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ABSTRACT

This article analyses the redistributive efficiency of public spending and taxation in a panel of both advanced and developing economies during the last three decades (1984-2012). In order to explore how redistribution is achieved through fiscal policies, a two-stage approach is applied. First, we evaluate the redistributive efficiency of public spending and taxes by using Data Envelopment Analysis (DEA) and obtain considerable variation in redistributive efficiency scores across countries. Second, we use panel truncated and OLS regression analysis to identify the determinants of these differences and reveal the crucial role of economic development, government quality and demographic factors.

Key words: Government efficiency, redistribution, fiscal policy, data envelopment analysis, panel data

JEL codes: E02, E62, H11, H53

1. Introduction

The fact that income inequality has generally being rising in both advanced and developing economies in recent decades (IMF 2014; OECD 2008 and 2011), coupled with the growing realization that inequality could be harmful for economic development (Halter et al. 2014; Ostry et al. 2014), highlights the need for policies which can reduce inter-personal income differences. In this context, the redistributive potential of fiscal policies, both on the tax and spending sides, can play an important role.

The capacity of countries to deploy fiscal policies to reduce income differences faces important budgetary restrictions. Developing countries tend to have smaller public sectors and thus fewer fiscal resources available to address inequalities (Barreix et al. 2007; Goñi et al. 2011). And some developed countries have experienced an unprecedented increase in public debt in the context of the Great Recession of 2007-09, raising serious concerns about fiscal sustainability. Against this backdrop, many governments have been making substantial fiscal adjustments through a combination of spending cuts and tax hikes to reduce their ratios of debt to Gross Domestic Product (GDP). At the same time, public support for redistributive policies has grown, especially in advanced economies where the crisis has hit hardest (see, IMF 2014).

Because of increasing income inequalities and scarce budgetary resources, attention needs to be paid to the redistributive efficiency of fiscal policies: efficiency allows the attainment of a given level of redistribution at lower levels of spending and taxes, or the attainment of more redistribution at given tax and spending levels.

A range of studies have used Data Envelopment Analysis (DEA) to measure the efficiency of government spending, either total spending or spending in specific policy areas, in attaining a range of socio-economic objectives such as health and education outcomes (see, for example Gupta and Verhoeven 2001; Afonso et al. 2005). A number of contributions have gone further by, moreover, examining a set of non-discretionary factors which may explain cross country differences in public sector efficiency.[1] Thus, Afonso et al (2010) and Hauner and Kyobe (2010) use the DEA methodology to calibrate the efficiency of health, education or social spending in the pursuit of specific socio-economic objectives and then explain cross-country differences in government efficiency by way of factors which, they argue, are immutable in the short run.

In this article we focus on how efficient fiscal policies are in terms of redistribution and examine those variables which determine redistributive efficiency. Of course, different fiscal policies can have different objectives such as macroeconomic stability, public good provision, economic growth or redistribution. But regardless of their objective, public spending and tax policies may potentially impact on the distribution of income (see Woo et al. 2013 and IMF 2014 for a survey of empirical work). Our interest here is to apply DEA methodology to examine the overall impact of fiscal policy on the distribution of income and specifically we aim to consider how efficient total spending and taxation are in redistributing income. Having done so, we then aim to uncover those factors which might explain cross-country differences in the redistributive efficiency of fiscal policy based on panel regression analysis.

We analyze the impact of public expenditure and taxes since both affect the distribution of income (see Martinez Vazquez et al. 2012, Muinelo and Roca-Sagalés 2013, and Wang et al. 2012 and 2014). Moreover, we consider the impact of fiscal policy on a measure of

[1] This two-step approach is currently the prevailing one the DEA literature (see, Liu et al 2013).

redistribution which exploits the difference between market inequality (before government transfers and taxes) and net income inequality (after government transfers and taxes) – a measure that we fully explain below.

Our first stage results, based on the DEA analysis applied to a panel of 27 developing and developed countries for the period 1984-2012, allow us to identify countries with similar spending and tax levels that obtain very different redistributive results signaling important differences in redistributive efficiency across countries. Moreover, our second stage results obtained from panel truncated and OLS regression analysis, points to the crucial role of economic development, government quality and the country's population structure in explaining these differences. The paper is structured as follows. After analyzing the redistributive role of fiscal policy in section 2, we explain the empirical methodology and the data in sections 3 and 4, discuss the results in section 5 and then conclude the article.

2. Fiscal Policy and Redistributive Efficiency

Fiscal policy is the primary tool through which governments can affect the distribution of income. Both tax and spending policies can alter this distribution, both over the short and medium term. The use of regression-based models to study the redistributive impact of fiscal policy has grown in recent years. A range of empirical studies have regressed measures of disposable income inequality on fiscal policy variables in order to explain their distributive impact. In this sense, it is possible to distinguish between two main groups of contributions. A first group discuss the impact of fiscal policies on income distribution in OECD countries and find a significant negative effect of government spending and taxes on inequality (for example, Muinelo-Gallo and Roca-Sagáles 2013) and an especially strong redistributive effect coming from public pensions (Huber and Stephens 2006 and Wang et al. 2012 and 2014). A second group of studies evaluates the distributive impact of different fiscal policies implemented in developing countries showing, in general, very weak effects (Chu et al. 2000 and 2004). Overall, these two lines of work show that the distributive impact of fiscal policies is strongly related to the level of economic development and to the specific spending and tax policies adopted.[2]

While this literature provides important insights into the impact of fiscal policies on income distribution, it does not evaluate the efficiency of these policies with regards to redistribution. Afonso et al. (2010) reports significant cross-country differences in the efficiency of social spending in reducing disposable income inequality. However, in order to evaluate redistributive efficiency, we cannot simply rely on disposable income inequality. This ignores the possibility that the evolution of this measure may also be due to changes in market income inequalities which, beyond fiscal policies, may occur because of globalization and technological change as well as other policies such as product and labor market regulation (OECD 2011). Thus, if we were to assess redistributive efficiency based exclusively on disposable income inequalities, this could lead us to assign changes in inequality exclusively to fiscal policy and ignore the possibility that these changes may also be due to the evolution of market income.

In this article, we take advantage of the recent income inequality database developed by Solt (2009, 2014) that combines information from available surveys to infer comparable series of Gini coefficients for market and net income inequality in an extended sample of countries and years. Specifically we employ Solt's (2014) relative redistribution measure which is defined

[2] For a complete survey of this empirical literature see IMF (2014) and Ostry et al. (2014).

as the difference between the Gini coefficient for market and for net income as a proportion of the Gini coefficient for market income.

Figure 1 about here

In order to illustrate the usefulness of this measure, figure 1 plots it against net income inequality using data from some of the economies included in our sample. It shows that economies with similar levels of net income inequality have very different levels of relative redistribution. For instance, Sweden and Belgium in Group I, have net income Gini values close to 24 but very different levels of relative redistribution, stemming from the fact that Sweden has achieved greater reductions in market inequality. Specifically, market inequality in Sweden is much higher than that in Belgium (45 versus 32). So obviously, Sweden has experienced a significantly larger change in the distribution of income than Belgium. If we were to measure the redistributive impact of fiscal policy based on net income inequality, we could conclude that this is very similar. If instead we employ the relative redistribution indicator which also accounts for market inequality, we may observe substantial differences in the redistributive effect of fiscal policies. Similar examples include South Korea versus Portugal in Group II and Uruguay versus Sri Lanka in Group III.

3. Empirical methodology

In this section we detail the DEA methodology used to empirically evaluate the redistributive efficiency of fiscal policy, and then explain the empirical approach used to identify the non-discretionary determinants of this efficiency.

3.1 Data Envelopment Analysis Methodology

In this study we use DEA to evaluate the efficiency of fiscal policies in terms of income redistribution. Efficiency is defined with respect to a production possibility frontier, which indicates feasible output levels given the amount of inputs employed.

When performing DEA analysis several decisions must be taken. One concerns the choice between an input or output orientation. Whereas an input-oriented model maintains the current level of output constant and minimizes inputs, an output-oriented model maximizes output given the amount of inputs. We choose the latter model because we are interested in assessing the redistributive efficiency of given levels of public spending and taxation. In other words, the frontier methodology applied in this study takes governments as producers combining two inputs (public spending and taxes) to obtain one output (measured through relative redistribution). Governments are considered more efficient if they produce a larger output for given inputs. The DEA methodology translates efficiency into "scores", and based on these scores, one can build ordinal rankings of a country's relative performance (Coelli and Perelman, 1999). Another decision is whether to apply constant or variable returns to scale in the production function. Banker et al. (1984) was the first to incorporate variable returns to scale (VRS) to account for agents not operating at their optimal scale. We employ VRS since our inputs are ratio data and, as explained by Hollingsworth et al. (2003), in that case the model with the VRS constraint performs better.

The DEA method applies linear programming techniques to input and output data and estimates an efficiency frontier.[3] The general relationship is given by the following production function for each country *i*:

$$Y_i = f(X_i),\ i = 1,...,n \qquad (1)$$

Where, Y_i is the output index (relative redistribution) and X_i includes two inputs (government expenditure and taxes, both as a percentage of GDP).

If $Y_i < f(X_i)$, then the country exhibits inefficiency. That is to say, with the observed levels of inputs, the current or observed output (redistribution obtained) is smaller than the highest achievable potential output (output-oriented efficiency). Thus inefficiency can be measured by computing the distance to the estimated efficiency frontier.

Analytically, the linear programming output-oriented problem to be solved for country i assuming variable returns to scale is as follows (see Afonso et al. 2013). We assume that there are k inputs and m outputs for n countries. For country i, y_i is the column vector of results and x_i is the vector of inputs. We can define X as the inputs matrix with dimensions $(k * n)$, and Y as the output matrix with dimensions $(m * n)$. Thus:

$$\begin{cases} \underset{\delta,\lambda}{Máx}\ \delta_i \\ \text{s.t.:} \\ \quad -\delta y_i + Y\lambda \geq 0 \\ \quad x_i - X\lambda \geq 0 \\ \quad n1'\lambda = 1 \\ \quad \lambda \geq 0 \end{cases} \qquad (2)$$

The efficiency score represented by δ_i, a scalar that satisfies $1/\delta_i \leq 1$, that measures the distance between country i and the efficiency frontier, defined as a linear combination of those observations with best practices in the sample. It is important to note that this method considers indicators of relative efficiency within the sample of individuals (in our case, countries) analyzed.

If $1/\delta_i < 1$, the country is within the frontier (i.e. it is inefficient), while $\delta_i = 1$ implies that the country is on the efficient frontier (i.e. efficient). The vector λ is a $(n * 1)$ vector of constants that measure the weights used to compute the location of an inefficient country if it were to become efficient, and $n1$ is a n-dimensional vector of 1 ones. The restriction $n1'\lambda = 1$ imposes convexity on the frontier. This problem is solved for each of the n countries for the purpose of obtaining *n* efficiency indicators.

[3] For more details on DEA techniques and analysis, see, for example, Farrell (1957), Charnes et al. (1978), Thanassoulis (2001), and Coelli et al. (2002).

3.2 Analyzing the non-discretionary factors: a panel data approach.

The DEA method assumes that output efficiency is purely the result of discretionary inputs and as such ignores the influence of non-discretionary factors which may also impact on efficiency. To account for this, we perform a second stage analysis where the DEA efficiency scores are regressed on a set of possible exogenous factors that might explain redistributive efficiency.

Following McDonald (2009) and Simar and Wilson (2011), the DEA efficiency scores are corner solutions meaning that they are truncated. A corner solution variable is continuous and limited from above and/or below, and takes the value of one of the boundaries with a positive probability (see, Hoff 2007). Because of this, truncated regression provides consistent estimations in the second stage of our analysis.[4]

Thus, we undertake a truncated panel data regression analysis, by regressing the output efficiency scores δ_i, on a set of possible non-discretionary factors, Z_i:

$$\delta_i = f(Z_i) + \varepsilon_i \qquad (3)$$

In relation to these non-discretionary factors, we include the logarithm of the GDP per capita, several indicators of the quality of government, the percentage of population between 0 and 14 years as a proportion of the population between 15 and 64, the percentage of population of 65 years or more in proportion to the population between 15 and 64, a measure of asset inequality, indicators of educational attainment and unemployment rates and, finally, measures of fiscal discipline in the guise of indices of spending and revenue rules adopted by the different countries in our sample (we justify the choice of these variables in section 4.3).

4. Data

In this section we elaborate further on the indicator employed to measure redistribution, and discuss the other variables included in the DEA and the subsequent panel regression analysis. We construct a panel of 27 high and upper middle income economies taking 6 five year periods from 1984 to 2012, basing our selection of countries and time period on the availability, frequency and quality of the data.[5]

4.1 The DEA output variable: relative redistribution

Woo et al (2013) explain the main limitations of the most widely used datasets on income inequality in the last decades namely, the Luxembourg Income Study (LIS) and the World Income Inequality Database (WIID) of the United Nations University (UNU-WIDER, 2008): the first dataset suffers from low coverage (in terms of years and countries considered) and reduced comparability across countries and years, while the second one is hampered by the use of different income definitions.[6]

Considering this context, we take advantage of a recently updated cross-country dataset by Solt (2009 and 2014) that combines data from LIS and UNU-WIDER. This dataset, labeled

[4] It is important to note that the efficiency scores of the DEA analysis are not generated by a censoring process. They are fractional data and because of this, Tobit estimation of equation 3 yields inconsistent estimates or, at best, estimates similar to those obtained when applying OLS (see, McDonald 2009).

[5] The panel is almost balanced because it includes 6 observations for 25 countries, and 5 observations for 2 additional countries. See appendix for the list of countries included (Table A.1), for the summary statistics (Table A.2), and for the sources of all the data employed (Table A.3).

[6] For different definitions of income concepts, see Lustig and Higgins (2012).

SWIID, provides information on market and net income inequality in some 174 developing and advanced countries from 1960 to 2013. We restrict ourselves to a more reliable sub-sample of countries. Specifically, we focus on a sample of 27 countries for which we have information on redistribution and government spending and taxation, for the six five-year periods included in the analyzed time span (1984-2012).[7]

As previously stated, our chosen variable for measuring redistribution is a relative measure defined as the difference between the Gini coefficient for market and for net income over the Gini coefficient for market income. Some papers that analyze redistributive policies prefer to measure redistribution in absolute terms taking just the difference between both Gini indicators (Kenworthy and Pontusson 2005, Wang et al. 2014 and 2012, Thewissen 2014), while others consider redistribution in relative terms arguing that the percentage reduction in inequality captured by the relative redistribution measure is a better reflection of redistributive effort (Bradley et al. 2003, Mahler and Jesuit 2006; Iversen and Soskice 2011; Huber and Stephens 2014). For the purpose of measuring the redistributive efficiency of fiscal policy, the relative redistribution measure seems more precise. To see this, consider the case of two countries with similar public spending and taxation relative to GDP that obtain a net income Gini 15 points below the market Gini. But while the first country goes from 45 to 30 (these numbers approximate the case of France), the second country moves from 38 to 23 (Norway). Measuring redistribution in absolute terms would lead us to conclude that they have been equally effective in redistributing income. Employing relative redistribution however indicates that Norway redistributes more than France (Norway 0.39, France 0.33).

4.2 The input variables of the DEA

We include two input variables in the DEA namely, total public spending and total taxes, both as a percentage of GDP and taken from the Government Finance Statistics of the International Monetary Fund (GFS-IMF). It is important to remark that while the spending variable covers almost the totality of non-financial public expenditure, the tax variable represents a clearly lower percentage of total fiscal revenues because it does not include non-tax revenues.

Figure 2 about here

Figure 2 illustrates the relationship between both these aggregate fiscal measures and relative redistribution for our extended sample of 27 countries and shows a clear positive relationship in both cases. This is as expected since, on the one hand, public expenditure includes a variety of social expenditures with distributive implications (transfers like pensions or different subsidies) and, on the other hand, countries with higher tax burdens tend to have a more progressive tax structure. Of course, this figure is silent on the crucial issue of the redistributive efficiency of fiscal policies.

4.3 The non-discretionary variables for the regression analysis

As previously stated, we account for a range of non-discretionary factors that might explain redistributive efficiency differences across countries. First, we control for GDP per capita (in logs) in an attempt to account for the possibility that wealthier countries may enjoy a higher level of redistributive efficiency for a range of observable (but omitted) or unobservable non-discretionary factors related to development. Next, we control for cross-country differences in

[7] More details on Solt's database may be found at: http://myweb.uiowa.edu/fsolt/swiid/swiid.html. Babones and Alvarez-Rivadulla (2007) explain some of the advantages of SWIID database while Jenkins (2014) provides a comparative analysis between the WIID and SWIID databases.

institutional quality – based on perceptions of the extent to which the public sector is free from corruption, is endowed with a professional and efficient bureaucracy and observes the rule of law, – on the strength of the argument that countries with better quality institutions will be endowed with more efficient redistributive policies (Gupta et al. 2002; Rajkumar and Swaroom, 2008).[8] In addition, we control for educational attainment since it has been suggested that a more educated populace is likely to demand and be more vigilant of government efficiency (Afonso et al. 2010; Hauner and Kyobe, 2010). Moreover, we control for land distribution inequality (Gini Land) as a proxy of asset inequality in an effort to account for the presence of economic elites who may apply their superior resources to buy out public sector agents in order to preserve their privileges and, in doing so, undermine public sector efficiency (Glaeser et al. 2003 and Sonin, 2003). Further, we control for the percentage of population between 0 and 14 years and, separately, above 65 years of age (both as a percentage of the population between 15 and 64), to account for the redistributive effect of education spending and health and pensions (see, respectively, Gregorio and Lee 2002 and Wang et al. 2012, 2014). Similarly, we control for unemployment rates to allow for the fact that for any given unemployment insurance scheme in place, more unemployment implies more redistribution (Huber and Stephens 2014). Finally, we control for formal expenditure and revenue fiscal rules which can impose a degree of fiscal discipline. The impact of fiscal rules is a-priori ambiguous: to the extent that they contribute towards stabilizing a country's fiscal position they may improve redistributive efficiency. Alternatively, they may undermine this efficiency insofar as they limit a country's capacity to respond to exogenous factors.

GDP per capita, the unemployment rate and the demographic variables are taken, respectively, from the Penn World Tables and the World Development Indicators of the World Bank. Data concerning land inequality come from the World Census of Agriculture series produced by the United Nation's Food and Agriculture Organization (FAO). In the case of educational attainment, we use an indicator defined as the average years of schooling of the population aged 25 and over (Barro and Lee 2014).[9]

For specific measures of government quality we turn to the International Country Risk Guide (ICRG) database as developed by the Political Risk Services Group. The ICRG is based on the perceptions of a worldwide network of experts on a range of country-specific variables, including corruption, rule of law and bureaucratic quality across state institutions and jurisdictions. Because the first two dimensions are measured on a scale from 0 to 6 while the last one does so from 0 to 4, we normalize each dimension between 0 and 1. An aggregate quality of government indicator is obtained by summing up these normalized values and thus, ranges from 0 to 3 where a higher number implies higher government quality.

To take into account the presence of fiscal rules in different countries we employ two different dummy variables referring, separately, to the expenditure and revenue sides. A fiscal rule is considered as a long-lasting constraint on fiscal policy through numerical limits on budgetary aggregates. These dichotomous variables take the value of 1 in the presence of a fiscal rule which sets boundaries on the expenditure or revenue policies that can be adopted by the government. The data comes from the International Monetary Fund.[10]

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[8] Controlling for GDP per capita also helps to account further for institutional quality since a country's wealth has been identified as an important factor explaining its institutional quality (La Porta et al, 1999).

[9] This database is available at: http://www.barrolee.com/.

[10] Dataset available at: http://www.imf.org/external/datamapper/fiscalrules/map/map.htm. This said, the demarcation lines of what constitutes a fiscal rule are not always clear (see, Schaechter et al. 2012).

5. Results

5.1 Redistributive efficiency

In table 1 we present the DEA efficiency scores obtained using two inputs (government expenditure and taxes) and one output (relative redistribution) for the six five-year sub-periods. First, we can identify countries whose scores change very little over time (Sweden and Brazil), but also countries with important variation in their estimated scores through time (South Korea and Portugal). Second, several countries' efficiency scores are close to the production possibility frontier over the whole period (Sweden, Finland, the Netherlands and Germany) while in other countries there seems to be a large scope for improvement (Italy, Greece and Brazil). This can be appreciated in table 2 where we present the potential improvements in redistributive efficiency measured as the difference between effective and potential outputs. The results reported in both tables show that redistributive efficiency is relatively low in non-European and Southern European countries and high in Nordic and Central European countries.

This can also be seen in figure 3 which shows the production possibility curve in two dimensions, for the output-oriented case with a single output and two inputs (as before). Again, both graphs clearly show that Sweden, Finland, the Netherlands and Germany are more efficient redistributors, while the opposite is the case for Italy, Brazil, Sri Lanka and New Zealand among other countries.

Figure 3 about here

The case of New Zealand is, at first sight, surprising. It has high levels of spending and taxation, but is far away from the efficiency frontier implying that the public sector is not very efficient in bridging the gap between market and net income inequalities. It would be wrong however to conclude from this that New Zealand does not affect the distribution of income through public policies, including fiscal ones. In our sample, New Zealand has the lowest level of market inequality, 35 compared to 31 for net income inequality. This would suggest, that government policy may affect the distribution of income there ex-ante, through its impact on market income inequality rather than ex-post, from market income to net income. Neither our DEA analysis, nor previous ones employing net income inequality as an output can account for this.

Table 1 about here

It is important to state that the results obtained using two inputs in the DEA differ from those obtained when just taking into account public spending (see the last two columns of tables 1). The results excluding taxes show lower efficiency scores across all countries and also wider differences in redistributive efficiency. In some countries the results change substantially: for example, the Netherlands, the United States, Switzerland and Costa Rica experience a relatively large fall in their score and ranking when taxes are omitted. Conversely, several countries improve their ranking when ignoring taxes including, Portugal, New Zealand and South Korea.

5.2 Explaining redistributive inefficiencies via non-discretionary factors: a panel data analysis

Table 3 reports the results obtained using panel data truncated regressions of the estimated efficiency scores that appear in Table 1 on the non-discretionary factors presented in section

4.3. In column 1, we report a model that includes the aggregate indicator of government quality. Then, in columns 2 and 3 we additionally control for the presence of an expenditure or revenue rule, respectively. In columns 4 to 12, we follow the same approach but now considering the different components of government quality separately (control of corruption, bureaucratic quality and law and order). We find income per capita, the perception-based governance indicators, the demographic and fiscal rule variables to have a positive and statistically significant effect on the efficiency score. On the other hand, the land inequality measure reduces the redistributive effectiveness of fiscal policy. We do not find educational attainment or unemployment to be significant explanatory variables and since their inclusion does not affect the estimated impact of the explanatory variables, we drop them from the regressions. For robustness purposes, in table 4 we report the results of OLS panel data. As can be seen, changing the estimation method, something which includes a larger number of observations, does not alter our results and confirms the sign, magnitude and significance of the estimated coefficients.

Tables 3 and 4 about here

Our results are suggestive of the importance of development, governance, asset inequality, demography and fiscal rules for redistributive efficiency. Richer countries with better institutions – the two tend to go hand in hand – seem to be more efficient in redistributing income through fiscal policies. Higher asset inequalities reduce redistributive efficiency, a result which is consistent with the argument that economic elites may influence public agents to avoid redistribution since it is likely to go against their interests. In relation to the impact of demographics on redistributive efficiency, both the demographic cohorts included have a positive and statistically significant impact on redistributive efficiency. Moreover, the coefficient of the older cohort is higher than that of the young one in all the regressions, suggesting that public pensions and health expenditures may have a stronger impact on redistributive efficiency than education spending. In addition, countries with fiscal rules in place do better at redistribution perhaps because of the stabilizing effect of these rules on fiscal policy.

Finally, it is important to consider that because DEA is a data driven approach where the scores are obtained by an implicit data-generating process, it is convenient to analyze the sensitivity of the estimated efficiency scores to sampling variation (bootstrapping). Bootstrapping involves repeated simulations of the data generating process (Simar and Wilson 1998 and 2000). Thus, as an additional robustness test, all the efficiency scores obtained in the first stage of our DEA analysis are corrected through this bootstrapping procedure.[11] Then, in the second stage or regression analysis, the bias-corrected efficiency scores obtained for each of the six five-year means over the period 1984 to 2012, are regressed on the non-discretionary explanatory variables using the truncated regression model. Employing this bootstrapping procedure does not change our second-stage regression results and confirms the sign and significance of the estimated coefficients.[12]

[11] We employ two thousand bootstrap replications (for similar procedures see, also, Wolszczak-Derlacz and Parteka, 2011; and Varabyova and Schreyögg, 2013).

[12] Truncated regression allows us to take advantage of the bootstrap procedure and performs well in terms of confidence intervals coverage (see Simar and Wilson, 2007). This empirical evidence, as well as the bootstrap Stata codes, are not present here, due to space considerations, but are available from the authors upon request.

6. Conclusions

Recent theoretical and empirical work suggests that income inequality could have a negative impact on economic development. The redistributive potential of fiscal policy, both on the tax and spending sides, can therefore play an important role in both reducing inequalities and raising long-term growth. In the context of increasing income inequalities and scarce budgetary resources experienced by many countries, attention needs to be paid to the efficiency of fiscal policy in redistributing income. Efficiency alleviates budget constraints as it facilitates the attainment of greater levels of redistribution at given levels of spending and taxation. In this paper, we empirically evaluate the redistributive efficiency of aggregate public spending and taxation through the DEA methodology and we then use the efficiency scores obtained to analyze the determinants of cross-country variation in efficiency through panel regression analysis. Because fiscal policies have other objectives, it is important to state that we are not trying to evaluate the efficiency of the public sector beyond redistribution.

Our first stage results – obtained through the DEA methodology and based on a panel of 27 developing and developed countries for the period 1984-2012 – reveals important differences in redistributive efficiency across countries. Specifically we identify higher efficiency levels in the Nordic and Central European countries, while the Southern European and other countries display much lower levels and consequently a greater scope for improvement. And our second stage results point to the crucial role when explaining these differences of, economic development, the quality of institutions and the country's population structure – in the case of the latter, probably because of the redistributive importance of education spending and, especially, health expenditures and old age pensions.

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Appendix

Table A.1 List of countries

Country Code	Country
AUS	Australia
AUT	Austria
BEL	Belgium
BRA	Brazil
CAN	Canada
CRI	Costa Rica
DNK	Denmark
FIN	Finland
FRA	France
DEU	Germany
GRC	Greece
IRL	Ireland
ITA	Italy
KOR	Korea, Republic of
LUX	Luxembourg
NLD	Netherlands
NZL	New Zealand
NOR	Norway
PRT	Portugal
ESP	Spain
SGP	Singapore
LKA	Sri Lanka
SWE	Sweden
CHE	Switzerland
GBR	United Kingdom
USA	United States
URY	Uruguay

Table A.2 - Summary statistics

		Mean	Standard deviation	Minimum	Maximum	Observations
Redistribution efficiency score	Overall	0.798	0.204	0.170	1	N = 160
	Between		0.144	0.426	1	n = 27
	Within		0.146	0.267	1	T = 5.926
Relative redistribution	Overall	23.886	13.707	-11.347	51.180	N = 160
	Between		13.409	-3.314	48.037	n = 27
	Within		3.937	7.027	35.090	T = 5.926
Log of GDP per capita	Overall	9.968	0.674	7.485	11.000	N = 160
	Between		0.653	7.921	10.809	n = 27
	Within		0.204	9.243	10.478	T = 5.926
Government Quality	Overall	2.478	0.527	1.092	3	N = 160
	Between		0.504	1.379	3	n = 27
	Within		0.163	2.049	3	T = 5.926
Corruption	Overall	4.674	1.078	2.033	6	N = 160
	Between		0.933	3	6	n = 27
	Within		0.596	2.502	6	T = 5.926
Bureaucracy quality	Overall	3.521	0.698	1.983	4	N = 160
	Between		0.708	2	4	n = 27
	Within		0.199	2.780	4	T = 5.926
Law and order	Overall	5.1600	1.165	0.550	6	N = 160
	Between		1.119	2.207	6	n = 27
	Within		0.497	3.503	6	T = 5.926
Market Income Inequality	Overall	0.421	0.054	0.272	0.563	N = 160
	Between		0.019	0.388	0.440	n = 27
	Within		0.051	0.303	0.585	T = 5.926
Net Income Inequality	Overall	0.319	0.073	0.207	0.524	N = 160
	Between		0.082	0.306	0.326	n = 27
	Within		0.072	0.216	0.531	T = 5.926
Percentage of Population between 0 to 14 years over population between 14 and 64	Overall	0.305	0.084	0.161	0.620	N = 160
	Between		0.073	0.221	0.507	n = 27
	Within		0.042	0.157	0.437	T = 5.926
Percentage of Population of 65 or more over population between 14 and 64	Overall	0.196	0.059	0.067	0.326	N = 160
	Between		0.057	0.084	0.270	n = 27
	Within		0.019	0.130	0.261	T = 5.926
Land Inequality	Overall	0.575	0.164	0.232	0.857	N = 160
	Between		0.165	0.259	0.855	n = 27
	Within		0.020	0.496	0.633	T = 5.926
Revenue fiscal rule	Overall	0.105	0.307	0	1	N = 160
	Between		0.236	0	1	n = 27
	Within		0.201	0	1	T = 5.926
Expenditure fiscal rule	Overall	0.308	0.463	0	1	N = 160
	Between		0.342	0	1	n = 27
	Within		0.318	0	1	T = 5.926
Government Taxes (over GDP)	Overall	25.693	7.940	9.222	48.100	N = 160
	Between		7.338	12.722	46.938	n = 27
	Within		3.298	11.417	44.615	T = 5.926
Government Spending (over GDP)	Overall	36.590	11.567	13.255	65.915	N = 160
	Between		9.746	16.011	48.302	n = 27
	Within		6.423	23.632	55.716	T = 5.926

Table A.3 Data definitions and sources

Variable	*Definition*	*Source*
Market Income Inequality	*Gini coefficient based on market income inequality.*	*Solt (2014)*
Net Income Inequality	*Gini coefficient based on net income inequality.*	*Solt (2014)*
Relative redistribution	*Market-income inequality minus net-income inequality, divided by market-income inequality.*	*Solt (2014)*
Government quality	*Aggregate of corruption, law and order and bureaucratic quality dimensions each normalized between 0 and 1.*	*International Country Risk Guide (ICRG) as developed by the Political Risk Services Group*
Control of Corruption	*Discrete variable between 0 and 6 points. Assessment of corruption within the political system. Lower values imply a higher level of corruption*	*International Country Risk Guide (ICRG) as developed by the Political Risk Services Group*
Law and Order	*Discrete variable between 0 and 6 points. Law and Order are assessed separately, with each sub-component comprising zero to three points. The Law sub-component is an assessment of the strength and impartiality of the legal system, while the Order sub-component is an assessment of popular observance of the law.*	*International Country Risk Guide (ICRG) as developed by the Political Risk Services Group*
Bureaucracy quality	*Discrete variable between 0 and 4 points. High points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services.*	*International Country Risk Guide (ICRG) as developed by the Political Risk Services Group*
GDP per capita	*Real GDP per capita in logs (RGDPCNA, 2005 PPP$).*	*Penn World Table 8.0 database*
Government Public spending	*Total Expense of general government as a share of GDP*	*IMF Government Finance Statistics*
Government Public Taxes	*Public total taxes of general government as a share of GDP*	*IMF Government Finance Statistics*
Population between 0 and 14 years	*Population between the ages of 0 and 14 as a percentage of the total population.*	*World Development Indicators. World Bank*
Population between 15 and 64 years	*The number of people who could potentially be economically active.*	*World Development Indicators. World Bank*
Population of 65 years or more	*Population ages 65 and above as a percentage of the total population.*	*World Development Indicators. World Bank*
Land Inequality	*Land holding size and distribution (Gini index)*	*World Census of Agriculture series produced by the UN's Food and Agriculture Organization (FAO).*
Revenue fiscal rule	*Dummy which takes value 1 if the central or general government or the public sector set an explicit limit or target for public revenue in percent of GDP, 0 otherwise*	*IMF Fiscal Affairs Department*
Expenditure fiscal rule	*Dummy which takes value 1 if the central or general government or the public sector set an explicit limit or target for public expenditure in percent of GDP, 0 otherwise*	*IMF Fiscal Affairs Department*

Tables and figures to be embedded in the text

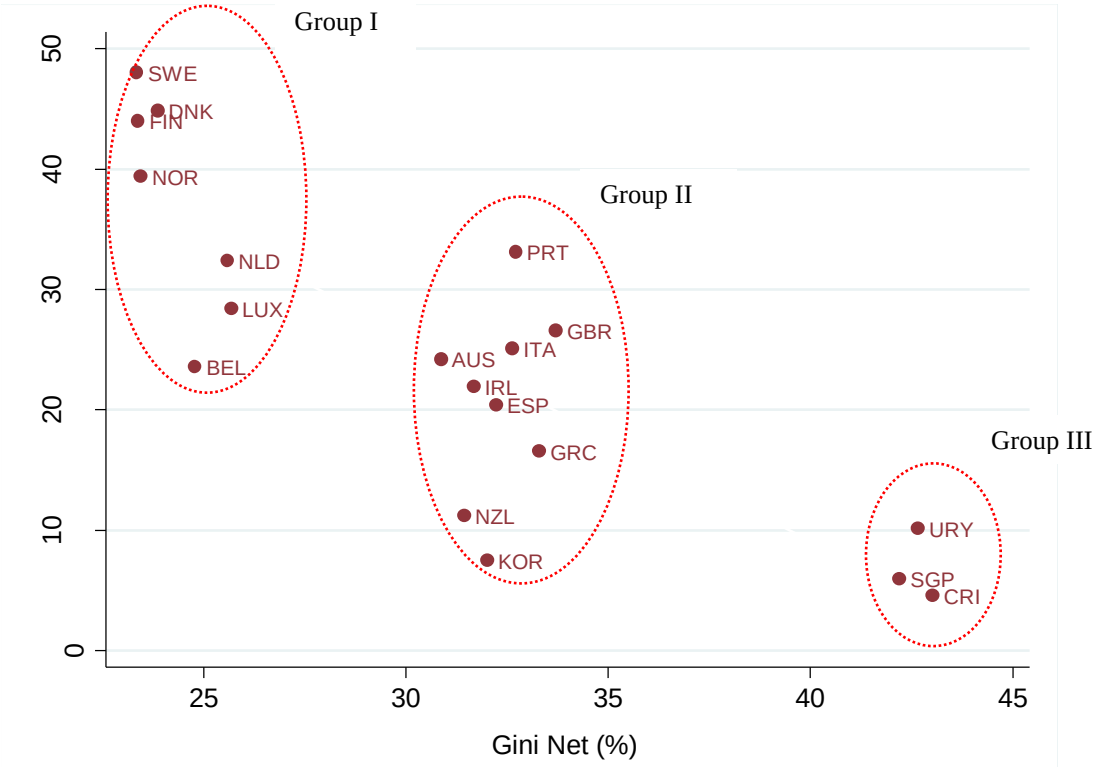

Figure 1 - Relative redistribution and net income inequality, by country (averages 1984 – 2012)
Source: Solt (2014).

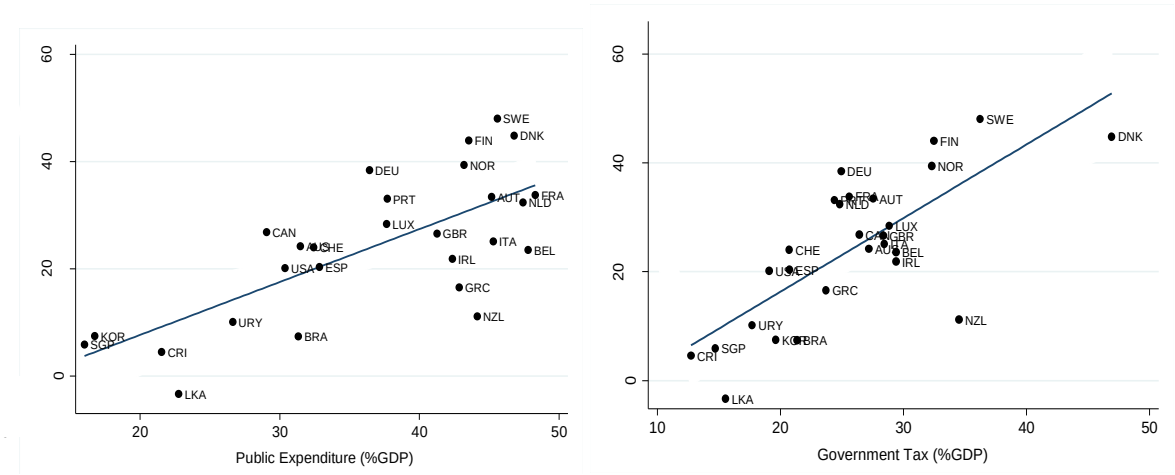

Figure 2 - Public expenditure, taxes and relative redistribution (1984 – 2012 average)
Sources: Solt (2014) and GFS (International Monetary Fund)

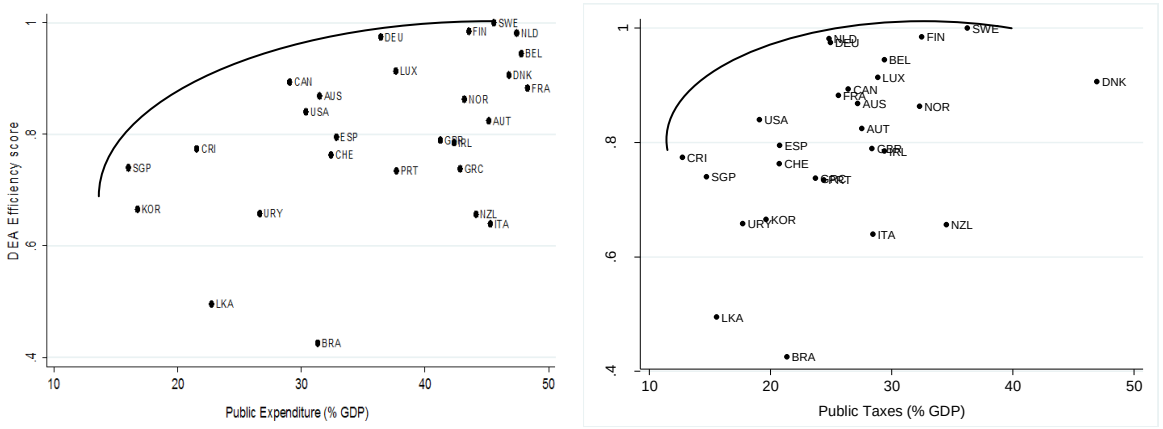

Figure 3 – DEA Efficiency frontier (1984 -2012 averages)

Table 1 – Redistribution efficiency by country (output oriented VRS TE)

	1984-1988		1989-1993		1994-1998		1999-2003		2004-2008		2009-2012		1984-2012		1984 -2012	
País	**Technical efficiency**	**Ranking**	**Technical efficiency**	**Ranking**	**Technical efficiency**	**Ranking**	**Technical efficiency**	**Ranking**	**Technical efficiency**	**Ranking**	**Technical efficiency**	**Ranking**	**Average Technical efficiency (2 inputs)**	**Ranking (Two inputs)**	**Average Technical efficiency (1 input)**	**Ranking (One input)**
Australia	0.854	15	0.818	16	0.781	16	0.920	10	1.000	1	0.839	15	**0.869**	**10**	**0.851**	**9**
Austria	0.870	14	0.762	20	0.785	15	0.908	12	0.810	16	0.812	17	**0.825**	**13**	**0.763**	**12**
Belgium	1.000	1	1.000	1	0.896	9	0.924	9	0.912	11	0.936	10	**0.945**	**5**	**0.900**	**5**
Brazil	0.605	25	0.434	26	0.516	25	0.396	26	0.275	19	0.328	24	**0.426**	**27**	**0.322**	**27**
Canada	0.683	22	0.938	10	1.000	1	1.000	1	0.742	26	1.000	1	**0.894**	**8**	**0.880**	**8**
Costa Rica	1.000	1	1.000	1	1.000	1	1.000	1	0.401	24	0.243	25	**0.774**	**17**	**0.343**	**25**
Denmark	0.775	19	0.831	13	0.916	8	1.000	1	0.966	5	0.952	8	**0.907**	**7**	**0.907**	**4**
Finland	1.000	1	1.000	1	1.000	1	1.000	1	0.958	6	0.950	9	**0.985**	**2**	**0.967**	**2**
France	1.000	1	0.801	18	0.836	11	0.918	11	0.904	12	0.838	16	**0.883**	**9**	**0.787**	**11**
Germany	0.873	13	0.975	9	1.000	1	1.000	1	1.000	1	1.000	1	**0.975**	**4**	**0.932**	**3**
Greece	0.831	16	0.767	19	0.566	24	0.653	23	0.829	15	0.782	18	**0.738**	**19**	**0.673**	**18**
Ireland	0.711	21	0.742	21	0.637	19	0.746	18	0.876	14	1.000	1	**0.785**	**16**	**0.763**	**13**
Italy	0.625	24	0.600	25	0.568	23	0.655	22	0.701	21	0.689	21	**0.640**	**25**	**0.604**	**23**
Korea, Rep.	1.000	1	1.000	1	0.937	7	0.434	25	0.393	25	0.231	26	**0.666**	**22**	**0.666**	**19**
Luxembourg	0.973	11	0.991	8	0.842	10	0.856	14	0.913	10	0.908	12	**0.914**	**6**	**0.880**	**7**
The Netherlands	1.000	1	1.000	1	1.000	1	1.000	1	0.956	7	0.934	11	**0.982**	**3**	**0.891**	**6**
New Zealand	0.629	23	0.661	23	0.597	22	0.730	19	0.674	22	0.649	22	**0.657**	**24**	**0.647**	**20**
Norway	0.789	18	0.820	14	0.803	12	0.888	13	0.928	9	0.953	7	**0.864**	**11**	**0.844**	**10**
Portugal	1.000	1	1.000	1	0.385	27	0.313	27	0.808	17	0.901	13	**0.735**	**20**	**0.701**	**15**
Singapore	0.424	27	0.339	27	0.709	17	0.971	8	1.000	1	1.000	1	**0.741**	**21**	**0.637**	**21**
Spain	0.591	26	0.859	12	0.801	14	0.760	16	0.898	13	0.860	14	**0.795**	**14**	**0.679**	**16**
Sri Lanka	0.733	20	0.628	24	0.508	26	0.730	19	0.170	27	0.203	27	**0.495**	**26**	**0.337**	**26**
Sweden	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	1.000	1	**1.000**	**1**	**1.000**	**1**
Switzerland	0.793	17	0.892	11	0.633	21	0.797	15	0.756	18	0.709	20	**0.763**	**18**	**0.634**	**22**
United Kingdom	0.893	12	0.819	15	0.803	12	0.753	17	0.740	20	0.730	19	**0.790**	**15**	**0.754**	**14**
The United States	1.000	1	0.803	17	0.694	18	0.613	24	0.931	8	1.000	1	**0.840**	**12**	**0.675**	**17**
Uruguay	1.000	1	0.672	22	0.636	20	0.672	21	0.534	23	0.435	23	**0.658**	**23**	**0.499**	**24**
Average	**0.839**	**--**	**0.820**	**--**	**0.772**	**--**	**0.801**	**--**	**0.780**	**--**	**0.773**	**--**	**0.798**	**--**	**0.723**	**--**

Note: *All results are based on one output (relative redistribution) and two inputs (government expenditure and taxes), except the last two columns that are obtained using just one input (government spending).*

Table 2 –Potential improvements in redistribution, by country and period (output oriented VRS TE)

	1984-1988		1989-1993		1994-1998		1999-2003		2004-2008		2009-2012	
País	**Effective output**	**Potential output**	**Effective output**	**Potential output**	**Effective output**	**Potential output**	**Effective output**	**Potential output**	**Effective output**	**Potential output**	**Effective output**	**Potential output**
Australia	34.417	40.286	30.923	37.789	35.166	45.023	35.332	38.390	35.683	35.683	33.828	40.340
Austria	34.886	40.121	37.257	48.883	38.208	48.678	41.668	45.870	36.573	45.142	38.175	46.989
Belgium	44.880	44.880	49.190	49.190	45.734	51.027	42.721	46.246	41.882	45.918	45.016	48.084
Brazil	13.033	21.536	12.663	29.196	13.527	26.235	12.272	30.965	12.229	44.531	14.839	45.270
Canada	30.495	44.663	34.278	36.526	26.235	35.649	32.267	32.267	32.961	44.393	33.508	33.508
Costa Rica	5.309	5.309	10.979	10.979	11.101	11.101	9.375	9.375	8.417	20.998	8.810	36.295
Denmark	38.664	49.903	42.324	50.938	47.181	51.489	49.225	49.225	46.771	48.410	46.923	49.279
Finland	47.228	47.228	50.528	50.528	54.328	54.328	46.893	46.893	44.363	46.290	45.828	48.236
France	34.609	34.609	36.656	45.775	39.990	47.850	41.850	45.570	40.717	45.016	39.960	47.685
Germany	39.335	45.035	42.312	43.410	41.943	41.943	43.722	43.722	43.496	43.496	42.732	42.732
Greece	31.404	37.782	30.552	39.808	25.787	45.591	28.602	43.816	31.667	38.188	35.172	44.963
Ireland	35.312	49.699	32.142	43.321	31.610	49.636	31.096	41.662	39.005	44.530	47.131	47.131
Italy	27.347	43.769	29.317	48.880	28.118	49.518	30.098	45.936	31.860	45.464	33.151	48.080
Korea, Rep.	16.603	16.603	9.806	9.806	10.242	10.927	8.316	19.173	8.414	21.398	8.344	36.192
Luxembourg	39.168	40.248	37.900	38.237	39.929	47.432	38.954	45.516	40.818	44.732	42.758	47.081
The Netherlands	49.770	49.770	43.185	43.185	44.442	44.442	44.718	44.718	42.136	44.063	43.696	46.803
New Zealand	30.339	48.246	31.743	48.028	30.684	51.400	34.464	47.229	31.273	46.380	31.224	48.101
Norway	37.277	47.263	40.723	49.661	42.501	52.903	41.678	46.923	43.816	47.192	45.736	48.014
Portugal	37.500	37.500	36.401	36.401	16.312	42.388	13.688	43.769	35.371	43.773	41.588	46.159
Singapore	7.969	18.778	4.039	11.927	4.324	6.102	8.065	8.310	8.536	8.536	9.556	9.556
Spain	14.436	24.409	29.976	34.897	29.662	37.014	29.680	39.065	31.464	35.053	35.467	41.253
Sri Lanka	17.762	24.223	13.120	20.879	9.880	19.450	10.074	13.798	2.986	17.615	6.834	33.736
Sweden	49.903	49.903	51.415	51.415	54.204	54.204	47.661	47.661	48.410	48.410	49.279	49.279
Switzerland	22.798	28.759	25.731	28.839	22.950	36.280	29.393	36.884	30.812	40.782	29.727	41.954
United Kingdom	38.344	42.948	34.095	41.627	36.895	45.974	11.329	45.863	33.697	45.565	34.994	47.939
The United States	27.112	27.112	26.379	32.851	25.146	36.230	23.424	38.203	23.511	25.246	26.018	26.018
Uruguay	20.141	20.141	13.363	19.886	16.483	25.917	17.639	26.241	17.167	32.144	17.748	40.812
Average	**30.594**	**36.323**	**31.000**	**37.143**	**30.466**	**39.583**	**29.785**	**37.900**	**31.261**	**38.850**	**32.890**	**42.277**
Average Output Difference	**5.729**		**6.143**		**9.117**		**8.114**		**7.589**		**9.387**	

Note: *All results are based on one output (relative redistribution) and two inputs (government expenditure and taxes).*

Table 3 –Truncated model results (dependent variable: output efficiency scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log of per-capita GDP	0.072*** (0.025)	0.069*** (0.024)	0.064*** (0.025)	0.071*** (0.027)	0.070*** (0.025)	0.062** (0.026)	0.064*** (0.024)	0.061*** (0.023)	0.056** (0.024)	0.053** (0.026)	0.052** (0.025)	0.045* (0.020)
Government quality	0.223*** (0.037)	0.203*** (0.035)	0.204*** (0.036)	--	--	--	--	--	--	--	--	--
Control of corruption	--	--	--	0.574*** (0.113)	0.527*** (0.104)	0.523*** (0.106)	--	--	--	--	--	--
Bureaucracy quality	--	--	--	--	--	--	0.604*** (0.102)	0.545*** (0.098)	0.551*** (0.100)	--	--	--
Law and order	--	--	--	--	--	--	--	--	--	0.494*** (0.106)	0.441*** (0.099)	0.435*** (0.102)
Gini land	-0.279** (0.117)	-0.297*** (0.114)	-0.266** (0.114)	-0.305** (0.127)	-0.322*** (0.121)	-0.283** (0.120)	-0.291** (0.117)	-0.309*** (0.115)	-0.278** (0.113)	-0.402*** (0.127)	-0.414*** (0.122)	-0.383*** (0.121)
Pop65	2.209*** (0.451)	2.425*** (0.452)	2.067*** (0.438)	2.197*** (0.486)	2.447*** (0.479)	2.021*** (0.463)	2.311*** (0.454)	2.509*** (0.456)	2.161*** (0.440)	2.619*** (0.500)	2.838*** (0.498)	2.448*** (0.480)
Pop014	0.982*** (0.318)	1.078*** (0.311)	0.869*** (0.306)	0.583* (0.324)	0.745** (0.314)	0.497* (0.306)	0.945*** (0.319)	1.033*** (0.312)	0.834*** (0.307)	1.177*** (0.366)	1.271*** (0.354)	1.027*** (0.350)
Revenue rule	--	--	0.181** (0.080)	--	--	0.219*** (0.085)	--	--	0.181** (0.081)	--	--	0.208** (0.091)
Expenditure rule	--	0.23*** (0.042)	--	--	0.143*** (0.044)	--	--	0.117*** (0.042)	--	--	0.140*** (0.047)	--
Log-likelihood	91.852	96.621	95.140	87.775	93.750	92.239	91.667	95.910	98.875	85.803	90.926	89.316
Observations	120	120	120	120	120	120	120	120	120	120	120	120

Notes: Standard Errors in parentheses. *, **, *** measures statistical significance at the 10, 5 and 1% levels respectively. All regressions include a constant (not shown).

Table 4 – OLS model results (dependent variable: output efficiency scores)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log of per-capita GDP	0.067*** (0.015)	0.070*** (0.017)	0.066*** (0.016)	0.064*** (0.018)	0.067*** (0.020)	0.064*** (0.018)	0.063*** (0.014)	0.066*** (0.016)	0.062*** (0.014)	0.055*** (0.012)	0.060*** (0.015)	0.054*** (0.013)
Government quality	0.204*** (0.058)	0.183*** (0.056)	0.190*** (0.058)	--	--	--	--	--	--	--	--	--
Control of corruption	--	--	--	0.522*** (0.153)	0.460*** (0.149)	0.488*** (0.150)	--	--	--	--	--	--
Bureaucracy quality	--	--	--	--	--	--	0.466*** (0.168)	0.411** (0.166)	0.430** (0.170)	--	--	--
Law and order	--	--	--	--	--	--	--	--	--	0.463*** (0.120)	0.415*** (0.115)	0.426*** (0.118)
Gini land	-0.136** (0.065)	-0.123* (0.069)	-0.147** (0.066)	-0.141* (0.054)	-0.130** (0.056)	-0.151*** (0.055)	-0.172*** (0.060)	-0.155** (0.066)	-0.183*** (0.064)	-0.226*** (0.051)	-0.199*** (0.057)	-0.232*** (0.051)
Pop65	1.100*** (0.270)	1.165*** (0.261)	1.077*** (0.270)	0.967*** (0.310)	1.056*** (0.298)	0.942*** (0.312)	1.356*** (0.227)	1.400*** (0.223)	1.311*** (0.222)	1.263*** (0.252)	1.313*** (0.240)	1.228*** (0.250)
Pop014	0.701*** (0.147)	0.706*** (0.141)	0.657*** (0.145)	0.317* (0.182)	0.363** (0.181)	0.295* (0.193)	0.717*** (0.165)	0.720*** (0.151)	0.665*** (0.153)	0.748*** (0.130)	0.757*** (0.115)	0.692*** (0.124)
Revenue rule	--	--	0.081*** (0.024)	--	--	0.095*** (0.022)	--	--	0.092*** (0.022)	--	--	0.089*** (0.026)
Expenditure rule	--	0.084*** (0.016)	--	--	0.086*** (0.019)	--	--	0.093*** (0.015)	--	--	0.097*** (0.017)	--
Adjusted R-squared	0.369	0.400	0.380	0.345	0.375	0.362	0.328	0.364	0.343	0.329	0.370	0.344
Observations	160	160	160	160	160	160	160	160	160	160	160	160

Notes: Standard Errors in parentheses. *, **, *** measures statistical significance at the 10, 5 and 1% levels respectively. Regressions use Period SUR weights. All regressions include a constant and period effects (not shown).