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Polarization, Inequality and Tax Reforms

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ABSTRACT

In this article, polarization measurement is presented as a useful tool for characterizing the net transfers of income between individuals caused by a tax reform. The bipolarization measure, which considers just two poles and represents the idea of the disappearance of the middle class, may complement inequality measures insofar as it provides an alternative explanation of the distributional impact of inequality neutral tax reforms. Some theoretical implications of an inequality- and revenue-neutral tax reform concerning polarization are examined. We conclude with an empirical application. A simulation to evaluate the effects on polarization of a potential substitution of the current Spanish tax system for an inequality- and revenue- neutral linear tax is carried out.

JEL Classification: D39, D63, H30.
Key Words: polarization, inequality, linear tax.

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1. Introduction

Recent tax system reforms in western economies provide evidence of an international trend towards the flattening of income tax structures. Efficiency gains are considered the main reason to move from a progressive tax system with graduated tax rates to one with a personal allowance and a single marginal tax rate. However, the redistributive pattern of linear tax reforms is complex and some careful analysis is required. In fact, it can be regarded as an application of a set of composite transfers, both progressive and regressive at the lower and higher tails of the initial distribution, respectively. In this context, we consider that not only inequality measurement but also polarization measurement has to be considered as far as the net transfers of these reforms are concerned[1].

Whereas inequality relates to the overall dispersion of the distribution, polarization concentrates on the income distribution on several focal or polar modes. A particular class of polarization is the bipolarization measure, which considers just two poles. Since, linear tax reform benefits both the poor and the rich, at the expense of the middle class, bipolarization measurement appears to be a useful tool for characterizing the net transfers of income between individuals caused by this kind of fiscal reform.

In this paper we analyze the effects of inequality- and revenue-neutral (non-necessarily linear) tax reforms. All possible scenarios of polarization changes are described in order to characterize the possible net transfers of a tax reform. Finally, a fiscal policy simulation is carried out to illustrate the theoretical results of the paper on bipolarization by substituting the Spanish tax system for an equivalent linear tax. We make use of the ECHP data set to carry out

[1] Many papers agree on the conceptual difference between polarization and inequality; see for instance, Wolfson (1994, 1997), Esteban and Ray (1994), Esteban, Gradín, and Ray (1999) and Rodríguez and Salas (2002).

the fiscal reform simulations.

2. Polarization versus Inequality

Polarization is a different concept from inequality as it has been formally defined in the literature. According to Wolfson (1994), a more bipolarized income distribution is one that is more spread out from the middle, so there are fewer individuals or families with middle level incomes. In addition, there is a sense that this spreading out is also associated with tendency towards bimodality, a clumping of formerly middle level incomes at either higher or lower levels.

Following Rodríguez and Salas (2002) approach, the Wolfson bipolarization index can be obtained by subtracting the within-groups from the between-groups Gini coefficients, computed for groups separated by the median value:

$$P_m = \frac{2\mu}{m}\left[G^B(F) - G^W(F)\right] \tag{1}$$

where m is the median, μ is the mean, G^B is the between-groups Gini coefficient and G^W is the within-groups Gini coefficient, computed for groups separated by the median value. Notice that the subgroup income ranges do not overlap, and therefore there is an exact decomposition of the Gini coefficient into between-groups and within-groups contributions. The conceptual advantage of this approach is that inequality and polarization can be viewed within the same framework,

with addition and subtraction of the within-groups component corresponding to inequality and polarization, respectively.[2]

Furthermore, Rodríguez and Salas (2003) proposed the *extended Wolfson bipolarization measure*: $P(v) = G^B(v) - G^W(v)$ in which the bipolarization measure depends on a sensitivity parameter v associated to the extended Gini coefficient defined by Donaldson and Weymark (1980) and Yitzhaki (1983).[3]

To illustrate the empirical difference between inequality and polarization, we present the values corresponding to the EU countries for the period 1993-1997 in Figure 1. We use micro-data drawn from the ECHP panel database.

We observe a high positive correlation between both variables. However, this does not imply a perfect correlation, as can be seen in Figure 1 where R^2=0.75. Moreover, the slope of the relationship between both variables is statistically different from 1.00 and the intercept is different from zero. Thus, polarization and inequality are also different concepts in empirical terms.

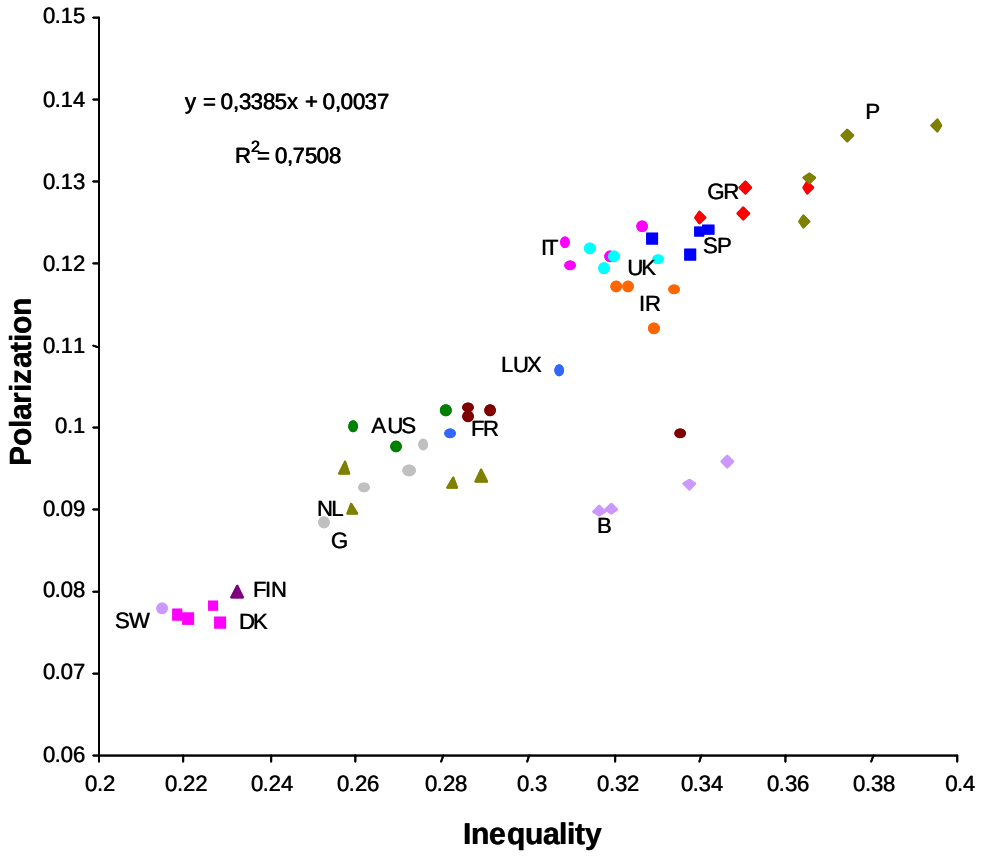
We also highlight differences among countries. Take for instance the case of Belgium versus Italy or the UK. Both sets of countries show the same inequality but different degrees of polarization (the polarization measure for Belgium is 0.9 compared with measures for Italy and the UK of around 0.12).If we compare Belgium with the Netherlands or Germany, on the other hand, it turns out that they have the same degree of polarization but different measures of

[2] It is a well-known result , see for instance Wolfson (1994, 1997) and Esteban and Ray (1994), that polarization is not consistent with the *principle of transfers*, the basic assumption in inequality measurement. Nonetheless, polarization is consistent with the principle of transfers between polar groups. This fact can be easily appreciated in expression (1).

[3] In Rodriguez and Salas (2003) is proved that given a particular income distribution X, the extended Wolfson bi-polarization measure, P(v), is consistent with the *second polarization curve* if $v \in$ [2, 3]. The second polarization curve plays a similar role in the context of bipolarization to that played by the Lorenz curve in the context of inequality (see Foster and Wolfson, 1992). A bipolarization index is consistent with the second polarization curve if a progressive median-preserving transfer within (between) polar subgroups never reduces (increases) polarization.

inequality (Belgium has an inequality measure of around 0.34 while that of the Netherlands or Germany is around 0.26).

Figure 1. Inequality versus polarization in the EU (1993-1997).



3. Theoretical Scenarios for the bipolarization Impact of a Tax Reform

We consider a tax reform and it is also assumed that behavior is unaltered by the tax system under consideration. As long as we consider a revenue- and inequality-neutral tax reform, polarization is the only variable that can change.

It has been told that polarization and inequality are different concepts. Now, we turn to the nature of the theoretical relationship between polarization and inequality. Unfortunately, we find that this relationship is not unambiguous in that positive or negative correlation between both terms depends on the variance of the within- relative to the between-groups Gini coefficients. Let us illustrate this result.

The covariance between the polarization and the inequality measures is given by:

$$Cov[G(v)P(v)] = E[(G(v) - E(G(v))(P(v) - E(P(v))] \tag{2}$$

If we substitute polarization and inequality indices for the within- and between-groups inequality terms, we obtain:

$$Cov[G(v)P(v)] = E[(G^B(v) + G^W(v))(G^B(v) - G^W(v)) - (G^B(v) - G^W(v))E(G^B(v) + G^W(v)) \tag{3}$$

and after tedious calculation we conclude that:

$$Cov[G(v)P(v)] = Var(G^B(v)) - Var(G^W(v)) \tag{4}$$

Therefore, polarization can increase, decrease or be constant whenever an inequality-neutral tax reform is considered. We thus identify three possible scenarios. We are going to show that polarization goes along with the between-groups inequality component in this context.

<u>Scenario 1</u>: *Polarization remains unchanged.* Not only do the revenue and inequality measures

remain unchanged but also the polarization measure remains unchanged. As $G(v) = G^B(v) + G^W(v)$ and $P(v) = G^B(v) - G^W(v)$, $G^B(v)$ and $G^W(v)$ have to remain constant as well.

<u>Scenario 2</u>: *Polarization increases.* The polarization measure increases when $G^B(v)$ goes up, $G^W(v)$ goes down, or both indices increase and decrease at the same time. However, when the extended Gini coefficient is unchanged, only the last option is possible. Thus, the extended between-groups Gini index increases and the extended within-groups Gini coefficient decreases in this scenario.

<u>Scenario 3</u>: *Polarization decreases.* By similar reasoning, the extended between-groups Gini index decreases and the extended within-groups Gini coefficient increases under this scenario.

<u>Proposition</u>: Let consider an inequality-neutral tax reform, then polarization changes along with the between-groups inequality component:

$$\Delta P(v) > 0 \Leftrightarrow \Delta G^B(v) > 0 \tag{5}$$

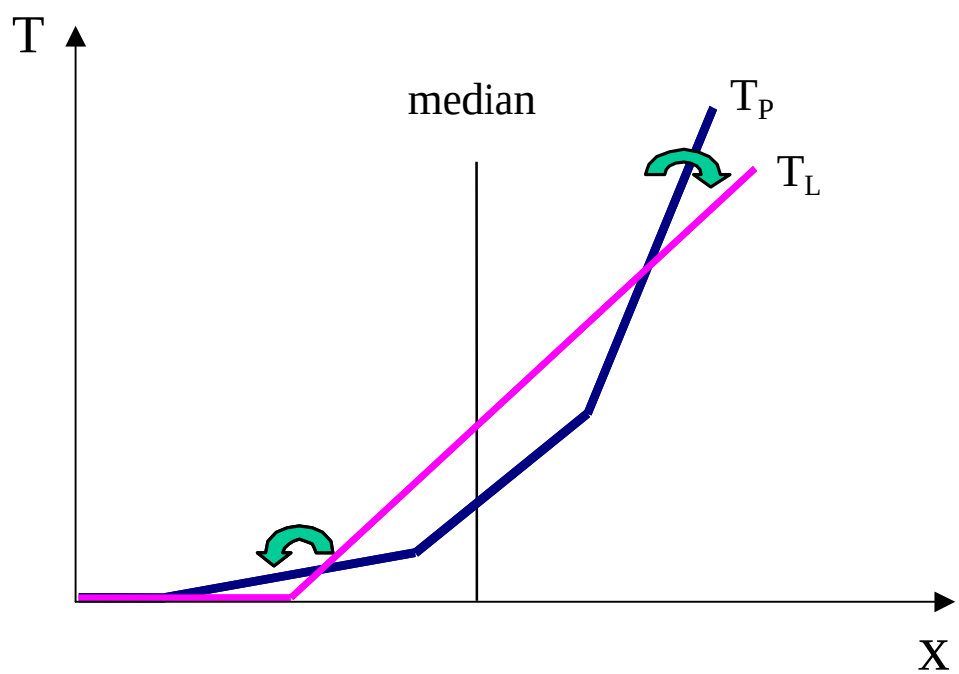
$$\Delta P(v) = 0 \Leftrightarrow \Delta G^B(v) = 0 \tag{6}$$

We can illustrate the intuitions and implications of this result with the following exercise. Let consider a revenue- inequality-neutral exercise that changes from a piecewise increasing marginal tax rate system T_P to a linear tax T_L reform, defined as:

$$T_L(x) = \begin{cases} (x - A)t & x \geq A \\ 0 & x < A \end{cases} \tag{7}$$

where t is the marginal tax rate and A is the personal allowance or the minimum threshold below which tax liability is zero.

Figure 2. Scenario 1: polarization unchanged

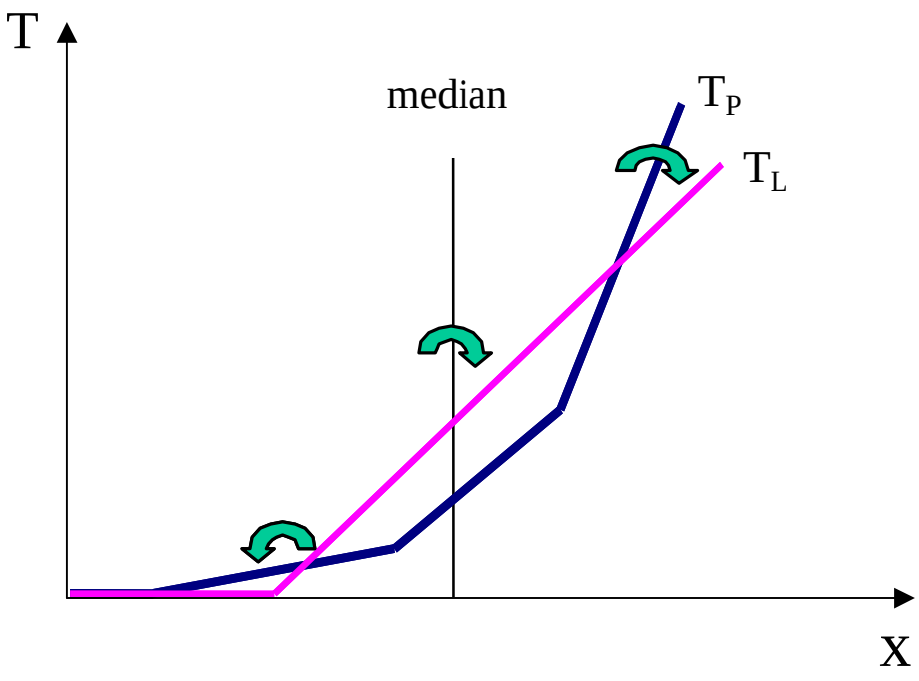


The whole population is separated into two groups by the median value and a piecewise progressive income tax structure (T_P line in Figure 2) is substituted by a linear tax system (T_L line). On the one hand, there cannot be any transfer between both groups when the extended between-groups Gini coefficient, $G^B(v)$, has to remain constant. On the other hand, a linear tax reform benefits both the poor and the rich, at the expense of the middle class, as can be observed

in the Figure 2. This means that two sorts of income transfers within the groups are occurring at the same time: a progressive income transfer within the poorest group and a regressive income transfer within the richest group. Moreover, in order to obtain unchanged extended within-groups Gini coefficient, $G^W(v)$, the progressive and the regressive transfers have to exactly compensate to each other.

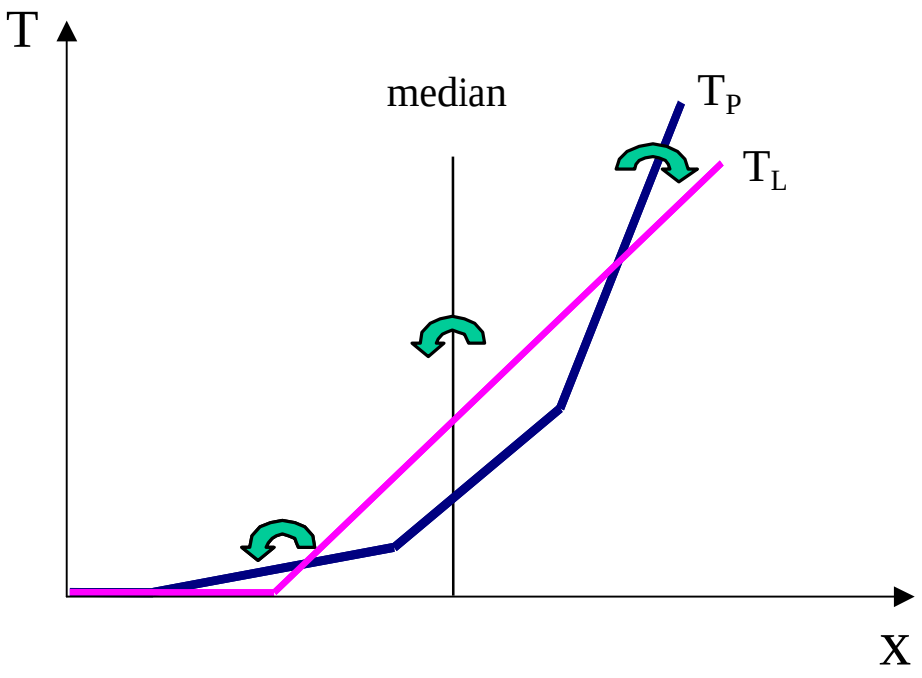
Figure 3 represents the second scenario when polarization increases. The income transfer between both groups is regressive and the progressive transfer within the poorest income group overcomes the regressive transfer within the richest income group.

Figure 3. Scenario 2: polarization increases



In Figure 4 (scenario 3) the income transfer between both groups is progressive and the regressive transfer within the richest income group overcomes the progressive transfer within the poorest income group.

Figure 4. Scenario 3: polarization decreases



Therefore, the analysis of a revenue- and inequality-neutral tax reform through its effects on polarization allow us to characterize in a very simple way the different sort of transfers that occur between and within the income groups.

4. A linear tax simulation exercise

In this section we carry out two simulation exercises in order to evaluate the empirical effects of the substitution of the Spanish tax system for a revenue- and inequality-equivalent linear tax. We use micro-data drawn from the ECHP panel database for 1997. The sample comprises 13,705 individuals. The equivalent income Y^e is computed using the Buhmann *et al.* (1988) and Coulter *et al.* (1992) parametric equivalence scale

$$Y^e = \frac{Y}{N^\alpha} \tag{8}$$

where N is the household size and α is the equivalent scale parameter in the household. All observations are weighted according to the number of persons in the household. In this illustration we do not consider the statistical inference problems dealt with in Davidson and Duclos (2000). We also ignore the measurement errors due to contaminated data dealt with in Cowell and Victoria-Feser (1996).

The effects on polarization change resulting from this tax reform are unknown even in this simple exercise. Two different simulations are carried out with different impacts on polarization change, each of them corresponds to Scenarios 2 and 3 of the theoretical section. Therefore, we can link in a very comphensive way these results with the set of the net transfers involved in either case.

On top of that, one important aspect related to such a reform arises. The design of the threshold matters. In the baseline simulation exercise, a constant individual nominal threshold (CINT) is imposed. For example if we establish CINT=1,000 euros, the household allowance

will be then A=1,000N.

The alternative exercise assumes a constant individual equivalent threshold (CIET). The individual equivalent threshold is constant for all individuals, in equivalent-income terms, regardless of the household size. If we set CIET=1,000 euros, the household allowance will be $A=1{,}000N^{\alpha}$ euros. This is an interesting exercise, as it does not incorporate any source of horizontal inequity due to the threshold.

Results under the baseline simulation are presented in Table 1, where marginal tax rates and income thresholds (t*, m*) are shown for different equivalent scales and different extended Gini inequality aversion parameters.

In fact the exercise can be done for any S-convex inequality index. Given any inequality index that satisfies continuity and S-convexity (symmetry and the principle of transfers), Davies and Hoy (2002) show that the substitution of the existing graduate rate tax for the proposed linear rate tax, with revenue and inequality neutrality, guarantees a single crossing of the Lorenz curves associated to the post-tax income distributions. In turn, this generates a unique solution (t*, m*) for any S-convex inequality index.

We adopt the extended Gini coefficient $G(v)$ because it is consistent, under a single Lorenz intersection, with the $v+1^{th}$-order inverse stochastic dominance (Zoli 2000 and Aaberge, 2000). The inverse stochastic dominance was defined by Muliere and Scarsini (1989) in a dual way to the classical direct dominance, except that successive cumulation is carried out with respect to ordered individuals instead of income. For this reason, this dominance criterion is connected with the principle of positional transfer sensitivity (Zoli 1999) and the rank-dependent Yaari welfare evaluation functions consistent with this principle (Yaari, 1987 and

1988). [4]

Table 1: Linear tax simulation under constant revenue and vertical redistribution

	1997 Tax System		Baseline simulation		
	S-Gini Coefficients	Bipolarization	Threshold CINT (Euros)	Marginal Tax Rate	Bipolarization
Alpha=0.25					
v=1.5	0.2142	0.0526	4233.80	30.7759	0.0760
v=2.0	0.3291	0.1263	4155.06	30.1661	0.1467
v=2.5	0.4035	0.1853	4108.09	29.8087	0.2036
v=3.0	0.4568	0.2264	4126.58	29.9488	0.2436
Alpha=0.50					
v=1.5	0.2093	0.0493	4006.79	29.0518	0.0730
v=2.0	0.3210	0.1209	3778.84	27.4169	0.1335
v=2.5	0.3932	0.1781	3670.91	26.6752	0.1869
v=3.0	0.4451	0.2184	3617.38	26.3144	0.2239
Alpha=0.75					
v=1.5	0.2121	0.0460	3738.94	27.1405	0.0545
v=2.0	0.3235	0.1174	3474.10	25.3795	0.1130
v=2.5	0.3951	0.1749	3312.69	24.3722	0.1668
v=3.0	0.4466	0.2149	3198.69	23.6861	0.2034

Source: ECHP database 1997. Sample size (N): 5427 households (13705 individuals).

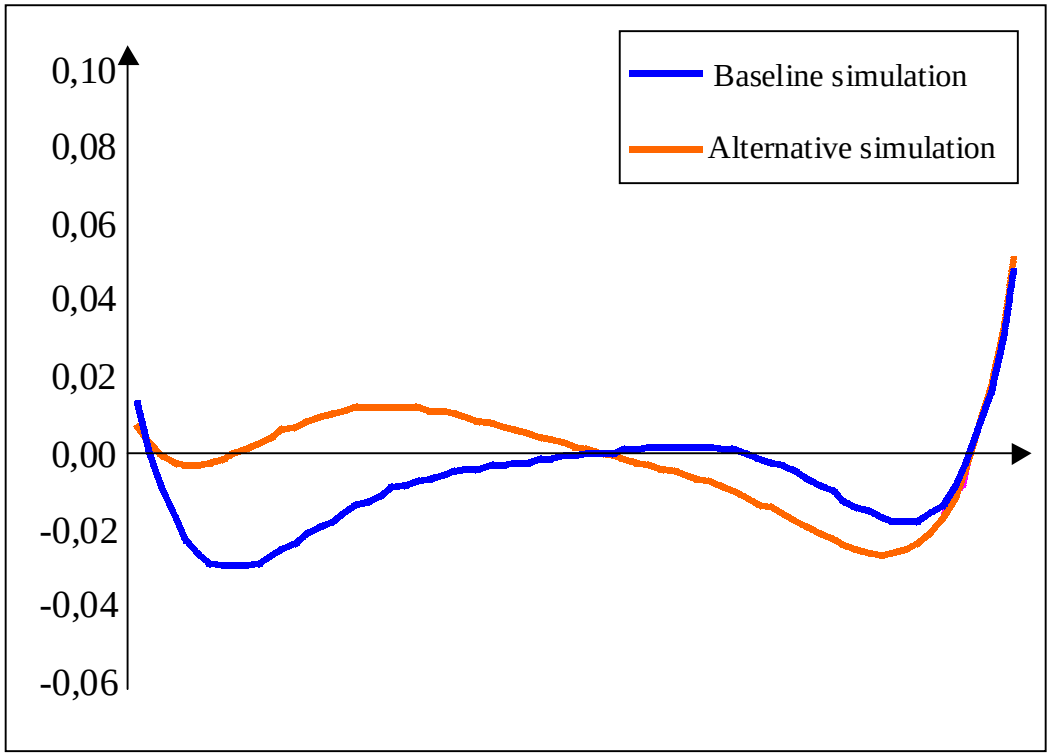
It can be observed that linear tax reform increases bipolarization (except from $\alpha = 0.75$ and $v \geq 2$). Therefore, in this simulation we are in Scenario 2, where between-groups inequality is increased and within-groups inequality is reduced (see Figure 3).

Furthermore, in Figure 5, we present the relative income gains by centiles derived from the reform under consideration. In general terms, it is observed that losses are concentrated on

[4] We could also apply the well-known result on third-order direct stochastic dominance (Shorrocks and Foster, 1987, Dardanoni and Lambert, 1988 and Davies and Hoy, 1994, 1995). In this case, the rule of thumb is the variance coefficient. This dominance criterion is connected with the principles of diminishing transfer (Kholm, 1976) or transfer sensitivity (Shorrocks and Foster, 1987) and it is consistent with all the expected utility welfare evaluation

two polar nodes of the income distribution, corresponding to the lower-middle and to the upper-middle classes. Winners are concentrated in both extremes of the income distribution. Therefore polarization is increased.

Figure 5. Relative income gains due to the Tax Reform by centiles



Thus, real-data results confirm the theoretical result regarding the net transfers within the middle-class income levels highlighted in Section 3 and summarised by the idea underlying Figure 3. In this context, our linear tax reform simulation is, in most cases, consistent with a *regressive* net transfer from lower-middle to upper-middle income individuals.

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functions that satisfies monotonicity, concavity and non-decreasing third derivative. In this case, we attain critical t*=0.33 and m*=4,500 euros, given α=0.5, for which there is third-order stochastic dominance.

However, polarization change is different under the alternative simulation. Indeed polarization decreases as it can be seen in Table 2. Then, Scenario 3 is the relevant one. From the theoretical framework must be a progressive transfer from upper-middle to lower-middle class, which is confirmed in Figure 5.

Table 2: Alternative linear tax simulation

	Alternative simulation		
	Threshold CIET (Euros)	Marginal Tax Rate	Bipolarization
Alpha=0.25			
v=1.5	8449.25	25.9155	0.0393
v=2.0	7990.32	24.7032	0.1055
v=2.5	7545.36	23.5860	0.1634
v=3.0	7228.04	22.8253	0.2038
Alpha=0.50			
v=1.5	6406.57	26.2269	0.0432
v=2.0	6103.78	25.1168	0.1079
v=2.5	5940.87	24.5402	0.1617
v=3.0	5726.28	23.8036	0.2001
Alpha=0.75			
v=1.5	4892.41	26.7180	0.0441
v=2.0	4578.64	25.1447	0.0923
v=2.5	4358.46	24.0967	0.1538
v=3.0	4202.22	23.3830	0.1927

Source: ECHP database 1997. Sample size (N): 5427 households (13705 individuals).

5. Concluding remarks

This article evaluates the polarization effects of inequality- and revenue-neutral tax reforms. Indeed, it can be shown that results are maintained under non revenue-neutrality. The

set of net transfers that these fiscal reforms generate is characterized. Using the *extended Wolfson bipolarization measure*, all potential polarization scenarios are identified, from a theoretical point of view, and it allows us to characterize the net transfers that this tax reform would produce. One important result is that bipolarization changes along with between-groups inequality: bipolarization goes up (down) if and only if between-groups inequality goes up (down). We illustrate this intuition by making use of graphical analysis applied to linear tax reforms.

We have carried out two simulations with opposite results on polarization. Despite, both cases match very well with our theoretical framework. Hence, the proposed theoretical scenarios can be used to anticipate the distributive effects of a tax reform with a minimum requirement of information. In the same way, these results can be extended to many other examples such as public utility pricing reforms or more general inequality-neutral public policy reforms.

A by-product result of the specific linear tax reform under consideration is that the design of the thresholds matters, from the distributive point of view, even if we consider an inequality-neutral tax reform.

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