The big trade-off between efficiency and equity - is it there?

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Abstract

Widely quoted cross-country evidence finds income to be negatively associated with inequality, suggesting the absence of a trade-off between efficiency and equity. However this evidence implicitly assume that all countries are at the frontier in an efficiency-equity space. We refute this for most OECD countries, and find a best-practice frontier displaying a trade-off. In accordance with standard economic theory, a larger tax burden is associated with lower efficiency and more equity. Interestingly, the trade-off has not become steeper over the sample period 1980-2010. Country positions differ significantly with some being consistently at the frontier, while others are well inside the opportunity set.

JEL: D61, D63, E02, H2.
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1 Introduction[1]

The most essential trade-off in economics is that between efficiency and equity. Okun (1975) dubbed it the big trade-off and explained it by the metaphor of the leaky bucket: “The money must be carried from the rich to the poor in a leaky bucket. Some of it will simply disappear in transit, so the poor will not receive all the money that is taken from the rich”, Okun (1975, p. 91).

The standard textbook version is slightly more elaborate. Redistributive policies via taxes and regulation cause private returns to fall below social returns for various forms of economic activity distorting incentives and leading to sub-optimal outcomes and thus efficiency losses.[2] Hence, policies improving equity come at a cost in terms of lower efficiency. Political preferences determine the willingness to substitute efficiency for equity. Economists work out the shape of the trade-off, and policy makers determine where to situate on the trade-off. In a classic public economics textbook, Atkinson and Stiglitz (1980, p. 360) phrase it "Thus, the government may be seen as designing the tax schedule to balance the gains in distributional equity against the costs in terms of distorted decisions about work effort, the allocation of effort, savings, risk-taking, etc.".

The above-mentioned reasoning is complicated by the presence of market imperfections justifying policy interventions on efficiency grounds, leaving some scope to improve both efficiency and equity, see e.g. Aghion et al (1999). However, it does not negate that at some point further intervention would strike a trade-off between efficiency and equity. If the social welfare function is increasing in both efficiency and equity (as assumed in the standard reasoning), it is always optimal to intervene at least up to the point where a trade-off between efficiency and equity arises. That is, even if the opportunity set between efficiency and equity has a positively sloping segment to be exploited by policy intervention, these points are in welfare terms dominated by points further out at the negatively sloped segment of the opportunity set, for an example see Appendix C (online). Hence, if policies satisfy weak optimality criteria, the relevant part of the frontier at which countries ideally should be positioned has a negative slope in efficiency-equity space. In this paper we are interested in this part of the trade-off.[3]

Despite the profound importance of this trade-off, it is striking how little is known about it. In theoretical work it is often implicitly underlying optimal

[1] As a supplement to the main text, we have an extensive online appendix (Appendices C and D) available at: https://sites.google.com/site/jonasmaibom/research/work-in-progress

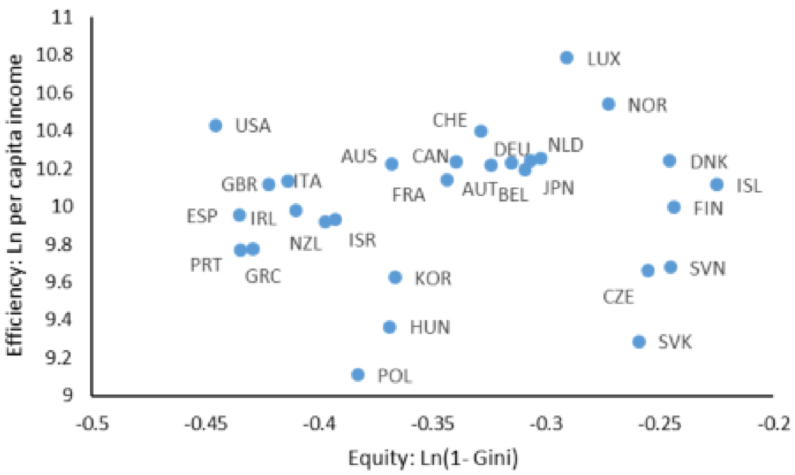
[2] Often efficiency is measured by economic activity (per capita income). While (in the absence of market imperfections) the efficiency loss is unambiguous, the specific effect of taxation on e.g. labour supply - and thus economic activity - is ambiguous due to oppositely signed substitution and income effects. When the former dominates, efficiency losses are related to employment and thus output.

[3] Obviously the are countries located on the upward sloping part of the frontier empirically (e.g. developing countries), either due to transition or political impediments. This may be one reason why the relation between growth and inequality is different for low-income and high-income countries as suggested by e.g. Barro (2000) and Castelló-Climent (2010). Here we focus only on OECD countries (excluding Mexico, Chile and Turkey).

(usually Utilitarian) policies but seldom explicitly worked out. In empirical work it is rare to find direct evidence of the trade-off[4]. Most applied work has focussed on the efficiency implications of taxation, unemployment insurance etc. being largely silent on the implications for equity. Work on inequality, on the other hand, is largely descriptive and focussed on country-specific changes over time. The two lines of research are rarely combined, implying that empirical knowledge on the precise form and slope of the trade-off is scant.

In policy reports and debates, the big trade-off frequently appears, and often per capita income is used as a measure of efficiency and the GINI coefficient for disposable income as a metric of equity. We plot such data for OECD countries in Figure 1.[5] Obviously, data like those used in Figure 1 takes a very broad and aggregate perspective on the trade-off. While numerous measurement issues can be raised on both the use of per capita income as a measure of efficiency and simple measures of income inequality (like the GINI coefficient) as a measure of equity, they are routinely used in cross-country comparisons. At the same time, if the trade-off is as profound as suggested by the economics literature, it should be expected to show up clearly in the data despite the measurement issues. It is therefore of interest to consider the lessons to be learned from cross-country data as is the aim of this paper.

Figure 1: Efficiency and equity, OECD countries 1995



Note: Efficiency is here measured by log Gross Domestic Product per capita, PPP US $, and Equity is log 1-Gini coefficient defined over equivalized disposable income. See Appendix

[4]For an early micro-approach see Browning and Johnson (1984).

[5]Considering countries at different levels of development and income levels is also problematic, since per-capita over time can be both positively and negatively related to income inequality, cf. the so-called Kuznets curve, Kuznets(1955). This may also be supported by theoretical work as many of the suggested channels which are found to be detrimental or instrumental for growth may vary with the level of development in the country as they depend on e.g. political instability, the initial distribution of wealth or other initial conditions (see e.g. Cinago, 2014 and Forbes, 2000 for references to theoretical work).

A for data definitions and sources, and Appendix D (online) for similar cross-plots for other years.

The cross-plot in Figure 1 does not display an apparent trade-off between efficiency and equity (inequality). Actually, the simple correlation between the two is positive (about 0.2 for the data depicted in the Figure), which at face value suggests that more equity is associated with more efficiency (or vice versa), see e.g. the widely cited book "The Spirit Level" by Wilkinson and Pickett (2009) and the OECD (2011). The position of some Northern European countries to the northeast in such graphs is also often interpreted as examples of how the trade-off has been escaped. A finding of a positive relation between per capita income and equality challenges standard economic theory and has potential wide ranging policy implications.[6]

But there are some more fundamental reasons why it would be misleading to draw policy conclusions from the correlation observed in data like in Figure 1. The statements about the trade-off in economic theory applies to the frontier of the possibility set derived by maximizing efficiency for a given level of equity or vice versa. At the frontier it is impossible to improve equity without harming efficiency, and vice versa. Inside the possibility set, clearly there is scope to make improvements both in the efficiency and the equity dimension. These considerations are of paramount importance in interpreting the data. There are numerous institutional, historical, and political reasons why particular countries may not be at the frontier in the efficiency–equity space. Taking this seriously makes it impossible to make inference about the trade-off simply on the basis of cross-plots as in Figure 1 or more sophisticated versions including various control variables. There is a fundamental difference between the scope for improvement in both the efficiency and equity dimension when policies for some reason are inappropriately set, and the trade-off available when such impairments are not present.[7]

The aim here is to identify the best-practice frontier from cross-country data, and use this to make inference about the relation between efficiency and equity. To this end, we use so-called stochastic frontier analysis to identify the best-practice frontier. This methodology is often used in microstudies of e.g. productivity differences across firms in specific sectors, but rarely in macro-

[6] Reflected in the fact that major institutions like the OECD, IMF and the World Bank recently have published studies on the nexus between inequality and economic growth, see e.g. Cingano (2014), Ostroy et al. (2014) and Brueckner and Lederman (2015).

[7] The litterature so far have focused on a standard growth equation relating output growth to initial income (convergence hypothesis), inequality and possible control variables or even county fixed effects. Such studies mostly find a negative effect of inequality. For a survey of this type of empirical analyses, see Cingano (2014). However this methodology does not distinguish between movements along the frontier and movements towards the frontier. Therefore if the distance to the frontier in the countries in the sample under investigation is changing over time this also translates into changes in economic efficiency confounding with changes in inequality. This makes inference from such analyses difficult to interpret, and this may be why such growth regressions have been shown to be quite unstable, see Banerjee and Duflo (2003).

contexts. This approach has the advantage (compared to the alternative, Data Envelopment Analyses, see Kumbhakar et al., 2000 for references) that it allows a statistical representation of the frontier explicitly taking into account the possibility of measurement errors and unobserved components influencing the trade-off.[8]

Identifying the best practice frontier immediately raises a number of questions. How is the relation between efficiency and equity along the best practice frontier (i.e. focusing on the best practice countries)? Has the slope of the trade-off changed over time, as being suggested, by drivers like globalization, technological changes etc.? Does a movement along the frontier by changing the tax burden release the effects (higher taxes: more equity and less efficiency) as predicted by basic economic insights? Which countries are at the frontier, and which are not? Is the distance to the frontier changing over time, and is it related to measures of institutional and political indicators often highlighted in comparative studies?

We address these questions based on OECD data and the main finding is that the best practice frontier does display a trade-off between efficiency and equity. We are not able to reject that the slope of the trade-off has remained stable across the sample period 1980–2010. Some countries, e.g. the US and Sweden, have experienced significant increases in inequality, but our results suggest that this is primarily attributed to a policy driven shift of position along the frontier (both countries are close to the frontier) accepting less equity to attain more efficiency. Other countries are well inside the opportunity set, suggesting that there may be scope for improvements both in the efficiency and equity dimension by reducing the distance to the frontier. Even if public intervention is measured coarsely by the tax burden, we find for the "frontier" countries that a higher tax burden is associated with lower efficiency and more equity as predicted by standard economic theory. The distance of a given country to the frontier is a metric of the importance of various political impediments, and the ranking of countries on the basis of this distance (scale factor) has remained fairly stable across time with a few notable exceptions, like Ireland having moved closer to the frontier, and New Zealand moving further away. Interestingly, in recent years there is a tendency that the distance to the frontier generally has been reduced (upward trend in scale factors).

The paper is organized as follows. Section 2 outlines the data used and the estimation methodology, and the main results on the efficiency-equity frontier are presented in Section 3. To analyse the mechanisms underlying the identified frontier, we consider the role of taxes for efficiency and equity in Section 4, while Section 5 considers whether the efficiency score of different countries can be related to institutional and political indicators. Section 6 gives a few concluding remarks.

[8] We specify the trade-off in terms of the output level as is standard in economic theory, and then later return to the growth issue as a robustness check and to assess whether the trade-off changes slope over time, see Section 3. We assume that countries in the sample face same trade-off but may differ in the distance to the frontier (are located inside the opportunity set).

2 Data and estimation methods

2.1 Data

We measure efficiency by average per capita income (in 2005 prices) and extract it from the WDI (World Bank Database). Equity is measured by the GINI coefficient calculated on the basis of disposable income, and data is extracted from the Standardized World Income Inequality Database (Solt (2009, 2016)). These are our prime data, but we also employ various control variables, cf below. Appendix A provides precise definitions of variables and gives the data sources. Our data set covers observations for 34 OECD countries at five-year intervals over the period 1980-2010. As discussed above, we focus on OECD countries to ensure that countries are close to the possibility frontier.[9]. MORE ON NORWAY LUCXEMBOURG

2.2 Stochastic frontier analysis

We approach our problem empirically by using stochastic frontier analyses (SFA).[10] The econometric model allows us to estimate a production possibility frontier (PPF) and readily gives a measure of how single countries are positioned relative to the frontier. SFA originated in two papers in 1977 (Meeusen & Van Der Broeck (1977) and Aigner, Lovell & Schmidt(1977)). The econometric model essentially takes into account that the data observed follow a data generating process which is "constrained" in the sense that countries can be below or at the frontier, but never above it (in the absence of random noise/measurement error). The data generating process (DGP) is thereby constrained, and failure to take this into account in specifying the econometric model may affect the estimates of the trade-off. This particular feature of the DGP also forms the basis of a test of the residuals from a linear regression (more below). Let the realized efficiency/output y_{jt} (per capita income) of a country j in period t be represented by a function:

$$y_{jt} = \xi_{jt} \cdot f(i_{jt}, \mathbf{z}_{jt}) \tag{1}$$

where $f(i_{ijt},\ \mathbf{z}_{jt})$ represents the maximum attainable efficiency in a country given a level of inequality i_{jt}[11] and other control variables $\mathbf{z}_{jt}$. The f-function thus represents the production possibility frontier. The term $\xi_{jt} \in (0, 1]$ is

[9] Norway and Luxembourg may be considered as outliers due to the role of oil and the financial sector respectively. We have retained these two countries in the sample, but in most regressions we include a country dummy for these two countries (our results are robust to excluding these countries entirely).

[10] The procedure is mainly used in operations research and production function estimations. Compared to traditional Data Envelopment Analysis (DEA), SFA has the advantage of being a stochastic estimation technique, hence allowing for statistical inference. Moreover, it allows for unmodelled factors and measurement errors.

[11] We formulate the frontier in terms of inequality rather than equality to ensure that the functional form estimated implies a convex opportunity set.

a scale factor[12] capturing that countries are either at or below the frontier. Specifically, $\xi_{jt} = \exp(-u_{jt})$ where $u_{jt} \geq 0$.[13] The scale factor captures country-specific reasons for not being at the best-practice frontier due to e.g. political or institutional factors. The formulation in (1) attributes all randomness in the data to the scale factor. To allow for country-specific random shocks and measurement error, an error-term is added to the model:

$$y_{jt} = \xi_{jt} \cdot f(i_{jt}, \mathbf{z}_{jt}) \cdot \exp(v_{jt}) \tag{2}$$

This specification allows for a separation between deviations from the PPF due to either the scale factor (ξ_{jt}) or unmodelled environmental variations or measurement error (v_{jt}). Taking logs (and choosing a functional form for the production function) we arrive at the estimating equation:

$$\begin{aligned} \ln y_{jt} &= \ln f(i_{jt}, \mathbf{z}_{jt}) + \ln \xi_{jt} + v_{jt} \\ &= \alpha + \gamma \ln(i_{jt}) + \beta \ln(\mathbf{z}_{jt}) - u_{jt} + v_{jt} \end{aligned} \tag{3}$$

The difference to a standard regression model is the composite term ($-u_{jt} + v_{jt}$), which consists of a "standard" error-term (v_{jt}) and the transformed scale factor ($u_{jt} \geq 0$). Since $u_{jt} \geq 0$, this term will be non-standard and skewed to the left. We procced to estimation by making distributional assumptions for the scale factor and the error term. Different models arise depending on whether ξ_{jt} is treated as a random effect (uncorrelated with variables i_{jt} and z_{jt}) or whether correlation with other explanatory variables are allowed for. From the estimated model we proceed by generating estimates of the composite term ($-u_{jt} + v_{jt}$). In a second step we use the Jondrow et. al (1982) estimator to decompose the error term and determine the size of the scale factor ξ_{jt} (thus scale factors are determined by: $E\left[\exp(u_{jt})|v_{jt} - u_{jt}\right]$).[14]

In our empirical analysis each country-time pair is treated as a single observation. Due to data limitations, we treat ξ_{jt} as uncorrelated with the explanatory variables in the estimations.[15] We therefore assume that both the scale factor (ξ_{jt}) and the error term (v_{jt}) are independent of $f(i_{jt}, \mathbf{z}_{jt})$, which is similar to the normal identifying assumption in OLS. Due to the limited number of observations in our data, we only work with "one-parameter" distributions for the scale factor (we estimate the variance in the distribution of the scale factor).

[12] In the literature it is denoted the inefficiency term capturing possibilities for improvement by moving closer to the frontier. To avoid confusion with the term efficiency in th economics literature, we term it the scale factor.

[13] I.e. u_{jt} (ξ_{jt}) is zero (one) for countries at the frontier, and higher (lower) values indicate the distance to the frontier.

[14] We have also tried alternative methods to predicting the scale factors. This does not affect our results below. For instance, the rankings (levels) of the efficiency scores in Table 2 does not change if instead the procedure suggested by Batese and Coelli (1988) is used.

[15] We have also explored some of the panel "fixed effect" frontier models, but as our data is limited, the estimates are not stable (and for some models not converging). We therefore prefer estimators which exploit all available variation. Therefore u_{jt} varies across both time and countries.

We try two specifications, the so-called half-normal model where the u_{it}'s are independently half-normally distributed $N^+(0, \sigma_u^2)$ and the exponential model where the u_{it}'s are independently exponentially distributed with variance σ_u^2.[16] The error term v_{it} is assumed iid $N(0, \sigma_v^2)$. The model (3) is estimated by a maximum likelihood method[17] which provides estimates of the parameters in (3) as well as σ_u^2 and σ_v^2.

Prior to frontier estimation it is possible to test for the presence of scale factors based on the residuals from an OLS regression of (3), see D'Agostino et al. (1990). Appendix B shows the density plot of the residuals from such a regression, and it shows that the density is skewed to the left and we formally reject the null of non-skewed residuals (p-value 0.0003). In practice this implies that OLS-estimations overpredict efficiency, and we take this as a clear indication of important unmodelled differences in the distance to the frontier in our data and thus further support for our procedure.

We include a full set of year dummies in z_{jt} to account for aggregate time effects. Naturally, per capita income in a given year may be affected by the country-specific business cycle situation which may contaminate the analysis which is about the underlying structural relation. The way data is combined and the approach of estimating a common slope parameter here minimizes the importance of a given country-specific observation being strongly affected by cyclical or temporary factors. Ideally, z_{it} should include all conditioning variables which affect both the level of inequality and output at a given point in time. Misspecification may confound the relationship between inequality and efficiency, implying that we do not recover the "true" frontier. In particular the extent to which countries face the same frontier can be discussed at length, and there are arguments why particular countries have unique possibilities unavailable to others. We take a parsimonious or pragmatic approach here based on the view that if a trade-off can be recovered using this approach, it gives a strong case for its presence. Moreover, (see Appendix D.3–6 (online)) we have included various control variables to capture country differences, and checked the robustness of the results to inclusion/exclusion of particular countries (the particular aspects relating to Norway and Luxembourg have been taken into account in the estimations, cf. above). None of these specifications seriously challenge the findings from the more parsimonious specification reported in the main text. However, due to its position in the north west corner, the U.S. is

[16] Kumbhakar et al. (2000) summarize some selected studies that all show that estimation of distributions with more parameters generally require more data.

[17] Hence, in the case of the normal/exponential model the likelihood function becomes:

$$\ln L = \sum_{i=1}^{N} - \ln \sigma_u + \frac{\sigma_v^2}{2\sigma_u^2} + \ln \Phi\left(\frac{-s\epsilon_i - \frac{\sigma_v^2}{\sigma_u}}{\sigma_v}\right) + \frac{-s\epsilon_i}{\sigma_u} \tag{4}$$

This expression is maximized to determine the parameter values yielding the highest probability possible given the data. The estimation strategy we follow consists of two steps. First, we estimate the parameters of the model. Then, conditional on these estimates, the technical efficiency term is estimated for each country by decomposing the composite residual term into a noise term and the scale factor term.

important for the estimated frontier relationship, see Appendix D.5 (online).

In the main text we report the results from the exponential model and standard errors which are calculated based on the outer product of gradients of the likelihood function. See Appendix D (online) for a robustness discussion and alternative estimations (half-normal model) and inference.

3 The best practice frontier

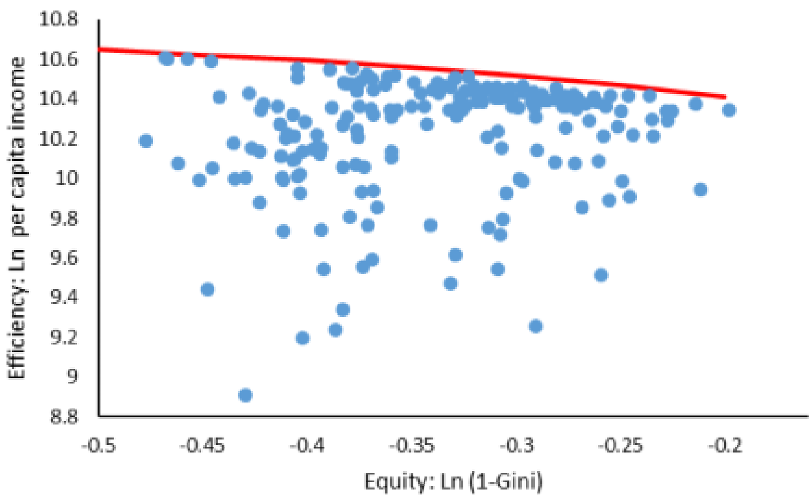
The key parameter of interest in the estimation of (3) is the slope parameter of the frontier (γ), and the estimate is reported in Table 1. The point estimate of the slope implies an elasticity of per capita income (efficiency) wrt. income inequality (1-equity) of 0.3. That is, along the best practice frontier an increase in inequality by 1% increases per capita by about 0.3%. In the table we also report the result of a standard OLS estimation pointing to a negative relation between inequality and efficiency. The importance of approaching the data explicitly taking the possibility frontier into account is thus clear. This is also supported by two tests. First, as mentioned earlier, the density of the residulas from the OLS model is skewed to the left, and we formally reject the null of non-skewed residuals (p-value 0.0003). Second, a likelihood ratio test of no differences in technical inefficiencies across countries ($\sigma_u = 0$) is rejected with a p-value of 0.001. The best practice frontier is illustrated in Figure 2 for the entire sample and in Figure 3 for a selected year.

Table 1: Relation between efficiency and equity

Dependent variable: ln(efficiency)	OLS	Frontier
Ln (Gini)	$-0.290**$	$0.304**$
	(0.151)	(0.089)
Constant	$9.41**$	$10.93**$
	(0.237)	(0.111)
$Ln(\sigma_v^2)$ (error term) (frontier only)		$-5.521**$
		(0.541)
$Ln(\sigma_u^2)$ (scale factor term) (frontier only)		$-2.265**$
		(0.181)
N	193	193

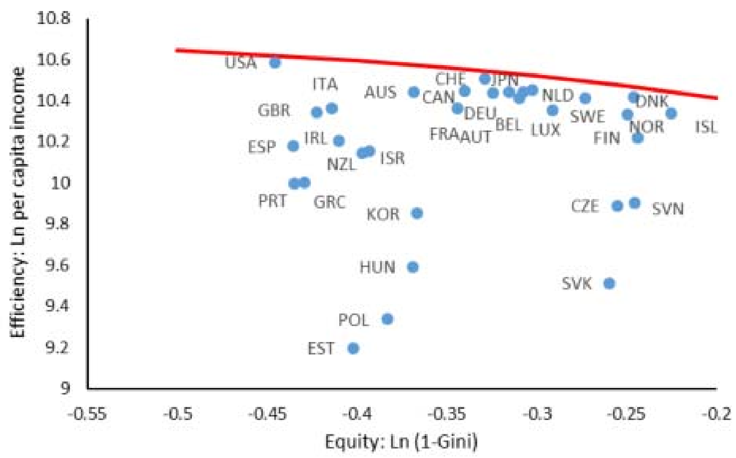
Note: Standard errors in parenthesis.*p<0.10. **p<0.05. The regressions include year dummies and dummies for Norway and Luxembourg (see complete regression output in Appendix D.4 (online)). For the OLS estimation the standard errors reported in brackets are Huber/White standard errors, and for the frontier regression we rely on standard errors calculated by the outer product of the gradients (in the online Appendix D3 we also report standard errors from a bootstrap procedure). The frontier model assumes that the scale factors are exponentially distributed. In Appendix D.5-6 (online) we provide further evidence of the estimated frontier relationship as further variables are added to the model.

Figure 2: Efficiency-equity frontier and sample observations



Note: Observations are corrected by the time-dummy and the noise term (v).

Figure 3: Efficiency-equity frontier and 1995 observations



The estimation merges data for the period 1980-2010, and the estimation is thus based on the premise that the slope of the best-practice frontier is unchanged across the sample period. This assumption is debatable, and in particular discussions about globalization and technological changes suggest that the trade-off has become steeper in recent times. We test the assumption of an invariant slope of the frontier within the sample period in several ways.

First, we consider whether the slope parameter displays any time dependence. We both estimate the best practice frontier for each year separately, and by removing one year at a time from the sample (results are available in Appendix D.3 (online)). Neither procedure gives strong evidence in support of a changing slope of the efficiency-equity frontier. In the former case there is a tendency that the slope becomes less steep from the 1980s into the 1990s, and then afterwards turns more steep. However, these estimations suffer from few observations, and the estimations are too imprecise to make any firm conclusions (estimates are within one standard error). In the latter case the estimations change very little (all estimates are within 0.5 standard errors of the benchmark estimate), and they do not support that there is a change in the slope of the efficiency-equity frontier.

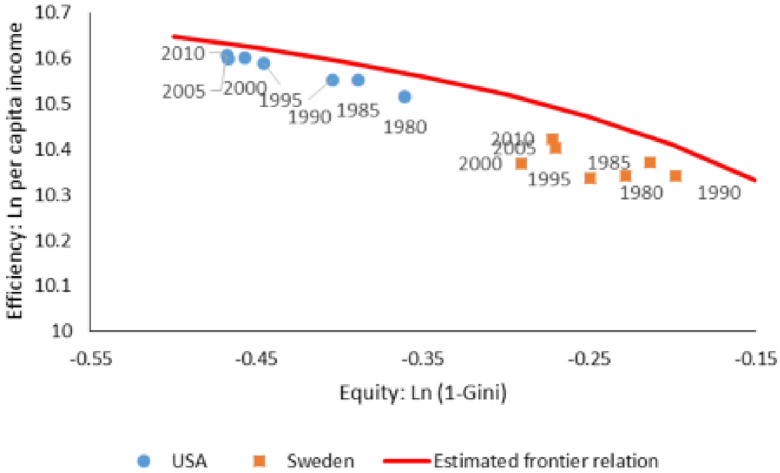
Secondly, we reformulated the best practice frontier to have output growth as the efficiency variable. Under the maintained assumption of a constant slope of the best practice frontier over the sample period, there should be no relation between output growth and inequality. Along the frontier, output growth is the same for all levels of inequality, corresponding to a parallel upward shift (but unchanged slope) of the best practice frontier between two observation points.[18] The estimation results from a simple OLS regression of the reformulated model are reported in Appendix D (online).[19] We are not able to identify any relation between growth and inequality along the frontier over the sample period, and hence this approach is not able to reject that the best practice frontier has an unchanged slope over the sample period. Finding no evidence of a changing slope of the efficiency-equity frontier is interesting in light of much discussion of such a change having taken place. Note also that this finding does not necessarily extrapolate to countries well inside the opportunity set (see also footnote 3).

Our findings stress the importance of distinguishing between changing position along the frontier, on the one hand, and inside the opportunity set, on the other. To illustrate, consider the US and Sweden; two countries often discussed because inequality has increased significantly in recent years. We plot the observations for these two countries together with the estimated efficiency-equity frontier in Figure 4. Consider first Sweden, which tends to be close to but not quite at the frontier (scale factor between 0.87 and 0.93, cf. below), and the distance has not changed much over the sample period. Sweden has clearly moved to the north-west accepting less equity and gaining more efficiency. More or less the same story applies to the US being close to the frontier with a scale factor between 0.95 and 0.97. This suggests that the developments in countries like the US and Sweden reflect political choices, and that the development in these countries is not prima facie evidence of a changed slope of the efficiency-equity frontier.

[18] In the base estimation we have included a time dummy and it captures the upward shift caused by growth.

[19] The results are similar if we restrict the sample to countries close to the frontier only.

Figure 4: US and Sweden move north-west



Note: The figure reports the individual predictions of the frontier model subtracted year effects (year dummies) and the noise term (v)

In Table 2 we report both the estimated scale factors and the efficiency ranking of the countries in the sample. It is seen that Sweden and the US consistently have been at (or very close to) the best-practice frontier. A general finding is a tendency in later years for the average scale factor to increase; that is, countries have in general moved closer to the best practice frontier (see year averages in the last row of the Table). Changes in country rankings reflect differences in relative performance. Ireland is an example of a country with a significant change in the scale factor (ranking) from 0.49(20) in 1985 to 0.93(6) in 2010.

Table 2: Level and rank of predicted scale factors

Country	ISO	1980	1985	1990	1995	2000	2005	2010
Australia	AUS	0.87 (8)	0.88 (10)	0.81 (14)	0.88 (12)	0.88 (13)	0.91 (10)	0.92 (9)
Austria	AUT	.	0.89 (8)	0.86 (9)	0.91 (9)	0.93 (5)	0.91 (11)	0.92 (7)
Belgium	BEL	0.88 (7)	0.90 (6)	0.89 (7)	0.90 (11)	0.88 (12)	0.89 (13)	0.90 (11)
Canada	CAN	0.92 (4)	0.94 (3)	0.91 (4)	0.91 (8)	0.90 (10)	0.91 (12)	0.90 (12)
Czech Republic	CZE	.	.	0.62 (20)	0.56 (24)	0.53 (26)	0.59 (25)	0.66 (23)
Denmark	DNK	0.88 (6)	0.95 (2)	0.87 (10)	0.95 (3)	0.94 (4)	0.93 (7)	0.90 (13)
Estonia	EST	.	.	.	0.25 (31)	0.31 (31)	0.42 (30)	0.43 (31)
Finland	FIN	0.79 (12)	0.86 (12)	0.86 (11)	0.79 (17)	0.82 (17)	0.85 (14)	0.86 (15)
France	FRA	0.81 (11)	0.80 (13)	0.82 (13)	0.83 (15)	0.82 (16)	0.80 (18)	0.78 (18)
Germany	DEU	0.85 (9)	0.89 (9)	0.89 (8)	0.92 (7)	0.89 (11)	0.84 (15)	0.89 (14)
Greece	GRC	0.64 (17)	0.60 (18)	0.55 (22)	0.55 (25)	0.56 (25)	0.63 (23)	0.61 (26)
Hungary	HUN	.	.	.	0.38 (29)	0.40 (28)	0.46 (28)	0.46 (29)
Iceland	ISL	.	.	.	0.90 (11)	0.91 (9)	0.94 (4)	0.91 (10)
Ireland	IRL	0.49 (20)	0.51 (20)	0.57 (21)	0.68 (19)	0.92 (8)	0.96 (2)	0.93 (6)
Israel	ISR	.	.	.	0.65 (20)	0.63 (21)	0.58 (26)	0.64 (24)
Italy	ITA	0.74 (14)	0.77 (14)	0.78 (16)	0.79 (16)	0.76 (19)	0.72 (19)	0.69 (21)
Japan	JPN	0.77 (13)	0.87 (11)	0.90 (5)	0.93 (5)	0.83 (15)	0.81 (17)	0.80 (17)
Korea	KOR	0.18 (22)	0.26 (22)	0.35 (24)	0.49 (27)	0.53 (27)	0.60 (24)	0.69 (19)
Luxembourg	LUX	0.60 (18)	0.66 (17)	0.79 (15)	0.86 (14)	0.92 (7)	0.94 (3)	0.94 (4)
Netherlands	NLD	0.93 (3)	0.92 (5)	0.90 (6)	0.94 (4)	0.96 (3)	0.94 (5)	0.96 (3)
New Zealand	NZL	0.70 (16)	0.75 (16)	0.63 (19)	0.64 (22)	0.62 (23)	0.65 (22)	0.64 (25)
Norway	NOR	0.82 (10)	0.89 (7)	0.83 (12)	0.92 (6)	0.92 (6)	0.93 (8)	0.92 (8)
Poland	POL	.	.	0.29 (25)	0.29 (30)	0.34 (30)	0.36 (31)	0.45 (30)
Portugal	PRT	0.47 (21)	0.48 (21)	0.53 (23)	0.54 (26)	0.57 (24)	0.54 (27)	0.55 (27)
Slovak Republic	SVK	.	.	.	0.38 (28)	0.37 (29)	0.45 (29)	0.55 (28)
Slovenia	SVN	.	.	.	0.57 (23)	0.62 (22)	0.68 (21)	0.69 (20)
Spain	ESP	0.60(19)	0.60 (19)	0.65 (18)	0.65 (21)	0.69 (20)	0.72 (20)	0.68 (22)
Sweden	SWE	0.90(5)	0.94 (4)	0.93 (3)	0.88 (13)	0.87 (14)	0.92 (9)	0.93 (5)
Switzerland	CHE	0.98(1)	.	0.98 (1)	0.97 (1)	0.96 (2)	0.94 (6)	0.96 (2)
United Kingdom	GBR	0.73(15)	0.76 (15)	0.74 (17)	0.77 (18)	0.80 (18)	0.84 (16)	0.82 (16)
United States	USA	0.95(2)	0.97 (1)	0.96 (2)	0.96 (2)	0.97 (1)	0.97 (1)	0.96 (1)
Year Average		0.75	0.78	0.76	0.73	0.74	0.76	0.77

Note: Scale factor is determined using the Jondrow et. al (1982) estimator (thus scale factors are determined by: $E[\exp(u_{jt})|v_{jt} - u_{jt}]$).We have also tried alternative methods to predicting the scale factors (e.g. Batese and Coelli (1988)). This does not affect our results.

From the table it is evident that while some specific countries have experienced significant changes in their scale factor over time (e.g. Ireland. Iceland. Germany). most countries do not experience large changes in their relative positions.[20] The spearman rank correlation matrix is reported in Table 3. A similar

[20] Consistent with the empirical results surveyed in Cinago (2014) in the context of panel

correlation table for the levels of the scale factors supports the same conclusions and is therefore not reported. Furthermore. a dynamic regression model on the levels of predicted scale factors: $\xi_{it} = \delta\xi_{it-1} + \varepsilon_{it}$ delivers an estimate of δ of 0.9 (standard error 0.017) showing strong persistence in country positions.

Having established the existence of a frontier and identified countries located at the frontier we proceed in the next section by analysing the impact of policy at the frontier.

data models. If a large part of the countries in a given sample does not change distance to the frontier studied country fixed effects will adequately control for differences in distance to the frontier across countries. See also Forbes (2000).

Table 3: Spearman rank correlation matrix

	1980	1985	1990	1995	2000	2005	2010
2010	0.6234	0.6195	0.6390	0.6870	0.8844	0.9519	1

Note: The table gives the spearman rank correlation between year t and 2010.

4 The role of taxes

The standard explanation of a trade-off between efficiency and equity is that the taxes needed to ensure a more equitable outcome distort incentives. which in turn causes efficiency losses. cf. introduction. Our approach so far treats the frontier as a reduced form relation subsuming the underlying mechanisms. To interpret the findings. it is of interest to relate the properties of the frontier to policy choices. A simple and crude approach can be taken by considering taxation (tax burden) as the policy instrument (a coarse metric of the extent of redistribution or public involvement in the economy). The best practice frontier is given as

$$y_{jt} = f(i_{jt}.\mathbf{z}_{jt}) \tag{5}$$

Let efficiency and equity be determined as follows

$$y_{jt} = g(\tau_{jt}.\mathbf{z}_{jt}) \text{ where } \frac{\partial g(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}} < 0. \tag{6}$$

$$i_{jt} = h(\tau_{jt}.\mathbf{z}_{jt}) \text{ where } \frac{\partial h(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}} < 0. \tag{7}$$

where τ_{jt} is the tax rate (burden) in country j in period t. A higher tax rate will thus lower output (y) and inequality (i). or vice versa. This captures the standard trade-off that inequality can be lowered by more redistribution (higher taxes). but it comes at a cost of lower efficiency here measured in terms of per capita income. The trade–off relation (5) follows straightforwardly from (6) and (7) as an implicit function[21], and we have

$$\frac{\partial y_{jt}}{\partial i_{jt}} |_{\mathbf{z}_j} = f_i(\cdot) = \frac{\frac{\partial g(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}}}{\frac{\partial h(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}}} > 0$$

The next step is therefore to decompose the slope of the frontier ($\frac{\partial y_{jt}}{\partial e_{jt}} |_{\mathbf{z}_i}$) into its two components: an efficiency part ($\frac{\partial g(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}}$) and an equity/inequality

[21] Invert $i_{jt} = h(\tau_{jt}, z_{jt})$ to read $\tau_{jt} = k(i_{jt}, z_{jt})$ and insert in $y_{jt} = g(\tau_{jt}, z_{jt})$, yields $y_{jt} = g(k(i_{jt}, z_{jt}), z_{jt}) \equiv f(i_{jt}, z_{jt})$.

part ($\frac{\partial h(\tau_{jt}.\mathbf{z}_{jt})}{\partial \tau_{jt}}$). The two components can in principle be determined empirically, but to proceed we need to take into account that some countries are well inside the opportunity set.

For the estimation we therefore select countries at or close to the frontier. We have employed various selection criteria and below we report the results when including countries either at or above rank 5 or 10 (the results are not sensitive to the particular cut-off point). Separately, we estimate how taxes affect efficiency and equity. Table 4 reports the estimations for different selection criteria for the "frontier" countries. Interestingly. the basic textbook insights are recovered. Higher taxes lead to lower income and less inequality.[22] It is noteworthy how clear the result comes out despite the very coarse approach taken.[23] The findings strongly stress the importance of carefully taking the distance to the frontier into account when interpreting cross-country evidence. For countries at (or close to) the frontier, there is a classical trade-off between efficiency and equity. For countries within the opportunity set, there is clearly scope for improvements both in the efficiency and the equity dimension. However, this is related to the impediments positioning these countries below the frontier (the estimates are only correlations), and hence it is not possible to conclude generally that an increase in taxes will increase efficiency and lower inequality. To illustrate this latter point, we re-run our regression on all countries, including a the predicted scale factors from our frontier model as a control variable measuring "distance to the frontier". The results (reported in column 4 of the table) suggest that the impact of taxes have the expected sign.

Table 4: Efficiency. equity and tax burden

	(1) All	(2) Rank 5	(3) Rank 10	(4) All - with controls
Dep. variable: ln(efficiency)				
Ln(taxburden)	0.360	-0.345^{**}	-0.286^{**}	-0.118^{*}
	(0.274)	(0.057)	(0.088)	(0.062)
Dep. variable: ln(Gini)				
Ln(taxburden)	-0.430^{**}	-0.645^{**}	-0.531^{**}	-0.379^{**}
	(0.089)	(0.123)	(0.105)	(0.102)

Note: a) All refer to all countries included,b) as in a and including controls for distance to frontier. Rank 5 (10) includes observations for countries having obtained rank 5 (10) or higher on the scale factor in a given year. The sample size is 35 (70 countries) in column 2(3). *p<0.10. **p<0.05. The table reports the results of simple OLS regressions regressing the

[22] Note that the coefficients estimated here do not imply the same elasticity between efficiency and equity as implied by the frontier estamation. Equivalence would require that the exogenous variables z are of no role, which is a strong assumption. The fact that the implied elasticities are close is taken as evidence that the parsimonious approach of neglecting the exogenous variables can be justified.

[23] Economic theory stresses marginal taxes as crucial for incentives and for labour supply along the extensive margin, the so-called extensive taxes. Both of these are only coarsely approximated by a measure of the overall tax-burden.

ln(taxburden) on either efficiency or equity measures. In column 4 we include the predicted scale factor as an explanatory variable in the regression. Standard errors are Huber/White.

5 Determinants of scale factors

Countries differ in their distance to the frontier, with some countries being systematically at or close to the frontier, while others are clearly inside the opportunity set. It is accordingly of interest to consider whether it is possible to identify some of the institutional and political factors which can help explain the position of countries vis a vis the frontier, cf. Table 2. In comparative studies references is often made to various institutional factors in accounting for country performances[24], and they also often appear in country league tables. We consider three such measures: globalization, trust and human capital. Do these measures help explain country performance in the efficiency-equity space?

Table 4 shows the correlation between the above-mentioned indicators and the scale factor for the countries.[25] They are all positively correlated with the scale factor suggesting that they play a role in accounting for country positions vis a vis the frontier.

Table 4: Pairwise correlations with predicted scale factor (level and rank)

Index	Correlation (levels)	Correlation (ranks)	Obs
Globalization	0.29	0.47	185
	(0.00)	(0.00)	
Trust	0.55	0.52	121
	(0.00)	(0.00)	
HC score	0.52	0.57	159
	(0.00)	(0.00)	

Pairwise correlation with the rank determined from scale factors. The three indices are KOF Index of Globalization. OECD index of human capital and a combined measure of trust (world value survey and Eurobar data). See Appendix D.8 for more details.

To asses which of the three indicators matters most for the "distance to the frontier", we standardize the variables and regress them on the predicted scale factors.[26] The regression output is presented in Appendix D.8 (online).

[24] See e.g. Alesina and Giuliano (2015) for a discussion and references.

[25] Appendix D.7 (online) gives more detail on the chosen metrics. Generally, some indices are challenged by not being available throughout the sample period and therefore the number of observations falls.

[26] It is well known that a second stage analysis with predicted scale factors is biased because the model estimated in the first stage is misspecified (important predictors in the second stage should have been included in the first stage also, see for instance Wang & Schmidt, 2002). In column 4 and 5 in Table 5 we assess the importance of this bias for our conclussions above by running two frontier models where important predictors are introduced as either i) affecting the variance of the scale factor (column 5) or ii) enters the conditioning set of the model. Both versions does not appear to change our findings above and thus the practical implication of this bias is very limited.

The R-squared of the regression is 0.44, and the strongest predictor of the scale factor is the index of trust (although not statically significantly different from the others), suggesting that the scale factor increases by 8% if trust increases by one standard deviation.[27]

Controlling for these institutional factors in the simple OLS-estimation should thus lead to an estimation of the trade-off coefficient closer to the one found in the frontier estimation. This is indeed what happens as seen from Table 3 (columns 2 and 3). Adding the metrics changes the sign of the OLS model, but the estimated trade-off is still below what is obtained in the frontier model (see column 3 and 4). We see this as further evidence supporting the importance of the frontier approach to assess the trade-off between efficiency and equity.

Table 5: The importance of controlling for distance to the frontier

	(1) OLS	(2) OLS	(3) OLS	(4) Frontier	(5) Frontier w. heterosked.
ln(*Gini*)	-0.290*	0.114	0.176	0.410**	0.393**
	(0.151)	(0.206)	(0.188)	(0.112)	(0.035)
Std_trust		0.187**	0.093**	0.108**	-0.739**
		(0.029)	(0.034)	(0.029)	(0.206)
Std_indexglobal			0.080**	0.050**	-0.709**
			(0.040)	(0.014)	(0.322)
Std_humancap			0.124**	0.092**	-0.250
			(0.032)	(0.002)	(0.238)
Observations	193	121	93	93	93

Note: Standard errors in parenthesis.*p<0.10. **p<0.05. Constant. Year dummies and Luxembourg and Norway dummies included in all regressions. Column 4 and 5 report versions of the Frontier model where determinants of the scale factors i) affect the variance of the scale factor (column 5) or ii) enters the conditioning set of the model (this adress the concern that our two stage analysis is biased, see e.g. Battese & Coelli (1995) and Wang & Schmidt (2002)).

6 Concluding Remarks

Economic theory posits a trade-off between efficiency and equity as a cornerstone for economic policy discussions. Yet, cross-country evidence seems to negate the presence of such a trade-off. However, in interpreting empirical observations it is crucial to take into account that countries can be at the frontier or inside the opportunity set. For OECD countries we find strong empirical support for such a "frontier" interpretation of the data. The frontier displays a trade-off between efficiency and equity, and a higher tax burden is associated with lower efficiency and more equity as predicted by standard economic theory.

[27] The results are robust to e.g. a Tobit model which takes into account that the scale factor is constrained between 0 and 1.

It is an implication that countries inside the opportunity set have scope for improvements in both the efficiency and equity dimension (a win-win situation). However, to infer which policy changes release such gains, it is necessary first to understand which barriers (institutional. political etc.) position countries inside the opportunity set. It is an interesting topic for further research to pursue this line of inquiry.

We find that there has been a given upward trend in efficiency scores across countries, i.e. a tendency that countries move towards the frontier. One possible explanation is the increasing focus on so-called structural reforms. It is an interesting question for future research to analyse whether the changing efficiency in particular countries can be explained by such reforms.

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Appendices

A Data - definitions and sources

Our data set includes 34 OECD countries. The data is primarily collected from 2 sources namely the SWIID5 database (Solt. 2009 & 2016) and the OECD database. The Gini index is based on income net of redistributions (post-tax and post-transfers) (source SWIID: http://myweb.uiowa.edu/fsolt/swiid/swiid.html). The Gini index measures the extent to which the distribution of income or consumption expenditure on an equivalenced scale within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality. while an index of 1 implies perfect inequality. We therefore define equity as 1-Gini.

The other variables are:

- The income measure is per capita GDP in PPP US $ in fixed prices, 2005 (source: OECD).

- Tax burden (Datasource: OECD. see also: http://www.oecd.org/employment/labour-stats/2771299.pdf)

We also use three different metrics of "social capital" in the text:

- An index covering investment in human capital. quality adjustment and outcomes (OECD Economic outlook database. see also: Kwon. Dae-Bong: "Human Capital and its Measurement". OECD World Forum).

- 2014 KOF Index of Globalization (http://globalization.kof.ethz.ch/)

- Trust data[28] (a mixture of EuroBar and the World Value surveys)

[28] We thank Christian Bjørnskov for making his data available.

Table A-1: Countries and observation indicators

	1980	1985	1990	1995	2000	2005	2010	Total
Australia	1	1	1	1	1	1	1	7
Austria	0	1	1	1	1	1	1	6
Belgium	1	1	1	1	1	1	1	7
Canada	1	1	1	1	1	1	1	7
Czech Republic	0	0	1	1	1	1	1	5
Denmark	1	1	1	1	1	1	1	7
Estonia	0	0	0	1	1	1	1	4
Finland	1	1	1	1	1	1	1	7
France	1	1	1	1	1	1	1	7
Germany	1	1	1	1	1	1	1	7
Greece	1	1	1	1	1	1	1	7
Hungary	0	0	0	1	1	1	1	4
Iceland	0	0	0	1	1	1	1	4
Ireland	1	1	1	1	1	1	1	7
Israel	0	0	0	1	1	1	1	4
Italia	1	1	1	1	1	1	1	7
Japan	1	1	1	1	1	1	1	7
Korea	1	1	1	1	1	1	1	7
Luxembourg	1	1	1	1	1	1	1	7
Netherlands	1	1	1	1	1	1	1	7
New Zealand	1	1	1	1	1	1	1	7
Norway	1	1	1	1	1	1	1	7
Poland	0	0	1	1	1	1	1	5
Portugal	1	1	1	1	1	1	1	7
Slovakia	0	0	0	1	1	1	1	4
Slovenia	0	0	0	1	1	1	1	4
Spain	1	1	1	1	1	1	1	7
Sweden	1	1	1	1	1	1	1	7
Switzerland	1	0	1	1	1	1	1	6
United Kingdom	1	1	1	1	1	1	1	7
United States	1	1	1	1	1	1	1	7
Total	22	22	25	31	31	31	31	193

Note: 1 indicates that an efficiency. equity observation exists in a given year.

B Residual plot

Below we plot the density of the residuals for a linear regression of log income on log(gini). The residuals are clearly skewed to the left, which can be seen as an indication of a misspecified DGP.

Figure: Residual plot