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Redistributive Efficiency of Fiscal Policy: The Role of Decentralisation

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Redistributive Efficiency of Fiscal Policy: The Role of Decentralisation

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Abstract

In this paper, we empirically analyse redistributive efficiency of fiscal policy -instruments and their degree of decentralisation- and its determinants for a sample of thirty-five developed and developing countries over the 2000-2016 period. To do this, a two-stage procedure is followed. First, we estimate the redistributive efficiency of fiscal policy -taking into account size and decentralisation degree of cash transfers and direct taxes- by employing a Data Envelopment Analysis (DEA) method. We obtain evidence that efficiency varies across countries and -on average- has diminished over time. Yet, fiscal decentralisation might not play a role in efficiency. Second, a truncated regression analysis is used to identify the potential factors that might explain redistribution efficiency variation across countries and time. Our results show that efficiency is associated with having a non-federal political system, high government effectiveness and democratic accountability, low education inequality and the existence of debt fiscal rules.

***Key words*:** Redistributive efficiency, fiscal policy, decentralisation, DEA, truncated regression analysis.

***JEL codes*:** C14, C34, H30, H50.

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1. Introduction

Income distribution has become one of the most relevant topics in current economic literature (Piketty and Saez 2006; Gasparini and Lustig 2011; Piketty 2014; Alvaredo et al. 2018). Indeed, the attention has been focussed on the shaping inequality as a consequence of the expansion of finances -including wealth-, globalisation and skill-biased technological change (Franzini and Pianta 2015).

While inequality in market income (i.e., before transfers and direct taxes) sharply increased in the world during the 1980s and most of the 1990s, a downward trend has been observed in inequality since the early 2000s. This is a result of an inequality gap reduction between developed economies and the rest of the world, in particular as a consequence of the decrease of inequality in China and India, and the increase of inequality in many advanced economies (OECD 2015; IMF 2017). Additionally, the data has shown that inequality in disposable income (i.e., after transfers and direct taxes) has also increased in many advanced economies over the last twenty-five years (Caminada et al. 2019). Specifically, Caminada et al. (2019) emphasise the fact that income redistribution has weakened or stagnated in the aftermath of the Great Recession because governments have been focused on restoring public finances; and, adjustment programs frequently hurt the most vulnerable groups in society (Gasparini and Lustig 2011).

This is important because the increase in income inequality could be harmful to economic growth and development since it creates social pressures for fiscal redistribution, which may undermine and divert public resources from productive activities (Alesina and Rodrik 1994; Halter et al. 2014; Berg et al. 2018).

Against this background, one of the main driving forces behind the differences in inequality reduction across countries groups is attributed to asymmetries in the role played by the redistributive fiscal policies (Brandolini and Smeeding 2007; Wang et al. 2014). While developed economies have shown a strong fiscal redistributive policy through transfers and taxes, in developing countries this is very limited since they tend to have fewer fiscal resources available to affect redistribution (Goñi et al. 2011; Villela et al. 2007).

Thus, an efficient use of the fiscal resources (transfers and direct taxes) might contribute to achieving a greater level of income redistribution. However, not often in the literature is it discussed how efficiently the instruments of fiscal policy could improve income redistribution. That is, to reach a given level of redistribution at lower levels of transfers and direct taxes or to reach more redistribution at given transfers and direct taxes levels. Moreover, another strand of the literature (see, for example, Sepulveda and Martinez-Vazquez 2011) indicates that the size of fiscal resources as well as their decentralisation is relevant in affecting income distribution. Yet, the link between redistribution and decentralisation has rarely been discussed in the literature. Thus, the central question we want to examine is how redistributively efficient has been the fiscal policy -instruments and their degree of decentralisation- across countries and over time?

Our purpose in this research is to empirically analyse in depth the redistributive efficiency of government resources and decentralisation degree of public social cash transfers (henceforth transfers) and direct taxation for a sample of thirty-five developed and developing countries over 2000-2016. The study focuses on two main instruments that involve transfers and direct taxes because these policies may have a relevant redistributive impact; in particular, transfers are relevant for the most income vulnerable groups in a society and income taxes are mainly paid by the rich (Wang et al. 2012; Caminada et al. 2019).

Furthermore, given that this study considers a cross-country perspective, naturally we also expect to find that redistribution efficiency performance differs across countries and over time due to several determinants, such as demographic, economic, political and institutional factors (Mahler and Jesuit 2006). Thus, an additional relevant question we want to deal with is which are the forces that underlie achieving redistribution efficiency objectives? Specifically, our interest here centres on knowing the role of a federal political system on redistributive efficiency of fiscal policy.

This aim will be tackled by using a two-stage approach (Simar and Wilson 2007, 2011). In the first stage, we use a Data Envelopment Analysis (DEA) bootstrapping technique to empirically evaluate the redistributive efficiency of fiscal policy instruments and their degree of decentralisation (of transfers and direct taxes) comparing between countries. By employing this, an efficiency score is obtained for each country (and also a country efficiency ranking), which arises from comparing the individual redistributive performance of each country with respect to the best possible redistributive performance in the sample of countries. In the second stage, we examine the potential exogenous or non-discretional determinants of redistribution efficiency variation across countries and over time by applying bootstrap truncated panel regression analysis. The focus of this second stage is the identification of the possible sources of (in)efficiency. Understanding this variation is crucial for identifying potential policy options to improve redistribution and thus reduced income inequality.

This paper contributes to redistribution and fiscal policy empirical literature in three ways. First, we provide empirical evidence on the redistributive efficiency of fiscal policy instruments and decentralisation (of transfers and direct taxes) for a panel of developed and developing countries. To our knowledge, such an efficiency analysis has not been applied before considering fiscal instruments and their degree of decentralisation to compute efficiency scores and countries' efficiency ranking. This is one of the main novelties of this paper. Secondly, we provide new insight into the income distribution literature about the redistributive impact of the Great Recession. Our empirical results reveal that efficiency varies across countries and -on average- has diminished over time. This fact highlights the need for policies that can counter this decline. Thirdly, we explore in depth the underlying determinants of efficiency differences across countries and over time. Our article naturally complements previous works in this redistribution field covering different explanatory factors. While some previous findings of the empirical literature of redistributive efficiency are confirmed (e.g., is directly associated with high government effectiveness and low education inequality), some new results are also obtained that it is straightforwardly associated with having a non-federal (or unitary)

political system, high democratic accountability as well as the existence of debt fiscal rules.

The remainder of this paper is structured as follows. Section 2 provides a descriptive analysis of the macroeconomics relationships between income redistribution and fiscal policies. Section 3 reviews the related literature. Data is detailed in Section 4, while the empirical strategy is presented in Section 5. Section 6 presents the empirical results and robustness tests. Section 7 concludes.

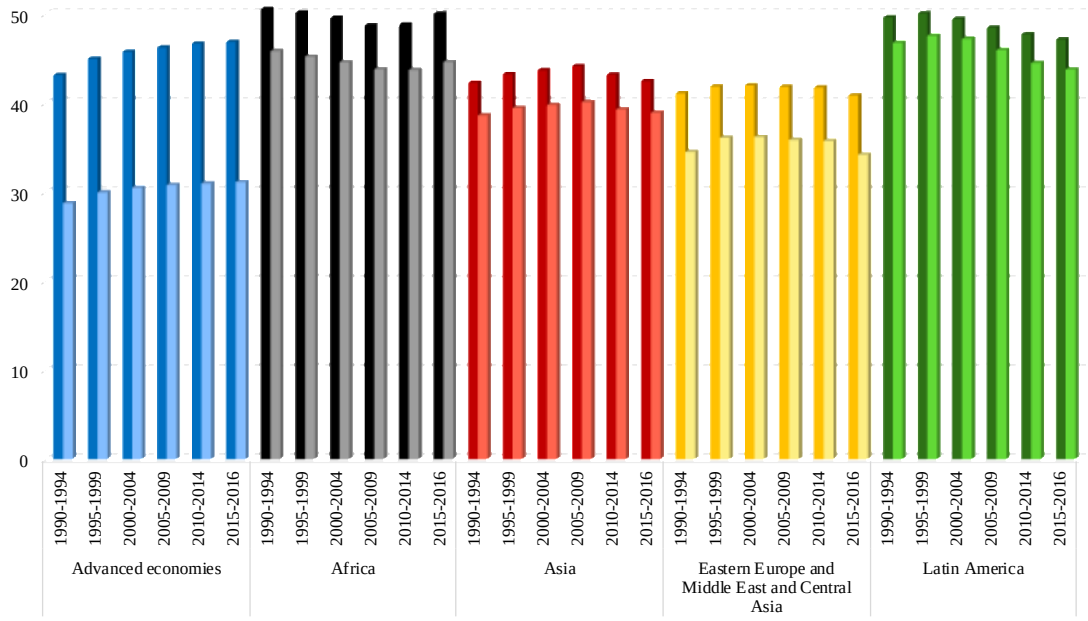
2. Income redistribution and fiscal policy: A brief overview

Income distribution is considered unequal in all countries of the world (and between them), hence, for the purpose of promoting economic equity it is important how government affects redistribution though the instrument of fiscal policy (Brandolini and Smeeding 2007; Guillaud et al. 2019). Inequality can be analysed using different approaches, although the most standard metric is income. Income inequality among households is typically measured by the Gini index, which takes values from 0 to 100; a value of 0 represents perfect equality and a value of 100 extreme inequality among households.

According to the IMF (2017), fiscal policy design could have an important redistributive effect on reducing income inequality -Gini index- by three channels. First, it can reduce inequality in market income via government transfers and progressive direct taxes. Second, it can reduce inequality in disposable income through subsidies and indirect taxes (or consumption taxes). Finally, it can reduce inequality in market income through in-kind transfers (e.g., education and health). Our proposed analysis is concerned with the first channel, which represents direct government redistribution.

One of the most prominent features of all regions of countries around the world is their high and persistent levels of income inequality, described by the Gini market index in Figure 1. The evidence suggests that Africa and Latin America are the regions with the most unequal income distribution in the world (see, for instance, Gasparini and Lustig 2011). We focus on the change in income distribution from inequality in market income -Gini market- to inequality in disposable income -Gini net-; this is the redistributive effect of transfers and direct taxes. As Figure 1 illustrates, from the Gini market index (left bar) to the Gini net index (right bar), the redistributive effect of transfers and direct taxes differ considerably across regions and over time. They play a major role in the reduction of market income inequality in advanced economies –this group shows the highest level of absolute redistribution. Yet, the trend of inequality in disposable income is upward in advanced economies while in the other regions it declines. Overall, the effectiveness of fiscal redistribution to reduce inequality has remained relatively steady over time.

Figure 1 – Market and net income Gini indices around the world
(mean five-year period 1990-2016)

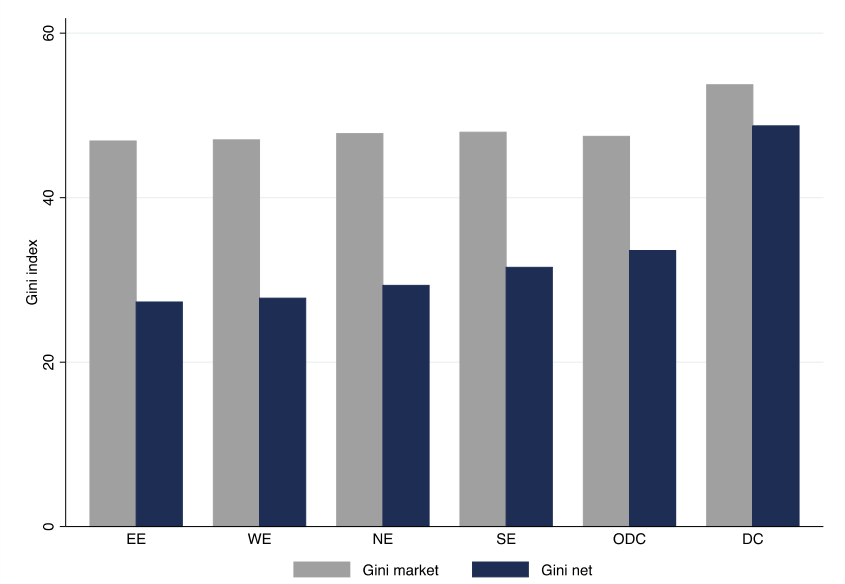


Note: The left bar represents the Gini market index (dark colour) and the right bar represents the Gini net index (light colour).
Source: Own elaboration base on Standardized World Income Inequality Database (SWIID).

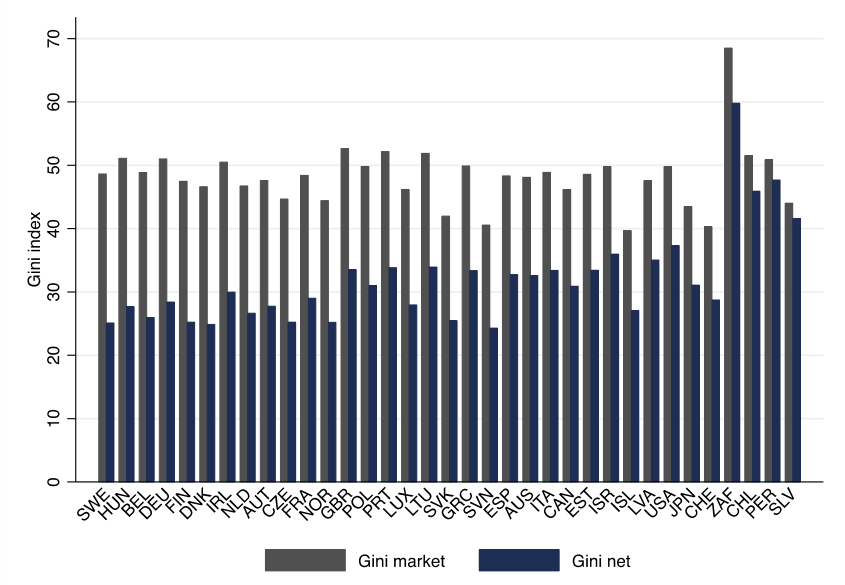
Figure 2 compares the market and net Gini indices for the sample of countries (panel -a- by regions and panel -b- by countries) considered in this study from 2000 to 2016; countries are listed in order of their absolute redistribution level from largest to smallest. The plots show important differences between developed countries for the two types of Gini indices and between them and developing countries. While the policy of transfers and direct taxes in Eastern Europe (EE) (e.g., Hungary and the Czech Republic), Western Europe (WE) (e.g., Belgium, Germany, Netherlands, and so on) and North Europe (NE) (e.g., Sweden, Finland, Denmark, and so on) economies seem to be more effective in reducing market income disparities -the absolute redistribution of these regions is 19.6, 19.2 and 18.5 points, respectively-, in Southern Europe (SE) (e.g., Italy, Spain, and so on) -the absolute redistribution in the region is 16.4 points- and other developed countries (ODC) (e.g., the United States and Israel) -ODC absolute redistribution is 13.9 points- are shown less effective. The policy appears irrelevant to reduce market income inequality disparities in developing countries (DC) (e.g., South Africa, Chile, Peru and El Salvador) -the absolute redistribution is 5.0 points-. Therefore, there are important opportunities for the redistributive government policies to affect income distribution.

Figure 2 – Market and net income Gini indices in the sample of countries (mean period 2000-2016)

Panel (a): By regions



Panel (b): By countries



Note: Gini market index is computing on market income and Gini net index is compute on disposable income (disposable income = market income + transfers – direct taxes). For a complete description of the regions, see Table A.1 in the Appendix. Regions and countries are listed in order of their absolute redistribution level from largest to smallest.
Source: Own elaboration base on Standardized World Income Inequality Database (SWIID).

Nevertheless, the absolute redistribution measure does not consider the initial market income disparities between countries. For instance, the market Gini of Iceland, Slovenia, Slovakia and Switzerland is about 40 points, below that of other developed and developing economies in the sample; in other words, they are initially more equal

societies. Consequently, a fiscal policy that achieves a similar reduction in inequality in market income (i.e., absolute redistribution) in two countries (e.g., Iceland and the United States), does not mean that they are equally redistributively effective, it going to be more effective in a country that presents lower initial inequality. This is the relative redistribution measure that takes into account cross-country differences in the initial level of inequality in market income. To sum, our aim is to identify where the redistributive efficiency comes from. The methodology proposed in this study allows us to advance in this direction (see Section 5).

3. Background

In recent decades, there has been increased interest and demand among citizens about the efficient use of public resources and the quality of the fiscal policies of governments (Afonso et al. 2010a; Christl et al. 2020). Several scholars have studied public sector efficiency and its determinants (Afonso et al. 2005; Afonso et al. 2010b; Afonso et al. 2013; Christl et al. 2020) and find significant inefficiency in many countries. For instance, Afonso et al. (2005), using a Free Disposal Hull (FDH) analysis, find for twenty-three OECD member states that, on average, countries with a "small" public sector report the highest public sector performance. Afonso et al. (2010b), employing a DEA method and Tobit regression analysis, obtain for "new" European Union member states and some emerging markets that public expenditure efficiency is rather diverse across them. They also find that higher income, a competent civil service, high education levels and the security of property rights tend to prevent inefficiencies in the public sector. Afonso et al. (2013), using a DEA and Tobit regression methods, examine twenty-three Latin American countries covering 2001-2010. They find that government size is inversely correlated with public sector efficiency while transparency, regulatory quality and control of corruption are directly correlated with it. Recently Christl et al. (2020), using FDH and order-m efficiency techniques, study twenty-three European countries during 1995-2015, and find that decentralisation positively affects public sector efficiency while fiscal rules do not affect it.

The vast majority of the public sector efficiency literature has focussed on analysis of education and health services across countries –most of them using DEA and regression analysis techniques (Gupta and Verhoeven 2001; Afonso and Aubyn 2005; Hauner and Kyobe 2010; Afonso and Aubyn 2011; Adam et al. 2014). For both services, the most resounding conclusion is that high government spending in terms of GDP tends to be associated with low efficiency. This is found, for instance, by: Gupta and Verhoeven (2001) for thirty-seven countries in Africa from 1894 to 1995; Afonso and Aubyn (2005) in OECD countries for 2000; Afonso and Aubyn (2011) examine only health services efficiency in OECD in the whole 2000-2003 period; Hauner and Kyobe (2010) for a large panel of economies from 1980 to 2004; Adam et al. (2014) for twenty-one OECD countries during 1970-2000; among others.

Another strand of literature studies income distribution across countries, examining the effects of transfers and direct taxes systems on income redistribution and their effectiveness on inequality reduction; in particular, in developed countries (Korpi and Palme 1998; Brandolini and Smeeding 2007). Regarding this, the evidence from OECD countries shows that the bulk of the fiscal redistributive impact is due to the effect of public transfers (Wang et al. 2014; Jesuit and Mahler 2017). However, Adema et al. (2014) point out that similar levels of government spending in OECD countries have not affected redistribution to the same extent. In relation to developing countries, Villela et al. (2007) and Goñi et al. (2011) attribute poor redistributive performance of fiscal policy in Latin American countries to lower tax revenue raising capacity, which limited the available resource to increase the size of transfers.

A priori, we could use various combinations of instruments of fiscal policy to generate the same redistributive level. However, the distributional impacts of fiscal policy may vary depending on the expenditure structure and specific taxes across countries. With regard to this, several empirical studies (see, for example, Wang et al. 2012; Joumard et al. 2013; Caminada et al. 2017; Causa and Hermansen 2017; Caminada et al. 2019) indicate a greater redistributive impact of transfers than taxes.[1] From these studies, we observe that the fiscal redistributive impact is between 25% and 35% on reducing inequality in market income; while social transfers account for 67%-84% of total redistribution, the taxes only account for 16%-33%. However, other studies (Guillaud et al. 2019; Avram et al. 2014) for developed countries show that if pensions are classified as market income rather than transfers, redistribution from taxes is greater than that from transfers.

Most of these studies have concluded that the impact of redistributive fiscal policy is strongly associated with the budget size and less so with the extent to which they are targeted to low-income groups, e.g., the efficiency of the tax system progressivity (see, for instance, Korpi and Palme 1998 and Mahler and Jesuit 2006). Indeed, these results do not exclusively concern developed countries; similar conclusions are reported for Latin American countries (Goñi et al. 2011).

In this vein, other scholars have investigated the determinants of the redistributive fiscal policy across countries and over time –most of them show a weak performance and heterogeneity of expenditures and taxes to affect redistribution (Afonso et al. 2010b; Kyriacou et al. 2018). For instance, Afonso et al. (2010b) focus on the efficiency of fiscal policy with respect to income distribution for OECD countries in the 1995-2000 period using a DEA and a Tobit regression method. Kyriacou et al. (2018) study the impact of fiscal policy on redistributive efficiency for OECD countries from 1995 to 2010 using a DEA and a bootstrap truncated regression. Both analyses provide evidence that high quality of institutions is associated with more redistributive efficiency. Apart from that,

[1] These studies are based on the micro-household income data from Luxembourg Income Study (LIS), which is a harmonised version of national household income surveys –using a budget incidence approach; excluding Joumard et al. (2013) that use the OECD Income Distribution and Poverty Database. LIS data set is very useful to explain the variation in levels of redistribution in a cross-country comparison; however, many times restrict the exploration of the determinants of redistribution in a temporal dimension because data are collected at irregular time points (in waves) and vary across countries (Solt 2015).

many studies (e.g., Bradley et al. 2003; Kenworthy and Pontusson 2005; Huber and Stephens 2014) report that the most important determinant of redistribution is welfare state generosity.

The effect of fiscal decentralisation on income redistribution

The seminal literature of decentralisation (Tiebout 1956; Oates 1972; among others) underlies on the "decentralisation theorem" of Oates (1972). Assuming the government as a benevolent agent, Oates argues that subnational governments are superior to the central government to adapt policies to specific local preferences and needs –given the information advantages, resulting in an improvement of government performance and well-being of society. Also, this theory indicates that certain functions, such as income redistribution, should be under the central government provision. A basic reason indicates that a strong redistributive policy to support low-income groups enhanced by a specific jurisdiction may induce an influx of the poor from other jurisdictions and encourage an exodus of taxpayers (high-income) groups to other jurisdictions (Oates 1999). Yet, a new generation of literature indicates that the presence of externalities, such as imperfect information, economies of scale and selfish officials (e.g., political rent-seeking), has undermined the normative "decentralisation theorem" (Oates 2005).

In this article, naturally, the key questions are whether fiscal decentralisation might influence income redistribution, and which are the possible channels of transmission of it. In this sense, several scholars point to a positive effect of decentralisation on various measures of governance (Christl et al. 2020; Besley and Smart 2007) and income inequality (Neyapti 2006; Sepulveda and Martinez-Vazquez 2011).[2]

Along this line, some authors indicate that a certain degree of decentralisation increase efficiency by greater electoral control and yardstick competition among competing jurisdictions (Adam et al. 2014). For instance, Christl et al. (2020) indicate that revenue decentralisation increases information about the preferences and needs of the communities and accountability which disincentivizes overspending of subnational governments and thus improves public sector efficiency. Pauly (1973) indicates that redistribution may be a local public good and so decentralisation may increase it. Besley and Smart (2007) ague that decentralisation enhances the public interest to compare the public services and taxes across their jurisdictions contributing to a reduction in the "bad" use of the resources by politicians. Additionally, inter-jurisdictional competition might be observed in terms of the provision of public goods and services and taxation in order to keep their tax bases or attract new taxpayers from other jurisdictions (Sepulveda and Martinez-Vazquez 2011). However, decentralisation can negatively affect public sector efficiency due to higher average costs of producing public goods and services, consequent to the effect of economies of scale (see, for instance, Adam et al. 2014 who refer to an inverted U-shaped between decentralisation and public sector efficiency). Moreover,

[2] See, for instance, Martinez-Vazquez et al. (2017) for a survey of the impact of fiscal decentralisation on the economy, society and politics; also, for a discussion of decentralisation measurement and endogeneity issues.

Treisman (2000) indicates that federal states are more corrupt than unitary one because autonomous subnational governments competition for private business gains at the national level lead to bribes for the appropriation of it.

Besides, Sepulveda and Martinez-Vazquez (2011) study thirty-four developing countries and twenty-two developed countries between 1971 and 2000 and show that fiscal decentralisation reduces income inequality only if the size of the public sector in the overall economy is relatively large (twenty percent or more). They argue that, for affecting income distribution, both the type of redistributive programs that could be implemented at the subnational government level and the size of public resources available for redistributive aims from central government to subnational governments are relevant. Indeed, distribution of disposable income might be altered by expenditure and revenue decentralisation because it could affect the composition of public spending modifying income inequality (e.g., direct income transfers to individuals as part of the redistributive policy objectives) and it could impact the progressivity of the income tax schedule (e.g., implement a progressive or regressive tax system). Additionally, Neyapti (2006) indicates that revenue decentralisation may reduce income inequality but only in cases of good governance. Naturally, transfers and taxation of subnational governments cannot necessarily be focused on these redistributive aims (Sepulveda and Martinez-Vazquez 2011).

In sum, our starting point is that not only do transfers and direct taxes shares affect redistribution but also it is important to account for fiscal decentralisation. We find some authors (Adam et al. 2014; Christl et al. 2020) who account for fiscal decentralisation as an explanatory variable in their regression analysis to explain public sector efficiency. To our knowledge, however, such an analysis of redistributive efficiency of fiscal policy has not been applied before by considering decentralisation to compute efficiency. Our work aims to fill this gap. Additionally, using the previous literature and their results, we can also identify some further factors that may possibly affect efficiency that have not yet been explored in the redistribution literature, such as federal political system.

4. Data

To analyse redistributive efficiency of fiscal policy instruments and their degree of decentralisation -of transfers and direct taxes-, a panel of 35 countries is used during the 2000-2016 period. This panel is composed of 31 developed economies and 4 developing economies (see Table A.1 of Appendix). The four periods examined are 2000-2004, 2005-2009, 2010-2014 and 2015-2016; this is, the observations for each country are arranged in five-year averages and the last one arranged in two-year averages; this is due to redistribution moves very slowly over time and we are interested in capture long-term trends and structural changes, i.e., we neutralise the business cycle effect (see, for instance, Afonso et al. 2005 and Sepulveda and Martinez-Vazquez 2011). The specific

countries and period considered cover most available data; in particular, the inclusion of developing countries in the analysis is limited by the lack of a decentralisation dataset.

The fiscal policy variables used in this analysis are transfers (public social cash transfers spending) and direct taxes, both at the central government (CG) level and at the subnational government (SNG) level. The transfers categories include social security benefits, welfare benefits and social benefits related to employment (for example, the unemployment insurance); they are obtained from International Financial Statistics of the International Monetary Fund database (IFS-IMF) and Social Expenditure Database (SOCX) from OECD statistics. Direct taxes include income taxes profits and capital gains, social security contributions, payroll taxes and property taxes; data are obtained from the revenues statistics database of OCDE. Transfers and direct taxes data are obtained at general government level in terms of GDP, annual data frequency.

In the empirical literature, fiscal decentralisation has traditionally been measured as the share of revenues and expenditures of SNGs over total revenues and expenditures of the general government (GG) and computed with data from the Government Financial Statistics of the IMF (see, for example, Adam et al. 2014; Canavire-Bacarreza et al. 2016; Martinez-Vazquez et al. 2017). Since 2018, the decentralisation dataset is summarized in the Fiscal Decentralisation dataset from the IMF, which covers seventy-five countries and covers 1972-2018, annual data frequency. Specifically, the Fiscal Decentralisation dataset contains information on transfers and direct taxes that the GG has transferred to SNGs (state, provincial, regional, and local governments, including districts and municipalities), and transfers and direct taxes decentralisation is expressed as a ratio of transfers and direct taxes of SNG level as a proportion of the GG level (Lledó et al. 2018).[3] Thus, we employ this information to obtain transfers and direct taxes at CG and SNG levels (as percentage of GDP). Note that our decentralisation variable does not concern political decentralisation (degree of decentralisation of elections) or administrative decentralisation (degree of sub-division of nation states) (Sepulveda and Martinez-Vazquez 2011). In other words, high tax and expenditure decentralisation do not necessarily involve high subnational autonomy power (Kyriacou and Roca-Sagalés 2011, 2020).

In this study we propose to use two redistribution measures. The first is obtained as the difference between the Gini market index (before transfers and direct taxes) and the Gini net index (after transfers and direct taxes), called absolute redistribution. The second measure is calculated as the difference between the Gini market index and Gini net index divided by the Gini market index, called relative redistribution. These measure are extensively used by several authors (Korpi and Palme 1998; Bradley et al. 2003; Mahler and Jesuit 2006; Huber and Stephens 2014). The Standardized World Income Inequality Database (SWIID) developed by Solt (2019) provides information on the Gini indices and is available for 196 countries from 1960 to the present, annual data frequency; it also includes information on the measure of absolute and relative redistribution.[4]

[3] Figure A.1 in the Appendix illustrates the fiscal decentralisation in our sample of countries, showing that countries are characterised as having more decentralised direct taxes than transfers.

[4] See Solt (2019) for a complete description of the SWIID; we employ version 8.1 (update in May 2019).

We examine a wide range of variables, based on previous work, that capture demographic, economic, political and institutional factors to identify the potential determinants of the variation of redistributive efficiency between countries and over time. Variables are obtained through the exploration of various data sources (see Tables A.2 of Appendix). Specifically, we focus on the role of a federal political system, as a proxy of political decentralisation, on redistributive efficiency of fiscal policy.

Thus, we introduce the variable "federalism" from Gerring and Thacker (2004) that involves two components: territorial government and bicameralism. On the one hand, territorial government refers to a political system where the national government is or is not sovereign relative to its territorial units, namely, unitary and federal states respectively. On the other hand, bicameralism refers to the relative power between the lower and upper houses (i.e., share of policy-making power between two chambers) at the national level. Consequently, a federal state is characterised by federal territorial government and strong bicameralism (i.e., upper house has some effective veto power); in this case, the "federalism" variable takes the highest value. In a fully federal state, territorial units have constitutional recognition of subnational authority, independently elected territorial legislature, specific policy purviews reserved to them, and revenue-raising authority.

5. Empirical strategy

The aim of this section is to present the empirical strategy proposed for measuring the redistributive efficiency of the government resources and decentralisation (of transfers and direct taxes), and then, analyse the factors that might explain how efficiency varies across countries and over time.

To undertake this analysis, a two-stage methodology is proposed (Simar and Wilson 2007, 2011). First, we use a bootstrap-DEA to empirically evaluate the effect of fiscal policy instruments and their degree of decentralisation on redistributive efficiency. Second, we examine the possible determinants of redistribution efficiency heterogeneity across countries and over time by using a bootstrap truncated regression analysis (pooling the data across the periods). In particular, in this second stage we are interested in analysing the role of a federal political system (basically political decentralisation) on redistributive efficiency.

5.1 First-stage DEA analysis

DEA is a linear programming (LP) methodology for measuring efficiency by comparing each decision making units (DMUs), with an efficient production frontier (Farrell 1957; Charnes et al. 1978). DEA uses data on input and output variables to construct a non-parametric efficiency frontier over the data points solved by the sequence of LP problem– one data point solution for each DMUs. The DEA analysis methodology can be performed

input-oriented or output–oriented. That is, an input-oriented model minimises inputs for a given amount of output and an output-oriented model maximises output for a given amount of inputs. The result of the LP problem is an efficiency score for each DMUs, which makes possible to rank the efficiency of DMUs by comparing each performance with the best-practice (or performance) in the sample at period *t*. This is, the DEA method defines the set of observations with the best performance for the DMUs of the analysis and produces a frontier of production possibilities by linearly connecting them, under the assumption of convex technology; DMUs that are not defining the frontier are considered inefficient (Bogetoft and Otto 2011).

Analytically, suppose there are *N* inputs and *M* outputs for each of *I* DMUs; and for the *i-th* DMU, $\boldsymbol{x}_i$ is the column vector of the inputs and $\boldsymbol{y}_i$ is the column vector of the outputs. We can define $\boldsymbol{X}$ as the (*N* x *I*) input matrix and $\boldsymbol{Y}$ as the (*M* x *I*) output matrix. The output-oriented efficiency score for the *i-th* DMU is then estimated via the following LP problem (Coelli et al. 2005):

$$\max_{\theta,\lambda} \theta_i \qquad (1)$$

Subject to

$$-\theta_i \boldsymbol{y}_i + \boldsymbol{Y}\boldsymbol{\lambda} \geq 0, \qquad (2)$$

$$\boldsymbol{x}_i - \boldsymbol{X}\boldsymbol{\lambda} \geq 0, \qquad (3)$$

$$\boldsymbol{I}\boldsymbol{1}'\boldsymbol{\lambda} = 1, \qquad (4)$$

$$\boldsymbol{\lambda} \geq 0 \qquad (5)$$

where θ_i is the output-oriented efficiency score that measures technical efficiency, i.e., the optimal solution to this problem (Equation 1), $1 \leq \theta_i \leq \infty$, and $\theta_i - 1$ is the potential proportional increase in the output quantities that could be achieved without altering the input quantities by the *i-th* DMU. If $\theta_i > 1$, the country is within the frontier (i.e., it is inefficient), while $\theta_i = 1$ implies that the country is on the efficiency frontier (i.e., efficient).

Equation 2 stands for the "output constraint", indicating that the weighted sum of outputs from all DMUs in the sample must be greater than or equal to the potential output for *i-th* DMU given the "input constraint" shown by Equation 3.

The vector λ is a (*Ix1*) vector of constants that measures the weights used to compute the location of an inefficient country if it became efficient. Equation 4 represents the "convexity constraint" that accounts for variable returns to scale (VRS) production function technology, where $\boldsymbol{I}\boldsymbol{1}$ is an *Ix1* dimensional vector of ones. Note that the convexity constraint essentially ensures that an inefficient DMU is only "benchmarked" against DMUs of a similar size. That is, the projected point (for that DMU) on the DEA frontier is a convex combination of observed DMUs. Finally, this problem has to be solved for each of the *i-th* DMUs to obtain the *i* efficiency scores.

DEA efficiency scores may be influenced by exogenous (or "environmental") factors that potentially downward bias efficiency. To correct it, we compute the bootstrapping DEA method (Simar and Wilson 2007, 2011; Bogetoft and Otto 2011; Du et al. 2018). That is based on the numerical simulation of the original data set and

calculating efficiency of the simulated sample through DEA to generate bias-corrected efficiency and confidence intervals (Efron 1979; Simar and Wilson 1998, 2000).

This study will take countries' DMUs, the income redistribution (two specifications, absolute and relative) as the one output variable and transfers and direct taxes variables, two each at the CG and SNG levels, as the four input variables. This is, we take into account size and decentralisation degree of transfers and direct taxes as inputs, which is a novelty.[5] Note that fiscal decentralisation is discretionary fiscal policy and thus we capture it in the first stage of the DEA analysis (as input). Moreover, we will select an output-oriented model (i.e., increase the output given fixed the inputs) because the government's target we assume is redistribution. The measure of technical efficiency is calculated as the distance between the observed country and the efficiency frontier, which is represented by the best performing countries in the sample. The frontier and ranking of efficiency are computed for each sub-period of analysis.

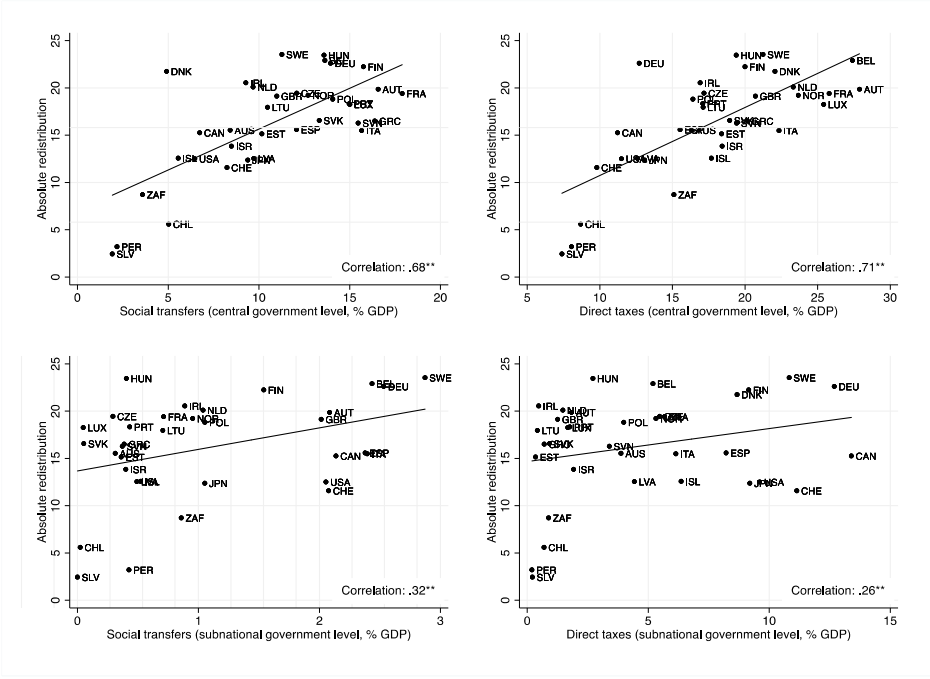
Moreover, the relationship between output measures and inputs are describe in Figure 3. The plots suggest that the countries with higher levels of transfers and direct taxes of CG and SNG (i.e., inputs), which include different categories with different distributional implications, tend to have greater income redistribution (i.e., outputs) during the 2000-2016 period. Specifically, we observe a direct link between the degree of fiscal decentralisation (as share of transfers and direct taxes at the SNG level in terms of GDP) and redistribution measures. Besides, Figure 3 depicts the fact that countries with diverse fiscal resources and decentralisation (e.g., European countries) show different redistributive performances. Our methodology approach allows to examine this issue.

[5] See Table A.3 in the Appendix for descriptive statistics of input-output variables.

Figure 3 – Relationship between income redistribution measures and fiscal policy (mean period 2000-2016)

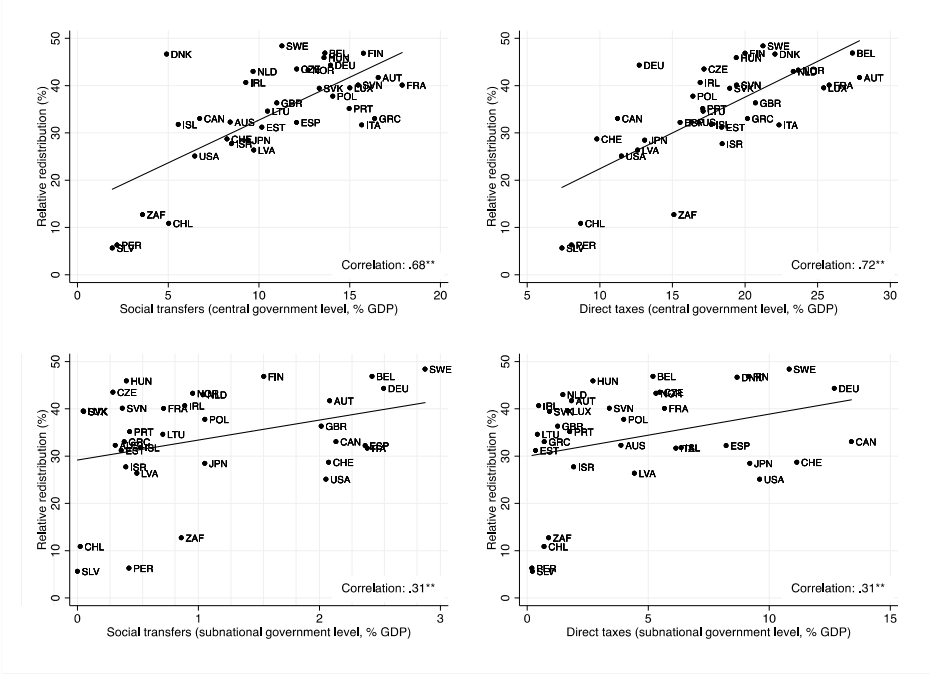
Panel (a) Absolute redistribution

Panel (a.1): Social transfers *Panel (a.2): Direct taxes*



Panel (b) Relative redistribution

Panel (b.1): Social transfers *Panel (b.2): Direct taxes*



Note: Denmark is excluded from the plot's representation between income redistribution measures and social transfers at the SNG level for a scale reasons (social transfers at the SNG level are above 10% in terms of GDP) but not in the correlation value. The country code and description are detailed in Table A.1 in the Appendix. (**) is the level of significance 5%.
Source: Own elaboration based on data from SWIID, IFS-IMF and OECD (SOCX) statistics.

5.2 Second-stage regression analysis

Once the bootstrap-DEA efficiency scores are obtained in the first stage of the analysis, we proceed to the second stage. We regress the efficiency scores on a set of possible explanatory factors that might explain differences in the variation of the redistributive efficiency across country and over time, and which do not respond to the discretionary fiscal policy decisions.

Thus, we regress the estimated bias-corrected efficiency scores, $\hat{\theta}_{it}$, on a set of non-discretionary (or exogenous) variables, Z_{it}, that potentially influence the efficiency level. Specifically, we consider the following model:

$$\hat{\theta}_{it} = \propto + Z_{it}\beta + d_t + d_j + \varepsilon_{it} \qquad (6)$$

where $i = 1, 2, \ldots I$ represents the countries in the sample and $t = 1, 2, \ldots T$, refers to the time period, $\propto$ is a constant, β a vector of parameters to be estimated that capture the effect of the explanatory variables on efficiency scores, d_t represents period fixed effects, d_j represents the time-invariant variables and ε_{it} is statistical noise, $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$, with left-tail truncation given by $\varepsilon_{it} \geq 1 - \propto - Z_{it}\beta - d_t - d_j$ since DEA efficiency scores are larger than or equal to 1 in the output-orientation approach.

A couple of problems arise since true DEA efficiency scores are unobserved and replaced by the previously estimated $\hat{\theta}_i$, which in turn are serially correlated in an unknown way. Additionally, the explanatory variables are correlated with the error term as input and output variables are correlated with explanatory variables. Therefore, a bootstrap procedure is implemented to overcome the correlation problem and obtain unbiased coefficients and valid confidence intervals. Thus, following Simar and Wilson (2007, 2011) and Du et al. (2018), a double bootstrap method will be used, in which DEA scores are bootstrapped in the first stage of the analysis to obtain bias-corrected efficiency scores, and then the second stage is performed, consisting of regressing the bias-corrected efficiency scores on a set of potential explanatory factors using a bootstrap truncated regression.

Specification of the empirical model

We estimate the following empirical model:[6]

$$Efficiency\ score_{it} = \beta_0 + \beta_1 federalism_i + \beta_2 X_{it} + \beta_3 Z_i + \beta_4 dr_i + \beta_5 dt_t + \varepsilon_{it} \qquad (7)$$

where i indexes the 35 countries in the cross-section dimension of the sample and t denotes the sub-period during 2000-2016. "Efficiency score" is the dependent variable pertaining to absolute redistribution or relative redistribution outputs. "Federalism" is the key time-invariant variable of interest. X is a vector of time varying control variables, Z

[6] The definitions and sources of all variables are presented in Table A.2 and descriptive statistics in Table A.4, both in the Appendix.

is a vector of time-invariant control variables, and ε an error term. Also, we include region and period fixed effects, dr_i and dt_t respectively.

First of all, our specification includes the variable "federalism". Based on the background section, we would expect that countries with high "federalism" (federal and bicameral) are less redistributive efficient; because reduce available resources to central government and redistribution is principally a national level policy, and; because the decentralised political power is more corrupt.

To evaluate if wealthier economies show a more redistributively efficient fiscal policy, we control for "GDP per capita" (in log). Among others, Bradley et al. (2003) refer to GDP per capita as a typical measure of economic development in almost all studies of income distribution. We would expect that economies with higher real income are more productive and developed, therefore, they may possible be more efficient. Additionally, by employing GDP per capita we also control for population size, and our advance expectation is that a large population may have difficulty in governing redistribution (Campante and Do 2007).

We also control for "elderly people", the share of the population over 65 years of age, in an attempt to account for the pressure of the pension system on redistributive efficiency. Note that old-age benefits are (one of) the most important social transfers in countries and its effect on redistributive efficiency would we depend on the fiscal policy design and implementation of them. Additionally, we also control for "unemployment rate" since it affects redistribution via the amount of government resources through unemployment subsidies (Huber and Stephens 2014). Again, we expect that the impact on redistributive efficiency will depend on the specific unemployment compensation scheme. In this sense, Mahler and Jesuit (2006) indicate a positive effect of the elderly (weak effect) and unemployment rate (strong effect) on fiscal redistribution but they do not examine efficiency.

We also control for "government effectiveness" used to proxy government quality (Kaufmann et al. 2011), which involves attributes such as quality of public and civil services, independence from political pressures, policy design and execution and government credibility. Kyriacou et al. (2018) provide evidence of a strong positive effect of government quality on redistributive efficiency. Therefore, we expect that countries with high government effectiveness should be able to achieve more redistribution for a given level of government resources and decentralisation.

Moreover, we control for "ethnic fractionalisation" in attempt to account for the possibility that high ethnic heterogeneity in the society makes it difficult to agree about what constitutes "good" fiscal policies and therefore the income redistribution needed. Our fractionalisation variable is from Alesina et al. (2003) and is higher when there are many small groups in the society. We expect a negative effect on redistributive efficiency because ethnic fractionalisation may lead to rent-seeking behaviour of multiple interest groups, creating an inefficient provision of public good (Easterly and Levine 1997; La Porta et al. 1999; Alesina et al. 2003).

We also control for human capital by including the variable "education inequality" from Castelló-Climent and Doménech (2014). The expectation is that lower education inequality leads to higher societal demands for a more efficient redistribution.

Furthermore, we include a variable from International Country Risk Guide (ICRG) called "democratic accountability". This is an indicator of political stability of the country and is computed on the basis of the type of a country's governance, from altering democracies (i.e., high democratic accountability) to autarchies governance. We would expect countries with high democratic accountability to show more redistributive efficiency.

Apart from that, in recent decades, the increase in public debt and overspending in developed countries led to introducing and strengthening the fiscal rules (such as the Fiscal Compact in European Union member states after the Great Recession) with the consensus being that they foster fiscal discipline (Heinemann et al. 2018). Fiscal rules are laws designed to impose a budgetary constraint to limit countries' scope on fiscal aggregates (Lledó et al. 2017). Nevertheless, the empirical literature is inconclusive about the budgetary impact of the fiscal rules on public sector efficiency. A recent work (Christl et al. 2020) indicates that fiscal rules are relevant to positively affect public sector efficiency particularly in the presence of high fiscal imbalance of SNGs. Thus, we control for the existence of "debt fiscal rules" in an attempt to account for the possibility that the debt boundary prevents overspending and enforces government to be more efficient in using public resources.

Finally, we account for "geographical region" dummy control variables, which allow us to partially account for country-specific effects (Sepulveda and Martinez-Vazquez 2011). In this sense, Canavire-Bacarreza et al. (2016) claim that more geographically diverse countries present more heterogeneous population with different preferences and needs for public goods and services provision, which is positively associated with higher levels of fiscal decentralisation. In addition, Ligthart and Oudheusden (2017) argue that geographical proximity draws countries to adopt policies similar to neighbouring countries, such as the kind of decentralisation. Therefore, we expect that geographical regions affect redistribution although we do not have any prior expectation about the effect on efficiency.

6. Results

In this section, we first discuss our main empirical findings of estimates of the redistributive efficiency of fiscal policy in a panel of thirty-five countries over 2000-2016. Next, we present the regression outcomes to explain the factors that may affect the redistributive efficiency scores between countries and over time. And finally, we perform several robustness tests for our findings.[7]

[7] To obtain the DEA efficiency score, we use the "Benchmarking" package (function DEA.boot) in R software and the bootstrap truncated regression analysis was performed in STATA. All code is available from the authors upon request.

6.1. First-stage results

Table 1 and 2 show the efficiency scores and country rankings obtained from estimating the bootstrap-DEA output-oriented model (VRS technology) considering four inputs (transfers and direct taxes, both at CG and at SNG levels) and one output, absolute and relative redistributions respectively, for the four selected periods of analysis (2000-2004, 2005-2009, 2010-2014 and 2015-2016). Both tables indicate that the efficiency scores, on average, increase during the period of analysis, which means that the "average" country is becoming more inefficient over time. Accordingly, countries could potentially increase their redistributive efficiency without altering transfers and direct taxes resources and decentralisation degree. Specifically, the averages efficiency scores suggest a range of 12.5%-24.7% in the case of absolute redistribution and a range of 8.6%-22.2% in the case of relative redistribution for countries to be deemed efficient. Note that some authors (see, for instance, Christl et al. 2020) highlight the fact that countries' public sector efficiency improved in the aftermath of the Great Recession based on the argument that despite budget cuts do not cause a reduction in public sector goods and services to the same extent. Nevertheless, we are providing evidence that income redistribution (i.e., distribution component of the public sector) became more inefficient in many countries after the 2009 crisis and this outcome may be because redistribution has weakened or stagnated and governments have been focused on restoring public finances (Caminada et al. 2019).

In Table 1, we present the efficiency score outcomes using the absolute redistribution measure as an output and find that Sweden (2000-2004), the Czech Republic (2005-2009), Iceland (2010-2014) and Belgium (2015-2016) are the most efficient in the sample (first rank), being located very close to the efficiency frontier (scores close to 1). In contrast, Italy (2000-2014) and Japan (2015-2016) are the least efficient. The economic interpretation is as follows: for instance, Belgium has an efficiency score of 1.066 in the 2015-2016 period, which means it could increase absolute redistribution by 6.6% without altering the transfers and direct taxes resources and their degree of decentralisation. On the other side, the efficiency score of Japan is 1.875 in the 2015-2016 period, therefore, it could increase absolute redistribution in 87.5% without altering the transfers and direct taxes levels and their degree of decentralisation, thus, there is an important possibility for increasing redistributive efficiency.

Table 1 – Absolute redistribution: Efficiency scores and country rankings

Country	2000-2004		2005-2009		2010-2014		2015-2016	
	Efficiency score	Ranking	Efficiency score	Ranking	Efficiency score	Ranking	Efficiency score	Ranking
Australia	1.037	3	1.062	9	1.059	3	1.369	29
Austria	1.130	26	1.159	26	1.192	28	1.193	19
Belgium	1.054	8	1.049	4	1.068	6	1.066	1
Canada	1.049	6	1.063	10	1.082	13	1.105	5
Chile	1.074	18	1.066	11	1.079	11	1.134	17
Czech Republic	1.049	5	1.037	1	1.064	4	1.129	10
Denmark	1.067	11	1.080	19	1.087	16	1.133	14
El Salvador	1.075	22	1.081	21	1.088	18	1.134	16
Estonia	1.074	17	1.076	15	1.089	19	1.130	11
Finland	1.075	21	1.109	22	1.096	21	1.084	4
France	1.145	27	1.259	32	1.266	31	1.270	24
Germany	1.073	15	1.079	17	1.079	10	1.119	7
Greece	1.091	24	1.179	30	1.155	25	1.312	26
Hungary	1.062	10	1.060	8	1.077	8	1.127	8
Iceland	1.068	12	1.068	12	1.051	1	1.206	20
Ireland	1.075	19	1.073	14	1.077	9	1.129	9
Israel	1.047	4	1.140	24	1.259	30	1.864	34
Italy	1.596	35	1.592	35	1.547	35	1.522	33
Japan	1.214	30	1.218	31	1.470	34	1.875	35
Latvia	1.159	28	1.051	6	1.131	22	1.388	30
Lithuania	1.053	7	1.057	7	1.088	17	1.210	21
Luxembourg	1.061	9	1.072	13	1.087	15	1.131	12
Netherlands	1.037	2	1.050	5	1.067	5	1.151	18
Norway	1.262	32	1.177	29	1.187	27	1.284	25
Peru	1.073	14	1.078	16	1.087	14	1.133	13
Poland	1.123	25	1.173	28	1.179	26	1.247	23
Portugal	1.068	13	1.045	2	1.237	29	1.327	27
Slovak Republic	1.074	16	1.081	20	1.089	20	1.133	15
Slovenia	1.289	33	1.437	33	1.405	33	1.449	31
South Africa	1.075	20	1.079	18	1.081	12	1.111	6
Spain	1.508	34	1.501	34	1.402	32	1.453	32
Sweden	1.035	1	1.046	3	1.068	7	1.076	2
Switzerland	1.241	31	1.129	23	1.056	2	1.077	3
United Kingdom	1.087	23	1.167	27	1.133	23	1.237	22
United States	1.170	29	1.156	25	1.138	24	1.338	28
Average	1.125		1.136		1.152		1.247	

Note: Output-oriented variable returns to scale (VRS) technical efficiency. Efficiency score: = 1 represents maximum efficiency and > 1 means greater inefficiency. All results are based on one output (absolute redistribution) and four inputs (transfers and direct taxes at CG level and at SNG level). Estimation method: DEA bootstrap with 10,000 repetition.
Source: Own estimations.

Table 2 reports the efficiency scores employing the relative redistribution measure as an output. This is, we account for initial income inequality conditions in calculating the redistributive measure. In other words, we account for the proportional change of the redistribution.

The most relevant finding is that Belgium is the most efficient in the sample regardless of the sub-period examined (ranks first). Additionally, other countries that show good performance are Finland, Hungary, Lithuania, Netherlands, Norway and Sweden throughout the 2000-2016 period. During this timeframe, Italy (2000-2014) and Israel (2015-2016) are the least efficient. Other countries that present low redistributive efficiency include Greece, Japan, Portugal, South Africa, Spain and United States in the period 2000-2016. The economic intuition is as above, for instance, Belgium has an efficiency score of 1.042 in the 2015-2016 period, that means it could increase relative redistribution by 4.2% without changing the transfers and direct taxes resources and their degree of decentralisation.

Table 2 – Relative redistribution: Efficiency scores and country rankings

Country	2000-2004		2005-2009		2010-2014		2015-2016	
	Efficiency score	Ranking	Efficiency score	Ranking	Efficiency score	Ranking	Efficiency score	Ranking
Australia	1.095	**29**	1.058	**12**	1.044	**3**	1.310	**27**
Austria	1.084	**26**	1.071	**23**	1.127	**22**	1.130	**19**
Belgium	1.022	**1**	1.023	**1**	1.033	**1**	1.042	**1**
Canada	1.037	**7**	1.053	**10**	1.082	**14**	1.102	**7**
Chile	1.051	**17**	1.053	**11**	1.055	**4**	1.123	**16**
Czech Republic	1.039	**9**	1.050	**7**	1.077	**11**	1.123	**12**
Denmark	1.051	**15**	1.065	**19**	1.084	**18**	1.123	**14**
El Salvador	1.053	**22**	1.065	**21**	1.084	**19**	1.124	**17**
Estonia	1.052	**20**	1.065	**18**	1.085	**21**	1.123	**15**
Finland	1.025	**2**	1.040	**3**	1.034	**2**	1.043	**2**
France	1.095	**30**	1.183	**30**	1.216	**28**	1.222	**23**
Germany	1.051	**14**	1.062	**15**	1.073	**8**	1.099	**5**
Greece	1.070	**24**	1.263	**33**	1.242	**29**	1.311	**28**
Hungary	1.035	**5**	1.041	**4**	1.068	**7**	1.101	**6**
Iceland	1.050	**13**	1.064	**16**	1.083	**17**	1.109	**8**
Ireland	1.052	**18**	1.059	**14**	1.073	**9**	1.119	**11**
Israel	1.139	**31**	1.182	**29**	1.247	**30**	1.734	**35**
Italy	1.523	**35**	1.530	**35**	1.528	**35**	1.507	**32**
Japan	1.043	**12**	1.084	**24**	1.388	**34**	1.602	**34**
Latvia	1.065	**23**	1.098	**26**	1.131	**24**	1.290	**26**
Lithuania	1.035	**4**	1.039	**2**	1.082	**15**	1.273	**25**
Luxembourg	1.041	**11**	1.052	**9**	1.081	**13**	1.116	**10**
Netherlands	1.039	**10**	1.052	**8**	1.077	**12**	1.072	**3**
Norway	1.092	**28**	1.049	**6**	1.065	**5**	1.135	**20**
Peru	1.051	**16**	1.065	**17**	1.083	**16**	1.123	**13**
Poland	1.085	**27**	1.166	**28**	1.130	**23**	1.185	**22**
Portugal	1.038	**8**	1.087	**25**	1.266	**32**	1.336	**29**
Slovak Republic	1.052	**19**	1.065	**20**	1.085	**20**	1.124	**18**
Slovenia	1.071	**25**	1.143	**27**	1.186	**25**	1.169	**21**
South Africa	1.052	**21**	1.070	**22**	1.252	**31**	1.589	**33**
Spain	1.354	**34**	1.406	**34**	1.373	**33**	1.414	**30**
Sweden	1.033	**3**	1.042	**5**	1.065	**6**	1.075	**4**
Switzerland	1.036	**6**	1.058	**13**	1.075	**10**	1.111	**9**
United Kingdom	1.192	**32**	1.217	**32**	1.210	**27**	1.262	**24**
United States	1.201	**33**	1.206	**31**	1.193	**26**	1.435	**31**
Average	1.086		1.109		1.142		1.222	

Note: Output-oriented variable returns to scale (VRS) technical efficiency. Efficiency score: = 1 represents maximum efficiency and > 1 means greater inefficiency. All results are based on one output (relative redistribution) and four inputs (transfers and direct taxes at CG level and at SNG level). Estimation method: DEA bootstrap with 10,000 repetition.
Source: Own estimations.

In general, we observe that the efficiency scores using absolute and relative redistribution outputs show different outcomes. Specifically, the efficiency scores employing the absolute redistribution measure as an output depict more countries' inefficiencies than the efficiency scores using the relative redistribution measure as an output (see Figure A.2 of Appendix).

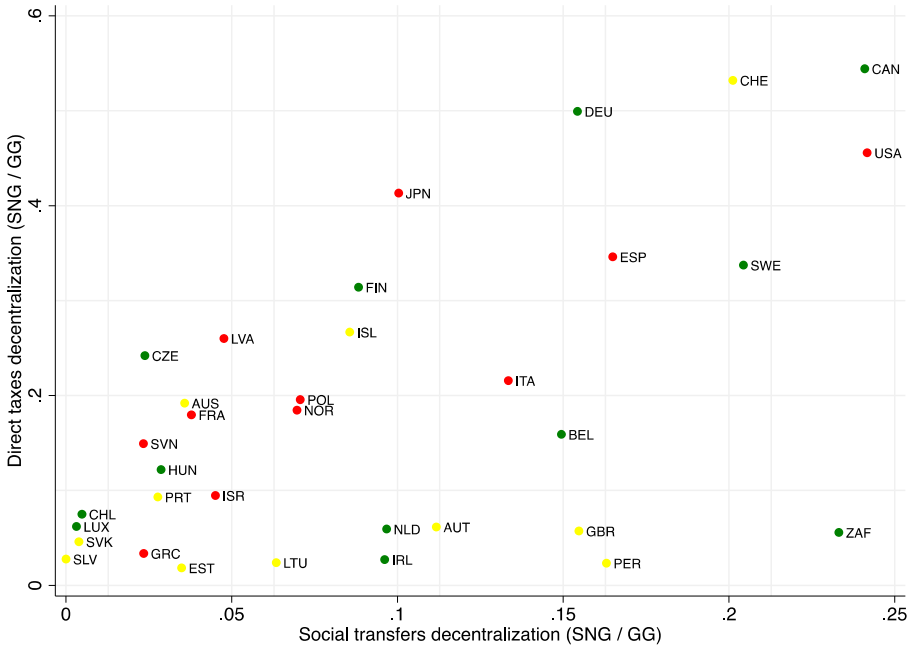
Here, we identify that there are possibilities in most of the countries to increase redistributive efficiency. Our findings are in line with previous analyses that report low efficiency in Southern European countries, high efficiency in Nordic countries and no clear pattern in Anglo-Saxon countries (Afonso et al. 2010b; Kyriacou et al. 2018). Developing countries, surprisingly, do not show the worst redistributive performance although they display high inefficiency, which may indicate that efficiency does not only concern the amount of government resources available. In this sense, to the existing empirical literature, we add new findings in this first stage of the analysis (i.e., including

fiscal decentralisation) and our results may be used to explain the many differences with previous empirical studies (e.g., Kyriacou et al. 2018).

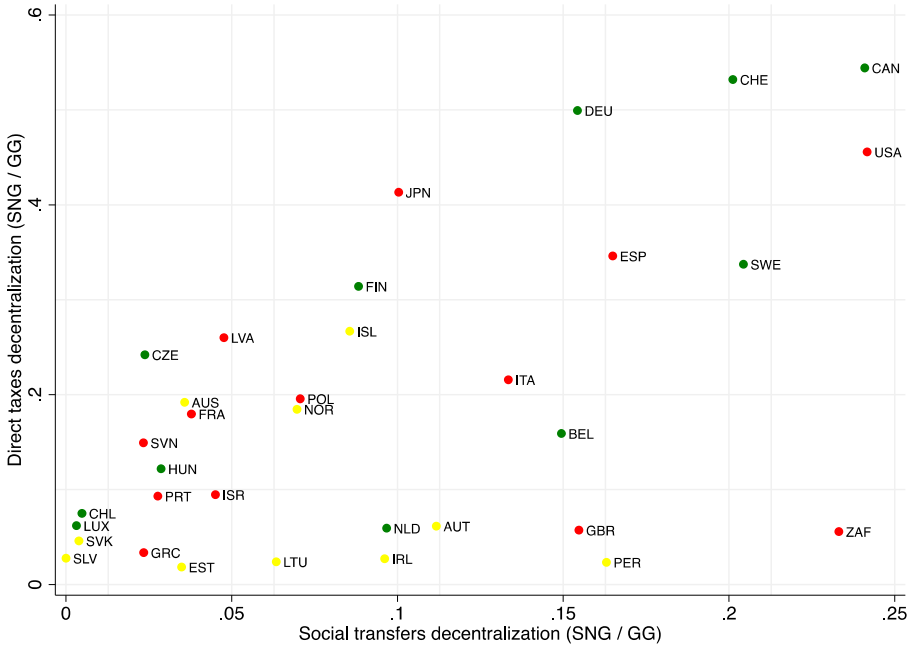
Besides, we visually inspect the countries to identify a potential pattern or relationship between efficiency scores and fiscal decentralisation over 2000-2016 (see Figure 4). From it, panel (a) and panel (b) show the link between fiscal decentralisation and efficiency scores of absolute and relative redistribution outputs, respectively. The y-axis represents the direct taxes decentralisation and x-axis represents the transfers decentralisation, measuring the share of direct taxes and transfers of the SNGs as proportion of total direct taxes and transfers of the GG, respectively. Dots represents the countries' efficiency scores and colour their ranking (green=high-efficiency; yellow=medium-efficiency; red=low-efficiency). From the visual exploration, we do not observe a clear cluster of countries (dots are relatively well distributed) and thus we conclude that fiscal decentralisation may not be able to explain differences in redistributive efficiency across countries in this first stage of the analysis (see, for instance, Belgium -BEL- and Italy -ITA-).

Figure 4 – Efficiency scores and fiscal decentralisation
(mean period 2000-2016)

Panel (a): Output absolute redistribution



Panel (b): Output relative redistribution



Note: The variable-axis represents the decentralisation variable, measuring the share of the variable of the SNG as proportion of total variable of the GG. Dot represents the country' efficiency score and its colour represents the level of efficiency which involves green=high, yellow=medium and red=low, which is based on the country rankings considering as thresholds the percentiles 33% and 66% of a normal distribution. The country code and description are detailed in Table A.1 in the Appendix.
Source: Own elaboration.

6.2. Second-stage results

Table 3 summarises the main findings arising from Equation 7; we regress the redistributive efficiency, i.e., efficiency scores, obtained in the first stage of the analysis, on a set of non-discretionary explanatory factors by using a bootstrap truncated regression model. The first regression (Model 1) and second regression (Model 2) report the cases of estimate the efficiency scores employing the absolute and relative redistribution outputs, respectively.

We find that federal countries tend to be less redistributively efficient than unitary countries –the coefficient of "federalism" variable shows a negative sign in both models, but it is only significant at the 1% in Model 2. The impact of "federalism" is relevant when the redistributive measure takes into account initial inequality conditions; ultimately, it is the relevant measure because reflect the redistribution effort. This result is not contrary to the normative "decentralisation theorem" of Oates since redistribution should be a central government issue. Additionally, Gerring and Thacker (2004) find that "federalism" is linked with more political corruption, which may explain our result of the weakness of the fiscal policy on redistribution; this is also in line with Oates (2005) and Treisman (2000). Moreover, "federalism" is characterised such as the presence of multiple veto points in the political process, that may affect negatively redistributive efficiency because obstructing the fiscal policy decision-making process; this is in line with Kyriacou et al. (2018).

For both models (1 and 2), we found that the log of per capita GDP does not display a significant effect on redistributive efficiency and thus, contrary to what we expected, our evidence shows that wealthier countries do not necessarily report a higher level of redistributive efficiency. In addition, we control for population 65 years and above and unemployment rate, but do not have a significant impact on redistributive efficiency. For elderly population, one possible reason is due to having on average lower but less unequal income than the working population, who may not be the focus of the redistributive fiscal policies. In the case of unemployment rate, it may not explain redistributive efficiency because benefits, such as unemployment subsidies, are conditional on past contributions and are earnings-related in most countries (Joumard et al. 2013).

Moreover, we account for a significant positive impact of government effectiveness on redistributive efficiency for Model 2 (coefficient in Model 1 is not significant but presents the expected sign). Based on previous findings (Gupta et al. 2002; Afonso et al. 2010b), we interpret and explain this result based on the idea that "better" government quality improves the design of the fiscal policy and its credibility as well as reducing the levels of corruption, which might foster redistributive efficiency.

Contrary to what one would expect, we find an insignificant impact of ethnic fractionalisation on redistributive efficiency in both models. Given that developed countries are less ethnically divided than developing countries and our sample of countries cover mainly developed countries, this probably can explain this outcome.

Furthermore, we find that more education inequality reduces the redistributive efficiency, being only significant at the 5% level in the case of Model 2. Inequality in education has been decreasing in the last period but inequality remains high (Castelló-

Climent and Doménech 2014). Possibly, more educated people increase pressure on monitoring activities of politicians and bureaucrats to be more efficient and also increase social demands to reduce inequality (Afonso et al. 2010b).

The democratic accountability variable directly affects redistributive efficiency of fiscal policy, significant at the 1% level in Model 1 and at 10% in Model 2. One possible interpretation is because accountability gives voters some control over politicians, such as to punish them at re-election, which directly strengthens the politicians' incentives for good behaviour (Persson and Tabellini 2004). In addition, the highest democratic accountability refers to alternating democracies regimes that are characterised as a government that switches (e.g., after two successive terms) and also has the presence of more than on political party, which can lead to an overall effectiveness of fiscal policies.

Moreover, debt fiscal rules positively affect redistributive efficiency and thus it is in line with the notion that it drives an efficient use of resources (only significant at the 5% level in Model 1).

The dummy geographical region control variables are positive and most of them significant at an at least 5% level, suggesting that all reporting regions are more redistributive efficient than the omitted region, namely Southern Europe. Thus, time-invariant characteristics of these regions are detrimental in explaining efficiency scores, such as the geographical position, the climate, the cultural background, etc. Contrary to Kyriacou et al. (2018), we control by geographical region instead of welfare states variable in the regression analysis; here, we believe that our outcomes constitute an improvement because the generosity of the welfare state is discretionary fiscal policy and thus we capture it in the first stage of the DEA analysis (as input).

In sum, our empirical findings reveal that redistributive efficiency of the fiscal policy vary across countries and over time, and it is directly associated with having a non-federal (or unitary) political system (i.e., low political decentralisation), high government effectiveness and democratic accountability, low education inequality as well as the existence of debt fiscal rules.

Table 3 – Determinants of redistributive efficiency of fiscal policy

Dependent variable	*Model 1* Efficiency score of output absolute redistribution			*Model 2* Efficiency score of output relative redistribution		
Explanatory variable	Coefficient	95% Confidence interval		Coefficient	95% Confidence interval	
		lb	ub		lb	ub
Federalism	-0.014	-0.047	0.018	-0.050***	-0.017	-0.084
	(0.017)			(0.017)		
Log of per capita GDP	-0.038	-0.164	0.084	-0.044	-0.165	0.077
	(0.064)			(0.062)		
Elderly people (% of total population)	0.000	-0.027	0.026	0.004	-0.021	0.030
	(0.013)			(0.013)		
Unemployment rate	0.002	-0.007	-0.010	-0.005	-0.014	0.004
	(0.004)			(0.005)		
Government effectiveness	0.054	-0.106	0.215	0.144**	0.000	0.288
	(0.082)			(0.073)		
Ethnic fractionalisation	0.171	-0.069	0.412	0.064	-0.147	0.275
	(0.123)			(0.108)		
Education inequality	-0.014	-0.750	0.722	-0.952**	-1.743	-0.161
	(0.375)			(0.403)		
Democratic accountability	0.179***	0.053	0.305	0.141*	-0.003	0.284
	(0.064)			(0.073)		
Debt fiscal rules	0.125**	-0.013	0.238	0.022	-0.070	0.114
	(0.057)			(0.047)		
Constant	-2.023**	-3.631	0.415	-1.318*	-2.810	0.175
	(0.830)			(0.792)		
Region fixed effects:						
EE	0.366***	0.144	0.588	0.186**	0.002	0.369
	(0.113)			(0.094)		
WE	0.317***	0.117	0.518	0.253***	0.073	0.433
	(0.102)			(0.092)		
NE	0.336***	0.139	0.534	0.125	-0.027	0.277
	(0.101)			(0.078)		
DC	0.653**	0.12	1.204	0.547**	0.040	1.053
	(0.281)			(0.258)		
ODC	0.206**	0.012	0.238	-0.023	-0.220	0.175
	(0.099)			(0.101)		
Period fixed effects	Yes			Yes		
Wald chi2	52.28			56.16		
Log likelihood	158.843			184.656		
Observations	140			140		

Notes: The dependent variable is the bias-corrected efficiency scores derived from the bootstrap-DEA method (1,000 repetition). Bootstrapping standard errors are presented in parentheses. Low boundary -lb- and upper boundary -ub-. Level of significance: 10% (*), 5% (**) and 1% (***).
Source: Own estimations.

6.3. Sensitivity analysis

In this subsection, we propose some robustness tests. Our analysis concerns assessment of the impact of using an alternative measure of "federalism" (the Regional Authority Index) and introducing additional variables (party orientation, control of corruption -as an alternative measure of government effectiveness- and presidential system) on redistributive efficiency in our baseline models 1 and 2 of Table 3 (in columns 1 and 2 of Table 4 respectively). Besides, we report in Table A.5 of Appendix the sensitivity of our bootstrap estimations of the baseline models, generating robust and clustered standard error estimations. In particular, robust standard errors allow to control for some kinds of misspecification and clustered standard errors, at the region level, allow to control for intragroup correlations. We find that "federalism" remains robust to different variance estimators. Apart from that, we do not find substantial differences in the significance of the other outcomes.

First of all, we employ an alternative measure of "federalism", the Regional Authority Index (RAI) from Hooghe et al. (2016) –they have a high positive correlation of 0.75. The authors built an overall indicator of "regional authority" as the sum of "self-rule" (five dimensions: institutional depth, policy scope, fiscal autonomy, borrowing autonomy, representation) and "shared-rule" (five dimensions: law making, executive control, fiscal control, borrowing control and constitutional reform). Higher points are given to countries that enjoy a high degree of authority by regional government. Data are available for most of our sample of countries (excluding South Africa). In columns 3 and 4 of Table 4 we present the results when considering the RAI variable. We find that "regional authority" is negatively associated with redistributive efficiency. Therefore, our analysis report robust empirical evidence that federal countries tend to be less redistributive efficient.

One of the most typical and relevant questions is whether the partisan orientation of governments affects redistribution, and commonly the expectation is that left-wing party orientation can be expected to favour social benefits policies to low- and medium-income groups (Mahler and Jesuit 2006). Indeed, Bradley et al. (2003) find that leftist government has a direct positive impact on redistribution while right-wing government tends to affect it negatively. They also point out that leftist government is highly correlated with union density and bargaining centralization, consequently, we do not consider these variables in the analysis. To check whether party orientation determines redistributive efficiency, we introduce the control variable "party orientation" concerning economic policy (right, centre and left) from the Database of Political Institutions (DPI). The estimate results are present in Table 4, models 5 and 6. We find that the party orientation does not affect redistributive efficiency and our main results do not change; additionally, our findings are complementary to Bradley et al. (2003) given that we focus on efficiency.

Moreover, Gupta et al. (2002) find that high levels of corruption lead to increased inequality in market income. Corruption involves the manipulation of public policies for private gain by the governing authorities. The authors argue that one possible channel operates by affecting redistribution programs of poor-income groups, such as siphoning

off or redirecting social transfers funds to benefits well-connected wealthy groups. Afonso et al. (2010b) argue that "good" quality of institutions (e.g., rule of law) is associated with less corruption, diminishing income inequality. In this context, we are interested in examining how corruption affects redistributive efficiency of fiscal policy. To do this, we introduce the variable "control of corruption" from the ICRG; the highest value of the variable represents least corruption and the lowest value represents more corruption. In addition, we exclude "government effectiveness" to estimates the base models given that both variables are high linked (correlation of 0.86); we would expect our corruption variable to directly impact redistributive efficiency. Note that the degree of corruption reduces the efficiency of politics and business, and also high corruption could lead in a fall of the government or restructuring of the country's political institutions (ICRG, 2013a). The estimate results are report in Table 4, models 7 and 8. We find a significant positive impact of "control of corruption" on redistributive efficiency, without substantially altering coefficients and significance of the rest of the variables. While previous studies provide evidence of the effect of corruption on income distribution, we present evidence that lower degree of corruption is significant and positively associated with more redistributive efficiency.

Furthermore, Adam et al. (2014) find a direct effect of presidential government on public sector efficiency. This is explained based on the fact that elected officials have incentives to perform well under presidential regimes because changes in the delegation of power are simpler than in parliamentary regimes (Persson and Tabellini 2004). To examine the potential effect of the forms of government on redistributive efficiency, we include the "presidential system" dummy variable in our baseline models that takes a value of 1 when the system of government is presidential regime, and a value of 0 otherwise (parliamentary or assembly-elected president), data are obtained from the DPI. The estimate results are reported in models 9 and 10, which describe an insignificant effect of presidential governments on redistributive efficiency. In conclusion, our empirical findings are robust in the face of each of these checks.

Table 4 – Robustness checks

Dependent variable – Efficiency score: (a) absolute and (b) relative redistribution outputs	Model 1 (a)	Model 2 (b)	Model 3 (a)	Model 4 (b)	Model 5 (a)	Model 6 (b)	Model 7 (a)	Model 8 (b)	Model 9 (a)	Model 10 (b)
Federalism	-0.014	-0.050***	---	---	-0.015	-0.056***	-0.014	-0.049***	-0.015	-0.049***
	(0.017)	(0.017)			(0.019)	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)
Regional Authority Index	---	---	-0.004*	-0.006***	---	---	---	---	---	---
			(0.002)	(0.002)						
Log of per capita GDP	-0.038	-0.044	-0.007	-0.002	-0.035	-0.043	-0.063	-0.056	-0.038	-0.046
	(0.064)	(0.062)	(0.066)	(0.062)	(0.065)	(0.058)	(0.046)	(0.043)	(0.065)	(0.063)
Elderly people (% of total population)	0.000	0.004	0.005	0.007	0.000	0.003	-0.002	0.002	0.000	0.004
	(0.013)	(0.013)	(0.015)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)
Unemployment rate	0.002	-0.005	0.003	-0.001	0.002	-0.004	0.004	-0.002	0.002	-0.006
	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)	(0.040)	(0.004)	(0.004)
Government effectiveness	0.054	0.144**	0.038	0.110	0.034	0.127*	---	---	0.054	0.148*
	(0.082)	(0.073)	(0.083)	(0.071)	(0.085)	(0.072)			(0.082)	(0.076)
Control of corruption	---	---	---	---	---	---	0.063*	0.099***	---	---
							(0.035)	(0.029)		
Ethnic fractionalisation	0.171	0.064	0.230*	0.137	0.124	-0.014	0.117	0.083	0.172	0.065
	(0.123)	(0.108)	(0.118)	(0.096)	(0.121)	(0.104)	(0.117)	(0.099)	(0.122)	(0.107)
Education inequality	-0.014	-0.952**	-0.018	-0.833**	-0.158	-1.261***	0.005	-0.925**	-0.013	-0.942**
	(0.375)	(0.403)	(0.369)	(0.387)	(0.416)	(0.432)	(0.342)	(0.365)	(0.376)	(0.396)
Democratic accountability	0.179***	0.141*	0.201***	0.142**	0.187***	0.135**	0.140**	0.084	0.180***	0.133*
	(0.064)	(0.073)	(0.063)	(0.064)	(0.066)	(0.066)	(0.062)	(0.067)	(0.064)	(0.071)
Debt fiscal rules	0.125**	0.022	0.142**	0.035	0.138**	0.054	0.126**	0.026	0.126**	0.021
	(0.057)	(0.047)	(0.056)	(0.040)	(0.057)	(0.049)	(0.054)	(0.044)	(0.057)	(0.047)
Party orientation: Right	---	---	---	---	-0.037	-0.025	---	---	---	---
					(0.075)	(0.070)				
Centre	---	---	---	---	0.031	0.068	---	---	---	---
					(0.081)	(0.076)				
Left	---	---	---	---	0.010	0.008	---	---	---	---
					(0.074)	(0.070)				
Presidential system	---	---	---	---	---	---	---	---	0.007	-0.049
									(0.088)	(0.090)
Region and period fixed effects:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald chi2	52.28	56.16	56.53	62.21	56.72	64.46	57.50	55.82	52.48	58.95
Log pseudolikelihood	158.843	184.656	153.410	183.471	155.654	179.644	160.483	188.003	158.85	184.88
Observations	140	140	136	136	135	135	140	140	140	140

Notes: All regression include a constant (not shown). Bootstrap standard errors are presented in parentheses. Level of significance: 10% (*), 5% (**) and 1% (***).
Source: Own estimations.

7. Conclusions

In this article, we empirically study the redistributive efficiency of fiscal policy instruments and their degree of decentralisation -transfers and direct taxes- for a sample of thirty-five countries during the 2000-2016 period, using a bootstrap DEA analysis. Given that we would expect to find that redistribution efficiency performance differs across countries and over time due to the influence of non-discretional or exogenous determinants, we also investigate the impact of demographic, economic, political and institutional factors on redistributive efficiency, applying bootstrap truncated panel regression techniques.

Our paper contains several contributions and findings. First, we analyse the redistributive efficiency of the fiscal policy instruments and their degree of decentralisation for a set of thirty-five countries composed of both developed and developing countries. Specifically, the study is novel in that it introduces fiscal size and their degree of decentralisation to compute efficiency scores and country efficiency rankings. Nevertheless, our outcomes indicate that fiscal decentralisation may not affect income redistribution efficiency. Second, we deliver new insight into the income distribution literature about the redistributive impact of the Great Recession. Contrary to the empirical literature on overall public sector efficiency, on average, we find that income redistribution inefficiency increasing over time. Thirdly, our analysis complements other recent works in this field by using different explanatory factors to explain redistributive efficiency variation across countries and over time. In particular, we account for federal political system as a proxy of political decentralisation and find that it is directly associated with less redistributive efficiency.

Moreover, the robustness tests include an alternative measure of “federalism”, additional explanatory factors (such as party orientation, control of corruption and presidential system) and alternatives standard error estimators, and do not substantially change our main conclusions.

Our agenda involves identify the weight of each input to explain its relative importance for efficiency score output. Advancement in this direction may contribute to a better understanding of the impact of fiscal instruments and decentralisation on redistribution efficiency.

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Appendix

Table A.1 – List of countries and regions

Code - Country	Code – Country
Southern Europe (SE)	*Developing countries (DC)*
GRC – Greece	CHL – Chile
ITA – Italy	SLV – El Salvador
PRT – Portugal	PER – Peru
SVN – Slovenia	ZAF – South Africa
ESP – Spain	
Eastern Europe (EE)	*(Other) Developed countries (ODC)*
CZE – Czech Republic	AUS – Australia
HUN - Hungary	CAN – Canada
POL – Poland	ISR – Israel
SVK – Slovak Republic	JPN – Japan
	USA – United States
Western Europe (WE)	
AUT – Austria	
BEL – Belgium	
FRA – France	
DEU – Germany	
LUX – Luxemburg	
NLD – Netherlands	
CHE – Switzerland	
Northern Europe (NE)	
DNK – Denmark	
EST – Estonia	
FIN – Finland	
ISL – Iceland	
IRL – Ireland	
LVA – Latvia	
LTU – Lithuania	
NOR – Norway	
SWE – Sweden	
GBR – United Kingdom	

Note: The list of geographic regions is from United Nations https://unstats.un.org/unsd/methodology/m49/
Source: Own elaboration.

Table A.2 – Definition of variables and sources

Variable	Definition	Sources
Federalism	Federalism involves 5 categories: 1, non-federal; 2, semi-federal (elective regional legislatures/constitutional sovereignty at national level); 3, federal (elective regional legislatures and constitutional recognition of subnational authority); add 1 if weak bicameral; add 2 if strong bicameral. Total range = 1-5, with higher values indicating more federal.	Gerring and Thacker (2004). Frequency data: one observation in 1997.
GDP per capita	Gross Domestic Product (GDP) in terms of population (constant 2010 U$S).	World Development Indicators (WDI). Frequency data: annual.
Elderly people	Population ages 65 years old and above.	WDI. Frequency data: annual.
Unemployment rate	Unemployment, total (% of total labour force) (modeled ILO estimate).	WDI. Frequency data: annual.
Ethnic fractionalisation	The probability that two randomly selected individuals belong to different ethnical groups, and so increase with the number of groups. Complete ethnic homogeneity (an index of 0) to complete heterogeneity (an index of 1).	Alesina et al (2003). Frequency data: one-year observation between 1979 to 2001.
Government effectiveness	Describes the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 (lowest) to 2.5 (highest).	World Governance Indicators (WGI) (Kaufmann et al. 2011). Frequency data: annual (except for 1996–2002, biannual data basis).
Education inequality	Gini coefficient for education, average years of schooling in the population 25 years old and above.	Castelló-Climent and Doménech (2014). Frequency data: five-year, from 1950 to 2010.
Democratic accountability	This is compute based on the type of the governance enjoyed by the country. The highest value (6) is assigned the lowest potential political risk (Alternating Democracies) and the lowest value (0) indicating the highest potential political risk (Autarchies) –total range = 0-6.	International Country Risk Guide (ICRG 2013). Frequency: annual data (from 1996 to 2002 biannual data).
Debt fiscal rules	Dummy variable: 1 if there is a debt rule, 0 otherwise.	Lledó et al. (2017). Frequency: annual data.
Regional authority index	The sum of "self-rule" and "shared-rule". See the article for full details.	Regional Authority Index (Hooghe et al. 2016). Frequency: annual.
Party orientation	Party orientation with respect to economic policy. Right: for parties that are defined as conservative, Christian democratic, or right-wing. Left: for parties that are defined as communist, socialist, social democratic, or left-wing. Centre: for parties that are defined as centrist or when party position can best be described as centric.	Database of Political Institutions (DPI) (Cruz et al. 2018). Frequency: annual.
Control of corruption	This is an assessment of the corruption within the political system. The highest value (6) is assigned the lowest potential political risk (least corruption) and the lowest value (0) indicating the highest potential political risk (most corruption).	ICRG. Frequency: annual data (from 1996 to 2002 biannual data).

Table A.2 (continuation) – Definition of variables and sources

Variable	Definition	Sources
Presidential system	Dummy variable = 1 if presidential system - president is elected directly by the people or by an electoral college, and also include system with unelected executive-, 0 if parliamentary or assembly-elected president.	DPI. Frequency: annual.

Source: Own elaboration.

Table A.3 – Descriptive statistics of input-output variables

Statistics	Input				Output	
	I1	I2	I3	I4	O1	O2
			2000 - 2004			
Mean	10.180	17.506	1.319	4.443	15.973	33.833
Std. Dev.	4.279	5.766	1.865	3.913	5.333	11.530
Min	0.708	5.578	0	0.102	1.360	2.895
Max	16.884	28.269	10.920	12.972	23.020	48.467
			2005 - 2009			
Mean	10.322	17.693	1.291	4.530	16.177	33.941
Std. Dev.	4.094	5.284	1.881	3.942	5.400	11.391
Min	2.188	7.000	0	0.173	2.200	4.909
Max	17.183	27.090	10.992	13.178	23.720	48.799
			2010 - 2014			
Mean	11.334	17.458	1.412	4.564	16.486	34.257
Std. Dev.	4.600	5.438	2.101	3.945	5.410	11.133
Min	1.735	7.725	0	0.228	2.900	6.161
Max	18.819	27.918	12.289	13.316	23.980	48.386
			2015 - 2016			
Mean	11.083	18.076	1.461	4.771	16.423	34.136
Std. Dev.	4.671	5.434	2.193	4.173	5.413	11.005
Min	1.728	8.354	0	0.189	2.850	6.064
Max	19.534	28.581	12.516	14.106	23.95	47.948

Note: O1 = absolute redistribution, O2 = relative redistribution, I1 = transfers at CG level, I2 = direct taxes at CG level, I3 = transfers at SNG level, I4 = direct taxes at SNG level. Number of countries: 35.
Source: Own estimations.

Table A.4 – Descriptive statistics of determinant variables

Variable	Observation	Mean	Std. Dev.	Min	Max
Federalism	140	2.086	1.386	1	5
Log of per capita GDP	140	10.239	0.815	7.901	11.584
Elderly people	140	15.208	4.151	4.160	26.290
Unemployment rate	140	8.384	5.125	2.962	31.326
Government effectiveness	140	1.253	0.629	-0.515	2.237
Ethnic fractionalisation	140	0.269	0.213	0.012	0.752
Education inequality	140	0.158	0.073	0.026	0.386
Democratic accountability	140	5.647	0.502	3.992	6
Regional authority index	136	13.252	10.767	0	37.44
Control of corruption	140	3.907	1.092	2	6

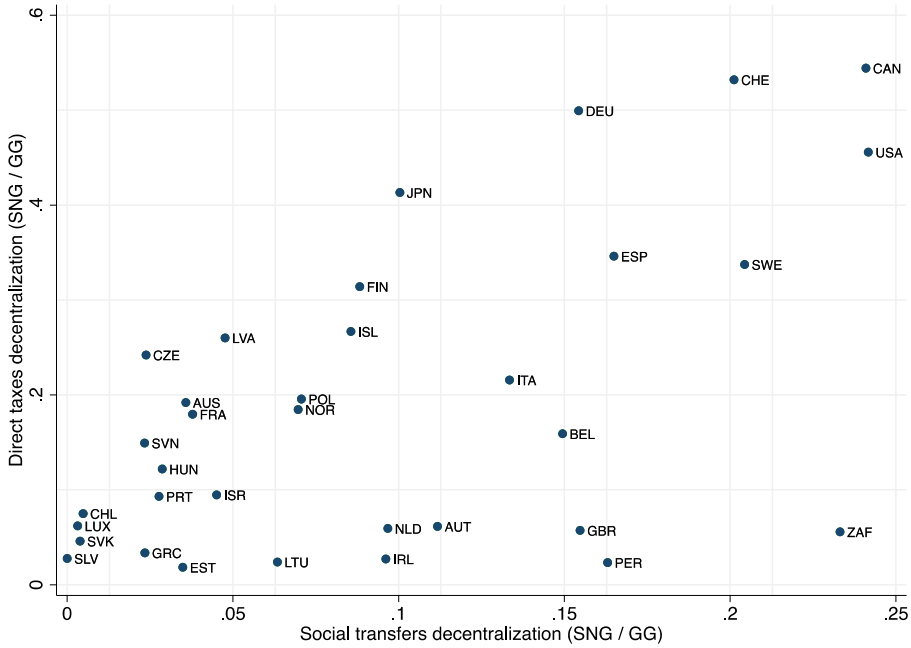
Note: The table presents the number of observations and summary statistics of the variables used in the second stage analysis (excluding the dummy variables).
Source: Own estimations.

Table A.5 – Truncated regression results by variance estimators

Estimator of variance	Bootstrap (benchmark model)		Robust		Cluster (at the region level)	
Dependent variable: Efficiency score	Output absolute redistribution (1)	Output relative redistribution (2)	Output absolute redistribution (3)	Output relative redistribution (4)	Output absolute redistribution (5)	Output relative redistribution (6)
Federalism	-0.014	-0.050***	-0.014	-0.050***	-0.014	-0.050**
	(0.017)	(0.017)	(0.015)	(0.015)	(0.027)	(0.023)
Log of per capita GDP	-0.038	-0.044	-0.038	-0.044	-0.038	-0.044
	(0.064)	(0.062)	(0.056)	(0.052)	(0.066)	(0.070)
Elderly people (% of	0.000	0.004	0.000	0.004	0.000	0.004
total population)	(0.013)	(0.013)	(0.013)	(0.012)	(0.008)	(0.008)
Unemployment rate	0.002	-0.005	0.002	-0.005	0.002	-0.005
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.006)
Government	0.054	0.144**	0.054	0.144**	0.054**	0.144***
effectiveness	(0.082)	(0.073)	(0.077)	(0.067)	(0.023)	(0.038)
Ethnic fractionalisation	0.171	0.064	0.171	0.064	0.171	0.064
	(0.123)	(0.108)	(0.117)	(0.097)	(0.215)	(0.181)
Education inequality	-0.014	-0.952**	-0.014	-0.952**	-0.014	-0.952*
	(0.375)	(0.403)	(0.328)	(0.403)	(0.305)	(0.487)
Democratic	0.179***	0.141*	0.179***	0.141**	0.179**	0.141**
accountability	(0.064)	(0.073)	(0.060)	(0.070)	(0.073)	(0.064)
Debt fiscal rules	0.125**	0.022	0.125**	0.022	0.125	0.022
	(0.057)	(0.047)	(0.057)	(0.043)	(0.079)	(0.088)
Region fixed effects:	Yes	Yes	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald chi2	52.28	56.16	64.50	72.84	---	---
Log pseudolikelihood	158.843	184.656	158.843	184.656	158.843	184.656
Observations	140	140	140	140	140	140

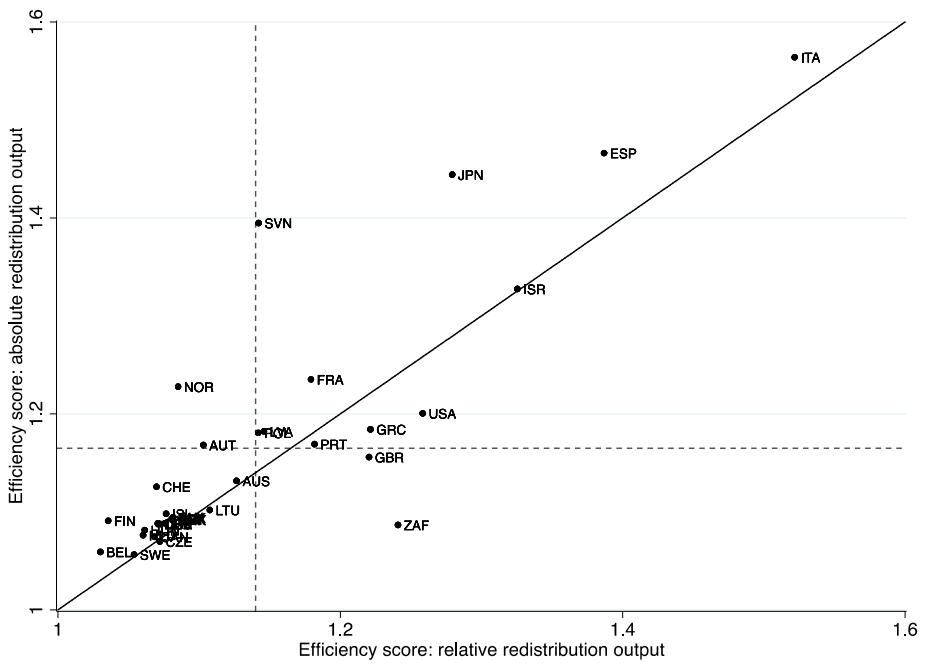
Notes: All regression include a constant (not shown). Standard errors are presented in parentheses. Level of significance: 10% (*), 5% (**) and 1% (***).
Source: Own estimations.

Figure A.1 – Fiscal decentralisation
(mean period 2000-2016)



Note: Excluding Denmark (decentralisation of transfers = 0.7 and direct taxes = 0.28) for reasons of clear plot representation. The country code and description are detailed in Table A.1 in the Appendix.
Source: Own elaboration based on data from IMF Fiscal Decentralisation dataset.

Figure A.2 – Efficiency scores of absolute and relative redistribution outputs
(mean period 2000-2016)



Note: Efficiency score: = 1 represents maximum efficiency and > 1 means greater inefficiency. The solid line represents the 45-degree line and the dash line represents the average of the axis variable. The country code and description are detailed in Table A.1 in the Appendix.
Source: Own estimations.

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