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# How Does the Public Spending Affect Technical Efficiency? Some Evidence from 15 European Countries

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# How does the public spending affect technical efficiency?
# Some evidence from 15 European countries

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## Abstract

The relationship between government size and economic growth has been widely debated. Departing from this issue, we provide an empirical analysis of the impact of government size on technical efficiency. The aim of this paper is to estimate by using a True Random Effect model the impact of public sector's size and of public expenditure components on 15 European countries' technical efficiency from 1996 to 2011. Using the total public expenditure as a proxy for the government size we estimate simultaneously national optimal production function and technical efficiency model by controlling for income distribution and institutional quality. Our main findings show that the effect of public sector's size on efficiency is positive while the type of public expenditures may have both positive and negative impact. In more details, results suggest that social protection, cultural, and health expenditures have a positive effect on technical efficiency, while others have a negative impact. More controversial is the impact of education expenditure, even if a positive effect on efficiency prevails when controlling for heteroscedasticity.

**Keywords:** Stochastic frontier production function, technical efficiency, government spending, European countries.

**JEL classification: C33, H10, H50**

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## 1. Introduction

The relationship between government size and economic growth is still a widely-debated issue. The established literature is full of apparently conflicting findings partially explained by variations in definitions, applied methodologies and the countries of study. Public spending is certainly seen as playing an important role in supporting economic growth (Munnel, 1990; Evans and Karras, 1994; Mazzucato, 2015) but, at the same time, a higher government size can contribute to lower growth rates (Fölster and Henrekson, 2001). A lower level of spending, implying fewer taxes, which in turn reduce distortions, may stimulate efficiency and growth (Romer and Romer, 2007; Furceri and Karras, 2009). Focusing on recent panel data studies, the majority of the papers finds a negative relationship between total government size and economic growth in rich countries (Fölster and Henrekson 2001, Dar and Khalkhali 2002, Afonso and Furceri 2010, Bergh and Karlsson 2010). This places in severe contrast to authors such as Agell *et al*. (2006), Colombier (2009), Aschauer (1989), Lindert (2004), Madrick (2010) and Alexiou (2009) who argue that there is no trade-off between economic growth and government size or public capital expenditure when they are investments in education and infrastructures. Other studies highlight that what limits the capacity of public expenditure to boost growth and employment is often the presence of corruption and poor quality institutions rather than the mere dimension of spending (Mo, 2001; Del Monte and Papagni, 2001; Rodrik *et al*., 2004). Thus, in the recent literature, a crucial role for economic growth is played by the quality of institutions measured in terms of transparent rules, well-defined property rights, judicial efficiency, and low levels of corruption (Asoni, 2008 and Rodrik, 2007).

However, Alesina (2012) underlines that the Great Recession has caused economists to re-evaluate what they know about macroeconomic policy. Departing from the multitude of previous studies conducted on the impact of government spending on economic growth, the originality of this study is three-fold. First, the main focus is on the relationship between government size and technical efficiency instead of the relationship between government size and economic growth. Second, the Stochastic Frontier Approach (SFA) is used to estimate the impact of total public spending and its components on countries' technical efficiency controlling for institutions' quality and income distribution. Specifically, the true random effect model (*TRE*) permits to take into account the unobserved country-specific heterogeneity (Farsi et al., 2005; Greene, 2005 a, b).

Third, we widen the methodology by distinguishing between inputs of production and factors affecting technical efficiency and by correcting for heteroscedasticity as suggested by Hadri et al. (2003). The authors demonstrate that correction for heteroscedasticity is essential to obtain valid estimates of efficiency scores. To control for heteroscedasticity, the inefficiency factors are included in the variance of the inefficiency component of the error term.

By threading at the finer level, the impact of each items of government expenditure[2] completes the picture on how public spending can stimulate efficiency and confirms the robustness of the previous findings.

The estimate of a stochastic frontier with country-specific and time-invariant effect allows analysing the influence of public spending on efficiency levels and identifying the conditioning factors of efficiency among the different public expenditure components. According to our results no empirical support can be found to assert that big government negatively affect total production (GDP) as it never widens the gap between actual and optimal efficiency frontier. In fact, empirical findings confirm a positive relationship between government size and economic performance. However, what matters most is the type of public expenditure. Under this respect, some expenditure items, such as social protection, culture and health expenditure, make efficiency to improve. More controversial are the effects in terms of education expenditure because the sign may be positive or negative depending on the specification of the model. But a positive effect on efficiency prevails when controlling for heteroscedasticity. Another somehow unexpected result comes from the estimation of defence expenditure effect, which shows a positive impact on inefficiency and hence a negative effect on country's performance.

The main policy implications of our results require first not to adopt the view that a trimming of the public sector is necessary to increase growth and second to

[2] The expenditures considered are: social protection, education, recreation, culture and religion, health, housing and community amenities, environment protection, economic affair, public order and safety, defence, and general public services.

deeply investigate the impact of every single items of expenditure as they have different impact on efficiency and indirectly on total production.

The paper is organized as follows. In Section 2, we briefly review the literature. Section 3 is dedicated to data description. In Section 4 we present our empirical model and Section 5 discusses the results of our regression analysis. Section 6 concludes.

## 2. Theoretical framework

The relationship between government size and economic growth is seemingly contradictory in the more recent literature. Two main features can be identified according to the way of measuring government size through total taxes, total expenditure relative to GDP or fiscal deficit and to the type of countries considered (developed or poor countries). As pointed out in Bergh and Henrekson (2011), the early cross-country studies typically find a negative correlation between total government size and economic growth, however what governments actually do and how they finance their activities matter (Marlow, 1986). The evidence generated by studies limited to cross-country regressions was not sufficiently robust to incorporate variations in the measure of government size, the time period considered or the countries included in the sample (Saunders, 1988). Panel studies, developed as more data became available, permit to estimate the effect of government size measures on growth taking into account the changes within countries over time. A negative correlation between government size and growth is also found by Fölster and Henrekson (2001), Dar and Khalkhali (2002), Romero-Avila and Strauch (2008), Afonso and Furceri (2010) and Bergh and Karlsson (2010). Other studies deviate from this result. Among these, Caselli *et al*. (1996) and Agell *et al*. (2006) find a positive or non-significant relationship between government size and growth. When considering only low-income countries, Gupta et al. (2005) and Baldacci et al. (2004) find that a reduction on fiscal deficit can have a positive effect on growth. Moreover, Baldacci et al. (2004) highlight that contrary to the case of high-income countries where private investment is the primary channel linking fiscal policy to growth, in low-income countries factor productivity is expected to be the principal fiscal-policy transmission channel for increasing the rate of growth. Colombier (2009), by using robust modified

Yohai *et al*. (1991)'s M-estimator finds a positive sign between government size and growth.

Some of the mentioned works have deeply analysed the issue by disaggregating government revenues and expenditure (Afonso and Furceri, 2010; Romero-Avila and Strauch, 2008; Bayraktar and Moreno-Dodson, 2012; Hansson and Henrekson, 1994). The composition of public spending is also a relevant topic, and if the aim is to promote growth, the focus should be on the more productive items of the budget. Thus, Nijkamp and Poot (2004) and Bergh and Henrekson (2011) in their literature review point out that public spending on education and public investment appear to be positively related to growth. Within the theoretical Barro (1990)'s model and the empirical Aschauer (1989)'s analysis, only productive public spending could have a positive effect on economic growth[3]. When the composition of public expenditure is considered, the productive expenditure appears to be good for growth and non-productive expenditure appears to be insignificant as in Kneller *et al*. (1999) and Bleaney *et al*. (2001), while in Bayraktar and Moreno-Dodson (2012) the core public spending[4] has a higher positive and significant impact when compared to the non-core component for fast-growing developing countries. In general, public capital expenditure, especially education expenditure, has a positive impact while government consumption component is insignificant or negative (Gupta *et al*., 2005; Colombier, 2009; Romero-Avila and Strauch 2008; Barbiero and Cournède, 2013).

Following another approach based on the nonlinearity hypothesis, a parabolic relationship between public spending and output emerges. Circumstances, such as public goods and the excess burden of taxation, disincentives from transfer mechanisms, market and state failures as well as rent-seeking activities, can be invoked to justify the nonlinearity hypothesis (Barro, 1990; Chen, 2006). According to this framework, an efficient level of government size can be found when the relationship shows an inverted U-shaped. As reported by Facchini and Melki (2013), the efficient size of government can vary from around 17 percent to 43.5 percent of

[3] See for more details the theoretical survey of Irmen and Kuehnel (2009) and the empirical survey of de Haan and Romp (2007)

[4] Here core spending includes productive expenditure (education, health, housing, transportation, and communication) plus fuel and energy.

GDP. Focusing only on European countries, the percentage is around 40 percent (Forte and Magazzino, 2011)[5].

As regards the relationship between income inequality and economic growth, the economic literature has extensively discussed the subject since Kuznets (1955)' pioneering work. As describe in the Thorbecke and Charumilind (2002)'s survey, the standard growth model implies that inequality is growth-enhancing. More saving promotes investment and growth and since the rich have a higher marginal propensity to save than the poor, a greater distributional inequality enhances total saving (Kaldor, 1956).

More recently some empirical studies have stressed the relationship among government size, economic growth and inequality. In the Muinelo-Gallo and Roca-Sagalés (2013)'s analysis, distributive expenditures and direct taxes may produce significant reductions in GDP growth and net income inequality reproducing the standard efficiency–equity trade-off. But they also find a reverse relationship, i.e. a cutting back of non-distributive expenditure could increase GDP growth while reducing income inequality[6].

A promising way of addressing the problem of government size and growth is that of focusing on countries' efficiency instead of directly on growth. The idea is that any public activity which boosts efficiency will have a positive effect on growth. A similar philosophy of approach can be found in Mazzucato (2015)[7]. To value the contribution given by the State to countries' growth, Mazzucato focuses on technical innovation and the role played by public expenditure in pushing it. In many well-documented case studies the role was positive and relevant.

Our research contributes to the existing literature by providing an empirical investigation on to what extent total public expenditure and its components affect country's technical efficiency, taking into account the role played by income inequality and governance quality.

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[5] For a comprehensive review of literature on linearity and nonlinearity hypothesis see Facchini and Melki (2013).

[6] As emphasized by Schaltegger and Weder (2014), austerity measures are not necessarily associated with an increase in income inequality.

[7] Incidentally our result in terms of the negative impact on efficiency of defense expenditure goes hand in hand with Mazzucato interpretation. What matters for growth is the "systems of innovation" given by the network of public and private institutions which introduces and/ or diffuses technical innovations. The circulation of knowledge is all that counts and in the case of military expenditure this is lacking. (p. 42-43).

## 3. Data description

Our empirical analysis uses annual data from 1996 to 2011 for 15 European Union member states (Austria, Belgium, Denmark, France, Finland, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the UK). Focusing on a sample of rather homogeneous countries such as EU's offers the following advantages: first, a longer span of data is available for EU15 than for a broader number of countries; and second, higher data quality and cross-countries comparability are more likely when less developed countries are excluded. Different data sources are chosen with the aim of both reducing missing values as much as possible and ameliorating comparability across countries and across time. Data collected constitute an unbalanced panel data with 161 observations.

Our output measure is GDP (at constant 2005 US dollars) per worker taken from the World Bank Indicators database. To estimate the production function, as a proxy of human capital, we adopt the total number of years of schooling of the working-age population over 15 years of age (Barro and Lee, 2013). Gross capital formation per worker is computed from real investment following the same perpetual inventory procedure as in Caselli (2005). Following Méon and Weill (2010), we assume a depreciation rate of 6 per cent and hypothesize that the initial capital stock corresponds to its steady-state value in the Solow growth model.

Gini coefficients, total general government expenditure and its components, government effectiveness and regulatory quality indexes are the variables used in the estimation of the inefficiency model.

In a comparison perspective among countries, the estimation of efficiency cannot disregard the level of inequality of a country, thus we control for the trade-off between equality and efficiency. Country-specific income distribution, measured by the Gini index, could represent the different distributive policy applied by European countries. The Gini index series is collected by United Nations University (UNU-WIDER).

The total government expenditure and its components such as general public services, economic affairs, social protection, recreation, culture and religion, public order and safety, education, health, housing and community amenities, environment protection and defence expenditure are taken from Eurostat dataset. The size of government is expressed by total public expenditure as percentage of GDP. In the framework of the European System of National Accounts (ESA95), Eurostat collects data on general government expenditure by economic function according to the international Classification of the Functions of Government (COFOG). This choice is based on the Barro (1990)'s model where productive or non-productive expenditures, i.e. public capital spending and public consumption spending, have different impact on economic growth.

The quality of country's governance is also included in the estimation of technical efficiency. From the largest and most comprehensive set of data assessing institutional quality (Worldwide Governance Indicators), two variables are selected, Government Effectiveness and Regulatory Quality. Kaufmann *et al*. (1999a, 1999b) provide these two composite indicators representing the two main facets of governance. Accordingly, the first one is defined as the "perceptions of the quality of public service provision, the quality of the bureaucracy, the competence of the civil servants, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies." The second one also called ''regulatory burden" captures ''the incidence of market unfriendly policies such as price controls or inadequate bank supervision, as well as perceptions of the burden imposed by excessive regulation".

A summary statistics of variables used in the analysis is presented in Table 1.

## 4. Estimation strategy

To empirically estimate the relationship between countries' technical efficiency and government expenditure we apply the stochastic production frontier technique originally developed by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977)[8].

This technique was developed to investigate firms' efficiency, but was later used to measure technical efficiency at the aggregate level as applied by Moroney and Lovell (1997), Méon and Weill (2005 and 2010), Méon, Schneider and Weill (2011) and Brock and Ogloblin (2014). According to Méon and Weill (2010), this methodology should be considered as a better strategy to estimate macroeconomic

[8] A country can be far from the optimal frontier due to randomness. Technical efficiency allows measuring how close a country's production is to the country's optimal production based on the same bundle of inputs.

productivity than the standard productivity measures such as output-to-input ratio. Moreover, this methodology provides a relative productivity measure and therefore each country can be compared to the best practice countries.

An economy could be considered technically efficient when it reaches the maximum level of output using the best combination of inputs within the existing technology. The estimated production frontier coincides with the optimal output level and represents the benchmark in respect to which the country-level efficiency is measured. Following Greene (2005a and 2005b) who proposes the *TRE* model as an extension of the parametric stochastic frontier approach, we are able to control for omitted variable biases due to unobserved heterogeneity of countries and to avoid heterogeneity biases in the estimated values of technical inefficiency. This model has had several applications in recent studies as in Farsi *et al.* (2005, 2006) since it allows for time-varying inefficiency and country-specific heterogeneity. However, the TRE model can provide biased estimates of the production function parameters if the assumption of no correlation between country-specific effects and regressors does not apply. In their comparative analysis of methodologies, Farsi *et al.* (2005) underline that the time-variant inefficiency estimates are not so sensitive to the above correlation mainly because it is captured by the production function coefficients without affecting the residuals. Adding the country-specific time-invariant effects to the Aigner *et al.* (1977) stochastic frontier model, the TRE model allows to separate unmeasured, unobserved time-invariant heterogeneity effects from time-varying efficiency estimates. As a consequence, efficiency estimates provide information on the transient component of productive efficiency (Filippini and Greene, 2014).

The production function within the TRE model can be parameterized as:

$$(1) \qquad Y_{it} = \alpha_i + x_{it}\beta + \varepsilon_{it} \qquad i=1,\ldots, N; \quad t=1,\ldots, T$$

where $\varepsilon_{it} = v_{it} - u_{it}$. $Y_{it}$ and $x_{it}$ represent respectively the observed output and inputs of country $i$ in period $t$ and $\alpha_i$ is the time invariant, country-specific random term which should capture the unobserved heterogeneity among countries and is assumed to have an *i.i.d.* normal distribution. As regards the composite error term ($\varepsilon_{it}$), it has two components. The first component, $v_{it}$, represents the measurement errors and other statistical noises, and it follows the usual assumption of normally distributed error term (*i.i.d.*, N(0, $\sigma_v^2$)). The second independent component, defined as $u_{it}$, denotes the degree of inefficiency. It is distributed as a non-negative normal random variable ($N^+(0, \sigma_{u_{it}}^2)$) and captures the transient effect of inefficiency.

As argued by Greene (2005a, 2005b), in this model the three different disturbances can be simplified. The composite error term $\varepsilon_{it} = v_{it} - u_{it}$ can be considered as a unique random term which follows an asymmetric mixed distribution and the model is estimated applying maximum simulated likelihood estimation method (MSLE).

However, the main purpose of this approach is to distinguish between production inputs and inefficiency factors, which directly affect the time-varying inefficiency. Distinguishing between the production frontier model and the inefficiency equation and including a set of exogenous variables in the inefficiency model, the influence of observed heterogeneity of countries on the inefficient component can be explained. These inefficiency determinants do not represent inputs but nonetheless exert an influence on the production structure of a country.

The stochastic frontier model as specified in eq. (1) should be enlarged to consider the inefficiency error component as a function of efficiency determinants ($z_{it}$), as in Hadri *et al.* (2003) but differently from them the inefficiency factors are included in the variance of the inefficiency component to control for heteroscedasticity and to avoid endogeneity issues. Moreover, the variation of $\sigma_{u_{it}}^2$ over individuals and/or time captures not only the heteroscedasticity but also affects the mean of $u_{it}$ (see Zieba, 2011). The inefficiency function can be parameterized as:

$$\sigma_{u_{it}}^2 = exp(\gamma' z_{it}) \qquad (2)$$

where $z_{it}$ is a vector of variables that may have an indirect effect on the production function of a country such as the role of public sector in the economy; and $\gamma$ is a $1 \times p$ vector of unknown parameters to be estimated. The advantage of this approach is twofold. On one hand, it allows estimating simultaneously the parameters of equation (1) and (2) by performing a two-stage procedure, and on the other hand, it permits to control for observed and unobserved heterogeneity of countries.

In this estimation, similarly to the augmented neoclassical model[9], human capital is introduced as inputs in addition to physical capital and labour force within the production function. Considering that the production function takes the constant returns-to-scale log-linear Cobb-Douglas form[10], our stochastic frontier production model can be specified as follows:

$$\text{(3)} \qquad \ln(Y/L)_{it} = \beta_0 + \beta_1 \ln(K/L)_{it} + \beta_2 \ln(H/L)_{itt} + (v_{it} - u_{it}) + \alpha_i$$

where the dependent variable is the logarithm of the economic performance of the *i-th* country at time *t* (*i=1,..., N; t=1,...,T*) divided by workers to remove potential problems of multicollinearity and output measurement (Hay-Liu, 1997). The independent variables are the logarithm of physical capital per worker (*K/L*) of the *i-th* country at time *t* and human capital per worker (*H/L*) of the *i-th* country at time *t*.

To check the robustness of our results, two alternative specifications are considered: the Cobb-Douglas specification and the constant returns-to-scale translog production function, which is specified as follows:

$$\text{(4)} \qquad \begin{aligned} \ln(Y/L)_{it} &= \beta_0 + \beta_1 \ln\left(K/L\right)_{it} + \beta_2 \ln\left(H/L\right)_{it} + 0.5\beta_3 \left[\ln\left(K/L\right)_{it}\right]^2 + \\ & 0.5\,\beta_4 \left[\ln\left(H/L\right)_{it}\right]^2 + 0.5\beta_5 \ln\left(K/L\right)_{it} \ln\left(H/L\right)_{it} + (v_{it} - u_{it}) + \alpha_i \end{aligned}$$

To take into account inefficiency determinants of European countries, the second component of the error is a function of several observable explanatory variables such as inequality degree, government spending and governance quality as shown in the following equations:

$$\text{(5)} \qquad \sigma^2_{u_{it}} = \gamma_0 + \gamma_1 \ln gini_{it} + \gamma_2 \ln TGGE_{it} + \gamma_3 \ln GE_{it} + \gamma_4 \ln RQ_{it} + \varepsilon_{it}$$

and

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[9] To account for international differences in growth paths, suffices to add human capital in a neoclassical Solow model (Mankiw, 1995).

[10] As Moroney and Lovell (1997) underline that at the economy-wide level, constant returns-to-scale is virtually compelling.

(6) $$\sigma^2_{u_{it}} = \gamma_0 + \gamma_1 \ln gini_{it} + \gamma_2 \ln SPE_{it} + \gamma_3 \ln EE_{it} + \gamma_4 \ln RCRE_{it} + \gamma_5 \ln HE_{it} + \gamma_6 \ln HCAE_{it} + \gamma_7 \ln EPE_{it} + \gamma_8 \ln \mathrm{EAE}_{it} + \gamma_9 \ln POSE_{it} + \gamma_{10} \ln DE_{it} + \gamma_{11} \ln GPSE_{it} + \gamma_{12} \ln GE_{it} + \gamma_{13} \ln RQ_{it} + \varepsilon_{it}$$

Where the Gini index ($\ln gini_{it}$) and the two control variables for the country's governance quality, Government Effectiveness ($GE_{it}$) and Regulatory Quality ($RQ_{it}$), are common in the two specifications. The difference between eq. (5) and eq. (6) resides in how public expenditure is considered. In eq. (5), in addition to the inequality and governance quality measures, the total general government expenditure ($TGGE_{it}$) as percentage of GDP is included in the model while in the second equation (eq.(6)) ten different components of the public expenditure as percentage of GDP are introduced: Social protection expenditure ($SPE_{it}$), Education expenditure ($EE_{it}$), Recreation, culture and religion expenditure ($RCRE_{it}$), Health expenditure ($HE_{it}$), Housing and community amenities ($HCAE_{it}$), Environment protection expenditure ($EPE_{it}$), Economic affair expenditure ($EAE_{it}$) Public order and safety expenditure ($POSE_{it}$), Defence expenditure ($DE_{it}$), and General public services expenditure ($GPSE_{it}$).

The technical efficiency of the *i-th* country in the *t-th* time period, is estimated using the conditional mean of the inefficiency term $E\{exp(-u_{it}|\varepsilon_{it})\}$ proposed by Battese and Coelli (1988) and is given by:

(7) $$TE_{it} = e^{(-u_{it})} = e^{(-z_{ti}\delta - \varepsilon_{ti})}$$

The technical inefficiency values will oscillate between 0 and 1, being the latter the most favourable case. If $TE_{it}<1$ then the observable output is less than the maximum feasible output, meaning that the statistical unit is not efficient.

## 5. Estimation results

The simulated maximum-likelihood method is used to estimate the parameters of the production stochastic frontier and of the inefficiency model for the unbalanced dataset of 15 European countries. In Table 2, alongside the columns the results for different functional specifications (Cobb-Douglas and Translog) are reported while alongside the rows variables of production function model and those of the inefficiency model are presented. As robustness check, for each functional form, two different models are provided. In model A the error term is considered homoscedastic while in model B the estimations are performed controlling for heteroscedasticity in the noise component $v_{it}$.

The estimated production frontiers are stable across models. As expected, in the Cobb-Douglas specification the two inputs for physical and human capital per worker contribute positively to GDP[11] in line with the established literature (Kneller and Stevens, 2003, Afonso and St. Aubyn, 2013 and Méon and Weill, 2010). As regards the Translog specification, there exits increasing marginal productivities for physical and human capital per worker since the coefficients of the squared variable have significant and positive signs. However, the interaction between the two inputs shows a negative and statistically significant sign. This suggests that physical and human capitals per worker are complements.

The inefficiency components have instead mixed signs and different significance levels in the two specifications. Where the Gini index is significant, the sign is negative as in model B of the Cobb-Douglas function while is positive when the Translog equation is estimated. Due to the lack of robustness of the relationship between the Gini index and the technical inefficiency, we can neither confirm nor reject the standard trade-off between efficiency and equity. We share these conclusions with several empirical studies of the 1990s (Persson and Tabellini, 1992; Alesina and Rodrik, 1994; Corry and Glyn 1994). According to our results the relationship between income inequality and economic growth can be of any type from trade-off to complementarity (Blank, 2002). It follows that welfare policy not necessarily influence country's efficiency in a negative way.

Total general government expenditure findings are robust and stable across estimation. The coefficient signs are all negative and significant, meaning that an increase in total public expenditure raises technical efficiency of the country and as consequence country's economic performance[12]. In explaining why some countries

[11] The only exception can be found in Model A of the Translog specification where human capital per worker coefficient is negative. However, in model B where the heteroscedasticity is taken into account the sign turns positive as expected.

[12] As in Aschauer, 1989, Lindert, 2004, Madrick, 2010 and Alexiou, 2009.

can maintain large government sector with no detrimental growth effects, the quality of public institutions can be crucial. In the inefficiency model, the two control variables related to the governance quality of a country show negative signs and significant coefficients with the exception of Model B in C-D function. These results are in line with those reported by Kaufmann *et al*. (1999a), Méon and Weill (2010) and with the meta-regression analysis of Efendic *et al.* (2011), meaning that the quality of governance, measured through the World Bank indicators, enhances efficiency and economic performance of a country.

A generalized likelihood ratio test to verify the appropriate functional form of the production model is implemented. Under the null hypothesis of linearly homogeneous Cobb-Douglas, this statistics has approximately a chi-squared distribution with degrees of freedom equal to the number of parameters involved in the restriction and it is equal to:

$$(6) \qquad \lambda = -2\left[l(H_0) - l(H_1)\right]$$

where $l(H_0)$ is the log-likelihood value of the restricted frontier model. As reported in Table 3, we do not reject the null hypothesis so the Cobb-Douglas functional form is preferred for model A, in line with other empirical studies (Kneller and Stevens, 2003; Méon and Weill, 2010; Méon *et al*., 2011). The translog specification is instead preferred for model B, but since it requires the estimation of a large number of parameters, which increases the risk of multicollinearity, we stay with the Cobb-Douglas function when the single items of public expenditure are scrutinized.

Table 4 reproduces our results when the composition of government spending is considered and it reveals the contribution of each item to efficiency. Not all the government-spending components are efficiency-increasing. They assume both positive and negative signs. Thus, the negative sign of expenditure variables means that when the government spending increases, the composite error term decreases due to technical inefficiency and thus country's economic performance rises. Social protection expenditure, culture and religion expenditure and health expenditure show negative signs although not always significant in the two models. Culture is often perceived as a non-economic activity and it is considered as a sterile and useless expense. Despite such preconceptions empirical evidences such as Last and Wetzel

(2010) and Zieba (2011) highlighted that culture and performing arts enhance technical efficiency. Similarly, the effect of health on aggregate output is positive, sizeable and statistically significant as outlined by Bloom *et al*. (2004).

Other public expenditure components such as economic affairs, housing, general public services, and defence expenditure show a positive and significant sign with respect to inefficiency as in Hansson and Henrekson (1994), Romero-Ávila and Strauch (2008) and Afonso and Furceri (2010) [13].

As regards education expenditure, results highlight a positive impact on technical inefficiency in model A and vice-versa in model B. However, when the coefficients' signs are unstable, model B estimation findings are more reliable than those of model A after controlling for heteroscedasticity. Thus a positive effect on GDP prevails as found by Hansson and Henrekson, (1994) and more recently by Hanushek and Woessmann (2012).

In addition and in order to further check the robustness of our results in terms of total government expenditure impact and of its components on the estimated technical efficiency scores, the sample was split into two groups according to GDP growth rate and employment rate[14]. The analysis of variance (ANOVA) reported in Table 5 and 6 confirms that the mean values are significantly different for the two groups of countries. As expected, in Table 5 where the total public expenditure is considered, the average technical efficiency scores are higher for the best performers EU countries. When the composition of public expenditure is taken into account results are more puzzling and require country specific interpretation. Moreover, comparing the distribution of technical efficiency scores between the aggregated and disaggregated public expenditure as in Table 6, the scores are less dispersed in the case of total government spending. This implies that inefficiencies corresponding to the various items of public expenditure tend to offset each other and thus countries appear to be more efficient and more concentrated in the last quintile. Therefore, the need of deepening the analysis on public expenditure at disaggregated level stems from the fact that each item contributes differently to the increase of economic

[13] A detailed meta-analysis of the effect of military expenditure on economic growth can be found in Alptekin and Levine (2012)

[14] The dummy variable introduced in splitting the sample is equal to 1 for countries such as Austria, Belgium, Denmark, Finland, Germany, Luxembourg, Netherlands, Sweden, United Kingdom and 0 otherwise.

performance. Moreover, each country productive structure does matter when a same type of public expenditure is carried out by the different countries.

## 6. Concluding remarks

The aim of this study has been to tackle the long debated question about the relationship between government size and growth. We revisited the subject from a distinct angle with respect to the mainstream approach. Instead of asking whether government spending is directly beneficial/detrimental to growth we focused on countries efficiency arguing that a positive impact on efficiency is a boost to growth. The distance between the actual production frontier and the optimal one is our basic measure: any reduction in this gap is interpreted as a positive impact on economic performance i.e. on growth.

First, we have based our analysis on an unbalanced panel data collected from different sources and spanning from 1996 to 2011. This approach has the advantage of both reducing missing values as much as possible and ameliorating comparability across countries and across time.

Second, and perhaps most importantly, we have focused on the impact of government size and public expenditure components on EU15 countries' efficiency, inserting this relationship in the broader growth theory branch. Applying the *TRE* model developed by Greene (2005a, 2005b), which can be used to exploit the assumption of time-varying technical efficiency and dynamic phenomenon, the model treats all time-invariant effects as unobserved heterogeneity. Moreover, we include the inefficiency determinants in the variance of the inefficiency error to take into account heteroscedasticity. The production function and the inefficiency equation are simultaneously estimated, providing a synthetic measure of productivity and discriminating between production inputs and technical efficiency factors.

Third, as a means to check the robustness of results, we consider different production function specifications (Cobb-Douglas and Translog), we compare models with and without the heteroscedasticity of the statistical noise term and finally we develop ANOVA analysis of technical inefficiency scores.

The results of the analysis highlight that total government expenditure, as a proxy of government's size, has a positive effect on technical efficiency and is therefore beneficial to a country's economic performance. In fact, the average technical efficiency scores are higher for the best performance EU countries in terms of GDP and employment rate.

As for the single items of public expenditure we found that, social protection, cultural and religion, and health expenditures have a positive effect on technical efficiency and hence on country's performance, while others such as general public services and defence expenditure have a negative effect. By controlling for heteroscedasticity a positive impact on GDP prevails when the effects of education expenditure are considered.

In conclusion, the important policy implications of our results require first not to adopt the view that a trimming of the public sector is always necessary to increase GDP and second not to forget that institutions quality does matter as they affect countries' efficiency in a positive way. Finally, since every single items of expenditure has a different impact on efficiency in different countries, depending on the features of their productive structure, a scrupulous scrutiny is necessary.

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**Table 1. Descriptive statistics.**

| | mean | p50 | sd | min | max | N |
|---|---|---|---|---|---|---|
| GDP in US dollars (constant 2005) | 56958.38 | 55707.71 | 22551.04 | 10070.87 | 127634.8 | 730 |
| K_L | 15399.44 | 13280.56 | 12310.85 | 3003.973 | 130219 | 630 |
| H_L | 17736.53 | 18245.85 | 2634.456 | 10284.17 | 23739.1 | 315 |
| Gini | 29.57071 | 29 | 5.347199 | 19.7 | 48.5 | 419 |
| Total general government expenditure (% of GDP) | 48.40346 | 48.5 | 6.457381 | 31.2 | 66.1 | 289 |
| Social protection (% of GDP) | 18.5436 | 18.1 | 3.820491 | 8.3 | 28.4 | 289 |
| Education (% of GDP) | 5.474394 | 5.5 | 1.101562 | 2.5 | 8 | 289 |
| Recreation, culture and religion (% of GDP) | 1.152249 | 1.1 | 0.390339 | 0.2 | 2.3 | 289 |
| Health (% of GDP) | 6.417993 | 6.5 | 1.026737 | 3.8 | 8.8 | 289 |
| Housing and community amenities (% of GDP) | 0.882699 | 0.8 | 0.538044 | 0.1 | 5.8 | 289 |
| Environment protection (% of GDP) | 0.746021 | 0.7 | 0.352166 | 0.2 | 1.9 | 289 |
| Economic affairs (% of GDP) | 4.592388 | 4.4 | 1.671953 | 1.4 | 25 | 289 |
| Public order and safety (% of GDP) | 1.583391 | 1.6 | 0.415583 | 0.6 | 2.8 | 289 |
| Defense (% of GDP) | 1.525606 | 1.5 | 0.736948 | 0.2 | 4.2 | 289 |
| General public services (% of GDP) | 7.491349 | 6.9 | 2.634235 | 3.1 | 16 | 289 |
| Government Effectiveness | 1.586616 | 1.720302 | 0.491523 | 0.284696 | 2.344899 | 195 |
| Regulatory Quality | 1.438831 | 1.525017 | 0.356648 | 0.509778 | 2.076635 | 195 |

**Table 2. Stochastic frontier estimation results, total government expenditure.**

| | Cobb-Douglas function | | | | Translog function | | | |
|---|---|---|---|---|---|---|---|---|
| | **Model A** | | **Model B** | | **Model A** | | **Model B** | |
| | *coef* | *p-value* | *coef* | *p-value* | *coef* | *p-value* | *coef* | *p-value* |
| **Frontier production function** | | | | | | | | |
| K/L | 0.337*** | 0.000 | 0.378*** | 0.000 | 4.754*** | 0.000 | 2.011*** | 0.000 |
| H/L | 0.442*** | 0.000 | 0.457*** | 0.000 | -5.263*** | 0.000 | 1.115*** | 0.009 |
| (K/L)^2 | | | | | -0.071*** | 0.000 | 0.113*** | 0.000 |
| (H/L)^2 | | | | | 0.445*** | 0.000 | 0.149*** | 0.000 |
| (K/L)*(H/L) | | | | | -0.307*** | 0.000 | -0.396*** | 0.000 |
| _cons | 5.992*** | 0.000 | 3.136*** | 0.000 | 11.755*** | 0.000 | -2.046 | 0.428 |
| **Inefficiency model** | | | | | | | | |
| Gini | 0.234 | 0.267 | -0.539*** | 0.010 | 1.129*** | 0.00 | 0.240** | 0.026 |
| Government Effectiveness | -0.698*** | 0.000 | 0.008 | 0.909 | -3.249* | 0.075 | -2.582*** | 0.000 |
| Regulatory Quality | -3.716 | 0.103 | 7.826* | 0.091 | -2.246 | 0.183 | -2.973** | 0.015 |
| Total general government expenditure | -5.094** | 0.049 | -7.337** | 0.050 | -1.010*** | 0.00 | -0.599*** | 0.000 |
| _cons | 24.752** | 0.035 | 1.087 | 0.451 | 2.232 | 0.608 | 17.684*** | 0.001 |
| Vsigma | -6.903*** | 0.000 | | | -6.983*** | 0.000 | | |
| Theta | 2.065*** | 0.000 | 0.288*** | 0.000 | 2.266*** | 0.000 | 2.676*** | 0.000 |
| Number of observations | 167 | | 167 | | 167 | | 167 | |
| Log-Likelihood | 255.33 | | 296.39 | | 265.93 | | 239.61 | |

*Note: *** p<0.01, ** p<0.05, * p<0.1*

**Table 3. Tests for functional form of the production function.**

| | H0 restricted model | H1 unrestricted model | Restrictions | LR test | Decision |
|---|---|---|---|---|---|
| Model A | Linearly Homog. C-D | Linarly Non-homog. Translog | 3 | 15.38 | Don't Reject H0 |
| Model B | Linearly Homog. C-D | Linarly Non-homog. Translog | 3 | -58.46 | Reject H0 |

*Notes: H0 is the null hypothesis, H1 the alternative. Tests were conducted at the 5% level*

**Table 4. Stochastic frontier estimation results, composition of government expenditure.**

| | Cobb-Douglas function | | | |
|---|---|---|---|---|
| | Model A | | Model B | |
| | *coef* | *p-value* | *coef* | *p-value* |
| **Frontier production function** | | | | |
| lK_L | 0.226*** | 0.000 | 0.267*** | 0.000 |
| lH_L | 0.143*** | 0.000 | 0.315*** | 0.000 |
| _cons | 9.782*** | 0.000 | 7.270*** | 0.000 |
| **Infefficiency model** | | | | |
| Gini | -0.071 | 0.493 | -0.365 | 0.224 |
| Social protection expenditure | -0.105 | 0.523 | -0.073 | 0.852 |
| Education expenditure | 1.340* | 0.060 | -1.666* | 0.081 |
| Recreation, culture and religion expenditure | -4.542** | 0.024 | -2.768 | 0.167 |
| Health expenditure | -2.299** | 0.030 | -0.292 | 0.521 |
| Housing and community amenities | 3.014*** | 0.000 | 1.922** | 0.050 |
| Environment protection expenditure | 1.298 | 0.205 | -0.022 | 0.971 |
| Economic affair expenditure | 0.012 | 0.941 | 0.354** | 0.019 |
| Public order and safety expenditure | -0.664 | 0.456 | 1.585 | 0.478 |
| Defense expenditure | 0.272 | 0.664 | 1.592** | 0.048 |
| General public services expenditure | 0.181 | 0.344 | 1.060*** | 0.000 |
| Government Effectiveness | 0.961 | 0.645 | 4.641** | 0.020 |
| Regulatory Quality | 1.881 | 0.175 | 2.781 | 0.109 |
| _cons | 0.667 | 0.906 | -10.017 | 0.565 |
| Vsigma | -7.459*** | 0.000 | | |
| Theta | 2.036*** | 0.000 | 1.808*** | 0.000 |
| Number of observations | 167 | | 167 | |
| sigma_v | 0.024 | | | |
| Log-Likelihood | 268.68 | | 309.03 | |

*Note: *** p<0.01, ** p<0.05, * p<0.1*

**Table 5. ANOVA Analysis of technical inefficiency for total public expenditure**

| | Cobb-Douglas function | | Translog function | |
|---|---|---|---|---|
| **dEU** | **model A** | **model B** | **model A** | **model B** |
| 0 | 0.586 | 0.997 | 0.604 | 0.342 |
| 1 | 0.995 | 0.988 | 0.977 | 0.950 |
| | | **ANOVA analysis** | | |
| F | 137.43*** | 10.67*** | 88.08*** | 222.96*** |
| Prob> F | 0.00 | 0.00 | 0.00 | 0.00 |

*Nota: *** significant at 1%*

**Table 6. Frequency distribution of technical efficiency scores based on Cobb-Douglas function.**

| | Aggregated public expenditure | | Items of public expenditure | |
|---|---|---|---|---|
| Efficiency interval | **Model A** | **Model B** | **Model A** | **Model B** |
| 0.00 - 0.19 | 17 | 0 | 40 | 30 |
| 0.20 - 0.39 | 7 | 0 | 37 | 53 |
| 0.40 - 0.59 | 8 | 0 | 16 | 17 |
| 0.60 - 0.79 | 9 | 0 | 25 | 14 |
| 0.80 - 1.00 | 126 | 167 | 49 | 53 |

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