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Abstract

Income polarization adds to the literature of income distribution by providing information on poles of the distribution of income. Yet little is known about this issue in Europe. This paper explores income polarization and its determinants for 20 European countries over the period 2004-2013 based on EU-SILC micro data and Shapley decomposition. The results suggest that income polarization is rather low in Europe, although rising in West-EU15 countries during 2004-2008, but declining afterwards. The opposite development is witnessed for Central and Eastern European New Member States. Moreover, in most cases, market income induced higher polarization while tax-benefit systems were polarization-reducing.

JEL Classification: I32, H53, H55

Key-words: income polarization, inequality, EU-SILC, Shapley decomposition

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1. Introduction

In the comparative welfare state literature, many empirical analyses have relied on popular income inequality measures, such as the Gini coefficient and median (equivalized) income, to investigate changes in the middle of the distribution. Recently, increasing attention has been paid to the notion and measurement of income polarization (Petrarca and Ricciuti, 2015; Seshanna and Decornez, 2003; Taptué, 2015a, 2015b). Income polarization is different from income inequality. While the latter concerns the distances of different individuals in a society from the population mean, the former focuses on income differences and income clusters, comparing the homogeneity within a group with the overall heterogeneity of a given population (Castro, 2003). Suppose that a distribution is divided into several groups. When individual incomes in a group become less dispersed, within group income inequality would be lower, therefore leading to lower total income inequality. However, clustering of individual incomes towards poles means a higher polarization. The concept of income polarization is also different from ethnic or job polarization, since in the latter case people are divided into groups by ethnic background or job rather than income. So far economists usually focus on income polarization, which refer to the disappearance of the middle of the income distribution (Gornick and Jäntti, 2013).

The basic idea of a polarization indicator is to capture the potential conflict in a given distribution (Duro, 2005b; Esteban and Ray, 1999, 2011). A well-off middle class is important to every society since it is associated with high income, high economic growth and social and political stability (Easterly, 2001; Pressman, 2007). In contrast, high income polarization may lead to the emergence of social conflict, social unrest and tension since it implies a 'divided society' (Duro, 2005a; Esteban and Ray, 1994, 1999; Gradín, 2000; Zhang and Kanbur, 2001). While both income polarization and income inequality reflect the changes in the middle of the income distribution, it is income polarization that may give rise to social tension and social and political conflict (Esteban and Ray, 1994).

Besides social unrest and conflict, income polarization may generate several harms. First of all, a highly income polarized society means less social mobility since the relatively poor may face difficulties in moving up the income ladder (Motiram and Sarma, 2014). Income polarization further affects economic growth (Brzezinski, 2013; Ezcurra, 2009). One reason is that social conflict and political instability underlying income polarization may negatively disrupt market activities and labor relations and reduce the security of property rights (Keefer and Knack, 2002). Moreover, income polarization harms health since increase in social tension and conflict creates psychosocial stress and reduces the provision of certain public goods (Pérez and Ramos, 2010).

The issue of income polarization has received wide attention outside Europe, for instance in China (Araar, 2008; Zhang and Kanbur, 2001), in India (Chakravarty and Majumder, 2001; Motiram and Sarma, 2014), in Nigeria (Awoyemi and Araar, 2009; Clementi et al., 2015), in Latin American countries (Deutsch et al., 2014; Gasparini et al., 2008) and in more developed countries like the United States and Canada (D'Ambrosio and Wolff, 2001; Foster and Wolfson, 1992, 2010). However, studies on income polarization for European countries are relatively rare. Especially, little attention has been paid to income polarization in Central and Eastern European New Member States (CEE NMS). In literature only case studies have been applied for Denmark (Hussain, 2009), Germany (Gigliarano and Mosler, 2009), Italy (D'Ambrosio, 2001; Poggi and Silber, 2010), Poland (Brzezinski, 2011) and Spain (Gradín, 2000). Few cross-country

comparisons can be found for a limited number of European countries (Atkinson and Brandolini, 2013; Brzezinski, 2013; Chakravarty and D'Ambrosio, 2010; Esteban et al., 2007; Seshanna and Decornez, 2003).

Hence, we first make a contribution to the literature to track the trends in income polarization in 20 European countries, including the CEE NMS. With respect to the recent European Union (EU) enlargement it is particularly interesting to see how the CEE NMS compare to the well-established welfare states of Western Europe. We split the time-series 2004-2013 into two, using 2008 as the mid-point to investigate effects before and since the Great Recession.

Second, we add to the existing literature on the relationship between income polarization and income inequality by using cross sectional time series data for the 20 European countries between 2004 and 2013. We decompose income polarization by the identification-alienation framework proposed by Duclos et al. (2004). As such, we examine to what extent changes in income polarization are driven by changes in income inequality between groups (alienation) and changes in identification within groups. Hussain (2009) shows that the increasing alienation matters more for the increasing polarization in Denmark between 1984 and 2002.

Furthermore, the impact of the tax-benefit system on income inequality indicators as the Gini coefficient has been widely studied, but not the impact on income polarization. Only Araar (2008) decomposes income polarization at one moment in time for China, and Gradín (2000), and Wang and Wan (2015) study country-cases of Spain and China, respectively. Therefore, the third contribution of our paper lies in the decomposition of the changes in income polarization by income source for a large group of European countries and over time. Moreover, we apply a Shapley growth-redistribution decomposition method. This method has been used in studies on poverty (Baye, 2006), but not on income polarization. Specifically, we are interested in how labor income, capital income, social transfers, and taxes are related to the changes in income polarization. It has been pointed out that there has been pervasive job polarization in the EU, resulting in unequally distributed and polarizing market income (Goos et al., 2009; Massari et al., 2013). Since market income is the main component of disposable income, polarization of market income may also lead to polarization of disposable income. In addition to labor income, business and property income also contribute to unequally distributed income (Paul, 2004). The tax-benefit system is the other driving force offsetting most of the increase of disposable income inequality (Wang et al., 2012, 2014). Differences in the form and structure of welfare state provisions or changes in taxation might contribute to changes in income polarization (Hamnett, 1996).

The remainder of the paper is structured as follows. Section 2 presents approaches of measuring income polarization and decomposition methods. Section 3 describes our data (EU-SILC). Section 4 contains empirical analyses on both the level and change in income polarization in 20 European countries for the period 2004-2013. Section 5 presents the decomposition results. Section 6 concludes.

2. Income polarization and income inequality

2.1 Polarization indicators

So far a number of income polarization indicators has been put forward. These indicators can be generally classified into two families: bipolarization and multi-peaked polarization. First, bipolarization describes the process in which the middle class diminishes while clusters move to the two opposite poles. Literature on bipolarization can be traced back to Foster and Wolfson (1992, 2010). Polarization indicators proposed by Chakravarty and D'Ambrosio (2010), Chakravarty and Majumder (2001), Deutsch et al. (2007), Lasso de la Vega et al. (2010), Rodriguez and Salas (2003) and Wang and Tsui (2000) also belong to the family of the bipolarization indicators. The most notable Foster and Wolfson (FW) indicator is expressed as follows:

$$FW = (G^B - G^W)\frac{\mu}{m} \tag{1}$$

Where G^B is inter group inequality and G^W is intra group inequality. The population is divided into two groups by the median. $\frac{\mu}{m}$ is a simple measure of income skewness as the ratio of mean and median income. It is clear from formula (1) that the bipolarization indicator can increase in three cases: (a) greater distance between persons with an income level below the median and those above the median (higher G^B); (b) persons below and/ above the median are more alike (lower G^W); (c) persons with top incomes are further away from the middle.

Secondly, multi-peaked polarization indicators attempt to capture the formation of income groups clustering around any arbitrary number of groups. Leading studies include D'Ambrosio (2001), Duclos et al. (2004), Esteban and Ray (1994), Esteban et al. (1999, 2007) and Poggi and Silber (2010). Especially, Esteban and Ray (1994) derive the 'identification-alienation' framework to assess individuals' identity with one another belonging to the same group and alienation from those belonging to other groups. In societies where income groups are far apart from each other, they are likely to have different preferences for redistribution. Such distances will give rise to a feeling of alienation, which may lead to the lack of understanding of and tolerance for other income groups. Such alienation brings about societal tension. Additionally, as income groups are internally more homogenous, their members identify more closely to others within the same group and have stronger feelings of belonging to their group, which in turn may also increase societal tension. Based on this framework, more polarization arises in case of stronger inter group heterogeneity (alienation) and intra group homogeneity (identification).

Suppose the original distribution consists of n groups where group i ($i = 1, 2, 3 \dots, n$) has population p_i and mean income μ_i. The Esteban and Ray (ER) indicator is defined as:

$$ER = K \sum_{i=1}^{n} \sum_{j=1}^{n} p_i^{1+\alpha} p_j \left|\mu_i - \mu_j\right| \tag{2}$$

where K and α are constants with $K > 0$ and $\alpha \in [0, 1.6]$.[1] Within the 'identification-alienation' framework, the identification (ID) of group i and alienation (AL) between group i and group j are defined as $ID_i = p_i^{\alpha}$ and $AL_{ij} = |\mu_i - \mu_j|$. The selected sensitivity parameter α reflects the cohesion within a group. The higher α gives more weight to homogeneity within group in the measurement of polarization. As the individuals identify themselves more closely to others within the same group and have stronger feeling to belong to their group, social tension and political conflict may increase (Pérez and Ramos, 2010). Meanwhile, the higher α is, the larger is the departure of the ER

indicator from income inequality. The ER indicator becomes the well-known Gini coefficient when $\alpha = 0$.

However, when applying the ER indicator, the number of income groups n is decided by the researcher rather than driven by data. Later, Esteban, Gradín and Ray (1999, 2007) extend the polarization indicator:

$$EGR = K\sum_{i=1}^{n}\sum_{j=1}^{n} p_i^{1+\alpha} p_j \left|\frac{\mu_i}{\mu} - \frac{\mu_j}{\mu}\right| - \beta(G - G^B) \tag{3}$$

Where μ is the mean income of the original distribution. G is the inequality of the original distribution and G^B is the inter group inequality. β is a constant reflecting the internal cohesion of the groups. The first term coincides with formation of the ER index. The difference between G and G^B in the second term approximately estimates the intra group inequality, therefore expressing the error associated with the grouping process. Adding the second term can decrease the bias as a result of inaccurate groupings (Duro, 2005b).

Both the ER indicator and the EGR indicator are based on a discrete, finite set of income groups. This generates two drawbacks. Conceptually, a discrete, finite number of points presents an unpleasant discontinuity. Practically, difficulty arises when the population in one group could also be regarded as population in other groups (Duclos et al., 2004). To overcome the two drawbacks, Duclos, Esteban and Ray (2004) refine the index for continuous distributions:

$$DER = (\frac{1}{n})\sum_{i=1}^{n} \hat{f}(v_i)^{\alpha}\, \hat{a}(v_i) \tag{4}$$

The alienation ingredient (AL) is defined as:

$$\hat{a}(v_i) = \hat{\mu} + v_i\left[\left(\frac{1}{n}\right)(2i-1) - 1\right] - (\frac{1}{n})[2\sum_{j=1}^{i-1} v_j + v_i] \tag{5}$$

where $\hat{\mu}$ is the sample mean and income v_i is ordered such that $v_1 \le v_2 \le \cdots \le v$. The alienation ingredient is two times the Gini coefficient. $\hat{f}(v_i)$ is estimated by non-parametric estimation transformed from a Gaussian kernel, which estimates the income density at income level v_i:

$$\hat{f}(v_i) = \frac{1}{n}\sum_{j=1}^{n}\frac{1}{h}\frac{1}{\sqrt{2\pi}} exp[-\frac{1}{2}(\frac{v_i - v_j}{h})^2] \tag{6}$$

with the bandwidth $h = \sqrt[10]{\alpha}\frac{4.7}{\sqrt{n}}\sigma$; σ is the standard error of the normalized incomes.[2] The constant α expresses the weight given to the identification ingredient (ID) of the framework. The higher α is, the stronger homogeneity the individuals feel to others within the same group. Duclos et al. (2004) impose additional axioms on the polarization measure. To meet these axioms, α must be bounded: $\alpha \in [0.25, 1]$.

The DER indicator has been used widely (e.g. Hussain, 2009, Brzezinski, 2011, Wang and Wan, 2015, Wang et al., 2015). We also apply this indicator based on formula (4) throughout the paper. Following common practice, the value of $\alpha = 0.5$ is chosen. Polarization indicators measured by FW (based on formula (1)), EGR (based on formula (3)) and the DER (based on formula (4)) with different values of α would be accounted for as a sensitivity check (results are presented in the appendices).

2.2 The relationship between income polarization and income inequality: Decomposition by the identification-alienation framework

As the Gini coefficient, income polarization indicators lie between 0 and 1. Income polarization and Gini equal 0 for perfectly distributed income. When income polarization (Gini) increases, the society becomes more polarized (unequal). Both income inequality and income polarization are sensitive to changes in the middle class. However, the two indicators are different. Income polarization is closer to the notion of segregation than income inequality (Esteban and Ray, 1994). Income polarization places both emphasis on intra group homogeneity (identification) and inter group heterogeneity (alienation). As such, income polarization depicts the extent of similarities among members in a group and the distances between groups. As suggested by Pérez and Ramos (2010), it is inequality between relevant population subgroups, i.e. alienation, rather than simply overall population inequality, would increase the differences in preferences for redistribution and thus lead to disagreement and conflict. Similarly, the more identity the members feel to their income groups, the more likely societal tension would increase.

Income polarization and income inequality may not go hand in hand. Both inequality and polarization will decline if there is an 'equalizing transfer' of income from an individual above the median to an individual with income below the median. However, inequality and polarization might diverge when there are equalizing transfers entirely on one side of the median (Wolfson, 1994, 1997). With two or more groups, income polarization rises when inter group inequality increases or when intra group inequality decreases. The latter case can best describe the difference between income polarization and income inequality since it is violated by all standard inequality indicators (Brzezinski, 2013).

Nevertheless, income polarization and income inequality are highly correlated. Usually increasing inequality has negative impacts on the growth of median income, leading to a 'squeezed middle' (polarization), although there have been widely varying experiences across countries (Thewissen et al., 2015). In formula (4), the DER indicator is equal to the popular Gini coefficient of inequality if $\alpha = 0$. In practice, low values of α should produce the values of the DER indices that are close to the values of Gini, while values of α close to 1 lead potentially to the highest disparity between Gini and the DER indices. Furthermore, according to Duclos et al. (2004), the DER indicator can be expressed as:

$$DER = AL * ID * (1 + \rho) \tag{7}$$

The alienation ingredient AL is two times the Gini coefficient (see formula (5)). ID represents the summation of $f(v_i)^{\alpha+1}$. ρ is the normalized covariance between $AL$and ID. This formula implies that the DER can be decomposed into three components: the alienation ingredient AL (inequality) and the identification ingredient ID and the normalized covariance between the two.

Empirical evidence on the relationship between income polarization and income inequality is mixed. Ravallion and Chen (1997) and Zhang and Kanbur (2001) suggest that, contrary to the theoretical expectations, the polarization indicators do not generate very different results from the standard inequality measures such as the Gini coefficient. Lasso de la Vega and Urrutia (2006), and Brzezinski (2013), however, provide evidence that inequality and polarization indices differ empirically and in significant ways. For instance, based on micro data for more than 70 countries over 1960-2005, Brzezinski (2013) finds that while the impact of income inequality on economic growth is statistically insignificant, income polarization has a negative impact in the short term.

2.3 Decomposition of polarization change by income source: Shapley growth-redistribution framework

Former, extensive literature on 'welfare state retrenchment' that has emerged over the last decades seems to imply that welfare states have become less redistributive (Immervoll and Richardson, 2011, also published in OECD, 2011). Recent studies and data, on contrary, show that most welfare states became more redistributive (see also Kenworthy and Pontusson, 2005; Wang et al., 2014). Welfare states have not compensated completely for the rise in inequality of market income among households, but most have done so to some degree. By and large, welfare states have worked the way they were designed to work. It is markets, not redistribution policies that have become more inegalitarian. It should be noted here that because tax-benefit systems are generally progressive, one could expect that higher market income inequality automatically leads to more redistribution, even without policy actions (Immervoll and Richardson, 2011; Wang et al., 2014). But what about income polarization?

This paper examines changes in income polarization across 20 European countries for the period 2004-2013 decomposed into three income components: market income (labor and capital), social benefits (sum of unemployment benefits, old-age and survivor pension benefits, sickness and disability benefits, education allowances, and minimum income protection), and taxes and social contributions to households. To decompose the changes of income polarization by income source, we use Shapley decomposition which considers all possible sequences of changes of income sources, and growth-redistribution decomposition which shows the effects of income growth and reallocation on polarization separately; see sections 2.3.1 and 2.3.2.

2.3.1 Shapley decomposition

The idea of the Shapley decomposition procedure is precisely to average the contribution of each income component over all the possible sequences considering the combination of changes in all other components. Therefore, the Shapley decomposition allows overcoming the path dependency problem: the contribution of each factor (except when there are only two income sources) clearly depends on their order in the elimination process. Shapley decomposition has been discussed by many scholars but mainly in the fields of poverty and inequality (Baye, 2006; Shorrocks, 2013). Instead, decomposition of income polarization receives little attention in the existing literature. Therefore, this study relies on Shapley decomposition and further decomposition into growth and reallocation effects to estimate the contributions of specific factors to income polarization change over time. Similar to inequality and other social indicators, there are two broad categories related to the issue of decomposing income polarization by the Shapley value. The first category deals with decomposing income polarization by subgroups such as by age, sex, or race. Here we consider applying the Shapley value to the second category of decomposing income polarization, namely, to evaluate the different components of total income. Specifically, we disaggregate total income into several income components, such as market income, social transfers and taxes. Our target is to examine the contribution of each income component to the aggregate polarization change over time.[3]

Suppose there are only two income sources x and y. Total income equals to the sum of x and y. Let $p(x, y)$ denote the polarization depending on the two income sources x and y. Polarization at time t and $t+1$ can thus be expressed as $p(x_t, y_t)$ and $p(x_{t+1}, y_{t+1})$ respectively. Hence, the change in polarization between the two periods can be expressed as follows:

$$\begin{aligned}\Delta p &= p(x_{t+1}, y_{t+1}) - p(x_t, y_t) \\ &= \frac{1}{2}p(x_{t+1}, y_{t+1}) + \frac{1}{2}p(x_{t+1}, y_{t+1}) - \frac{1}{2}p(x_t, y_t) - \frac{1}{2}p(x_t, y_t) \\ &+ \frac{1}{2}p(x_{t+1}, y_t) - \frac{1}{2}p(x_{t+1}, y_t) + \frac{1}{2}p(x_t, y_{t+1}) - \frac{1}{2}p(x_t, y_{t+1}) \\ &= \frac{1}{2}[p(x_{t+1}, y_{t+1}) - p(x_t, y_{t+1})] + \frac{1}{2}[p(x_{t+1}, y_t) - p(x_t, y_t)] \\ &+ \frac{1}{2}[p(x_{t+1}, y_{t+1}) - p(x_{t+1}, y_t)] + \frac{1}{2}[p(x_t, y_{t+1}) - p(x_t, y_t)] \\ &= \Delta p(x) + \Delta p(y)\end{aligned}$$

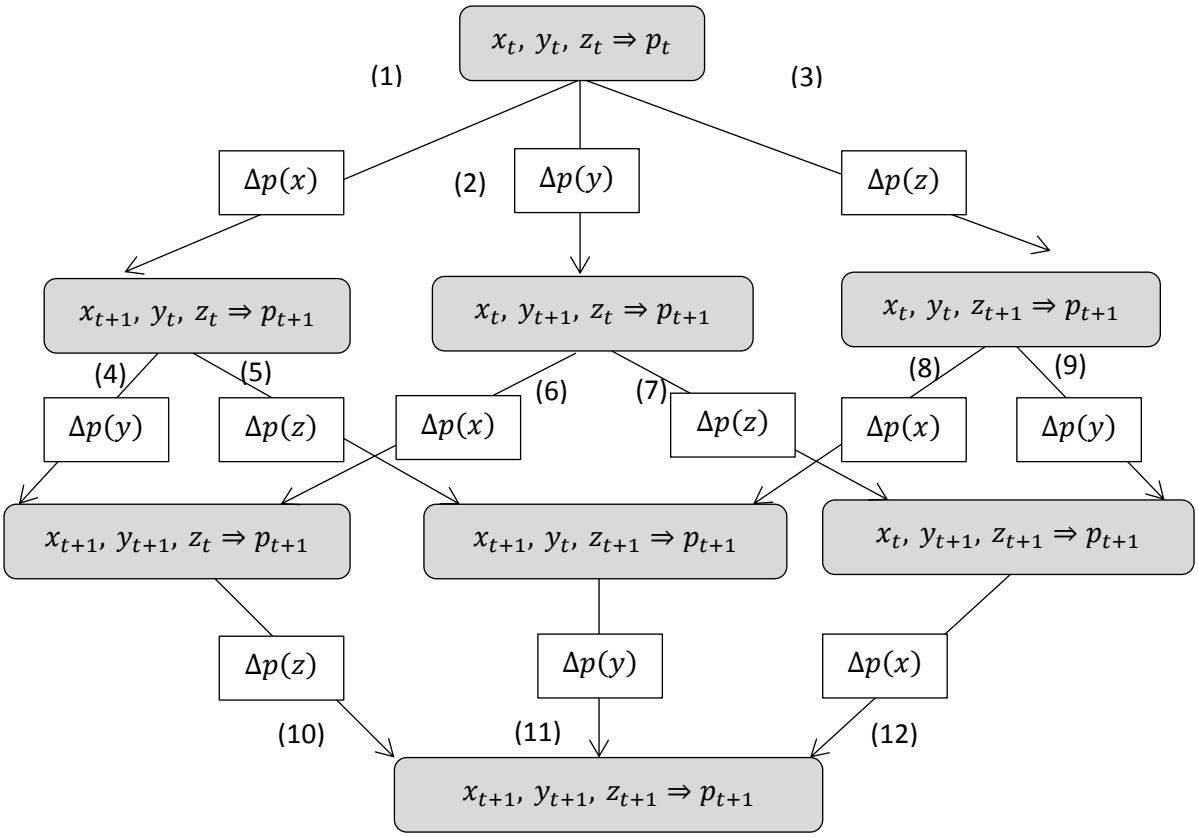
where

$$\Delta p(x) = \frac{1}{2}[p(x_{t+1}, y_{t+1}) - p(x_t, y_{t+1})] + \frac{1}{2}[p(x_{t+1}, y_t) - p(x_t, y_t)] \quad (8)$$

$$\Delta p(y) = \frac{1}{2}[p(x_{t+1}, y_{t+1}) - p(x_{t+1}, y_t)] + \frac{1}{2}[p(x_t, y_{t+1}) - p(x_t, y_t)] \quad (9)$$

Based on the formula, the change in polarization is contributed by the change $\Delta p(x)$ led by x and $\Delta p(y)$ led by y. $\Delta p(x)$ is the average effect x in all sequences (there are two possible sequences in the two factors' case, namely x changed first and y changed first) (Wang and Wan, 2015). Similarly, $\Delta p(y)$ is the average effect of y in all possible sequences. The extension of the decomposition over time for three income sources x, y and z (total income = x+ y + z) can be shown in Figure 1 (e.g. market income, social benefits and taxes):

Figure 1: Shapley decomposition of polarization



Source: Wan (2006) and own extension.

First, consider x changes from x_t to x_{t+1}, holding y_t and z_t as unchanged (route 1). We can thus obtain a counterfactual polarization p_{t+1}. The difference between p_{t+1} and p_t is the contribution of the changes in x, namely $\Delta p(x)$. Similarly, we can have three other $\Delta p(x)$ corresponding to three other possible consequences (routes 6, 8 and 12). Second, the effect by the changes in x on polarization is the average of the four $\Delta p(x)$. Finally, we can compute the effects of changes in y (average of $\Delta p(y)$ from routes 2, 4, 9 and 11) and in z (average of $\Delta p(z)$from routes 3, 5, 6 and 10) on polarization.

Likewise, with respect to four or more determinants, the marginal contribution of each component is calculated based on all possible routes considering the combination of changes in all other determinants. For instance, for income component $x_k \in \{x_1, x_2, \cdots, x_k, \cdots, x_n\}$, the marginal effect of x_k over time is the average of $\Delta p(x_k)$ obtained from all routes with all possible combination of changes in other determinants. More specifically, for each of the other components, there are two status in period t and $t+1$, e.g. x_{1_t} and $x_{1_{t+1}}$. Therefore, there are 2^{n-1} combinations of changes with regards to other $n-1$ determinants. Using Shapley decomposition, all contributions can be added up to 100% of the total changes in polarization with no residual left (Wang and Wan, 2015).

2.3.2 Further decomposition: growth and reallocation effects

The partial effect of each income component on changes of income polarization can further be divided into a growth component and a reallocation component. This dynamic decomposition procedure examines how economic growth contributes to a change in income polarization over time, and assesses whether and to what extent the effect of this growth is attenuated or reinforced by a change in inequality. Baye (2006), Datt and Ravallion (1992) and Kakwani (2000) put forward a growth-redistribution decomposition framework to decompose a change in poverty in growth and redistribution effects. The growth effect gives the effect on poverty of the change in the mean income while holding the Lorenz curve constant. The redistribution effect represents poverty changes due to resource reallocation, that is, to give the change in poverty due to change in the Lorenz curve when the mean income remains the same. Furthermore, Kakwani (2000) imposes three axioms to define the nature of the growth-redistribution framework. These axioms help to avoid the residual term and the 'benchmark period' problem (problem related to nominating the initial or terminal year as the reference, see Appendix D for details).[4] Similarly, we incorporate this axiomatic technique in our analysis of decomposing the change of income polarization. However, we use the term 'reallocation effect' instead of the 'redistribution effect' to distinguish the redistribution component in the growth-redistribution decomposition framework for market income from the redistribution effect of social benefits and taxes (the sum of the redistribution component and growth component in the growth-redistribution decomposition framework). Let $p(\mu_{x_t}, L_{x_t})$ be the polarization level at time t with income source x. μ_{x_t}denotes the mean source income x at time t and L_{x_t} indexes the Lorenz curve of income x at time t. Change in income polarization from time t to time $t+1$ is thus expressed as $\Delta p(x) = p(x_{t+1}) - p(x_t) = p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_t})$. Let $G(t, t+1)$ denote the growth effect from the year t to $t+1$ and $D(t, t+1)$ denote the reallocation effect. The growth and reallocation effects can be disentangled for the change in our polarization indicator, as shown below:

$$
\begin{aligned}
\Delta p(x) &= p(x_{t+1}) - p(x_t) \\
&= p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_t}) \\
&= \frac{1}{2}p(\mu_{x_{t+1}}, L_{x_{t+1}}) + \frac{1}{2}p(\mu_{x_{t+1}}, L_{x_{t+1}}) - \frac{1}{2}p(\mu_{x_t}, L_{x_t}) - \frac{1}{2}p(\mu_{x_t}, L_{x_t}) \\
&+ \frac{1}{2}p(\mu_{x_{t+1}}, L_{x_t}) - \frac{1}{2}p(\mu_{x_{t+1}}, L_{x_t}) + \frac{1}{2}p(\mu_{x_t}, L_{x_{t+1}}) - \frac{1}{2}p(\mu_{x_t}, L_{x_{t+1}}) \\
&= \frac{1}{2}\{[p(\mu_{x_{t+1}}, L_{x_t}) - p(\mu_{x_t}, L_{x_t})] + [p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_{t+1}})]\} \\
&+ \frac{1}{2}\{[p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t+1}, L_{x_t})] + [p(\mu_{x_t}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_t})]\}
\end{aligned}
$$

$$G(t, t+1) = \frac{1}{2}\{[p(\mu_{x_{t+1}}, L_{x_t}) - p(\mu_{x_t}, L_{x_t})] + [p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_{t+1}})]\} \quad (10)$$

$$D(t, t+1) = \frac{1}{2}\{[p(\mu_{x_{t+1}}, L_{x_{t+1}}) - p(\mu_{x_t+1}, L_{x_t})] + [p(\mu_{x_t}, L_{x_{t+1}}) - p(\mu_{x_t}, L_{x_t})]\} \quad (11)$$

The growth effect is computed as the mean of two effects: (1) the growth effect when the initial redistribution (Lorenz curve) remains the same and the growth effect when the final redistribution (Lorenz curve) remains the same. Similarly, the reallocation effect is computed as

the mean of two effects: (1) the reallocation effect when the initial mean income remains the same and the reallocation effect when the final mean income remains the same.

3. Underlying micro data from EU-SILC

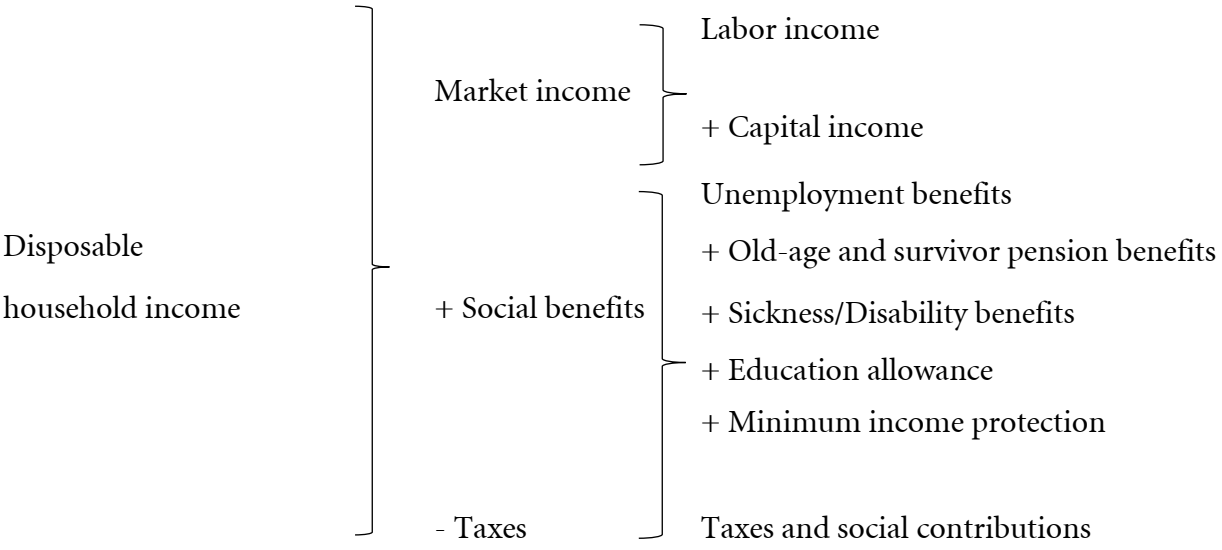
The European Union Statistics on Income and Living Conditions (EU-SILC) is the EU reference source for micro income data. EU-SILC provides an up-to-date source for comparative research on income and living conditions in the EU. This dataset contains internationally and cross-temporarily comparable variables for all EU member states and some other countries. EU-SILC is unique since it offers information on a range of social indicators. Many EU indicators designed to monitor poverty, income inequality and social inclusion in the EU are based on EU-SILC. EU-SILC has been widely used in internationally and cross-temporarily comparative research for EU member states and some other countries.

It should be noted that there are considerable differences between participating countries in EU-SILC in terms of sample design, sample frame and data source (Goedemé, 2013). Furthermore, the data collection approach varies over time. For instance, prior to 2007, some of the countries provided no information on gross incomes (France, Greece, Italy, Latvia, Portugal, Spain). Data from these countries is not used. Moreover, the analysis of trends of income polarization is restricted to European countries due to data availability. 20 countries are involved in our empirical analysis, including 18 European Member States and 2 non-EU members, namely Iceland and Norway. EU-SILC 2004-2013 data are taken into account. We split the period into two using 2008 as the mid-point to investigate effects before and since the Great Recession.

The reference population of EU-SILC consists of private households residing in the participating countries at the moment of selection. Detailed information on individual and household characteristics as well as income by source is contained. We first compute the polarization measure for household disposable income, equivalized using the square-root scale. Disposable income is defined as the sum of gross market income and cash benefits, net of direct taxes and social insurance contributions. In EU-SILC, all income information refers to the 'income reference period'. Except for Ireland and the United Kingdom, the income reference period is the 12 months of the calendar year prior to the survey year. In Ireland, the income reference period covers the last 12 months prior to the interview. In the United Kingdom, current weekly or monthly income is annualized and the income reference period presents the year of the survey (Eurostat, 2008).

Table 1 presents the components composing of disposable household income in our dataset. All incomes are expressed in gross values and converted into euros of 2005 (deflating by a country-specific consumer price index taken from World Bank, 2013). We follow the common practice (e.g. Lohmann, 2011) to exclude the non-positive disposable incomes. No top–coding of income has been applied. To calculate the level of income polarization across countries and over time, we use the DER indicator. The value of α =0.5 is chosen. In the sensitivity analysis, we compute the FW and EGR indicators and the DER indicator for a range of values of α. Information of the number of observations in each country, mean values of disposable income and the shares of market income, social benefit and taxes are presented in Appendix A.[5]

Table 1: Composition household disposable income



4. Trends in income polarization in Europe

Table 2 shows estimates for the polarization indicator for each country and the direction of movement in the indicator in the two sub-periods 2004-2008 and 2008-2013. The year 2008 is used as the mid-point to investigate effects before and since the Great Recession. In this paper, we compute asymptotic variance and standard errors for the DER indicator with the help of the DASP package in Stata (Duclos et al., 2004). All standard errors are between 0.001 and 0.009. In addition, all polarization indicator estimates are significantly different from zero at 0.05 significance level.

Table 2: Polarization indicator 2004, 2008 and 2013 ($DER\alpha$= 0.5)

	Country	Available in EU-SILC	Level polarization indicator			Change over time		
			2004	2008	2013	2004-2008	2008-2013	2004-2013
West EU-15								
AT	Austria	2004-2013	0.183	0.188	0.190	2.8%	0.9%	3.8%***
BE	Belgium	2004-2013	0.188	0.194	0.188	3.1%	-2.9%	0.1%
DE	Germany	2005-2013	0.191	0.193	0.194	1.4%	0.5%	1.9%
DK	Denmark	2004-2013	0.166	0.191	0.175	15.4%**	-8.2%	5.9%
FI	Finland	2004-2013	0.187	0.189	0.187	1.0%	-1.1%	-0.1%
IE	Ireland	2004-2013	0.216	0.215	0.202	-0.5%	-5.8%**	-6.2%***
LU	Luxembourg	2004-2013	0.189	0.212	0.198	11.9%***	-6.5%**	4.7%
NL	Netherlands	2005-2013	0.172	0.181	0.171	5.4%**	-5.2%***	-0.1%
SE	Sweden	2004-2013	0.164	0.169	0.175	3.0%	4.0%***	7.1%***
UK	United Kingdom	2005-2013	0.223	0.217	0.202	-2.8%	-6.9%**	-9.5%**
Mean-10			0.188	0.195	0.188	3.8%	-3.3%	0.3%
CEE NMS-13								
CY	Cyprus	2005-2013	0.199	0.200	0.219	0.6%	9.3%**	10.0%**
CZ	Czech Republic	2005-2013	0.186	0.178	0.177	-4.2%**	-0.8%	-5.0%**
EE	Estonia	2004-2013	0.220	0.200	0.206	-9.1%**	3.1%*	-6.3%*
HU	Hungary	2005-2013	0.188	0.182	0.187	-3.0%	2.4%	-0.6%
LT	Lithuania	2005-2013	0.219	0.214	0.212	-2.5%	-0.6%	-3.0%
PL	Poland	2005-2013	0.217	0.203	0.198	-6.7%	-2.2%***	-8.7%***
SI	Slovenia	2005-2013	0.172	0.171	0.175	-0.4%	2.4%**	1.9%*
SK	Slovakia	2005-2013	0.186	0.177	0.176	-4.6%	-0.9%	-5.4%
Mean-8			0.198	0.191	0.194	-3.9%	1.6%	-2.3%
Other								
IS	Iceland	2004-2013	0.177	0.191	0.176	7.8%**	-7.6%*	-0.4%
NO	Norway	2004-2013	0.188	0.173	0.164	-7.9%	-5.6%***	-13.0%***
Mean-20			0.191	0.192	0.189	0.2%	-1.7%	-1.5%

Source: own calculations EU-SILC. *** Significant at the 0.01 level; ** significant at the 0.05 level; * significant at the 0.1 level.

Table 2 shows rather low levels of income polarization in Europe, relative to for example Asian countries with polarization levels mostly above 0.2 (Gochoco-Bautista et al., 2013). A modest rise of income polarization is witnessed from 2004 to 2008 for 8 out of 10 West EU countries, but a decline afterwards (with the exception of 3 countries). The opposite development

is witnessed for CEE NMS: a decline of income polarization from 2004 to 2008 for 7 out of 8 CEE NMS countries, but a slight increase afterwards (with the exception of 4 countries). So the pattern for West EU countries differs from CEE NMS. Moreover, the changes are significant in most countries. Cross-country differences declined over time, especially between 2004 and 2008.[6] Our empirics show that income polarization in European countries is rather low and stable over time, also compared to Asian countries, the developing countries and to a lesser extent the United States (Brzezinski, 2013: 35-36).

5. Decomposition results

5.1 Decomposition of income polarization by the identification-alienation framework

In Table 3, we present the alienation and identification ingredients for the DER indicator across the 20 European countries in 2013. Note that the alienation (inequality) is the same for all DER indicators with different values of α. In addition to the large variation in alienation, differences in identification across countries can be detected together with polarization differences. The coefficient of variation shows that alienation's variation across countries is more than 2.5 size of the identification's variation, and 0.6 times larger than that of polarization's variation. In fact, not only across countries, but also for each country and over time, the variation of the alienation is greater than that of the identification and the overall polarization. From the coefficient of variation we can also infer that cross country variation of income inequality is much higher than that of income polarization. Thus, for example, although Norway and Denmark have much lower income inequality (AL) than the United Kingdom, income polarization between the countries is not that different. This may explain why increases in income polarization in some countries, although statistically significant, are much less documented than increases in income inequality.

Table 3: *DER* indicator, alienation and identification for a range of values for α, 2013

Country	*AL*	$\alpha = 0.25$			$\alpha = 0.5$			$\alpha = 0.75$			$\alpha = 1$		
		DER	*ID*	ρ	*DER*	*ID*	ρ	*DER*	*ID*	ρ	*DER*	*ID*	ρ
Norway	0.216	0.181	0.929	-0.096	0.164	0.892	-0.150	0.155	0.876	-0.183	0.150	0.873	-0.205
Netherlands	0.228	0.190	0.926	-0.101	0.171	0.887	-0.151	0.162	0.868	-0.180	0.157	0.862	-0.199
Denmark	0.240	0.197	0.915	-0.102	0.175	0.862	-0.151	0.163	0.829	-0.180	0.155	0.807	-0.198
Sweden	0.242	0.199	0.900	-0.085	0.175	0.833	-0.130	0.160	0.784	-0.157	0.149	0.748	-0.175
Slovenia	0.242	0.200	0.898	-0.080	0.175	0.829	-0.126	0.159	0.779	-0.155	0.148	0.741	-0.176
Slovakia	0.240	0.200	0.897	-0.071	0.176	0.827	-0.115	0.159	0.776	-0.144	0.148	0.739	-0.164
Iceland	0.240	0.198	0.913	-0.095	0.176	0.859	-0.146	0.163	0.825	-0.176	0.155	0.803	-0.195
Czech Republic	0.240	0.198	0.917	-0.100	0.177	0.871	-0.155	0.165	0.848	-0.188	0.159	0.840	-0.209
Hungary	0.268	0.216	0.887	-0.092	0.187	0.811	-0.141	0.168	0.757	-0.171	0.155	0.716	-0.191
Finland	0.267	0.214	0.894	-0.104	0.187	0.826	-0.154	0.170	0.779	-0.183	0.159	0.745	-0.201
Belgium	0.267	0.217	0.884	-0.084	0.188	0.803	-0.125	0.169	0.741	-0.148	0.155	0.692	-0.163
Austria	0.282	0.223	0.871	-0.091	0.190	0.783	-0.142	0.168	0.719	-0.173	0.152	0.670	-0.193
Germany	0.287	0.226	0.881	-0.106	0.194	0.801	-0.156	0.174	0.744	-0.184	0.160	0.700	-0.203
Luxembourg	0.288	0.229	0.882	-0.098	0.198	0.801	-0.144	0.178	0.743	-0.170	0.164	0.699	-0.186
Poland	0.300	0.235	0.864	-0.091	0.198	0.770	-0.140	0.174	0.700	-0.170	0.157	0.645	-0.189
United Kingdom	0.301	0.237	0.870	-0.094	0.202	0.782	-0.143	0.179	0.719	-0.172	0.163	0.670	-0.190
Ireland	0.301	0.236	0.874	-0.101	0.202	0.792	-0.151	0.182	0.735	-0.179	0.168	0.695	-0.197
Estonia	0.313	0.246	0.858	-0.087	0.206	0.761	-0.137	0.180	0.691	-0.167	0.162	0.637	-0.187
Lithuania	0.331	0.255	0.856	-0.100	0.212	0.759	-0.153	0.186	0.688	-0.184	0.167	0.634	-0.202
Cyprus	0.333	0.256	0.876	-0.121	0.219	0.794	-0.173	0.196	0.736	-0.200	0.181	0.693	-0.215
Mean 20	*0.271*	*0.218*	*0.890*	*-0.095*	*0.189*	*0.817*	*-0.144*	*0.171*	*0.767*	*-0.173*	*0.158*	*0.730*	*-0.192*
Coefficient of variation	*0.125*	*0.099*	*0.024*	*-0.110*	*0.077*	*0.048*	*-0.089*	*0.060*	*0.072*	*-0.077*	*0.049*	*0.097*	*-0.070*

Source: own calculations EU-SILC.

5.2 Decomposition of income polarization change by Shapley growth-redistribution decomposition method

Figures 2a-2c show the changes in income polarization ($DER\ \alpha = 0.5$), further splitting the countries into West EU, CEE NMS and other European countries. In each group countries are ranked in order of their change in income polarization from largest to smallest. For the three main income components, we present the partial effect of each income component which is the sum of the partial growth effect and the partial reallocation effect. Between 2004 and 2008, the West EU countries observed an increase in income polarization (see Figure 2a). Market income contributed to this increase to a large extent. Surprisingly, also social benefits and taxes added to more income polarization. CEE NMS, on the contrary, saw a decrease in income polarization on average, where the redistribution effects of social benefits and taxes offset the polarization-increasing factor of market income.

An opposite trend can be found for the period 2008-2013 (see Figure 2b). Income polarization decreased in the West EU countries and this was mainly because of the more redistributive effects of social benefits and taxes. The CEE NMS, on the other hand, experienced an increase in income polarization since the Great Recession. Market income had a positive impact on income polarization, which has not been offset by the effects of social benefits and taxes.

Figure 2c shows the decomposition for the entire period 2004-2013. Income polarization increased in 6 out of the 10 West EU countries, while it declined in most of the CEE NMS. Taken together, income polarization slightly decreased for the 20-country average. Market income was polarization-increasing on average (mainly in West EU countries), while the redistributive effect of social benefits and taxes appears to be polarization-reducing, on average. Across countries the redistribution effect of social benefits and taxes is more than offsetting the polarization-increasing effect of dispersion of market incomes in 20 European countries in the period 2004-2013. However, cross-country variation is rather large.

Figure 2a: Change in polarization 2004-2008 due to market income, social benefits and taxes

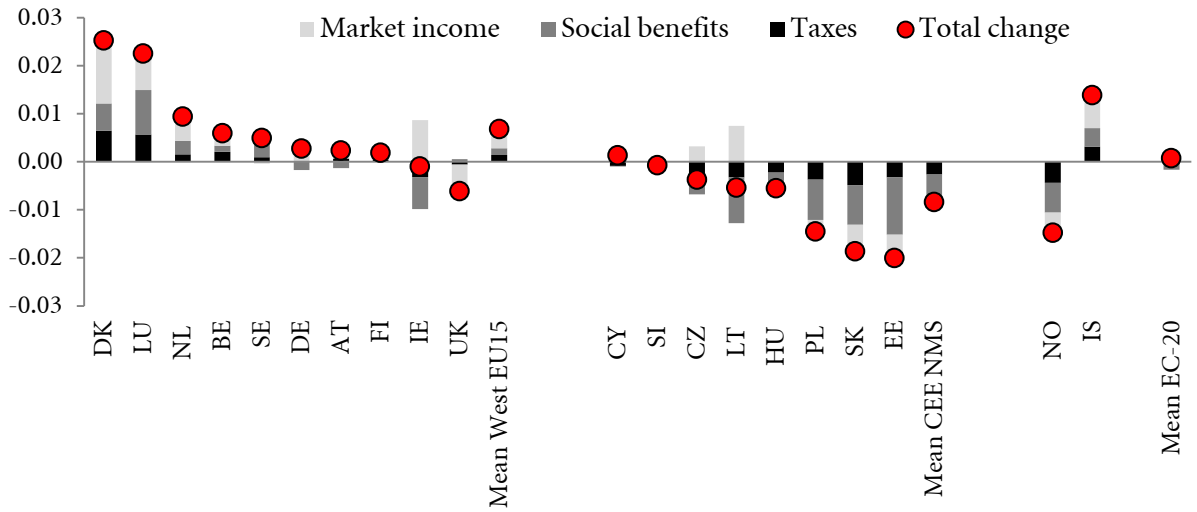


Figure 2b: Change in polarization 2008-2013 due to market income, social benefits and taxes

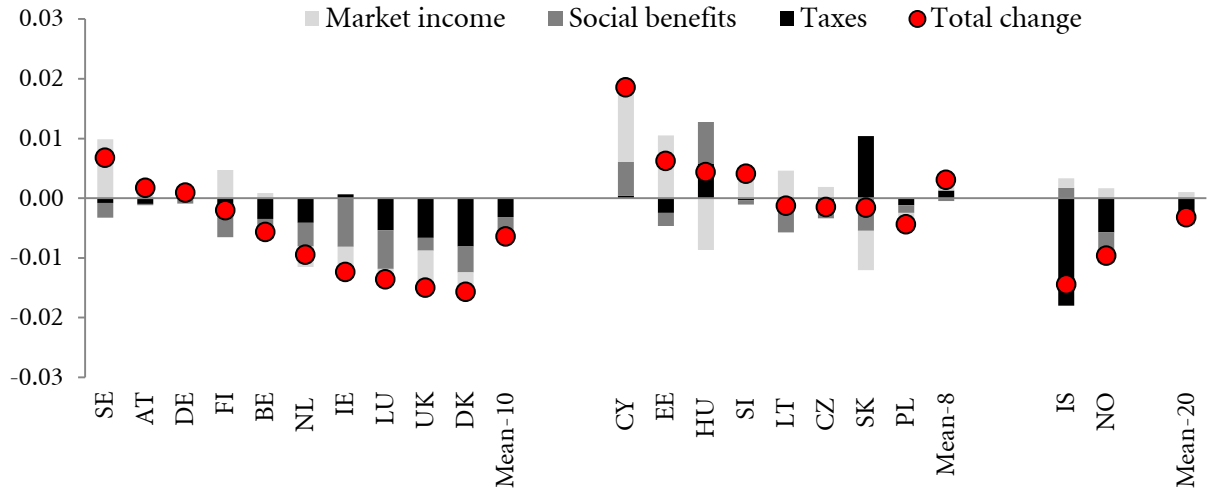
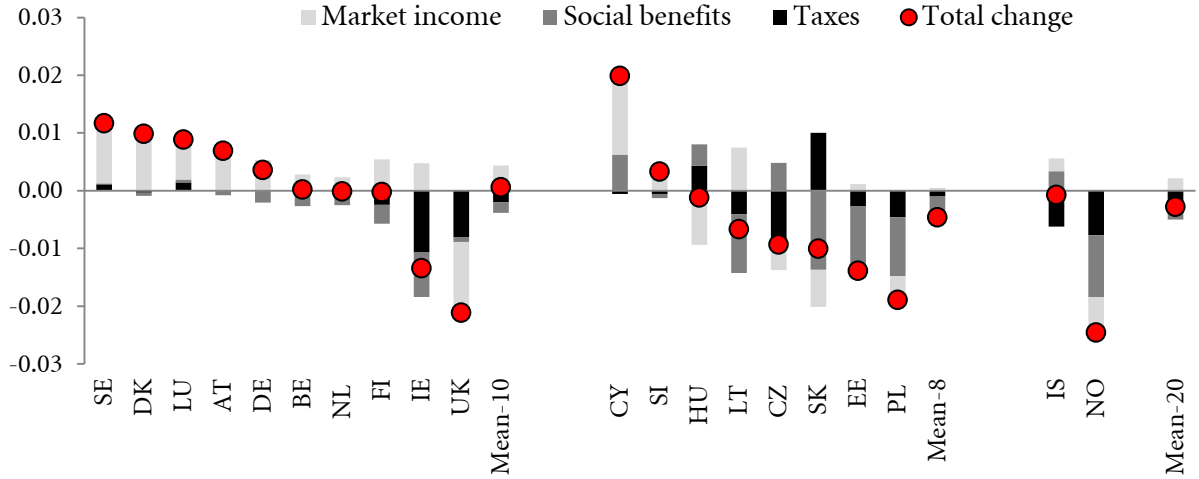


Figure 2c: Change in polarization 2004-2013 due to market income, social benefits and taxes



Source: own calculations EU-SILC.

Decomposition results including the (partial) growth effect and the reallocation effect for the period 2004-2013 are presented in Table 4. Table 4 shows the changes in income polarization in 20 countries from 2004/5 to 2013, further splitting the countries into groups (West EU, CEE NMS and other European countries). Countries are ranked in order of their change in income polarization 2004-2013 from largest to smallest. Ten countries have seen a non-positive change of income polarization, although the magnitude is mostly rather small due to the short period under study. Some countries show lower (higher) income polarization compared to other countries.

Table 4 decomposes total change into a growth and reallocation effect by country. For our 20-country-average polarization decreased in the period 2004-2013. The growth effect on polarization was quite small on average, while the reallocation effect appears to be polarization-reducing. However, cross-country variation is large.

Our analyses may be seen as an assessment how changes of the generosity of tax-benefit systems over the period 2004-2013 have had an impact on income polarization. Table 4 presents rather stable income polarization over the decade in most West-EU15 countries, and somewhat lower polarization in CEE NMS. While market income has contributed to increasing income polarization, the tax-benefit systems in European countries has resulted in reducing income polarization through the reallocation effect. We do not find that tax-benefit policies had become less effective before or after the Great Recession. Among the total population in European countries, both market income polarization (labor and capital) and redistribution from social benefits and taxes rose on average. As a result, the tax-benefit systems were more effective in offsetting income polarization in 2013 than in the mid-2000's in all countries, with Cyprus as an exception. So, social policy changes made by most European countries in the period 2004-2013 did have an anti-polarizing effect, even if other factors as market incomes were pushing in the other direction. This finding is in line with the work of Hills et al. (2014). Detailed decomposition results for the sub-periods 2004-2008 and 2008-2013 are presented in Tables E1 and E2 of Appendix E.[7]

With respect to the redistributive effect of the tax-benefit systems, our analysis indicates that the pattern is diverse across countries. On average across 20 countries, social benefits reduced income polarization by 0.003 in the period 2004-2013, while taxes account for a reduction of 0.002. Previous work showed - as far as social programs in most countries is concerned – that the public old-age pensions mitigated over half of the increase in income inequality, while taxes slowed down the increase of income inequality by 15 per cent (Wang et al., 2014). The negative effect of direct taxes for Czech Republic is also confirmed by Janský et al. (2016). Future research might take such a decomposition approach to detect partial effects per social program to the total change of income polarization across countries over time.

Table 4: Detailed decomposition change *DER* indicator 2004-2013 (α= 0.5)

Country	Available in EU-SILC	*DER* indicator		Decomposition of change *DER* indicator 2004-2013							
		Level around 2004	Level around 2013	Change 2004-2013			Partial effect: Market income		Partial effect: Social Benefit		Partial effect: Taxes	
				Total change	Growth effect	Reallocation effect	Growth effect	Reallocation effect	Growth effect	Reallocation effect	Growth effect	Reallocation effect
West EU-10												
Sweden	2004-2013	0.164	0.175	0.012	0.000	0.012	0.011	-0.001	-0.008	0.009	-0.002	0.004
Denmark	2004-2013	0.166	0.175	0.010	0.000	0.010	0.004	0.007	-0.003	0.002	0.000	0.000
Luxembourg	2004-2013	0.189	0.198	0.009	0.000	0.009	0.006	0.002	-0.003	0.004	-0.002	0.004
Austria	2004-2013	0.183	0.190	0.007	0.000	0.007	0.002	0.005	-0.001	0.001	-0.001	0.001
Germany	2005-2013	0.191	0.194	0.004	0.000	0.003	0.004	0.001	-0.003	0.001	-0.001	0.001
Belgium	2004-2013	0.188	0.188	0.000	0.000	0.000	0.002	0.001	-0.002	0.001	0.000	-0.001
Netherlands	2005-2013	0.172	0.171	0.000	-0.001	0.000	0.006	-0.004	-0.003	0.001	-0.004	0.004
Finland	2004-2013	0.187	0.187	0.000	0.000	0.000	0.006	-0.001	-0.004	0.001	-0.002	-0.001
Ireland	2004-2013	0.216	0.202	-0.013	-0.004	-0.010	0.007	-0.003	-0.006	-0.002	-0.005	-0.005
United Kingdom	2005-2013	0.223	0.202	-0.021	0.001	-0.022	-0.024	0.011	0.015	-0.016	0.010	-0.018
Mean-10		0.188	0.188	0.001	*0.000*	*0.001*	*0.002*	*0.002*	*-0.002*	*0.000*	*-0.001*	*-0.001*
CEE NMS-10												
Cyprus	2005-2013	0.199	0.219	0.020	-0.001	0.020	0.004	0.010	-0.002	0.008	-0.003	0.002
Slovenia	2005-2013	0.172	0.175	0.003	0.000	0.003	0.002	0.003	-0.001	0.000	-0.001	0.000
Hungary	2005-2013	0.188	0.187	-0.001	0.000	-0.001	-0.010	0.000	0.006	-0.002	0.004	0.000
Lithuania	2005-2013	0.219	0.212	-0.007	0.001	-0.008	0.015	-0.008	-0.012	0.002	-0.002	-0.002
Czech Republic	2005-2013	0.186	0.177	-0.009	0.004	-0.013	0.004	-0.008	-0.003	0.008	0.002	-0.012
Slovakia	2005-2013	0.186	0.176	-0.010	0.000	-0.010	0.004	-0.011	-0.012	-0.001	0.009	0.001
Estonia	2004-2013	0.220	0.206	-0.014	0.000	-0.014	0.015	-0.014	-0.014	0.002	-0.001	-0.002
Poland	2005-2013	0.217	0.198	-0.019	0.000	-0.019	0.014	-0.018	-0.011	0.001	-0.002	-0.002
Mean-8		0.198	0.194	-0.005	*0.001*	*-0.005*	*0.006*	*-0.006*	*-0.006*	*0.002*	*0.001*	*-0.002*
Other												
Iceland	2004-2013	0.177	0.176	-0.001	0.001	-0.002	-0.010	0.012	0.009	-0.006	0.002	-0.009
Norway	2004-2013	0.188	0.164	-0.025	-0.001	-0.024	0.012	-0.019	-0.008	-0.002	-0.004	-0.003
Mean-20		0.191	0.189	-0.003	*0.000*	*-0.003*	*0.004*	*-0.002*	*-0.003*	*0.001*	*0.000*	*-0.002*

Source: own calculations EU-SILC.

6. Conclusion

The issue of income polarization has been widely discussed outside Europe in recent decades. Instead, less attention has been paid to income polarization within Europe. More polarization can be associated with a divided society and may lead to increase in social unrest, harm economic growth and individual health, and therefore is of special interest in socio-political analysis. Meanwhile, a number of studies has applied various decomposition approaches to analyze the roles of market income, social benefits and taxes in changes in poverty and inequality. However, so far little is known about the roles of these factors in changing income polarization in Europe. To deal with these issues, this study first explores the development of income polarization in 20 European countries over the period 2004-2013, relying on micro data from EU-SILC. Then we engage on the relationship between income polarization and income inequality by decomposing the income polarization into the identification and alienation ingredients. Finally, we disentangle the change of income polarization by income source, such as market income (from labor and capital), social transfers, and taxes. The conclusions are as follows:

First, income polarization is rather low in Europe, compared with that in Asian countries; in West EU countries it is even lower than in the CEE NMS. Over the period 2004-2013, income polarization is rather stable in European countries. This finding seems to imply that the welfare states in Europe is different from other countries and that the harms originated from income polarization may not exist in Europe. More specifically, income polarization was rising among the West-EU15 countries in the sub-period 2004-2008, but declining afterwards. The CEE NMS witnessed an opposite development. The results are robust irrespective of the polarization indicator or the sensitivity parameter α we choose. We did not analyze *why* the trends in income polarization of CEE NMS differs from the trends in West EU countries, because this goes behind the scope of this empirical paper.

Second, income polarization is closely associated with income inequality (alienation) but the two measures are conceptually and empirically distinguishable. Variation in polarization across European countries or over time is much lower than that in inequality (alienation). Variation of income polarization between countries and over time can be associated with variation in alienation (income inequality), but the effect can be reinforced or offset by identification within groups as well as the normalized correlation between alienation and identification. In the end, income polarization and income inequality may not go hand in hand.

Third, to explore the effects of market income, social benefits, and taxes on changes of income polarization over 2004-2013, this paper relies on Shapley decomposition and further decomposition into growth and reallocation effects. The results vary to a large extent across European countries. On average, income polarization was upward driven by market income in the period 2004-2013. Conversely, both the tax and social benefit systems were polarization-reducing. As a result - despite the Great Recession – our income polarization indicator does not point at a sizeable increase in 20 European countries over the last decade, because tax-benefit systems have offset the increase of market income polarization in European countries. We do not find that tax-benefit policies had become less effective after the Great Recession.

However, our empirical analysis does not show *why* benefits and taxes have become more (or less) redistributive over time in European countries. It can be expected that, as market income inequality rises, the tax-benefit systems will automatically have a more redistributive impact

because of the progressivity built into these systems (Immervoll and Richardson, 2011). But also policy changes and demographic changes will certainly explain a part of the changes in redistribution. A wide range of factors influence the overall income distribution. Many of these, such as demographic change or the distribution of work across households, are not under the direct control of policy makers. In assessing the performance of government social policy in terms of (income) poverty or inequality reduction it is important to isolate the impact of the most relevant factors that policy makers are able to control (see Lambert and Thoresen, 2012), which is not done exhaustively in this paper. This might be an important omission if the policy changes introduced in the period considered were specifically designed to alter the incentive e.g. to increase labor force participation. An extension of the work here could attempt to further isolate policy effect from the total change in the levels and distribution of incomes across European countries.

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Note

[1] The α is bounded [0, 1.6] to satisfy the axioms imposed on the ER and other intuitive properties of the measure (Esteban and Ray, 1994).

[2] To construct the identification ingredient, Duclos et al. (2004) first operationalized a Gaussian kernel: $g(v_i) = \frac{1}{\mathrm{h}}\frac{1}{\sqrt{2\pi}} exp\left[-\frac{1}{2}\left(\frac{v_i - u}{\mathrm{h}}\right)^2\right]$. A Gaussian kernel function has a symmetric 'bell curve' shape. The bandwidth h is a free parameter controlling the width of the 'bell' and thus exhibits strong influence on the result. $\frac{1}{\mathrm{h}}\frac{1}{\sqrt{2\pi}}$ expresses the height of the curve's peak. u is the expected value of v, indicating the position of the peak centre. $\hat{f}(v_i)$ then is the average of the sum of $g(v_i)$ using the income distance $v_i - v_j$ of two individuals instead of $v_i - u$.

[3] One can find decomposition of income polarization by population in literature, see e.g. Araar (2008) and Gradín (2000) decompose the polarization by population group. Araar (2008) decomposes income polarization by income source as well, but only for China and Nigeria.

[4] The Appendix is added to the on-line version of our paper and is also available via our personal web pages at www.economie.leidenuniv.nl.

[5] The Appendix is added to the on-line version of our paper and is also available via our personal web pages at www.economie.leidenuniv.nl.

[6] In addition to the DER indicator (α = 0.5), we estimateincome polarization utilizing different indicators (FW, EGR) and the DER indicator with different values of α (α = 0.25, α = 0.75 and α = 1). Although the magnitude of the polarization indicators are different using different indicators or different values of α, the overall trends of income polarization estimated by the DER indicator (α = 0.5) are robust. Detailed information are presented in Tables B1-B3 and Figures B1 in Appendix B and Table C1 in Appendix C. The Appendix is added to the on-line version of our paper and is also available via our personal web pages at www.economie.leidenuniv.nl.

[7] The Appendix is added to the on-line version of our paper and is also available via our personal web pages at www.economie.leidenuniv.nl.

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Supporting information

Appendix A. European Union Statistics on Income and Living Conditions (EU-SILC)
Table A1. Descriptives composition disposable household income EU-SILC, 2013

Appendix B. Polarization's sensitivity to different indicators and to different α
Table B1. *DER*, *FW* and *EGR* indicators for the 20 European countries, 2004-2013
Table B2: Polarization by DER indicator, FW indicator and EGR indicator, 2013
Table B3: Change in income polarization expressed by different polarization indicators, 2004-2013 (DER $\alpha = 0.5$)
Figure B1: Correlation between changes in the DER indicator and other polarization indicators, 2004-2013 (DER $\alpha = 0.5$)

Appendix C. Polarization's sensitivity to different values of α
Table C1: Sensitivity analysis of polarization indicator DER for a range of values for α, 2013

Appendix D. Nature of decomposing a polarization change into growth and reallocation effects

Appendix E: Detailed decomposition change *DER* indicator 2004-2008 and 2008-2013 ($\alpha = 0.5$)
Table E1: Detailed decomposition change *DER* indicator 2004-2008 ($\alpha = 0.5$)
Table E2: Detailed decomposition change *DER* indicator 2008-2013 ($\alpha = 0.5$)

Appendix A. Descriptives composition disposable household income EU-SILC, 2013

	Number of observations	Equivalized disposable income in euro (mean)	Market income (share of 2)	Social benefit (share of 2)	Taxes (share of 2)
	(1)	(2)	(3)	(4)	(5)
West EU-10					
Austria	13,244	22,559	98.9%	36.6%	-35.5%
Belgium	14,601	21,465	100.0%	31.1%	-31.1%
Denmark	13,869	30,875	121.1%	30.4%	-51.6%
Finland	27,888	26,118	106.7%	27.8%	-34.5%
Germany	26,618	21,601	101.9%	34.8%	-36.7%
Ireland	12,646	21,316	90.1%	39.2%	-29.2%
Luxembourg	9,964	36,471	95.1%	34.2%	-29.3%
Netherlands	24,586	23,675	130.8%	28.9%	-59.7%
Sweden	15,174	28,259	104.3%	31.4%	-35.8%
United Kingdom	23,158	18,013	95.7%	32.4%	-28.1%
CEE NMS-8					
Cyprus	13,275	18,873	85.4%	28.8%	-14.2%
Czech Republic	19,085	7,712	86.3%	29.6%	-15.8%
Estonia	15,003	5,949	91.7%	26.7%	-18.4%
Hungary	25,421	3,747	85.8%	37.5%	-23.3%
Lithuania	11,712	4,506	82.1%	32.7%	-14.8%
Poland	36,413	5,226	93.3%	34.0%	-27.3%
Slovenia	27,265	12,494	100.6%	30.0%	-30.6%
Slovakia	15,456	6,950	82.6%	25.9%	-8.6%
Other					
Iceland	8,902	16,269	119.0%	20.2%	-39.2%
Norway	15,299	45,523	111.7%	26.3%	-38.0%

Note: All incomes are expressed in gross values and converted into euros of 2005.
Source: own calculations EU-SILC.

Appendix B. Polarization's sensitivity to different indicators and to different α

Table B1. *DER*, *FW* and *EGR* indicators for the 20 European countries, 2004-2013

Income concept: Equivalized disposable income

Polarization sensitivity parameter: $\alpha = 0.5$

Equivalence scale: The modified LIS' equivalence scales

West EU-15 countries

Austria (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.183	0.261	0.812	-0.136	0.105	0.073
2005	0.186	0.264	0.828	-0.152	0.104	0.074
2006	0.181	0.255	0.824	-0.136	0.104	0.072
2007	0.184	0.262	0.822	-0.145	0.105	0.074
2008	0.188	0.266	0.826	-0.146	0.108	0.075
2009	0.184	0.261	0.821	-0.139	0.106	0.073
2010	0.187	0.267	0.826	-0.151	0.105	0.075
2011	0.187	0.268	0.820	-0.150	0.106	0.075
2012	0.191	0.284	0.789	-0.146	0.114	0.080
2013	0.190	0.282	0.783	-0.142	0.113	0.079

Belgium (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.188	0.271	0.790	-0.122	0.114	0.077
2005	0.196	0.282	0.820	-0.154	0.111	0.080
2006	0.191	0.275	0.809	-0.143	0.110	0.078
2007	0.188	0.267	0.804	-0.127	0.110	0.076
2008	0.194	0.282	0.807	-0.148	0.112	0.079
2009	0.188	0.267	0.807	-0.127	0.110	0.075
2010	0.188	0.269	0.798	-0.122	0.112	0.076
2011	0.187	0.266	0.800	-0.123	0.111	0.075
2012	0.188	0.267	0.800	-0.122	0.113	0.076
2013	0.188	0.267	0.803	-0.125	0.111	0.076

Germany (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.191	0.279	0.814	-0.159	0.108	0.078
2006	0.193	0.286	0.808	-0.166	0.110	0.080
2007	0.192	0.287	0.802	-0.163	0.110	0.080
2008	0.193	0.288	0.805	-0.165	0.111	0.081
2009	0.190	0.280	0.805	-0.158	0.108	0.078
2010	0.192	0.283	0.803	-0.155	0.110	0.079
2011	0.192	0.283	0.798	-0.148	0.113	0.079
2012	0.189	0.275	0.798	-0.139	0.112	0.078
2013	0.194	0.287	0.801	-0.156	0.113	0.081

Denmark (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.166	0.217	0.908	-0.159	0.079	0.061
2005	0.163	0.212	0.903	-0.146	0.079	0.059
2006	0.167	0.219	0.904	-0.157	0.078	0.061
2007	0.176	0.238	0.913	-0.187	0.079	0.066
2008	0.191	0.266	0.922	-0.222	0.080	0.074
2009	0.167	0.220	0.898	-0.155	0.080	0.061
2010	0.166	0.218	0.884	-0.141	0.082	0.061
2011	0.172	0.231	0.877	-0.152	0.086	0.064
2012	0.170	0.227	0.880	-0.147	0.085	0.064
2013	0.175	0.240	0.862	-0.151	0.088	0.067

Finland (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.187	0.268	0.838	-0.166	0.101	0.075
2005	0.190	0.275	0.829	-0.165	0.105	0.077
2006	0.190	0.275	0.827	-0.165	0.105	0.275
2007	0.189	0.274	0.815	-0.152	0.108	0.077
2008	0.189	0.274	0.814	-0.154	0.106	0.077
2009	0.187	0.271	0.820	-0.156	0.104	0.076
2010	0.187	0.271	0.819	-0.157	0.104	0.076
2011	0.188	0.272	0.822	-0.157	0.105	0.076
2012	0.189	0.274	0.825	-0.162	0.105	0.077
2013	0.187	0.267	0.826	-0.154	0.105	0.075

Ireland (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.216	0.323	0.773	-0.135	0.141	0.092
2005	0.217	0.325	0.776	-0.142	0.142	0.093
2006	0.223	0.336	0.789	-0.161	0.145	0.096
2007	0.222	0.334	0.786	-0.156	0.147	0.096
2008	0.215	0.321	0.791	-0.155	0.138	0.092
2009	0.206	0.304	0.787	-0.139	0.134	0.087
2010	0.206	0.305	0.797	-0.151	0.131	0.087
2011	0.202	0.299	0.789	-0.144	0.131	0.086
2012	0.204	0.308	0.784	-0.154	0.130	0.087
2013	0.202	0.301	0.792	-0.151	0.128	0.086

Luxembourg (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.189	0.274	0.799	-0.135	0.113	0.077
2005	0.192	0.280	0.785	-0.127	0.116	0.079
2006	0.203	0.305	0.770	-0.136	0.129	0.087
2007	0.209	0.311	0.788	-0.148	0.131	0.088
2008	0.211	0.317	0.793	-0.158	0.133	0.090
2009	0.204	0.301	0.806	-0.156	0.126	0.086
2010	0.200	0.293	0.807	-0.153	0.123	0.083
2011	0.196	0.281	0.804	-0.133	0.123	0.080
2012	0.194	0.277	0.809	-0.133	0.119	0.079
2013	0.198	0.288	0.801	-0.144	0.118	0.082

Netherlands (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.172	0.232	0.863	-0.142	0.092	0.065
2006	0.174	0.232	0.890	-0.156	0.090	0.065
2007	0.179	0.243	0.889	-0.174	0.091	0.068
2008	0.181	0.247	0.890	-0.177	0.091	0.069
2009	0.180	0.247	0.878	-0.171	0.092	0.069
2010	0.175	0.234	0.880	-0.152	0.092	0.066
2011	0.175	0.235	0.878	-0.154	0.092	0.066
2012	0.175	0.235	0.880	-0.156	0.091	0.066
2013	0.171	0.228	0.887	-0.151	0.089	0.064

Sweden (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.164	0.214	0.871	-0.122	0.085	0.060
2005	0.168	0.224	0.874	-0.142	0.087	0.063
2006	0.166	0.221	0.865	-0.132	0.086	0.062
2007	0.166	0.221	0.869	-0.134	0.086	0.062
2008	0.169	0.226	0.862	-0.133	0.088	0.063
2009	0.171	0.232	0.858	-0.140	0.088	0.065
2010	0.170	0.230	0.854	-0.133	0.089	0.064
2011	0.172	0.235	0.842	-0.128	0.092	0.066
2012	0.174	0.240	0.831	-0.125	0.095	0.068
2013	0.175	0.242	0.833	-0.130	0.096	0.068

United Kingdom (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.223	0.355	0.762	-0.177	0.145	0.101
2006	0.211	0.329	0.752	-0.145	0.142	0.093
2007	0.211	0.329	0.759	-0.155	0.136	0.093
2008	0.217	0.339	0.762	-0.163	0.141	0.096
2009	0.210	0.325	0.768	-0.158	0.136	0.092
2010	0.213	0.330	0.766	-0.159	0.140	0.094
2011	0.213	0.332	0.770	-0.165	0.138	0.094
2012	0.208	0.317	0.786	-0.168	0.129	0.090
2013	0.202	0.301	0.782	-0.143	0.130	0.086

CEE NMS-8

Cyprus (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.199	0.295	0.782	-0.139	0.122	0.083
2006	0.202	0.301	0.795	-0.156	0.120	0.085
2007	0.207	0.313	0.802	-0.175	0.118	0.088
2008	0.200	0.295	0.799	-0.152	0.117	0.083
2009	0.203	0.303	0.789	-0.149	0.122	0.085
2010	0.205	0.309	0.786	-0.154	0.124	0.087
2011	0.202	0.301	0.785	-0.143	0.122	0.085
2012	0.214	0.326	0.790	-0.169	0.130	0.092
2013	0.219	0.333	0.794	-0.173	0.136	0.095

Czech Republic (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.186	0.257	0.847	-0.147	0.099	0.072
2006	0.182	0.250	0.861	-0.155	0.100	0.071
2007	0.180	0.246	0.866	-0.153	0.099	0.069
2008	0.178	0.240	0.875	-0.154	0.096	0.068
2009	0.179	0.244	0.875	-0.161	0.096	0.069
2010	0.180	0.248	0.866	-0.162	0.097	0.070
2011	0.180	0.249	0.857	-0.153	0.100	0.070
2012	0.177	0.243	0.862	-0.152	0.096	0.068
2013	0.177	0.240	0.871	-0.155	0.094	0.067

Estonia (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.220	0.358	0.719	-0.145	0.156	0.101
2005	0.208	0.326	0.744	-0.142	0.138	0.092
2006	0.205	0.315	0.757	-0.138	0.135	0.089
2007	0.206	0.314	0.767	-0.145	0.132	0.089
2008	0.200	0.298	0.765	-0.123	0.128	0.085
2009	0.199	0.294	0.768	-0.122	0.128	0.084
2010	0.197	0.293	0.768	-0.127	0.127	0.083
2011	0.200	0.303	0.758	-0.128	0.132	0.086
2012	0.204	0.310	0.757	-0.130	0.137	0.088
2013	0.206	0.313	0.761	-0.137	0.137	0.089

Hungary (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.188	0.269	0.830	-0.160	0.102	0.075
2006	0.206	0.318	0.795	-0.185	0.119	0.089
2007	0.185	0.265	0.823	-0.151	0.104	0.074
2008	0.182	0.255	0.833	-0.143	0.103	0.072
2009	0.180	0.250	0.834	-0.137	0.101	0.071
2010	0.179	0.245	0.837	-0.128	0.103	0.069
2011	0.191	0.272	0.809	-0.135	0.114	0.077
2012	0.187	0.268	0.813	-0.140	0.109	0.075
2013	0.187	0.268	0.811	-0.141	0.107	0.076

Lithuania (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.219	0.354	0.731	-0.153	0.153	0.100
2006	0.214	0.336	0.746	-0.147	0.146	0.096
2007	0.212	0.332	0.753	-0.151	0.142	0.094
2008	0.214	0.335	0.752	-0.150	0.141	0.095
2009	0.218	0.347	0.757	-0.168	0.144	0.098
2010	0.218	0.351	0.741	-0.164	0.145	0.099
2011	0.205	0.316	0.752	-0.136	0.137	0.090
2012	0.206	0.313	0.763	-0.137	0.138	0.089
2013	0.212	0.331	0.759	-0.153	0.142	0.094

Poland (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.217	0.357	0.719	-0.152	0.149	0.101
2006	0.206	0.320	0.752	-0.143	0.136	0.091
2007	0.203	0.311	0.767	-0.149	0.129	0.088
2008	0.203	0.309	0.774	-0.152	0.128	0.087
2009	0.202	0.306	0.771	-0.144	0.127	0.086
2010	0.202	0.307	0.767	-0.144	0.128	0.087
2011	0.202	0.308	0.768	-0.147	0.128	0.087
2012	0.199	0.301	0.769	-0.139	0.126	0.085
2013	0.198	0.300	0.770	-0.140	0.125	0.085

Slovenia (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	EGR
2005	0.172	0.234	0.846	-0.132	0.093	0.066
2006	0.173	0.234	0.843	-0.126	0.096	0.066
2007	0.172	0.233	0.847	-0.129	0.093	0.066
2008	0.171	0.233	0.842	-0.128	0.093	0.066
2009	0.170	0.230	0.848	-0.126	0.092	0.065
2010	0.173	0.236	0.839	-0.126	0.095	0.067
2011	0.174	0.237	0.836	-0.124	0.096	0.067
2012	0.173	0.236	0.837	-0.123	0.095	0.066
2013	0.175	0.242	0.829	-0.126	0.096	0.068

Slovakia (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2005	0.186	0.267	0.816	-0.148	0.104	0.075
2006	0.196	0.288	0.837	-0.187	0.102	0.080
2007	0.178	0.245	0.836	-0.135	0.100	0.069
2008	0.177	0.244	0.831	-0.127	0.100	0.069
2009	0.181	0.254	0.823	-0.137	0.104	0.072
2010	0.182	0.257	0.823	-0.140	0.103	0.072
2011	0.181	0.255	0.825	-0.138	0.102	0.071
2012	0.180	0.252	0.812	-0.117	0.107	0.072
2013	0.176	0.240	0.827	-0.115	0.102	0.068

Other countries

Iceland (2004-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.177	0.244	0.855	-0.152	0.093	0.068
2005	0.179	0.248	0.866	-0.163	0.093	0.069
2006	0.185	0.260	0.856	-0.170	0.097	0.073
2007	0.196	0.283	0.854	-0.189	0.104	0.080
2008	0.191	0.273	0.852	-0.180	0.100	0.077
2009	0.202	0.296	0.856	-0.202	0.105	0.084
2010	0.181	0.254	0.860	-0.170	0.095	0.072
2011	0.172	0.231	0.878	-0.151	0.088	0.065
2012	0.175	0.237	0.864	-0.145	0.095	0.067
2013	0.176	0.240	0.859	-0.146	0.094	0.068

Norway (2005-2013)	*DER*	Alienation	Identification	Correlation	*FW*	*EGR*
2004	0.188	0.263	0.917	-0.219	0.081	0.073
2005	0.192	0.273	0.916	-0.232	0.081	0.076
2006	0.200	0.293	0.895	-0.236	0.087	0.082
2007	0.168	0.228	0.869	-0.152	0.083	0.063
2008	0.173	0.237	0.886	-0.174	0.083	0.066
2009	0.171	0.232	0.877	-0.161	0.084	0.064
2010	0.170	0.229	0.887	-0.163	0.083	0.064
2011	0.166	0.220	0.888	-0.149	0.083	0.061
2012	0.165	0.218	0.887	-0.148	0.081	0.061
2013	0.164	0.216	0.892	-0.150	0.080	0.060

Table B2: Polarization by DER indicator, FW indicator and EGR indicator, 2013

	DER indicator ($\alpha = 0.5$)		FW indicator		EGR indicator	
	Level	Rank	Level	Rank	Level	Rank
Norway	0.164	(1)	0.080	(1)	0.060	(1)
Denmark	0.171	(2)	0.089	(3)	0.064	(2)
Slovenia	0.175	(3)	0.088	(2)	0.067	(3)
Sweden	0.175	(4)	0.096	(6)	0.068	(7)
Netherlands	0.175	(5)	0.096	(7)	0.068	(8)
Iceland	0.176	(6)	0.102	(8)	0.068	(6)
Czech Republic	0.176	(7)	0.094	(5)	0.068	(5)
Slovakia	0.177	(8)	0.094	(4)	0.067	(4)
Hungary	0.187	(9)	0.107	(10)	0.076	(10)
Belgium	0.187	(10)	0.105	(9)	0.075	(9)
Germany	0.188	(11)	0.111	(11)	0.076	(11)
Finland	0.190	(12)	0.113	(13)	0.079	(12)
Austria	0.194	(13)	0.113	(12)	0.081	(13)
Luxembourg	0.198	(14)	0.118	(14)	0.082	(14)
Poland	0.198	(15)	0.125	(15)	0.085	(15)
Estonia	0.202	(16)	0.130	(17)	0.086	(17)
Ireland	0.202	(17)	0.128	(16)	0.086	(16)
Lithuania	0.206	(18)	0.137	(19)	0.089	(18)
United Kingdom	0.212	(19)	0.142	(20)	0.094	(19)
Cyprus	0.219	(20)	0.136	(18)	0.095	(20)
Mean-20	*0.189*		*0.110*		*0.077*	

Note: According to Duro (2005b), that EGR indicator structured around three groups gives the best simplified description of income distribution. Therefore, we compute the EGR indicator by dividing the distribution into three groups. We also calculated the EGR indicator around 2, 4 and 5 groups; the results are robust.

Source: own calculations EU-SILC.

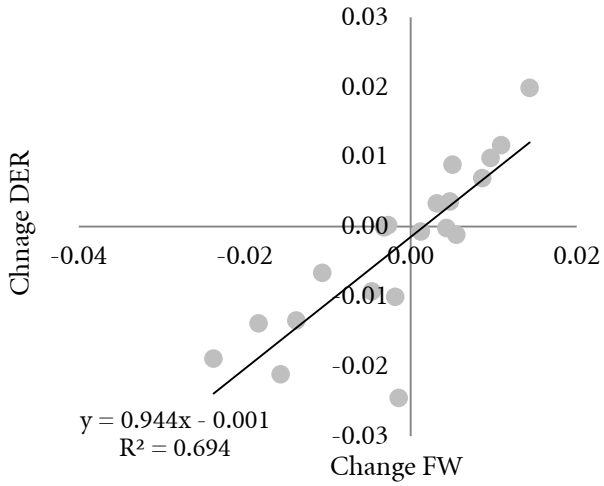
Table B3: Change in income polarization expressed by different polarization indicators, 2004-2013 (*DER* $\alpha = 0.5$)

Country	*DER* indicator ($\alpha = 0.5$)				*FW* indicator				*EGR* indicator			
	Around 2004	Around 2013	Change 2004-2013	Rank	Around 2004	Around 2013	Change 2004-2013	Rank	Around 2004	Around 2013	Change 2004-2013	Rank
Norway	0.188	0.164	-0.025	(1)	0.081	0.080	-0.001	(10)	0.073	0.060	-0.013	(3)
United Kingdom	0.223	0.202	-0.021	(2)	0.145	0.130	-0.016	(3)	0.101	0.086	-0.015	(2)
Poland	0.217	0.198	-0.019	(3)	0.149	0.125	-0.024	(1)	0.101	0.085	-0.016	(1)
Estonia	0.220	0.206	-0.014	(4)	0.156	0.137	-0.018	(2)	0.101	0.089	-0.012	(4)
Ireland	0.216	0.202	-0.013	(5)	0.141	0.128	-0.014	(4)	0.092	0.086	-0.007	(6)
Slovakia	0.186	0.176	-0.010	(6)	0.104	0.102	-0.002	(9)	0.075	0.068	-0.007	(5)
Czech Republic	0.186	0.177	-0.009	(7)	0.099	0.094	-0.005	(6)	0.072	0.067	-0.005	(8)
Lithuania	0.219	0.212	-0.007	(8)	0.153	0.142	-0.011	(5)	0.100	0.094	-0.006	(7)
Hungary	0.188	0.187	-0.001	(9)	0.102	0.107	0.006	(16)	0.075	0.076	0.000	(12)
Iceland	0.177	0.176	-0.001	(10)	0.093	0.094	0.001	(11)	0.068	0.068	-0.001	(11)
Finland	0.187	0.187	0.000	(11)	0.101	0.105	0.004	(13)	0.075	0.075	0.000	(13)
Netherlands	0.172	0.171	0.000	(12)	0.092	0.089	-0.003	(7)	0.065	0.064	-0.001	(9)
Belgium	0.188	0.188	0.000	(13)	0.114	0.111	-0.003	(8)	0.077	0.076	-0.001	(10)
Slovenia	0.172	0.175	0.003	(14)	0.093	0.096	0.003	(12)	0.066	0.068	0.002	(14)
Germany	0.191	0.194	0.004	(15)	0.108	0.113	0.005	(14)	0.078	0.081	0.003	(15)
Austria	0.183	0.190	0.007	(16)	0.105	0.113	0.009	(17)	0.073	0.079	0.006	(17)
Luxembourg	0.189	0.198	0.009	(17)	0.113	0.118	0.005	(15)	0.077	0.082	0.005	(16)
Denmark	0.166	0.175	0.010	(18)	0.079	0.088	0.010	(18)	0.061	0.067	0.007	(18)
Sweden	0.164	0.175	0.012	(19)	0.085	0.096	0.011	(19)	0.060	0.068	0.008	(19)
Cyprus	0.199	0.219	0.020	(20)	0.122	0.136	0.014	(20)	0.083	0.095	0.011	(20)
Mean	*0.191*	*0.189*	*-0.003*		*0.112*	*0.110*	*-0.001*		*0.079*	*0.077*	*-0.002*	
Coefficient of variation	*0.094*	*0.077*	*-0.017*		*0.214*	*0.161*	*-0.053*		*0.166*	*0.130*	*-0.036*	

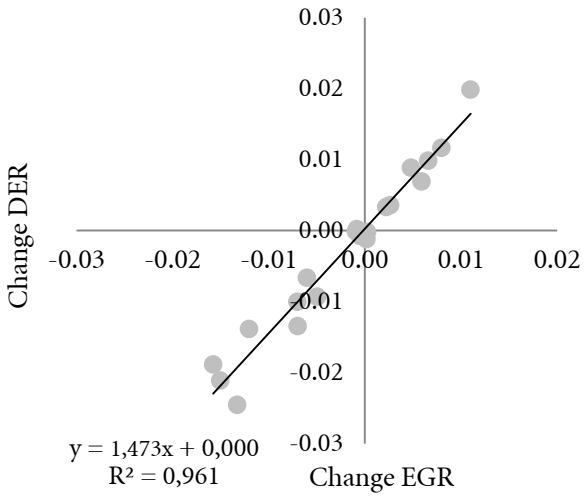
Note: Countries are ranked in order of the changes of the *DER* indicator from lowest to highest.
Source: own calculations EU-SILC.

Figure B1: Correlation between changes in the DER indicator and other polarization indicators, 2004-2013 ($DER\ \alpha = 0.5$)

Panel a: DER and FW indicators



Panel b: DER and EGR indicators



Source: own calculations EU-SILC.

Appendix C. Polarization's sensitivity to different values of α

Table C1: Sensitivity analysis of polarization indicator *DER* for a range of values for α, 2013

	$\alpha = 0$ (Gini)		$\alpha = 0.25$		$\alpha = 0.5$		$\alpha = 0.75$		$\alpha = 1$	
Country	Level	Rank	Level	Rank	Level	Rank	Level	Rank	Level	Rank
Norway	0.216	(1)	0.181	(1)	0.164	(1)	0.155	(1)	0.150	(4)
Netherlands	0.228	(2)	0.190	(2)	0.171	(2)	0.162	(5)	0.157	(11)
Denmark	0.240	(3)	0.197	(3)	0.175	(3)	0.163	(6)	0.155	(7)
Sweden	0.242	(8)	0.199	(6)	0.175	(4)	0.160	(4)	0.149	(3)
Slovenia	0.242	(7)	0.200	(8)	0.175	(5)	0.159	(2)	0.148	(1)
Slovakia	0.240	(5)	0.200	(7)	0.176	(6)	0.159	(3)	0.148	(2)
Iceland	0.240	(6)	0.198	(5)	0.176	(7)	0.163	(7)	0.155	(9)
Czech	0.240	(4)	0.198	(4)	0.177	(8)	0.165	(8)	0.159	(13)
Hungary	0.268	(11)	0.216	(10)	0.187	(9)	0.168	(10)	0.155	(8)
Finland	0.267	(9)	0.214	(9)	0.187	(10)	0.170	(12)	0.159	(12)
Belgium	0.267	(10)	0.217	(11)	0.188	(11)	0.169	(11)	0.155	(6)
Austria	0.282	(12)	0.223	(12)	0.190	(12)	0.168	(9)	0.152	(5)
Germany	0.287	(13)	0.226	(13)	0.194	(13)	0.174	(14)	0.160	(14)
Luxembourg	0.288	(14)	0.229	(14)	0.198	(14)	0.178	(15)	0.164	(17)
Poland	0.300	(15)	0.235	(15)	0.198	(15)	0.174	(13)	0.157	(10)
United	0.301	(16)	0.237	(17)	0.202	(16)	0.179	(16)	0.163	(16)
Ireland	0.301	(17)	0.236	(16)	0.202	(17)	0.182	(18)	0.168	(19)
Estonia	0.313	(18)	0.246	(18)	0.206	(18)	0.180	(17)	0.162	(15)
Lithuania	0.331	(19)	0.255	(19)	0.212	(19)	0.186	(19)	0.167	(18)
Cyprus	0.333	(20)	0.256	(20)	0.219	(20)	0.196	(20)	0.181	(20)
Mean 20	*0.251*		*0.500*		*0.191*		*0.434*		*0.159*	
Coefficient of variation	*0.135*		*0.043*		*0.076*		*0.024*		*0.049*	

Source: own calculations EU-SILC.

Appendix D. Nature of decomposing a polarization change into growth and reallocation effects

Based on Kakwani's (2000) axiomatic approach, the nature of decomposing a polarization change into growth and reallocation effects can be described through three axioms:

Axiom 1: If $G(t,t+1)=0$, then $\Delta p(x)=D(t,t+1)$ and if $D(t,t+1)=0$, then $\Delta p(x)=G(t,t+1)$

If the growth effect (reallocation effect) is equal to zero, then the change in polarization is entirely dependent on a change in inequality (change in mean income). Further, if the growth and reallocation effects are both equal to zero, then polarization does not change between the two periods.

Axiom 2: If $G(t,t+1)\leq 0$ and $D(t,t+1)\leq 0$, then $\Delta p(x)\leq 0$, and if $G(t,t+1)\geq 0$ and $D(t,t+1)\geq 0$, then $\Delta p(x)\geq 0$.

This axiom indicates that if both the growth and reallocation effects are less (greater) than zero, total polarization change must be less (greater) than zero. If, however, $G(t,t+1)\leq 0\ (\geq 0)$ but $D(t,t+1)\geq 0\ (\leq 0)$, then the total change in polarization would be determined by the magnitude of $G(t,t+1)$ and $D(t,t+1)$. Note that $G(t,t+1)\leq 0\ (\geq)$ implies that change in the mean source income x has a favorable effect on the polarization.

Axiom 3: $G(t,t+1)=-G(t,t+1)$ and $D(t,t+1)=-G(t,t+1)$

$G\binom{t,}{t+1}$ and $D(t,t+1)$ are the growth and reallocation effects when one moves from the terminal year $t+1$ to the initial year t. The effects should be of the same magnitude but with opposite signs when going from the initial year t to the terminal year $t+1$. This axiom guarantees symmetry between the initial and terminal periods. Avoiding the Axiom 3 may give rise to the problem of nominating the initial or the terminal year as the reference.

Applying these axioms to decomposing polarization helps us to overcome two limitations: the residual term and the use of the 'benchmark period' problem. The first two axioms ensure that $\Delta p(x)$ is linear and additive and the third axiom guarantees symmetry.

Appendix E: Detailed decomposition change *DER* indicator 2004-2008 and 2008-2013 ($\alpha = 0.5$)

Table E1: Detailed decomposition change *DER* indicator 2004-2008 ($\alpha = 0.5$)

Country	Available in EU-SILC	*DER* indicator					Decomposition of change *DER* indicator 2004-2008					
		Level around 2004	Level around 2008	Change 2004-2008			Partial effect: Market income		Partial effect: Social Benefit		Partial effect: Taxes	
				Total change	Growth effects	Reallocation effects	Growth effects	Reallocation effects	Growth effects	Reallocation effects	Growth effects	Reallocation effects
West EU-10												
Denmark	2004-2008	0.166	0.191	0.025	0.001	0.024	0.005	0.009	-0.002	0.008	-0.002	0.008
Luxembourg	2004-2008	0.189	0.212	0.022	0.000	0.022	0.000	0.007	0.001	0.009	0.000	0.006
Netherlands	2005-2008	0.172	0.181	0.009	0.000	0.009	0.005	0.000	-0.002	0.005	-0.003	0.004
Belgium	2004-2008	0.188	0.194	0.006	0.000	0.006	0.001	0.002	-0.001	0.002	0.000	0.002
Sweden	2004-2008	0.164	0.169	0.005	0.000	0.005	0.000	-0.001	0.000	0.004	-0.001	0.002
Germany	2005-2008	0.191	0.193	0.003	0.000	0.003	0.002	0.002	-0.002	0.000	-0.001	0.001
Austria	2005-2008	0.186	0.188	0.002	0.000	0.002	0.002	0.001	-0.001	0.000	-0.001	0.002
Finland	2004-2008	0.187	0.189	0.002	0.000	0.002	0.001	0.000	-0.001	0.001	0.000	0.001
Ireland	2004-2008	0.216	0.215	-0.001	0.000	-0.001	0.008	0.000	-0.007	0.000	-0.002	-0.001
United Kingdom	2005-2008	0.223	0.217	-0.006	0.000	-0.006	-0.007	0.000	0.004	-0.003	0.003	-0.003
Mean-10		*0.188*	*0.195*	*0.007*	*0.000*	*0.007*	*0.002*	*0.002*	*-0.001*	*0.002*	*-0.001*	*0.002*
CEE NMS-8												
Cyprus	2005-2008	0.199	0.200	0.001	0.000	0.001	0.003	-0.001	-0.002	0.001	-0.001	0.000
Slovenia	2005-2008	0.172	0.171	-0.001	0.000	-0.001	0.001	-0.002	-0.001	0.001	-0.001	0.000
Czech Republic	2006-2008	0.182	0.178	-0.004	0.000	-0.004	0.010	-0.007	-0.007	0.003	-0.003	0.000
Lithuania	2005-2008	0.219	0.214	-0.005	0.000	-0.005	0.020	-0.013	-0.015	0.005	-0.006	0.002
Hungary	2005-2008	0.188	0.182	-0.006	0.000	-0.006	0.005	-0.005	-0.003	-0.001	-0.002	0.000
Poland	2005-2008	0.217	0.203	-0.015	0.000	-0.014	0.014	-0.016	-0.011	0.003	-0.003	-0.001
Slovakia	2006-2008	0.196	0.177	-0.019	0.000	-0.018	0.009	-0.015	-0.006	-0.002	-0.003	-0.002
Estonia	2004-2008	0.220	0.200	-0.020	-0.001	-0.020	0.013	-0.018	-0.012	0.000	-0.002	-0.001
Mean-8		*0.199*	*0.191*	*-0.008*	*0.000*	*-0.008*	*0.010*	*-0.010*	*-0.007*	*0.001*	*-0.003*	*0.000*
Other												
Norway	2004-2008	0.188	0.173	-0.015	0.000	-0.015	0.006	-0.011	-0.004	-0.002	-0.002	-0.003
Iceland	2004-2008	0.177	0.191	0.014	0.000	0.014	0.003	0.004	-0.001	0.005	-0.001	0.004
Mean-20		*0.192*	*0.193*	*0.001*	*0.000*	*0.001*	*0.005*	*-0.003*	*-0.004*	*0.002*	*-0.002*	*0.001*

Table E2: Detailed decomposition change *DER* indicator 2008-2013 ($\alpha = 0.5$)

Country	Available in EU-SILC	*DER* indicator					Decomposition of change *DER* indicator 2008-2013					
		Level around 2008	Level around 2013	Change 2008-2013			Partial effect: Market income		Partial effect: Social Benefit		Partial effect: Taxes	
				Total change	Growth effect	Reallocation effect	Growth effect	Reallocation effect	Growth effect	Reallocation effect	Growth effect	Reallocation effect
West EU-10												
Sweden	2008-2013	0.169	0.175	0.007	0.000	0.006	0.010	0.000	-0.007	0.005	-0.002	0.002
Austria	2008-2013	0.188	0.190	0.002	0.000	0.002	0.000	0.003	0.000	0.000	0.000	-0.001
Germany	2008-2013	0.193	0.194	0.001	0.000	0.001	0.002	-0.001	-0.001	0.001	-0.001	0.001
Finland	2008-2013	0.189	0.187	-0.002	0.000	-0.002	0.005	-0.001	-0.004	0.000	-0.002	-0.001
Belgium	2008-2013	0.194	0.188	-0.006	0.000	-0.006	0.001	0.000	-0.001	-0.002	0.000	-0.004
Netherlands	2008-2013	0.181	0.171	-0.009	0.000	-0.009	-0.001	-0.002	0.000	-0.003	-0.002	-0.002
Ireland	2008-2013	0.215	0.202	-0.012	-0.001	-0.011	-0.001	-0.004	-0.002	-0.007	0.002	-0.001
Luxembourg	2008-2013	0.212	0.198	-0.014	0.000	-0.013	0.004	-0.006	-0.002	-0.004	-0.002	-0.003
United Kingdom	2008-2013	0.217	0.202	-0.015	0.001	-0.016	-0.017	0.011	0.011	-0.013	0.007	-0.014
Denmark	2008-2013	0.191	0.175	-0.016	0.000	-0.016	-0.003	0.000	0.001	-0.006	0.002	-0.010
Mean-10		0.195	0.188	-0.006	*0.000*	*-0.007*	*0.000*	*0.000*	*-0.001*	*-0.003*	*0.000*	*-0.003*
CEE NMS-8												
Cyprus	2008-2013	0.200	0.219	0.019	0.000	0.019	0.002	0.010	-0.001	0.007	-0.001	0.002
Estonia	2008-2013	0.200	0.206	0.006	0.000	0.005	0.006	0.005	-0.004	0.002	-0.002	-0.001
Hungary	2008-2013	0.182	0.187	0.004	0.000	0.004	-0.012	0.004	0.007	0.000	0.005	0.001
Slovenia	2008-2013	0.171	0.175	0.004	0.000	0.004	0.000	0.005	0.000	-0.001	0.000	0.000
Lithuania	2008-2013	0.214	0.212	-0.001	0.000	-0.001	-0.002	0.007	0.001	-0.005	0.001	-0.003
Czech Republic	2008-2013	0.178	0.177	-0.002	0.000	-0.002	0.005	-0.003	-0.004	0.002	0.000	0.000
Slovakia	2008-2013	0.177	0.176	-0.002	-0.002	0.001	-0.005	-0.001	-0.003	-0.003	0.006	0.005
Poland	2008-2013	0.203	0.198	-0.004	0.000	-0.005	0.001	-0.003	-0.001	-0.001	0.000	-0.001
Mean-8		0.191	0.194	0.003	*0.000*	*0.003*	*-0.001*	*0.003*	*-0.001*	*0.000*	*0.001*	*0.000*
Other												
Iceland	2008-2013	0.191	0.176	-0.014	0.001	-0.016	-0.004	0.006	0.010	-0.009	-0.005	-0.013
Norway	2008-2013	0.173	0.164	-0.010	0.000	-0.009	0.011	-0.009	-0.006	0.001	-0.005	-0.001
Mean-20		0.192	0.189	-0.003	*0.000*	*-0.003*	*0.000*	*0.001*	*0.000*	*-0.002*	*0.000*	*-0.002*

Source: own calculations EU-SILC.