findings of the papers mentioned earlier.

Arnold et al. (2011) find that shifting taxes on income towards consumption and immovable property enhances long-run GDP per capita. In particular, increasing revenue by raising current taxes on immovable property and consumption is least harmful to growth. Arnold et al.'s (2011) findings are supported by Xing (2012), suggesting that shifting tax revenue away from corporate income, personal income, and consumption taxes, and towards property taxes is associated with a higher level of income per capita in the long run. When investigating state-level data, Ojede and Yamarik (2012) obtained different results from Arnold et al. (2011) and Xing (2012). They found that increases in sales and property taxes reduce long-run real income growth.

Gemmell et al. (2011) observe that the growth effects of fiscal policy in the short run appear to persist. Although some fiscal variables only have transitory effects, others might have persistent growth effects. However, the positive growth effects associated with productive spending are often counteracted by the negative effects of tax changes.

Gemmell et al. (2016) raise awareness of the significance of financing methods for increasing any type of public expenditure when determining long-run GDP level. By using pooled mean group estimators (PMG) with contemporaneous correlation, they find robust long-run positive effects on GDP per capita levels for reallocating total spending towards transportation and communication, and education spending.

In contrast, Afonso and Jalles (2014) find that an increase in government revenue has no significant impact on growth. Moreover, the coefficients of government expenditures appear to have highly significant negative signs.

Acosta-Ormaechea and Morozumi (2013) find that an increase in education spending offset by a fall in social spending seems to be robustly related to higher growth rates. These results also hold true at the general government level. Their results also show that education spending promotes growth as well as public capital does in the long run.

2.2. Improvement of econometric methods

Recent developments in data collection have improved the availability of data, so it has become possible to investigate the compositional change of public spending and its impact on long-run GDP per capita level or growth.

From above reason, the updated data can be used under the assumptions of short-run heterogeneity and long-run homogeneity. This econometric method proposed by Pesaran Shin, and Smith (1999) is pooled mean group estimators (PMG). It is a compromise between the fixed effects model and the mean group estimator (MG). While intercept, short-run coefficients and error variances are allowed to differ across groups, the long-run coefficients are equal. This method has been analysed by Arnold et al. (2011), Gemmell et al. (2011), Ojede and Yamarik (2012), Xing (2012), and Gemmell et al. (2016).

2.3. Variables included in recent studies

Dependent variable

The choice of dependent variable is distinctly separable between growth of GDP and level of GDP. While most studies use the growth rate of either GDP or GDP per capita, Arnold et al. (2011) use a change in log of GDP per capita and a change in log of total factor productivity (TFP) of a given firm. Similarly, Xing (2012) also uses a change in log of real GDP

per capita as a dependent variable. While Gemmell et al. (2011) use a change in the growth rate of GDP in one of their studies, the level of GDP per capita is employed by Gemmell et al. (2016). The dependent variable in Ojede and Yamarik (2012) is the change in growth rate of real income.

It is important to note that all of these studies (Arnold et al., 2011; Gemmell et al., 2011; Gemmell et al., 2016; Ojede & Yamarik, 2012; Xing, 2012) estimate the results with an error correction model. When interpreting the results, we need to refer back to the equations in terms of the autoregressive distributed lag model: i.e. the long-run level of GDP per capita impact from fiscal change is analysed in Xing (2012), rather than the growth effect (change in log of real GDP per capita).

Afonso and Jalles (2014) use the real growth rate of GDP per capita, and Acosta-Ormaechea and Morozumi (2013) select the growth of output per capita.

Fiscal variables

Different classes of expenditure and revenue can be considered. Two broad categories of each type of fiscal variables are included, following the example of Kneller, Bleaney and Gemmell (1999) and based on the framework proposed by Barro (1990); namely productive expenditure, unproductive expenditure, distortionary taxes and non-distortionary taxes. We will now describe some of the fiscal variables included in recent studies.

Arnold et al. (2011) focus on tax structures which can be classified mainly into income taxes, consumption taxes and property taxes. Ojede and Yamarik (2012) and Xing (2012) also emphasise on the composition of tax revenues.

Gemmell et al. (2011) use broad categories of revenue and expenditure: productive expenditure, non-productive expenditure, distortionary taxes and non-distortionary taxes.

Gemmell et al. (2016) utilise broad categories of revenue similar to those used by Gemmell et al. (2011) and functional classifications of public expenditure, namely transportation and communication, education, health and housing etc.

Afonso and Jalles (2014) focus on both aggregate levels and GFS (Government Finance Statistics) classifications of fiscal variables. This includes functional and economic classifications of both government expenditure and revenue. Acosta-Ormaechea and Morozumi (2013) also look at both economic and functional classifications of public expenditure. Economic classifications include the compensation of employees, other expenses and the net acquisition of non-financial assets. Functional classifications include defence, transportation and communication, health, education, and social protection expenditures.

Non-fiscal control variables

A number of factors can be used as non-fiscal control variables. The criteria used to decide which variable should be chosen are highly dependent on the type of question or particular model being investigated. Since using pooled mean group estimators limits the number of control variables due to a decrease in the degree of freedom, this strand of literature often only includes a few non-fiscal control variables in analyses.

Arnold et al. (2011) and Xing (2012) include investment rate, human capital and population growth. Gemmell et al. (2011, 2016) use investment rate and employment growth. Like Gemmell et al. (2011, 2016), Ojede and Yamarik (2012) include growth in private employment and private investment share in their set of non-fiscal control variables.

While Afonso and Jalles (2014) use population growth, investment, education and trade openness, Acosta-Ormaechea

and Morozumi (2013) include initial GDP per capita and initial human capital in their set of non-fiscal control variables.

2.4. The role of government budget constraint

Government budget constraint needs to be considered in order to avoid the production of invalid results due to biases occurring as a result of not including both revenue and spending variables in the same equation. Recent studies take government budget constraint into account while avoiding perfect multicollinearity in accordance with the specification in Kneller et al. (1999). As a result, the important role played by the implicit financing element is highly relevant in this analysis.

2.5. Other econometric issues

There are also other econometric issues which should be addressed, such as endogeneity and a robustness check.

Firstly, Afonso and Jalles (2014) investigate the robustness of their results by adding variables (labour force participation and unemployment rates) into their baseline regression. Similarly, Acosta-Ormaechea and Morozumi (2013) add inflation, openness, population growth and terms of trade growth into their original set of control variables. Different specifications, including lagged fiscal variables and the different developmental levels of countries in the sample, might also be considered.

Secondly, using pooled mean group estimators to analyse the error-correction model requires some tests as prerequisites. Gemmell et al. (2016) tested the order of integration and cointegration, autoregressive distributed (ARDL) lag structure, and weak exogeneity. They found that their variables are best treated as non-stationary. Imposing two-lags of ARDL tends to strengthen the case for significant causal

effects from a number of public spending categories on the level of long-run GDP per capita. Their estimated results offer relatively strong support for the theory that expenditure share variables can be considered to be weakly exogenous, allowing interpretation of the estimated long-run expenditure parameters as capturing causal effects on GDP. The issues tested in Gemmell et al. (2016) will be further investigated in Section 4 of our study. Public expenditure composition is analysed in the next section.

3. Public expenditure composition of countries in our sample

In this section, we analyse the data on public expenditure composition for 38 selected countries in our sample according to the availability of control variables, which is mainly affected by labour growth. The set of countries in Table 1 is divided into two main groups: 17 developing countries and 21 high-income OECD countries.

As shown in Figure 1, total public spending in the group of countries in our sample has slightly increased in the past four decades. This can be seen from the increase in unweighted 10-year average total spending to GDP from 23.42% in 1972-1981 to 25.44% in 2002-2011 for developing countries. For high-income OECD countries, the level of total public spending to GDP increased from 32.55% in 1972-1981 to 35.19% in 2002-2011. Public spending in high-income OECD countries increased significantly during the 1970s and 1980s but subsided in later periods. On the other hand, the proportion of government spending to GDP in developing countries increased consistently during 1992-2001 and 2002-2011.

Table 1. List of countries in our study by group

Developing countries		**High-income OECD countries**	
Bolivia	Morocco	**Austria***	Korea, Rep.
Brazil	South Africa	**Canada***	**Luxembourg***
Cameroon	Thailand	Chile	**Netherlands***
Costa Rica	Tunisia	**Denmark***	**New Zealand***
Dominican Republic	Turkey	**Finland***	**Norway***
Egypt, Arab Rep.	Nepal	**France***	Portugal
India		Hungary	**Spain***
Indonesia		**Iceland***	**Sweden***
Iran, Islamic Rep.		Ireland	**UK***
Malaysia		Israel	**United States***
Mauritius		Italy	

Note: Our 14 OECD countries included in Gemmell et al.'s (2016) group of 17 OECD countries

3.1. The composition of public spending

Table 2 presents the average amount of particular types of public spending by groups of countries as percentages of GDP. In percentage terms, government spending in our sample of high-income OECD countries is obviously higher than in our sample of developing countries. The same also applies to many other types of spending, although not to spending on general public services. The level of spending on education as a share of GDP is relatively similar across different groups of countries in the sample, with an average of around 3.38% of GDP.

Figure 1. Unweighted 10-year averages of total public spending as percentages of GDP for groups of countries in our sample (1972-2011)

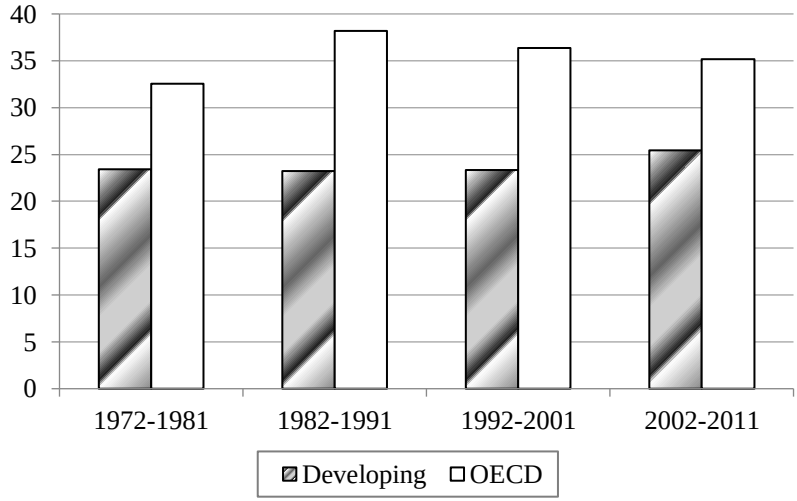


Table 2. Unweighted averages of public spending by type as percentages of GDP for groups of countries in our sample (1972-2012)

	Developing countries	**High-income OECD countries**
Total spending	23.96	35.74
General public services	3.80	2.73
Defence	2.07	2.41
Transportation and communication	1.42	1.64
Education	3.38	3.39
Healthcare	1.45	3.62
Social welfare	3.13	12.59

The composition of public spending in different groups of countries varies depending on the policies and problems that particular governments encounter. The unweighted averages of public spending by type as percentages of total spending from 1972 to 2012 for developing countries and high-income OECD countries are shown in Table 3. In developing countries, general public services (16.2%), education (14.1%) and social welfare (11.9%) spending are crucial elements of government budgets. In contrast, high-income OECD countries spend a large proportion of public expenditure on social welfare (34.7%), healthcare (10.1%) and education (9.7%). Social welfare spending accounts for more than a third of total public spending in high-income OECD countries.

Table 3. Unweighted averages of public spending by type as percentages of total spending for groups of countries in our sample (1972-2012)

	Developing countries	**High-income OECD countries**
General public services	16.20	7.65
Defence	8.69	7.30
Transportation and communication	6.51	4.71
Education	14.10	9.67
Healthcare	6.23	10.05
Social welfare	11.93	34.72

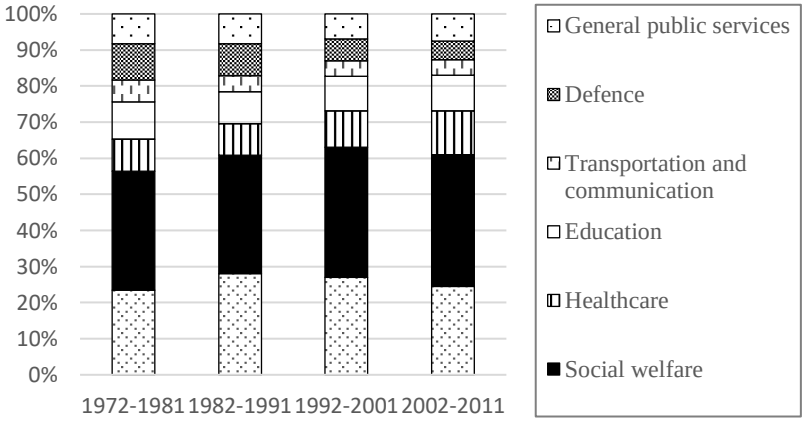
The public spending composition of developing countries is presented in Figure 2 using unweighted 10-year averages for the period from 1972 to 2011. It is clear that social welfare spending as a proportion of total public spending has increased significantly over time. In contrast, spending on defence, and

transportation and communication has decreased significantly relative to other types of public spending.

The proportions of most spending types, including general public services, education and social welfare spending, in relation to total spending in high-income OECD countries have not changed dramatically in the past forty years as can be seen in Figure 3. Healthcare spending has increased more noticeably over time than other types of expenditure, whereas spending on defence has been decreasing.

Figure 2. Unweighted 10-year averages of spending by type as percentages of total spending for developing countries in our sample (1972-2011)

Figure 3. Unweighted 10-year averages of spending by type as percentages of total spending for high-income OECD countries in our sample (1972-2011)



The following subsection explains the estimation method used to analyse long-run relationship between fiscal variables and GDP per capita.

4. Public spending and long-run GDP per capita investigating heterogenous panel data: estimation method

In this section, we discuss the econometric methods used to study the relationship between public spending and long-run levels of GDP per capita in our sample's groups of countries. Later (in Section 5), we present the estimates separately, according to the country groupings, i.e. developing countries and high-income OECD countries. This section includes the discussion of pooled mean group estimator (PMG), and tests for cointegration and ARDL lag structure.

4.1. Pooled mean group (PMG) estimator

The endogenous growth model in Devarajan, Swaroop and Zou (1996) captures the permanent growth effects from fiscal changes without transitional dynamics (Gemmell et al., 2016). Allowing for Solow-type transitional dynamics while the effects of fiscal change may be persistent requires a more flexible functional form than that of Devarajan et al. (1996). Using an autoregressive distributed lag (ARDL) model parameterised in error correction form in Gemmell et al. (2016) allows both the short-run dynamic and the long-run equilibrium relationships between GDP and fiscal variables to be identified separately. The ARDL(p,q) specification is:

$$y_{i,t} = \sum_{j=1}^{p} \alpha_{i,j} y_{i,t-j} + \sum_{j=0}^{q} \beta_{i,j} X_{i,t-j} + \mu_i + \varepsilon_{i,t} \qquad (1)$$

where $X_{i,t-j}$ includes all explanatory variables. Equation (1) can be expressed in error correction form:

$$g_{i,t} = \Delta y_{i,t} = \emptyset_i \left(y_{i,t-1} - \beta_i X_{i,t}\right) + \sum_{j=1}^{p-1} \alpha^*_{i,j} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \beta^*_{i,j} \Delta X_{i,t-j} + \mu_i + \varepsilon_{i,t} \qquad (2)$$

where $\emptyset_i$ captures the error correcting speed of adjustment and β_i captures the long-run equilibrium relationship between y and X with short-run effects measured by $\beta^*_{i,j}$. The estimates of long-run coefficient β_i are not affected by the choice between $X_{i,t}$ and $X_{i,t-1}$ in determining the long-run relationship. While Arnold et al. (2011), Ojede and Yamarik (2012), and Xing (2012) use $X_{i,t}$, Gemmell et al. (2011, 2016) prefer $X_{i,t-1}$. We use $X_{i,t}$ in our study, since it provides better computational convenience in our statistical package than using $X_{i,t-1}$.

Blackburne and Frank (2007) suggest several approaches which can be taken in order to estimate Equation (2). Firstly,

a fixed effect (FE) estimation approach could be used when data from each group is pooled and only the intercepts are allowed to differ across groups. Pesaran and Smith (1995) show that these regressions are likely to be biased if the assumption of homogeneity of the short-run parameter estimates across countries is rejected. Secondly, the model might be fitted separately for each group and the arithmetic average of coefficients could be calculated by using mean group estimators (MG). The MG estimators allow both short and long-run parameter heterogeneity. Thirdly, Pesaran et al. (1999) proposed a PMG estimation that combines both methods of pooling (FE) and averaging (MG). The intercept, short-run coefficients and error variances are allowed to differ across groups, but the long-run coefficients are constrained to be equal across groups. Furthermore, Pesaran et al. (1999) have also demonstrated that allowing for short-run parameter heterogeneity results in more reliable estimates of the long-run responses.

We present the results of PMG estimates, as the Hausman test prefers PMG to MG.[1] The implication of the results from the Hausman test is that the assumption of homogenous long-run parameter estimates across countries is valid. The PMG method selected is then comparable to Gemmell et al.'s (2016) study.

Our study investigates the long-run relationship between public spending and the GDP per capita level of the 38 countries (see Table 1) which are classified as developing countries (17 countries) and high-income OECD countries (21 countries). These groups of countries were selected based on the availability of control and fiscal variables. The groups of developing countries and high-income OECD countries in our

[1] We do not show the results of the Hausman test in this paper; however, they could be provided by request.

sample have been analysed separately, in a similar way to Gemmell et al. (2016), by looking at the effects of total public expenditure and public expenditure composition. The study period is 1972-2012.

Our dependent variable $g_{i,t}$ is the change in log of GDP per capita. Although the growth rate of per capita GDP is the dependent variable, as shown in Equation (2), the regression measures the impacts of fiscal and other variables on long-run per capita GDP level. Equation (2) is only a re-parameterisation of Equation (1). As discussed earlier, Gemmell et al. (2016) argue that using level specification allows the identification of the degree of persistence in GDP growth responses.

The non-fiscal control variables included in this study are labour force growth (LG) and investment ratio to GDP (K). Labour force growth before 1990 is assumed to be constant (from the average of available data) in a number of countries in the sample where accurate data is not readily available. When taking government budget constraint into account, our fiscal control variables include the ratio of total expenditure to GDP, distortionary taxes to GDP, non-distortionary taxes to GDP and budget surplus to GDP. In the cases where we consider public spending composition, the expenditure share of a particular type of public spending in relation to total public spending is added individually. The list of variables included in this study is shown in Table 4.

Table 4. List of variables for this study

Variables	Description of the variables
y	Log of GDP per capita (2005 USD)
K	Gross capital formation (% of GDP)
LG	Labour force growth (%)
tot_gdp	Total public spending (% of GDP)
distax_gdp	Distortionary taxation (% of GDP)
tgs_gdp	Non-distortionary taxation (% of GDP)
SURBP	Budget balance (% of GDP)
TOT	Total public spending in local currency unit
gps_tot	Spending on general public services (% of TOT)
def_tot	Spending on defence (% of TOT)
trc_tot	Spending on transportation and communication (% of TOT)
edu_tot	Spending on education (% of TOT)
hea_tot	Spending on health (% of TOT)
soc_tot	Spending on social welfare (% of TOT)

The first part of the analysis of each group of countries in our sample looks at the total public expenditure effect with four different implicit financing elements: budget deficit; distortionary taxes; non-distortionary taxes; and a mix of both distortionary and non-distortionary taxes. In the second part of the analysis, we use budget deficit as an implicit financing element, focussing on the impact of shifting expenditure towards a particular type of public spending composition on the long-run GDP per capita level. There are two groups of countries considered: developing countries and high-income OECD countries. The model specification will be explained further in Section 5.

Gemmell et al. (2016) raise an endogeneity concern with regard to the potential for simultaneity between GDP per capita and the independent variables, especially the fiscal and investment variables. According to certain conditions relating

to the cointegrating relationship, estimates of the long-run parameter vector derived from regression of models from Equation (2) are consistent. In addition, serial correlations can be sufficiently dealt with by using appropriate orders of the ARDL model (Pesaran & Shin, 1998). This implies that the endogeneity problem can be overcome by using an ARDL with sufficiently long lags, provided that the regressors are not cointegrated among themselves. Consistent with Gemmell et al. (2016), the variables are firstly checked to ascertain whether they are I(0) or I(1) and whether they are cointegrated. The appropriate ARDL lag structure is then considered.

4.2. Tests for cointegration and ARDL lag structure

Before discussing the results, we test the order of integration and cointegration, and the ARDL lag structure. The groups of developing countries and high-income OECD countries within the sample are separately tested. Although tests have been performed with regard to both the effects of total expenditure and functional spending, our discussion focusses on the former.

Testing the order of integration and cointegration

We firstly test whether our variables are I(0) or I(1). A non-stationary series is integrated of order d, denote I(d), if it becomes stationary after being differenced d times (Greene, 2012). Like Choi (2001), we use the Fisher-type unit root test, since it can be applied to unbalanced panels. The p-values from the unit root test applied to each group in the panel data are combined to derive an overall test of whether the panel series contains a unit root. The null hypothesis is that every panel contains a unit root, while the alternative is that at least one panel is stationary. While the evidence of non-stationarity

is found in all variables of developing countries in the sample, the null hypothesis of investment ratio, labour force growth and budget surplus is rejected for the sample of high-income OECD countries. However, the test rejects the null of non-stationarity for each of the variables after taking first differences.

Kwiatkowski, Phillips, Schmidt and Shin (1992) can distinguish series that appear to be stationary, series that appear to have a unit root, and series for which data is not sufficiently informative, by testing both the unit root hypothesis and the stationary hypothesis. Though Kwiatkowski et al.'s (1992) methodology is beyond our scope, it suggests that our unit root test might have low statistical power. This implies that we might falsely reject the null hypothesis of unit root. Hence, our variables are most suited to being treated as non-stationary.

For the cointegration test, we implement Westerlund's (2005) method using variance ratio test statistics. The advantage that this method has over the other tests is that it does not require a correct specification of the data generating process. Other tests require some forms of modelling and estimation to correct for the heteroscedasticity and serial correlation properties of the data. Therefore, the outcomes of other cointegration tests can be very sensitive to these choices. The null hypothesis of Westerlund's (2005) test is no cointegration, while the alternative hypothesis is that the variables are cointegrated in all panels. Another variant of Westerlund's test has the alternative hypothesis that the variables are cointegrated in some of the panels. According to variance ratio test statistics, we reject the null hypothesis of no cointegration for all of our PMG specifications.

With unit root and cointegration tests, our model appears to fulfil the conditions which allow the ARDL model to overcome endogeneity concerns.

Testing the ARDL lag structure

As discussed earlier, the appropriate modification of the orders of the ARDL model is sufficient to deal with the residual serial correlation and the problem of endogenous regressors (Pesaran & Shin, 1998).

Gemmell et al. (2016) discuss the argument that augmentation may be viewed as applying to an initial ARDL(p,q) model where lags are chosen a priori. For example, an initially selected ARDL(1,1) might suffer from endogeneity. This can be corrected by running the ARDL(p,m) model where $m \geq 1$. The numbers of lags p and m can be chosen by using the Schwarz Criterion.

However, there is data limitation in our sample, in that the second lag cannot be applied to all independent variables. This is partly due to unbalanced panel data. For this reason, our analysis focusses on the ARDL(1,1) model. Our tests on appropriate lag structure using the time series of each country suggest that only a few sample countries require second lag of independent variables. This indirectly implies that the endogeneity problem might not be an issue using the ARDL(1,1) model in our study. In fact, ARDL(1,1) model is also used by Arnold et al. (2011) and Xing (2012).

5. Public spending and long-run GDP per capita investigating heterogenous panel data: estimation results

Using the ARDL(1,1) model, the error correction form can be specified in order to analyse the long-run GDP impacts of both changes in total government spending and changes in the shares of different spending types for developing countries and high-income OECD countries in our sample.

Firstly, the equations in error correction form, for impact of changes in total spending, can be specified according to

different implicit financing elements. The equation in which budget balance is an implicit financing element is represented by Equation (3). While Equation (4) has distortionary taxation as an implicit financing element, non-distortionary taxation is a source of funds in Equation (5). Equation (6) omits both the distortionary and non-distortionary taxation variables.

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 distax\_gdp_t - \beta_5 tgs\_gdp_t\big) + \beta_{1i}^{*}\Delta K_{i,t} \\ + \beta_{2i}^{*}\Delta LG_{i,t} + \beta_{3i}^{*}\Delta tot\_gdp_{i,t} \\ + \beta_{4i}^{*}\Delta distax\_gdp_{i,t} + \beta_{5i}^{*}\Delta tgs\_gdp_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t - \beta_5 tgs\_gdp_t\big) + \beta_{1i}^{*}\Delta K_{i,t} \\ + \beta_{2i}^{*}\Delta LG_{i,t} + \beta_{3i}^{*}\Delta tot\_gdp_{i,t} \\ + \beta_{4i}^{*}\Delta SURBP_{i,t} + \beta_{5i}^{*}\Delta tgs\_gdp_{i,t} + \mu_i + \varepsilon_{i,t}\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t - \beta_5 distax\_gdp_t\big) + \beta_{1i}^{*}\Delta K_{i,t} \\ + \beta_{2i}^{*}\Delta LG_{i,t} + \beta_{3i}^{*}\Delta tot\_gdp_{i,t} \\ + \beta_{4i}^{*}\Delta SURBP_{i,t} + \beta_{5i}^{*}\Delta distax\_gdp_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t\big) + \beta_{1i}^{*}\Delta K_{i,t} + \beta_{2i}^{*}\Delta LG_{i,t} \\ + \beta_{3i}^{*}\Delta tot\_gdp_{i,t} + \beta_{4i}^{*}\Delta SURBP_{i,t} + \mu_i + \varepsilon_{i,t}\end{aligned} \tag{6}$$

Secondly, the impacts of changes in the shares of different spending types are investigated. As in Gemmell et al. (2016), budget balance is the implicit financing element. It has been claimed that omitting budget balance facilitates interpretation, because deficit-funded tax or expenditure changes have intuitive economic translations. The shares of each public spending category are then added to each equation. Equation (7) illustrates the equation in which the share of general public spending is considered. We also estimate the impacts of changes in the shares of defence, transportation and communication, education, health, and social welfare spending.

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 distax\_gdp_t - \beta_5 tgs\_gdp_t \\ - \beta_6 gps\_tot_t\big) + \beta_{1i}^{*}\Delta K_{i,t} + \beta_{2i}^{*}\Delta LG_{i,t} \\ + \beta_{3i}^{*}\Delta tot\_gdp_{i,t} + \beta_{4i}^{*}\Delta distax\_gdp_{i,t} \\ + \beta_{5i}^{*}\Delta tgs\_gdp_{i,t} + \beta_{6i}^{*}\Delta gps\_tot_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \tag{7}$$

We will firstly discuss the long-run GDP impacts of both changes in total government spending and changes in the shares of different spending types for developing countries, followed by a discussion of estimates for high-income OECD countries. Our results of high-income OECD countries will then be compared with previous results from Gemmell et al. (2016) in Section 7.

5.1. A sample of developing countries (1972-2012)

For the 17 developing countries, the estimated results for total public expenditure effects in Table 5 suggest that there is no evidence that an increase in total spending is positively related to long-run GDP per capita.

Instead, when increased total spending is financed by either budget deficit (Column (1)) or non-distortionary taxes (Column (3)), the long-run GDP per capital level might deteriorate. The adverse long-run effects on GDP per capita from budget deficit financing (at -0.2278) are greater than the effects from non-distortionary taxes financing (-0.0725).

As seen in Table 5, the estimated coefficient of budget surplus in Column (2) is positive, whereas that in Column (3) is negative. This implies that improving budget balance but simultaneously increasing distortionary taxes to finance additional spending has different impacts on GDP per capita than improving of budget balance but simultaneously increasing non-distortionary taxes.

The positive effects of gross capital formation on GDP are evident. The estimated coefficients of $\emptyset$ indicate speeds of convergence to equilibrium of around less than 2.3% per year. This implies that the effects of fiscal shock by permanent increases in total spending on the level of GDP per capita could be highly persistent in developing countries in our sample.

As stated earlier, we investigate the potential long-run impacts of public spending composition on GDP per capita by focussing on the specification in which changes in total public spending are implicitly financed by changes in the budget balance. To save space, the results for public expenditure composition in the tables present only the parameters for total public expenditure and the functional spending of interest.

Table 5. PMG for developing countries testing for total public expenditure effects

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (***Δ***y)			
Implicit financing element	SURBP	DISTAX	TGS	DISTAX, TGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Long-run effects				
Investment ratio	0.1446*	0.0407***	0.1111***	0.0057
	(0.08)	(0.01)	(0.03)	(0.03)
Labour growth	-0.5451	-0.0886*	0.2051***	-0.3935*
	(0.34)	(0.05)	(0.07)	(0.22)
Total expenditure	-0.2278**	0.0124	-0.0725**	-0.0799
	(0.11)	(0.01)	(0.03)	(0.05)
Budget balance		0.1315***	-0.1079***	0.5004***
		(0.03)	(0.04)	(0.19)
Distortionary taxes	0.2194**		0.0790***	
	(0.10)		(0.03)	
Non-distortionary taxes	0.1615***	0.1720***		
	(0.06)	(0.03)		
Error correction term	-0.0062*	-0.0232***	-0.0077	-0.0051**
	(0.00)	(0.01)	(0.01)	(0.00)

Table 5. (Continued)

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (***Δ***y)			
Implicit financing element	SURBP	DISTAX	TGS	DISTAX, TGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Short-run effects (first difference)				
Investment ratio	0.0042***	0.0041***	0.0042***	0.0048***
	(0.00)	(0.00)	(0.00)	(0.00)
Labour growth	-0.0002	-0.0028	-0.0045	-0.0028
	(0.00)	(0.00)	(0.00)	(0.00)
Total expenditure	-0.0033**	-0.0034**	-0.0025	-0.0025
	(0.00)	(0.00)	(0.00)	(0.00)
Budget balance		-0.0010	0.0030	-0.0002
		(0.00)	(0.00)	(0.00)
Distortionary taxes	0.0072		0.0090*	
	(0.01)		(0.01)	
Non-distortionary taxes	-0.0005	-0.0036		
	(0.00)	(0.00)		
Log-likelihood	1191.82	1347.73	1194.65	1334.68
N	496	572	496	572
n_g	17	17	17	17

Notes: Standard errors in parentheses below parameters
***, **, * Statistical significance at 1%, 5% and 10% respectively

As illustrated by Table 6, there is an evidence that an increase in the share of a particular type of spending could improve the level of per capita GDP in the long run for developing countries in our sample. This could be done through increases in the spending shares of healthcare and general public services. A 1% permanent increase in the share of general public services to total spending could improve the long-run GDP per capita level by 1.5%. A permanent increase in health spending has a more substantial favourable impact on long-run GDP (8.7%). In contrast, an adverse effect on long-run GDP per capita is found with defence spending (-5.5%) and education spending (-8.5%). Increases in the shares of transportation and communication, and social welfare do not have significant impacts on long-run GDP per capita. The low value of convergence rates again confirms the enduring effects of fiscal policy shock in developing countries in this sample. The positive value of estimated error correction coefficient in Column (5) for the change in the share of health spending might suggest divergence from a long-run equilibrium relationship after fiscal change. As a result, it is important to take care when interpreting the enhancing effect of an increase in the share of health spending on long-run GDP in developing countries using this sample

Table 6. PMG for developing countries using public expenditure composition

Estimation method	Pooled mean group estimates					
Dependent variable	Annual GDP per capita growth rate (***Δ***y)					
Implicit financing element	Budget surplus/ deficit					
Share of	GPS	DEF	TRC	EDU	HEA	SOC
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
Long-run effects						
Total expenditure	0.0064	-0.0171***	0.0249***	0.0518*	0.0446***	0.0186**
	(0.01)	(0.00)	(0.01)	(0.03)	(0.01)	(0.01)
Expenditure share	0.0148***	-0.0553***	-0.0209	-0.0849**	0.0865***	-0.0090
	(0.00)	(0.01)	(0.01)	(0.04)	(0.02)	(0.01)
Error correction term	-0.0197	-0.0800***	-0.0120	-0.0046	0.0032	-0.0165
	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)

Table 6. (Continued)

Estimation method	Pooled mean group estimates					
Dependent variable	Annual GDP per capita growth rate (***Δ***y)					
Implicit financing element	Budget surplus/ deficit					
Share of	GPS	DEF	TRC	EDU	HEA	SOC
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
Short-run effects						
(first difference)						
Total expenditure	-0.0035**	-0.0025	-0.0038**	-0.0051***	-0.0031	-0.0043***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Expenditure share	-0.0005	0.0035	-0.0017	-0.0039	-0.0001	-0.0012
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Log-likelihood	1155.63	1176.05	1155.80	1158.78	1152.41	1161.76
N	479	480	473	475	470	474
n_g	17	17	17	17	17	17

Notes: Standard errors in parentheses below parameters
***, **, * Statistical significance at 1%, 5% and 10% respectively

5.2. A sample of high-income OECD countries (1972-2012)

Looking at the total public expenditure effects on the 21 high-income OECD countries presented in Table 7, the only case in which an increase in public spending enhances the long-run level of GDP per capita is when the increase is financed by non-distortionary taxes. The long-run GDP per capita level could be raised by 1.2% with a 1% permanent increase in total spending as a share of GDP when financed by non-distortionary taxation.

An increase in total spending using financing methods related to budget deficit or distortionary taxation has a harmful effect on long-run GDP per capita levels in high-income OECD countries. The long-run GDP impact is most damaging when the increased total spending is funded by a combination of distortionary and non-distortionary taxation (-5.5%). As also seen in the results for developing countries in our sample, the speeds of convergence to equilibrium are low, at around 2.0% to 3.4% per year. The effect of fiscal policy shock could be long-lasting in high-income OECD countries. Though, the convergence rates are higher than in developing countries.

The results of the functional spending analysis of high-income OECD countries in Table 8 suggest that in the long term, increases in the share of spending for general public services will deteriorate the GDP per capita level. On the other hand, more could be spent on education relative to other types of spending while increasing the long-term level of GDP per capita, given the ratio of total spending to GDP. A 1% permanent increase in the share of spending for education will raise the long-run GDP per capita level by 15.9% in high-income OECD countries. This strong positive impact may need further verification. The convergence rates are similar to those in the analysis of change in total public spending.

Table 7. PMG for high-income OECD countries testing for total public expenditure effects

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (***Δ***y)			
Implicit financing element	SURBP	DISTAX	TGS	DISTAX, TGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Long-run effects				
Investment ratio	0.0216***	0.0176***	0.0515***	0.0521***
	(0.01)	(0.01)	(0.01)	(0.02)
Labour growth	0.0379*	0.0382**	0.0165	0.0347
	(0.02)	(0.02)	(0.02)	(0.04)
Total expenditure	-0.0264***	-0.0414***	0.0122**	-0.0547***
	(0.01)	(0.01)	(0.01)	(0.01)
Budget balance		-0.0252***	0.0471***	-0.0162
		(0.01)	(0.01)	(0.02)
Distortionary taxes	-0.0111		-0.0692***	
	(0.01)		(0.01)	
Non-distortionary taxes	0.1578***	0.1717***		
	(0.01)	(0.01)		
Error correction term	-0.0295***	-0.0344***	-0.0255***	-0.0202***
	(0.01)	(0.01)	(0.01)	(0.00)

Table 7. (Continued)

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (Δy)			
Implicit financing element	SURBP	DISTAX	TGS	DISTAX, TGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Short-run effects (first difference)				
Investment ratio	0.0059***	0.0060***	0.0057***	0.0059***
	(0.00)	(0.00)	(0.00)	(0.00)
Labour growth	0.0008	0.0008	0.0012	0.0013*
	(0.00)	(0.00)	(0.00)	(0.00)
Total expenditure	-0.0031***	-0.0024**	-0.0052***	-0.0032***
	(0.00)	(0.00)	(0.00)	(0.00)
Budget balance		0.0010*	-0.0022*	0.0001
		(0.00)	(0.00)	(0.00)
Distortionary taxes	0.0017*		0.0039**	
	(0.00)		(0.00)	
Non-distortionary taxes	-0.0076***	-0.0090***		
	(0.00)	(0.00)		
Log-likelihood	2153.14	2326.02	2128.86	2264.77
N	751	812	751	812
n_g	21	21	21	21

Notes: Standard errors in parentheses below parameters
***, **, * Statistical significance at 1%, 5% and 10% respectively

Table 8. PMG for high-income OECD countries using public expenditure composition

Estimation method	Pooled mean group estimates					
Dependent variable	Annual GDP per capita growth rate (***Δ***y)					
Implicit financing element	Budget surplus/ deficit					
Share of	GPS	DEF	TRC	EDU	HEA	SOC
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
Long-run effects						
Total expenditure	-0.0224***	-0.0266***	-0.0206***	-0.0255***	-0.0272***	-0.0288***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Expenditure share	-0.0217***	0.0075	-0.0161	0.1587***	0.0019	-0.0065
	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.00)
Error correction term	-0.0336***	-0.0308***	-0.0298***	-0.0191***	-0.0293***	-0.0308***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Table 8. (Continued)

Estimation method	Pooled mean group estimates					
Dependent variable	Annual GDP per capita growth rate (***Δ***y)					
Implicit financing element	Budget surplus/ deficit					
Share of	GPS	DEF	TRC	EDU	HEA	SOC
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
Short-run effects (first difference)						
Total expenditure	-0.0029***	-0.0032***	-0.0030***	-0.0034***	-0.0032***	-0.0035***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Expenditure share	0.0025***	-0.0246	0.0002	-0.0037	-0.0001	-0.0026***
	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
Log-likelihood	2158.86	2104.88	2121.31	2143.91	2155.40	2174.53
N	742	717	728	740	742	742
n_g	21	21	21	21	21	21

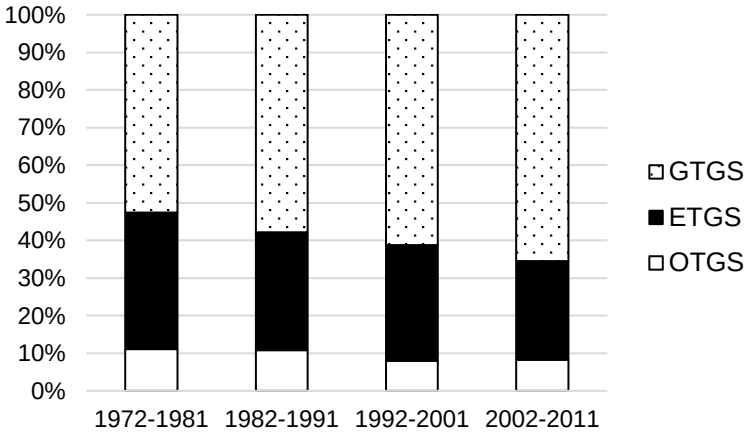
Notes: Standard errors in parentheses below parameters
***, **, * Statistical significance at 1%, 5% and 10% respectively

6. Breakdown of non-distortionary taxes for high-income OECD countries

Because financing from non-distortionary taxes (TGS) for additional public expenditure can enhance GDP per capita level in the long run for high-income OECD countries in our sample, we consider which kind of non-distortionary tax financing is conducive to increasing long-run GDP levels. As in the analysis in Section 5, the ARDL(1,1) model is applied to the pooled mean group (PMG) estimates, including the first difference of all control variables when considering short-run effects. The implicit financing element of non-distortionary taxes consists of three key components: general taxes on goods and services (GTGS); excise taxes on goods and services (ETGS); and other non-distortionary taxes (OTGS).

Figure 4 presents the 10-year unweighted averages of the composition of non-distortionary taxes in high-income OECD countries in our sample. The composition of non-distortionary taxes for high-income OECD countries between 1972 and 2012 comprises, on average, 59.5% of general taxes on goods and services, 31.0% of excise taxes and 9.5% of other non-distortionary taxes. The proportion of general taxes has increased over time. On the contrary, excise taxes and other non-distortionary taxes have steadily decreased.

Figure 4. Unweighted 10-year averages of non-distortionary taxes composition for high-income OECD countries in our sample



The specification of equations is similar to that in the analysis in Subsection 5.2 for long-run GDP impacts of the changes in total public spending using non-distortionary taxes as a source of funding (Equation (5)). The implicit financing elements considered in this section include general taxes, excise taxes and other non-distortionary taxes. They are all included additionally and separately in the equations as a share of GDP complementing Equation (5). The descriptions of variables are listed in Table 9.

Table 9. List of variables for the composition of non-distortionary taxation

Variables	**Description of the variables**
gtgs_gdp	General taxes on goods and services (% of GDP)
etgs_gdp	Excise taxes on goods and services (% of GDP)
otgs_gdp	Other non-distortionary taxes (% of GDP)

The error correction form equations can be specified by Equation (8) to Equation (10) according to implicit financing elements: general taxes in Equation (8), excise taxes in Equation (9) and other non-distortionary taxes in Equation (10). The estimates in Table 10 also include the results of Equation (5) in Column (1) in order to compare the financing of non-distortionary taxation and its constituents.

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t - \beta_5 distax\_gdp_t \\ - \beta_6 etgs\_gdp_t - \beta_7 otgs\_gdp_t\big) + \beta_{1i}^* \Delta K_{i,t} \\ + \beta_{2i}^* \Delta LG_{i,t} + \beta_{3i}^* \Delta tot\_gdp_{i,t} \\ + \beta_{4i}^* \Delta SURBP_{i,t} + \beta_{5i}^* \Delta distax\_gdp_{i,t} \\ + \beta_{6i}^* \Delta etgs\_gdp_{i,t} + \beta_{7i}^* \Delta otgs\_gdp_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \quad (8)$$

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t - \beta_5 distax\_gdp_t \\ - \beta_6 gtgs\_gdp_t - \beta_7 otgs\_gdp_t\big) + \beta_{1i}^* \Delta K_{i,t} \\ + \beta_{2i}^* \Delta LG_{i,t} + \beta_{3i}^* \Delta tot\_gdp_{i,t} \\ + \beta_{4i}^* \Delta SURBP_{i,t} + \beta_{5i}^* \Delta distax\_gdp_{i,t} \\ + \beta_{6i}^* \Delta gtgs\_gdp_{i,t} + \beta_{7i}^* \Delta otgs\_gdp_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \quad (9)$$

$$\begin{aligned}\Delta y_{i,t} = \emptyset_i\big(y_{i,t-1} - \beta_1 K_t - \beta_2 LG_t - \beta_3 tot\_gdp_t \\ - \beta_4 SURBP_t - \beta_5 distax\_gdp_t \\ - \beta_6 gtgs\_gdp_t - \beta_7 etgs\_gdp_t\big) + \beta_{1i}^* \Delta K_{i,t} \\ + \beta_{2i}^* \Delta LG_{i,t} + \beta_{3i}^* \Delta tot\_gdp_{i,t} \\ + \beta_{4i}^* \Delta SURBP_{i,t} + \beta_{5i}^* \Delta distax\_gdp_{i,t} \\ + \beta_{6i}^* \Delta gtgs\_gdp_{i,t} + \beta_{7i}^* \Delta etgs\_gdp_{i,t} + \mu_i \\ + \varepsilon_{i,t}\end{aligned} \quad (10)$$

Table 10. PMG for high-income OECD countries with broad categories of fiscal variables (non-distortionary taxes breakdown)

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (***Δ***y)			
Implicit financing element	TGS	GTGS	ETGS	OTGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Long-run effects				
Investment ratio	0.0515***	0.0229**	0.0063	0.0125
	(0.01)	(0.01)	(0.00)	(0.01)
Labour growth	0.0165	0.0790***	0.0056	0.0561
	(0.02)	(0.03)	(0.01)	(0.04)
Total expenditure	0.0122**	-0.0077	0.0443***	-0.1556***
	(0.01)	(0.01)	(0.00)	(0.02)
Budget balance	0.0471***	0.0269**	0.0651***	-0.0762***
	(0.01)	(0.01)	(0.01)	(0.03)
Distortionary taxes	-0.0692***	-0.0293**	-0.0595***	0.0535**
	(0.01)	(0.01)	(0.01)	(0.02)
General taxes			0.0329*	0.2733***
			(0.02)	(0.05)
Excise taxes		0.2921***		0.4369***
		(0.05)		(0.08)
Other taxes		-0.0087	0.1041***	
		(0.05)	(0.02)	
Error correction term	-0.0255***	-0.0196***	-0.0331**	-0.0169***
	(0.01)	(0.01)	(0.01)	(0.00)

Table 10. (Continued)

Estimation method	Pooled mean group estimates			
Dependent variable	Annual GDP per capita growth rate (***Δ***y)			
Implicit financing element	TGS	GTGS	ETGS	OTGS
	(1)	**(2)**	**(3)**	**(4)**
Regressor	**b/se**	**b/se**	**b/se**	**b/se**
Short-run effects (first difference)				
Investment ratio	0.0057***	0.0059***	0.0059***	0.0062***
	(0.00)	(0.00)	(0.00)	(0.00)
Labour growth	0.0012	0.0010	0.0016*	0.0007
	(0.00)	(0.00)	(0.00)	(0.00)
Total expenditure	-0.0052***	-0.0050***	-0.0052***	-0.0019
	(0.00)	(0.00)	(0.00)	(0.00)
Budget balance	-0.0022*	-0.0015	-0.0017	0.0015*
	(0.00)	(0.00)	(0.00)	(0.00)
Distortionary taxes	0.0039**	0.0033*	0.0026	-0.0003
	(0.00)	(0.00)	(0.00)	(0.00)
General taxes			-0.0062**	-0.0059**
			(0.00)	(0.00)
Excise taxes		-0.0096*		-0.0115**
		(0.01)		(0.00)
Other taxes		-0.0108	-0.0235	
		(0.01)	(0.02)	
Log-likelihood	2128.8558	2138.6254	2145.9160	2140.5469
N	751	731	731	736
n_g	21	21	21	21

Notes: Standard errors in parentheses below parameters
***, **, * Statistical significance at 1%, 5% and 10% respectively

As seen in Table 10, the results from the PMG estimation for high-income OECD countries show that the positive impact on GDP per capita from additional public spending only occurs when it is financed by an increase in excise taxes. A 1% of GDP increase in total spending financed by excise taxes will raise long-run GDP per capita by 4.4% (Column (3)). This positive effect is higher than the 1.2% increase from non-distortionary taxes financing at aggregate level shown in Column (1). While financing incremental spending by using other non-distortionary taxes has a negative impact on the level of GDP per capita in the long run, an increase in total spending financed by general taxes does not have significant effect on the long-run GDP per capita level.

Our analysis demonstrates that the favourable impact of changes in total spending through financing by non-distortionary taxes is highly influenced by the role played by excise taxes. The speed of adjustment to equilibrium long-run relationship is consistent with the findings in Subsection 5.2. The convergence rates are around 1.7% to 3.3% per year.

7. Comparison with the results of Gemmell et al. (2016)

The literature investigating impacts of fiscal changes on long-run GDP levels focusses on government revenues. To the best of my knowledge, Gemmell et al. (2016) is the only study that can be directly compared with our analysis of the effects of changes in government expenditure on the long-run GDP per capita.

While Gemmell et al. (2016) include data for 17 OECD countries between 1970 and 2008, we extend this to include data for 21 OECD countries between 1972 and 2012. It must be noted that their data is not nested in our sample. 14 out of 17 countries in their sample are included in our sample of high-income OECD countries, as shown in Table 1.

Firstly, we compare the estimates for the long-run level of GDP impacts of changes in total government spending. Our results for high-income OECD countries have shown that increasing total spending only has a favourable effect on the long-run GDP per capita level when the spending is financed by non-distortionary taxation. This finding is consistent with that of Gemmell et al. (2016). While they have found that a 1% permanent increase in total spending as a share of GDP financed by non-distortionary taxes will raise the long-run GDP per capita level by 2.0%, our analysis has shown that the impact is positive, but somewhat lower, at 1.2%. The speed of convergence to equilibrium in both studies is similarly low, at around 3.9% to 9.2% a year in Gemmell et al. (2016) and 2.0% to 3.4% in our study. Our results indicate that this may persist longer than Gemmell et al. (2016) suggest.

Secondly, we look at the long-run GDP impacts of shifting spending from the remaining categories into particular functions. Gemmell et al. (2016) find evidence of potentially positive GDP effects from changes in transportation and communication spending, and education spending. We also find that changing the share of education spending can have a favourable effect, although the impact from changing the share of transportation and communication spending is insignificant. This might demonstrate that the GDP-enhancing effect of an increase in the share of transportation and communication spending reported in Gemmell et al. (2016) is not robust when additional high-income OECD countries are included. Furthermore, their results might be specific to the period of 1970 to 2008. In contrast, the positive impact on long-run GDP per capita from a change in education spending share is reaffirmed. However, the GDP- promoting effect of 15.9% in our study might be overstated, compared with the 2.0% in Gemmell et al. (2016). Both studies observe significant

negative long-run associations between GDP and share of general public services spending.

8. Concluding remarks

When examining the relationship between public spending and the level of long-run GDP per capita when the first differences of control variables are all included in short-run effects, we see that an increase in total spending which is financed by non-distortionary taxes only enhances the level of GDP per capita in the case of our sample of high-income OECD countries. This is driven by excise taxes financing, in particular.

Given that total spending is level, increases in the shares of healthcare and general public services spending can improve the levels of GDP per capita in developing countries in our sample. On the other hand, increasing the share of education spending in a high-income OECD country is conducive to increasing the level of GDP per capita. This result differs from those of Gemmell et al. (2016); they found that a positive long-run effect on output level could be achieved in their OECD countries by reallocating total spending towards both transportation and communication, and education spending. This might imply that the favourable GDP impacts of changes to the transportation and communication spending share for OECD countries found by Gemmell et al. (2016) are not robust.

The speed of adjustment to the long-run equilibrium relationship in our analysis in our study is exceptionally low for both developing countries and high-income OECD countries. The impacts of fiscal changes on GDP can be extremely persistent. This also extends to transitory growth effects, which could also persist during this transition.

It is worth noting that the ARDL(1,1) model used excludes the possibility that fiscal changes on GDP per capita have longer, persistent effects which could be captured by, for example, the second lag. In other words, endogeneity might exist within our estimated parameters. However, we find that second difference is rarely required for the regressors using time series data to identify ARDL lag structure. Hence, there is reason to believe that endogeneity is not a major concern in our study.

In summary, our study shows that increasing revenue through distortionary taxes should be avoided, since it reduces the rate of economic growth. Moreover, the growth impacts of fiscal changes vary by different implicit financing elements. Governments of high-income OECD countries may be able to improve GDP per capita levels in the long run by using non-distortionary taxes to increase total spending. Changing the composition of public spending while holding the total spending constant, could also enhance the long-run GDP per capita level. In high-income OECD countries, this could be done by increasing the proportion of education spending. In developing countries, this could be done by increasing in the share of general public services or healthcare spending.

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