ESRI

Working Paper No.721

March 2022

How important are the unit of analysis and equivalence scales when measuring income poverty and inequality? Evidence from Ireland

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Abstract: We analyse the effect of varying equivalization scales and income-sharing units (households, tax-units and benefit-units) on inequality and poverty statistics using Irish microdata. We find that benchmark equivalence scales result in substantial variation in the degree of income poverty estimated at the household level, particularly for young children and the elderly. We test multiple permutations of child and adult weights in a set of hypothetical equivalence scales. Our simulation results show that over a range of commonly observed adult-child equivalence weights –0.5 to 0.7 for adults and 0.3 to 0.5 for children, Irish income poverty rates in 2019 ranged from 15.0 per cent to 19.5 per cent– most of this variation is attributable to changes in the adult weight. Inequality statistics tend to be less sensitive to the choice of equivalence scale but are sensitive to the choice of income-sharing unit. At the household level, the Gini coefficient varies between 0.29 and 0.32. At the tax-/benefit-unit level the range is elevated, with the Gini remaining stable over time but between 0.33 and 0.35. Other inequality metrics, such as the p90p10 ratio, exhibit increased volatility over the business cycle at sub-household unit levels.

Keywords: inequality, poverty, equivalence scales, unit of analysis
JEL Classification: D63 I32

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The authors are grateful to Karina Doorley and participants at the ESRI Lunchtime Seminar Series for valuable comments. Funding from the Economic and Social Research Institute's Tax, Welfare and Pensions Research Programme (supported by the Departments of Public Expenditure and Reform; Social Protection; Health; Children, Equality, Disability, Integration and Youth; and Finance) is gratefully acknowledged. The results presented here are based on EUROMOD version I1.0+. Having been originally maintained, developed and managed by the Institute for Social and Economic Research (ISER), since 2021 EUROMOD is maintained, developed and managed by the Joint Research Centre (JRC) of the European Commission, in collaboration with EUROSTAT and national teams from the EU countries. We make use of microdata from the EU Survey on Incomes and Living Conditions (EU-SILC) made available by Eurostat.

1. Introduction

Two important measurement issues underlie our understanding of income poverty and inequality. Firstly, these statistics are mostly produced at the household level. This assumes income is pooled equally amongst household members.[3] This convention implicitly assumes away intra-household inequality, and solely focuses on inter-household inequality. Secondly, income data is transformed non-monotonically using equivalence scales, which adjust for household size and composition for a given level of income, in order to better approximate welfare. In this paper, we examine how sensitive inequality and poverty statistics are to these assumptions and explain the underlying mechanisms using micro data from Ireland. We contribute to the literature by showing that poverty rates – child and elderly rates in particular– calculated at the household level tend to be particularly sensitive to the choice of expert equivalence, whereas the Gini coefficient is not. We show that this is due to equivalence scales being approximately monotonic at the middle and top of the income distribution, but non-monotonic at the bottom; as such, low-income specific statistics will be very variable to the choice of scale, where statistics which summarize the entire income distribution will not. The Gini coefficient is however quite sensitive to the choice of income aggregation and tends to rise at sub-household levels.

Our first point of analysis examines the level of income sharing or put differently, the unit of analysis. Conventions on income sharing in Europe and the United States are very different, and authors have found non-trivial differences between inequality and poverty statistics when calculated at the household as opposed to sub-household level. In the European Union, the statistical agency Eurostat measures inequality and poverty statistics at the household level using annual releases of the pan-European Survey of Income and Living Conditions household survey. This is in contrast to the United States, where the Bureau of Labor Statistics measures poverty using the Current Population Survey with the family as the primary unit of analysis.[4] This difference is important, as research has shown that household and sub-household units can produce substantial differences in statistical concepts of inequality and poverty. This has been particularly evident in the United Kingdom where Fiegehen & Lansley (1976) find that using the tax-unit, as opposed to the household as the primary income sharing definition, increases inequality and almost doubles poverty when analysing the UK Family Expenditure

[3] There are different definitions for what a household unit, a tax unit and a family unit is, depending of the country examined. In Ireland, for example, a household unit includes all the people that leave in the same house, a tax unit is a legally married couple or an individual and any cohabitating children less than 18 years of age or in education, whereas a family unit is a cohabitating couple and their children less 18 years of age or less than 23 years of age and in full time education (for more details see section 2.2).

[4] A family is defined as a group of two or more people residing together who are related by birth, marriage, or adoption; all such people are considered members of one family. A primary family consists of a householder and all other people related to and residing with the householder. Only primary family units are included in poverty headcounts. See https://www.bls.gov/opub/reports/working-poor/2018/pdf/home.pdf

Survey. Other studies have also found that UK income poverty rates at the household level tend to be substantially lower than tax-unit or family-based definitions (Lasley, 1980; Johnson & Webb, 1989), with the largest discrepancies relating to young adults living with their parents (Johnson & Webb, 1989). Top income shares, another measure of income inequality, also exhibit mild sensitivity to the unit of analysis, with top 1- and 5%-income shares being approximately half a percentage point lower at the family-level as opposed to individual (Burkhauser et al., 2016).

As inequality and poverty statistics are derived at the household level, with full income-sharing assumed between household members, a divergence between household membership and household income-sharing habits could have a significant effect on our understanding of societal inequality and poverty. The 2011 and 2016 Irish Censuses indicate that close to 12 per cent of private households are comprised of multiple separate families,[5] giving *prima facie* evidence that complete intra-household sharing of income may not fully measure the welfare of a non-trivial portion of the population. Watson et al., (2013) analyse the special income sharing module available in the 2010 EU-SILC data for Ireland and find that only 52 per cent of households fully share income, 44 per cent share a portion of their income whilst 14 per cent share no income. There is also substantial heterogeneity across household types. Unsurprisingly, couples with young children fully share their income in 68 per cent of cases, while 24 per cent pool some portion of their income. Non-family households fully share income in merely 11 per cent of cases and 27 per cent shared none of their personal income with other household members. Singletons, living with their parents were the least likely to share their income, with 47 per cent contributing nothing to the income of their parents. This gives empirical evidence that full income sharing within households is a strong assumption, as even married couples only fully share their income in less than 70 per cent of cases. In the literature, Lise & Sietz (2011) also provide strong evidence that intra-household inequality, amongst couples with no children specifically, can be large in certain circumstances. They highlight that the current approach to measuring inequality is only appropriate for one-adult households and for couples where partners have comparable incomes. In instances where there is a large gap between partner incomes, there will be asymmetric bargaining power amongst partners meaning that income will not be shared equally. Given the inequality that can be induced by marital sorting patterns, it is likely that income-sharing amongst independent families living within the same household will be even smaller. This is the main channel we analyse; in the empirical component of the paper we allow for full income-sharing across household and sub-household units, as is standard, and see how variation in the unit of analysis affects inequality and poverty. As such, we focus on intra-household inequality arising from

[5] Authors' calculations, with a given family type (e.g., married couple) living with "other persons" being indicative of a multi-family household.

multiple tax-/benefit-units living in a single household and abstract from imperfect income-sharing that may occur within a tax-/benefit-unit due to asymmetric bargaining power.

The other avenue we explore is the effect of income equivalization. This may also have a large bearing on our perception of inequality and poverty. Equivalization adjusts household income to be expressed in per adult equivalent terms, so that raw income can be adjusted based on the number of adults and children it must be shared between. Historically, Atkinson (1976) urged researchers to experiment with a range of equivalization indices incorporating different aspects of poverty, due to the possibility that the measurement of poverty may be sensitive to the precise index employed. Buhmann et al. (1988) use the Luxembourg Income Study database to compare inequality and poverty across ten countries, with an emphasis on testing how sensitive inequality and poverty rankings were to the choice of equivalence scale. Aside from Israel and Canada, if average family size was not very large, different equivalence scales did not affect the rankings of countries in a range of inequality measures. Overall, as the equivalence elasticity increases for a given country, inequality first decreases then increases, leaving somewhat of a U-shaped pattern. Cowell & Mercader (1999) also found that Spain exhibited this U-shaped pattern in inequality when child/adult weights were varied, but inequality in the United Kingdom exhibited an increasing profile in child/adult weights. Coulter et al. (1992) also supported this finding noting that higher equivalization weights led to higher inequality. The country-specific relationship of equivalization is very important and highlights how demographics and preferences in household formation can influence the recording of living standards in statistical terms. Abanokova et al. (2020) highlight the sensitivity of Russian poverty statistics to the choice of equivalence scale due to the high prevalence of three-adult households in Russia compared to the United Kingdom, Germany and Switzerland. The Russian poverty rate for 2017 increased by as much as four percentage points when the adult weight decreased from 1 to 0.5, depending on the child parameter values, and a U-shaped relationship was evident between the poverty rate and the equivalence weights.

There was considerable debate in the United Kingdom on the effect of equivalence scales in the early 1990s. Much of this debate centred around the pattern between inequality and poverty rates as the size of equivalence weights increased. A key feature of the literature at this time centred around the functional form of equivalence scales with authors utilizing scales which were purely a function of household size and others using scales with distinct weights/relatives for adults, and children- see (Jenkins & Cowell, 1994) for a comparison of the different empirical approaches. In an early paper, Coulter et al. (1992) disputed the assertion by the UK Central Statistics Office that “the choice of equivalence scale from those in common use does not appear crucial”. They show a U-shaped relationship is evident in both the Gini coefficient and poverty rate when using an equivalence scale based on household size. In contrast, Banks & Johnson (1994a, 1994b) claim that the weight given to children is of particular importance-–in Coulter et al. (1992) a weight of 1 was given to all people. They claim that a greater weight given to children leads to increased inequality and that U-shaped patterns poverty rates and Gini coefficient estimates, as a result of varying the economies of scale in household size, only occur when adult and child weights are close to 1. Jenkins & Cowell (1994) contribute by showing that inequality and poverty are more sensitive to variations in household size scale relativities, the weight given to larger households, compared to variations in adult-child weights. They also note that the equivalence scale used in the UK at the time, the McClements scale, was mainly due to "inertia" and appealed for more discussion of what constitutes a reasonable scale. Banks & Johnson (1994a, 1994b) also highlight that the effect of scales on poverty and inequality could vary over time within a country and could be specific to a data set. On the appropriateness of scale values, specific household groups –mainly single elderly and households with children– are found to be extremely sensitive to the equivalence scale applied when examining poverty. This mainly works through an economies of scale channel, as higher economies of scale mean for a given initial income level, the welfare of larger households will be increasing relative to smaller households. This can also give rise to a perverse result whereby there can be an increase in households living in poverty, but a decrease in the number of individuals due to compositional changes in those classified as poor (De Vos and Zaidi, 1997). As a result, elderly poverty rates tend to decrease in assumed economies of scale–as elderly headed households tend to be relatively small (Burkhauser et al, 1996). This highlights that the composition of those living in poverty could also be very sensitive to the choice of equivalence scale via implied economies of scale.

In Ireland, policy discussions to date have highlighted the high level of market income inequality in Ireland relative to average EU and OECD levels (Sweeney, 2019; Roantree, 2020). Roantree (2020) highlights that this can be attributed to a high-share of lone parent households relative to EU-counterparts —close to 30 per cent of whom have no labour market income— and a large share of working-age adults living alone with no earned income. This inequality in earned income is heavily reduced once taxes are accounted for, and further reduced once social welfare income are appropriated. Using this disposable income concept, Callan et al. (2018) show that Ireland appears as a mid-tier country in the EU and OECD in terms of inequality as measured by the Gini coefficient. Callan et al. (2018) also show that the Irish Gini coefficient measured over disposable income has remained very stable from 1987 through to 2014 based on household survey data. This has occurred in spite of large business cycle fluctuations in numerous aggregates over the period including unemployment rates, average household income and gross national product.

In contrast, there has been noticeable growth in inequality indicators from market sources when calculated over tax return data. Callan et al. (2020) contrast the stable pattern in the household level Gini coefficient calculated over disposable income from 1995 to 2015 to the upward trending top 1% income shares as calculated from administrative tax return data. Administrative tax data are naturally reported at the tax-unit level. Callan et al. (2020) show that the Gini coefficient, calculated using survey information rises from 32.0 to 43.5 when calculated at the household level and tax-unit level respectively.[6] This large rise in inequality from a change in the primary unit of analysis is alarming. Household survey data are known to underreport top-incomes –the so-called "missing rich" as coined by Lustig (2018). This underreporting of top incomes, combined with a sensitivity to the unit of analysis, could mean that our understanding of inequality in Ireland could be heavily biased by measurement-specific effects.

In this paper we complement the work by Callan et al. (2020) and find that equivalization and income-sharing assumptions have a large bearing on our perception of poverty and inequality. Specifically, we test the sensitivity of income poverty and inequality statistics to variations in two measurement parameters 1) the unit of analysis and 2) the choice of equivalence in scale. In the first case, we vary the unit of analysis at the household, tax-unit and benefit-unit and find that the outcomes of young people at the tax-unit/benefit-unit are only weakly correlated with outcomes at the household level, the traditional unit of analysis. On average, 18- to 24-year-olds on live in median income households, but live in tax-/benefit-units close to the 33rd percentile. This re-ranking results in a rise in income poverty rates for those aged in their twenties –from 12 per cent to 29 per cent. Inequality also rises, with the Gini coefficient rising by an average of 4 ppt. points (13 per cent) and 2.8 ppt. points (9 per cent) at the tax and benefit-units relative to the household. Secondly, the utilization of equivalence scales, have a large bearing on income poverty estimates. Equivalence scales attempt to adjust raw income into welfare terms by rescaling income data based on household size and composition. We vary the value assigned to adults in benchmark expert equivalence scales. This greatly affects the measurement of income poverty, with the level of income poverty measured decreasing in the adult-weight. Simulations show that over a range of common, empirically observed adult-child equivalence weights –0.5 to 0.7 for adults and 0.3 to 0.5 for children–, income poverty rates ranged from 15.0 per cent to 19.5 per cent. We contrast income rankings of individuals across different expert equivalence scales analysed qualitatively and notice that much of the re-ranking of individuals tends to occur close to the poverty line. We conclude that equivalence scales tend to be non-monotonic at the bottom of the income distribution, but are approximately monotonic for the middle and top of the income

[6] These estimates are derived from unequivalized disposable income using a microsimulation model.

distribution. As such, equivalence scales tend to be very important for the estimation of poverty rates, which are low-income specific measurements, but are less important for measures which summarize the entire income distribution, such as the Gini coefficient.

The rest of the paper is structured as follows; in Section 2 we discuss our methodology; Section 3 highlights our empirical findings; Section 4 continues with a discussion of and reconciliation of these findings. Section 5 concludes.

2. Methodology

We use numerous annual releases of the Irish Survey of Income and Living Conditions (EU-SILC) along with the tax-benefit model EUROMOD to estimate annual income levels. EUROMOD is a European wide tax-benefit microsimulation model. EUROMOD processes the detailed reported labour market and demographic information of individuals in SILC and calculates theirs, and other household members, tax liabilities and social welfare entitlements based upon the tax-benefit rules in place in Ireland spanning from 2007 to 2019. EUROMOD is calibrated with the latest release of SILC on an annual basis. In earlier years of analysis this was completed less regularly, meaning that in the earlier years included in our analysis, for adjacent policy years, identification of changes in inequality and poverty comes predominantly from policy changes, as captured in the microsimulation model, rather than changes in both market incomes and entitlement under tax-benefit parameters. For instance, the 2008 and 2009 EUROMOD simulation results both use the 2008 SILC data set but vary the tax-benefit parameters. In cases where the SILC data lags the policy year we uprate key monetary variables in EUROMOD to match the observed average growth recorded in national statistics.[7] For a review of the uprating process in EUROMOD see Sutherland & Figari (2013). In Appendix Table A11 we show the exact SILC data year used to generate the simulated disposable income for each policy year.

2.1 The effect of equivalization scales

We estimate the sensitivity of inequality and poverty estimates to equivalization and to the unit of analysis. Distributional statistics in Ireland are produced by the Irish Central Statistics Office (CSO) on an annual basis using the SILC data set. As in all European countries, and in line with Eurostat procedure, the household is the income-sharing unit across which incomes are summed. To arrive at an equivalized income concept, total household disposable income, i.e. income after the deduction of all tax liabilities and with the addition any net social welfare (means tested, non-means tested and universal payments such as Child Benefit), is divided by the sum of the household's equivalence scale. A household's equivalized disposable income is often referred to as "income per adult equivalent" to

[7] This has the implication that growth is distributionally neutral e.g. incomes of 10th percentile earners grow at the same rate as 90th percentile earners.

account for this adjustment based on household composition. The choice of equivalence scale is important as it embodies technical assumptions about the extent of economies of scale in consumption and subjective value judgments around the needs of non-earning household members –particularly children. Most importantly however, the utilization of an equivalence scale amounts to a non-monotonic transformation of income data. As such, researchers should appreciate that the choice of equivalence scale will cause re-ranking effects amongst households.

Buhmann et al. (1988) compare equivalence scales across countries and surmised that all scales are closely related to a power function, meaning that economic well-being (or equivalized income) could be expressed succinctly in terms of a single parameter called the equivalence elasticity. According to them, economic well-being or disposable income (W) is equal to unadjusted disposable income (D) divided by household size (S):

(1) $$W = D/S^e$$

The parameter e, with range 0 to 1 is the equivalence elasticity. Buhman et al. (1998) find that equivalence rules of the late 1980s, when applied to household data, encompass a broad range of equivalence elasticity values. For instance, scales used with the intention of identifying vulnerable groups, tend to have an average elasticity of 0.72 while elasticities inferred from consumption data tend to be much lower at 0.36. In any case, all the scales analysed, tended to be highly correlated with the log of household size, meaning that a power function closely approximated many variable equivalence rules. Modern equivalence scales tend to vary based on the weight given to adults, children and to household size in general. As such the equivalence elasticity is only directly observable in cases where income is equivalized solely on the basis of household size and independent of composition. In our analysis we test the sensitivity of inequality and poverty measures to the choice of equivalence scale using some commonly utilised scales outlined in Table 1. The scales we analyse are all typified as expert scales, as they rely on expert choices and are normative benchmarks. All these scales assign a value of 1 to the household head and as such all treat a single adult household as a reference category for assessing the size of scale economies and value judgements around the relevant weights of additional adults and children. The scales we analyse can be generalized to the functional form described in Equation 2, with the household equivalence weight being derived as a function of the number of adult equivalents (those older than 14), S_a, the number of child equivalents (those younger than 14), S_k, and a parameter γ denoting economies of scale in household size which are independent of the composition of adult-child variations. We define γ as the household size relativity parameter so as not to confuse it with the equivalent elasticity parameter e. We view γ as a functional form assumption regarding scale economies at the household level which are independent of household composition. If γ=0, additional household members generate no additional costs and there is no need for equivalization. If $0 < \gamma < 1$, economies of scale are decreasing in γ. With $\gamma = 1$, no economies of scale are assumed, and the household weight will be determined by α, β values. With the expert scales we analyse γ is typically valued at 1; meaning that net of variation in α,and β, the number of people in a household has no impact on the equivalence weight. The exception is the square root scale, where γ=0.5. The square root scale also treats adults and children identically, with $\alpha = \beta = 1$. This assumes that adults and children consume an even share of household resources. The per capita equivalence scale is identical to the square root scale, but with γ=1. As such, variation in household equivalence scales when using the per capita and square root scales are purely a function of household size, and independent of household composition. This is in contrast to the CSO, OECD-modified & OECD scale where variation in household equivalence weights are purely due to differences in the values of α and β, with γ=1 in all cases.

$$\text{(2)} \qquad \text{HH Eq. Weight} = (1 + \alpha(S_a - 1) + \beta S_k)^{\gamma}\ , \quad 0 \leq \alpha, \beta, \gamma \leq\ 1$$

The per capita and square root scales represent benchmark scales where the equivalence elasticity is *a priori* defined. In the case of the per capita scale, e=1, meaning there are no economies of scales in household size. The square root scale is characterized by e=0.5, as the scale amounts to indexing household size by 0.5. For all the other expert scales we examine, the equivalence elasticity is not known *a priori*, as for a given household size, variation in the number of adult and child equivalents would lead to variation in household weights. In contrast using the per capita scale one knows that the household weight will be n^1 and in the case of the square root scale $n^{0.5}$, where $n = S_a + S_k$.

The Irish national scale i.e. the CSO scale assigns a value of $\alpha = 0.66$ and $\beta = 0.33$. These ratios closely follow the ratios of additional adult and child dependant allowances payable through the Irish social welfare system.[8] In general, an individual in receipt of a social welfare scheme can avail of a top-up payment of 66 per cent of their weekly rate if they live with an adult who is dependent on their income, and 33 per cent in the case of a child.[9] Indeed, van de Den et al. (2017) find that using hypothetical households and the tax-benefit calculator –EUROMOD – equivalence weights implicit to the tax-benefit system in Ireland were close to OECD-modified scale. We believe this is a reflection of the Irish social welfare system endogenizing the Irish national equivalence scale, rather than a true exogenous reflection of societal values of equivalence weights.

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[8] As an aside, older research had used the relativities implicit in the social welfare system in Ireland to extrapolate equivalence scales. Conniffee & Keogh (1988) documents this and also gives an interesting timeline into the use of Engel curves and caloric need-based equivalence scales.

[9] In Budget 2019, different child dependent allowances were introduced for children under and over 12 so this relationship has been slightly modified.

The original OECD equivalence scale, which can be referred to as the “Oxford scale” or the “old OECD scale” was first mentioned by the OECD in 1982 (OECD, 1982) and was used throughout the 1980s and early 1990s by Eurostat. This scale was replaced with the OECD-modified scale, which was proposed by Hagenaars et al. (1994) and was adopted by Eurostat in the late 1990s. The modified scale gives a smaller weight to adult and child equivalents than the original OECD scale meaning that for a given level of income, larger households would be better-off with the modified scale than the original scale. In the international literature, the OECD-modified scale has become the benchmark equivalence scale for applied research (Garbuszus et. al, 2021). Interestingly, the OECD has adopted the square root scale as their baseline equivalence scale.[10]

Table 1: Parameter values of expert equivalence scales used in the analysis

	CSO	OECD-Modified	OECD-Original	Per capita	Square root
α	0.66	0.5	0.7	1	1
β	0.33	0.3	0.5	1	1
γ	1	1	1	1	0.5

Notes: Each scale assigns a value of 1 to the first adult in the household. In all scales adults are defined persons aged 14+ years old) and child equivalents are defined as those <14 years old.
α is the parameter value given to additional adult equivalents, β is the parameter value given to additional child equivalents and γ is the household size relativity parameter.

2.2 The effect of the unit of analysis

We examine the effect of the unit of analysis by examining the variation in inequality and poverty measures across multiple income-sharing definitions. We use three units throughout the paper; firstly, we use the household as our main income-sharing unit, as is standard in much of the literature and in the production of national statistics in the European Union. Secondly, we use a tax-unit definition, based on definitions from the Office of Revenue Commissioners. In Ireland, the tax system is partially individualized. Before 2000, couples were jointly assessed for income tax, meaning that a worker could use the unused tax credits of a non-working spouse to reduce their overall tax liability. A series of tax reforms from 2000 to 2002 meant that this 100% sharing of standard rate tax credits in a joint system was reduced to around 32% in a partially individualized system (Doorley, 2018). Income splitting at the standard income tax rate has remained stable since these reforms (Doorley, 2018). Due to the partial splitting of tax credits, the married couple as opposed to the individual is the relevant unit of analysis for tax purposes. Couples who cohabitate, but are not legally married, are treated as separate tax-units as a result. Singletons are also independent tax-units. We treat cohabitating children aged

[10] This square root equivalence scale is used in preparing the OECD Income Distribution Database, a key data set for comparing inequality across countries and over time (OECD, 2020).

18 years and older as singletons and assess them individually if they are not enrolled in education.[11] Thirdly, we develop a benefit-unit as a final unit of analysis. This is the basis for assessment of income in means-tested social welfare schemes. The benefit-unit is similar to the tax-unit but it relaxes the assumption of legal marriage and allows cohabitating couples to fully share their income. Additionally, children aged less than 18 and those aged less than 22 and in full-time education are included in their parent's benefit-unit.[12] The degree to which income is shared between individuals in a household varies across all three units. Implicitly, the household unit assumes all income is split evenly between all household members. With the tax-unit, income is shared equally between all members in a married couple, but there is no sharing within a cohabitating couple. This means that there is both within-household inequality but also intra-relationship inequality, in that the income-sharing only occurs through marriage. The benefit-unit on the other hand, assumes people in a relationship share their income fully, so there is no intra-relationship inequality. We estimate inequality and poverty measures across all three units to assess the variation induced by differential income aggregation. By examining these sub-household units, we intend to estimate intra-household inequality arising from multiple tax-/benefit-units living in a single household and abstract from imperfect income-sharing that may occur within a tax-/benefit-unit due to asymmetric bargaining power between spouses as per Lise & Sietz (2011).

We also assess the re-ranking effects introduced under different income-sharing assumptions. We do so by using a series of rank-rank regressions. We regress an individual's rank in the household income distribution onto their rank in the benefit-/tax-unit distribution. This is shown in Equation 3 below, where the household percentile rank of individual i, in year t, using equivalence scale j, is regressed onto a constant α and the individual's percentile rank in the income-sharing concept s. We focus solely on re-ranking effects from unit of analysis here, variations in s only, and keep the equivalence scale j, fixed at the CSO levels. In Equation 3, the vector $\boldsymbol{B}$ estimates the rank-rank coefficients. The model is estimated in percentile levels and the rank-rank coefficients can be interpreted as the correlation between household percentiles relative to the benefit-/tax-unit. An individual specific i.i.d. error term e completes the simple model. We estimate equation 3 for the population and for specific sub-groups of interest: the elderly, children and adults by age-employment status. We exclude adults older than 22 enrolled in full-time education so as to only assess the re-ranking effects that occur for individuals who have finished formal human capital formation.

[11] See: https://www.revenue.ie/en/personal-tax-credits-reliefs-and-exemptions/children/single-person-child-carer-credit/how-do-you-qualify-for-the-spccc.aspx for more details about what qualifies as a child for tax purposes

[12] See:https://www.citizensinformation.ie/en/social_welfare/irish_social_welfare_system/claiming_a_social_welfare_payment/claiming_and_increase_in_your_payment_for_a_child_dependant.html

$$HH\ Rank_{i,j,t} = \alpha + \boldsymbol{B}Rank_{i,s,j,t} + e_{i,j,t} \quad (3)$$

2.3 Measures of inequality and income poverty

We use key headline measures of inequality and income to gauge measurement sensitivity to the unit of analysis and equivalence scale. In constructing Gini coefficients and percentile ratios, we analyse a population of households, tax-units and benefit-units. To be precise, we collapse individual-level disposable income data to a dataset of sums at the relevant unit and then equivalize income. This allows us to analyse between-unit inequality and compare how this between-unit inequality varies with variation in the unit of analysis. The inequality and poverty measures used are discussed and defined below.

- **Gini coefficient** measures the extent to which income concentration deviates from perfect equality. In our context, perfect equality, a Gini coefficient of 0, would arise if in a given year all households have equal equivalized disposable income. Perfect inequality, a Gini coefficient of 1, would arise if one household held all income.
- **p90p10 ratio** is the ratio of income of the 90th percentile household divided by the income of the 10th percentile household. This statistic gives a sense of the gap in income between high- and low-income households.
- **p90p50** ratio is the ratio of income of the 90th percentile household divided by the income of the median household. This statistic gives a sense of the gap in income between high- and middle-income households.
- **p10p50 ratio** is the ratio of income of the 10th percentile household divided by the income of the median household. This statistic gives a sense of the gap in income between low- and middle-income households.
- **At-risk-of-poverty measure (AROP)** rate is calculated using a notional poverty line defined as 60 per cent of the median household (tax-/benefit-unit where appropriate) equivalised income. People residing in units below this poverty line are classified as being at risk of facing income poverty. We calculate AROP rates using headcount ratios, so that the percent of the population living in poverty is the relevant metric. This circumvents the issue that variation in equivalence scales could lead to compositional changes in household poverty due to differences in economies of scale in household size e.g. a declining portion of households living in poverty, but a rising portion of the population.
- **At-risk-of-extreme poverty measure (AROEP)** rate is calculated in the same manner as the AROP rate, but the notional poverty line is calculated as 40 per cent of the median household

(tax-/benefit-unit where appropriate), so the threshold for being classified as poor is even lower. As with the AROP rate, AROEP rates are calculated using a headcount ratio.

3. Results

3.1 Inequality

In Figure 1, we show how the Gini coefficient varies across different income-sharing concepts and equivalence scales.[13] Savage et al. (2019) note that despite the volatility in the Irish labour market surrounding the 2008 financial crisis, the Gini coefficient has been remarkably stable, with much of this stability induced by the automatic stabilisation effect of a robust social welfare system in place pre-2008.[14] Callan et al. (2018) also show the flat profile of the Gini coefficient in Irish survey data from 1987 through to 2013 and that quintile income shares have been remarkably constant over the same period. These trends are also evident in tax- and benefit-unit measurements we present in Figure 1. There is a noticeable increase in the Gini coefficient at sub-household levels, with the household producing the smallest estimates of inequality and increasing non-trivially as we allow for within-household inequality via the tax- and benefit-units. Our estimates of the time-series variation in the Gini coefficient differ from recent work by Roantree et al. (2021) using annual releases of the Irish SILC research microdata file, where the Gini coefficient can be seen to decrease from 2017 to 2019. This trend difference arises from differences in simulated incomes as estimated from our microsimulation model EUROMOD, relative to reported incomes in Roantree et al. (2021). Doorley & McTague (2020), in validating the robustness of the Irish EUROMOD model, also show a flat profile in Gini coefficient from 2017 to 2020. The primary aim of this piece is to isolate the effect of equivalence scale—income-sharing assumption variations in inequality and poverty statistics. As such, we are willing to tolerate the small amount of measurement error that simulated incomes from EUROMOD may incur to avail of its highly flexible modelling of intra-household relationships needed to establish tax and benefit-units.

Starting with the benchmark household case, the Gini coefficient is largest in all years when the per capita scale is used, with estimates at a low of 0.313 in 2009 and a high of 0.325 in 2019. All equivalence scales show a similar pattern, with the Gini coefficient dipping in 2009 and peaking in

[13] Tables reporting the inequality and poverty statistics presented in Figures 1 to 4 and Figures 7 to 12 are also available in the Appendix.

[14] Savage et al. (2019) developed a formal decomposition method which separately identified the contribution of discretionary policy and the contribution of automatic stabilisation to changes in overall levels of inequality between two points in time. From 2008 to 2013, they showed that approximately 70 per cent of the increase in the index of redistribution (Reynolds-Smolenksy) was due to automatic stabilisation, and the remaining 30 per cent was due to discretionary changes in policy.

2019. The other scales are quite similar in their estimates of the Gini coefficient, however, for 2018 and 2019, the square root scale approaches the relatively lofty estimates of the per capita scale. The CSO scale produces the smallest estimates of inequality —with a low of 0.289 in 2009, peaking at 0.313 in 2019. At the tax-unit level, the per capita scale no longer appears as an outlier and is comparable to all other scales. Once again, the CSO scale tends to give the most modest measurements of inequality, with the Gini coefficient varying between a low of 0.334 in 2009 and a peak of 0.347 in 2019. Overall, the level of inequality is much higher at the tax-unit level, with Gini coefficients routinely in the range of 0.34 to 0.36. Moving to the benefit-unit level, where non-married couples are assumed to evenly share income, reduces the size of the Gini coefficient, but these are still higher than traditional household measures. For instance, at the benefit-unit level, the CSO scale has a low of 0.334 in 2009 and a high of 0.336 in 2019. Across all three units, the CSO and OECD scales produce very similar results. The per capita scale leads to much higher estimates of inequality at the household level, but from 2013 onward, it yields estimates that are comparable to the OECD and CSO scales at the benefit and tax-unit level. This is attributable to a greater incidence of single-person units at the benefit/tax-unit level than will be the case at the household level. As all the scales assign a weight of one to single-person units, there will be less dispersion between scales as units become more granular. In contrast to the per capita scale, the square root scale produces similar results at the household level to the CSO and OECD scales but tends to exceed these scales at the benefit and tax-unit level.

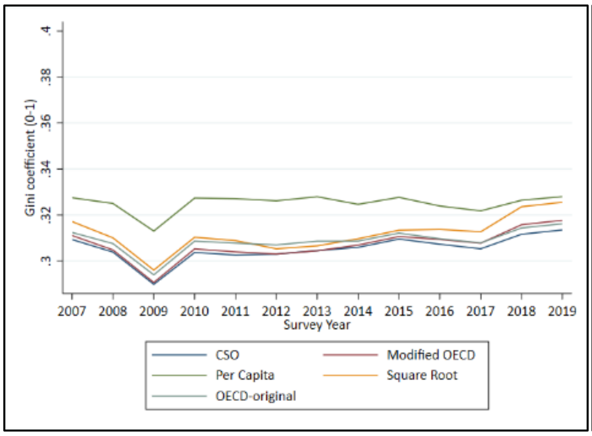
The Gini coefficient characterises inequality by measuring the area between a notional egalitarian 45-degree line in income shares and income rank from an empirically observed Lorenz curve. In this way, the Gini characterizes inequality using as a weighted average of deviations across the entire income distribution. Atkinson (1970) notes that the Gini is sensitive to transfers from one-point of the income distribution to another. Alison (1978) concludes that for the most commonly observed income distributions, the Gini index tends to be most sensitive to transfers around the middle of the distribution and the least sensitive to transfers among the very rich and very poor. Gastwrith (2017) highlights that most contemporary research has referred to the Gini as being sensitive to transfers around the middle or mode of the income distribution. However, Gastwrith (2017) also shows that the rank preservation plays a large role in the effect a transfer of income will have on the Gini coefficient. Where a transfer or increment preserves the order, transfers from the rich to the poor had a large effect on the Gini index. When transfers do not preserve the order, the difference in the ranks of the donor and recipient, before or after the transfer is the main contributor to a change in the Gini index. In our analysis, there will be re-ranking effects when moving from household to tax-/benefit-unit, e.g. a low-income singleton aged 26 may live with his/her high-income parents —in this case the 26 year old will be re-ranked from a high-income household to a low-income tax-/benefit-unit. As a robustness check on our findings, we also analyse other inequality measures, specifically ratio measures which will not be as sensitive to re-ranking effects as they are simply taken from discrete points of the income distribution rather than a characterization of the entire distribution.

Our ratio estimates highlight that the spike in inequality observed at the tax-unit level is induced by a greater differential between low- and high-income tax-units. In Figure 2, we present p90p10 estimates for the household, tax-unit and benefit-unit. At the household level, the p90p10 ratio in 2019 using the Irish CSO scale was 3.709. This is similar to all other scales, except for the per capita scale, which also produces larger estimates of inequality in the case of the Gini index. The ratio is higher at the benefit-unit level, at 4.012 in 2019 using the Irish scale- all other scales produced slightly higher estimates. The p90p10 ratio is stable through the time-series at the household level but demonstrates some cyclicality at the benefit-unit level, rising in 2010 before decreasing in 2014. The tax-unit produces very large p90p10 estimates, with all equivalence scales showing a ratio of 5.6-6.6 from 2010 to 2013. For the most part, these decline from 2014 onward and are close to 4.3 but are significantly higher than household levels for all scales except the per capita scale by 2019. The p10p50 ratio, shown in Figure 3, also follows a similar trend to the p90p10 ratio, with estimates at the household level comparable to those at the benefit-unit level. This means that the gap between low- and middle-income units is comparable across these income-sharing concepts, with estimates of 0.46-0.52 at the household level since 2007. There is a similar range at the benefit-unit level but with some smaller differences across equivalence scales. The tax-unit exhibits much more inequality, with estimates in the range of 0.32-0.48. The smallest estimates of the p10p50, which highlight the largest levels in inequality between low- and middle-income tax-units, occur in 2010 and 2011, indicating that high levels of unemployment during this period led to lower incomes for those at the bottom of tax-unit income distribution. In Figure 4, the p90p50 ratio is comparable across the household, tax- and benefit-units, indicating that differences in the p90p10 and p10p50 are caused by differences arising at the 10th percentile across income-sharing concepts.

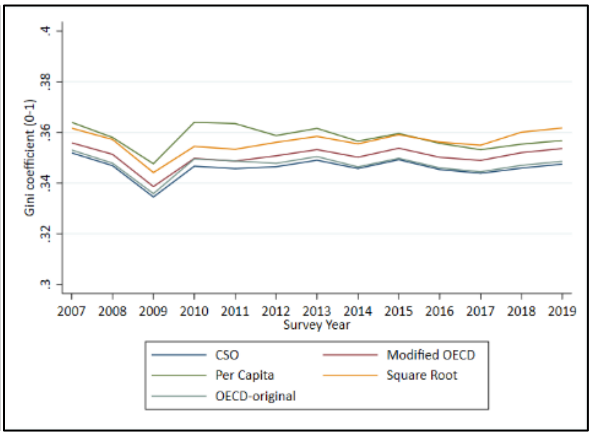
These results indicate that inequality measures are more sensitive to the unit of analysis used. For a given unit of analysis, the choice of equivalence scale affects the level of the inequality indices analysed only marginally. The exception is the per capita scale, which drastically changes results at the household level. This is less important as the per capita scale is not commonly used and can be viewed as a special, or even an extreme case –since the equivalence elasticity in this scale is equal to 1 (e=1), as adults and children are treated equally and there are no economies of scale in household size.

Figure 1: Gini Coefficient

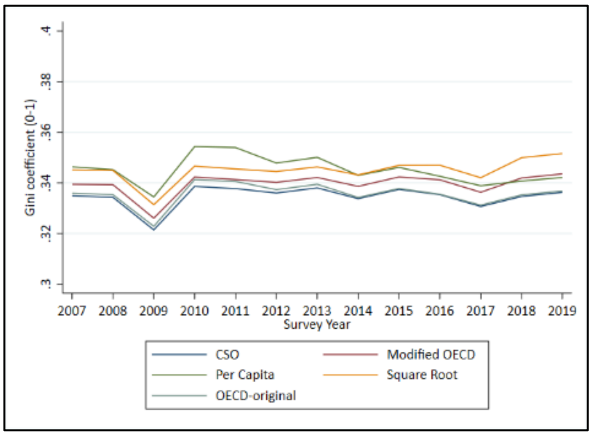
A. Household



B. Tax-Unit



C. Benefit-Unit

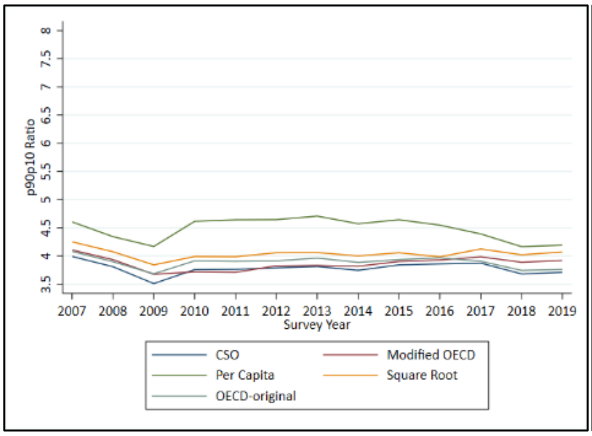


Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.

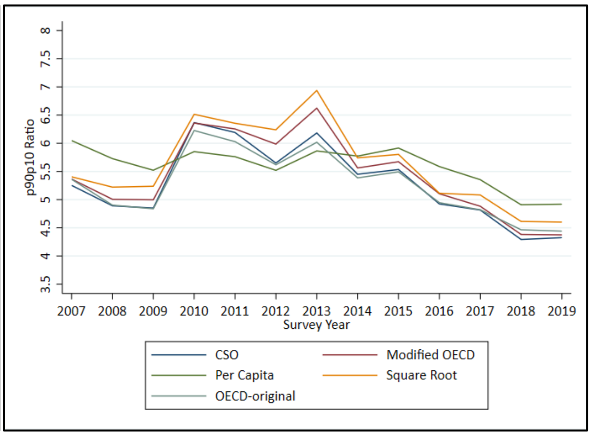
Notes: Gini coefficients are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated over a population of households (A), tax-units (B) and benefit-units (C). Statistics are also tabulated in Appendix Tables A1-A3.

Figure 2: p90p10 ratio

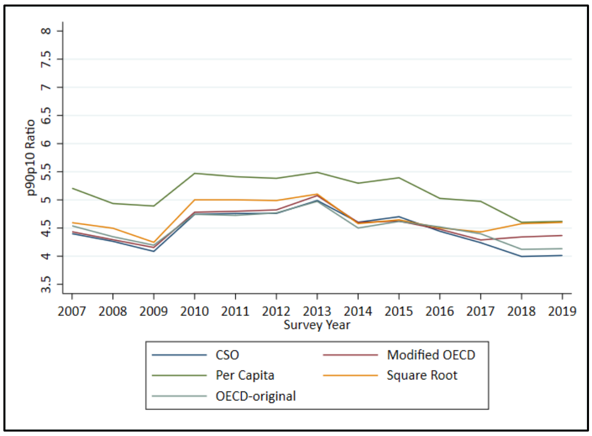
A. Household



B. Tax-Unit



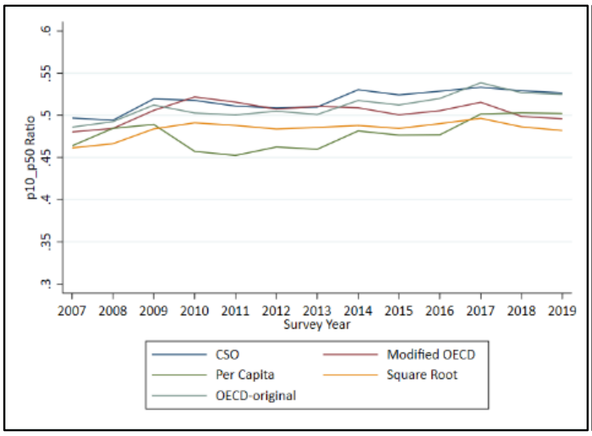
C. Benefit-Unit



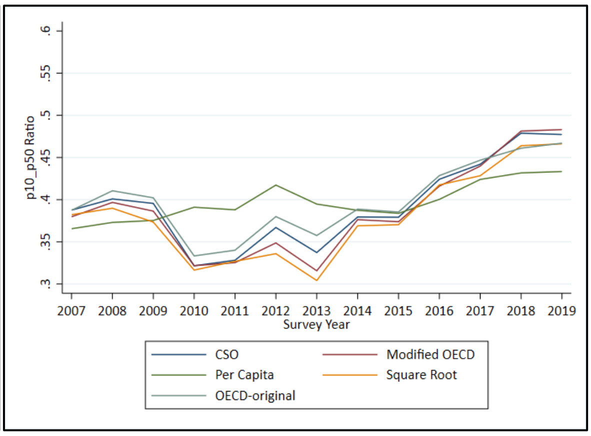
Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.
Notes: p90p10 ratios are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated over a population of households (A), tax-units (B) and benefit-units (C) and represent the ratio of income of the 90th percentile unit relative to the 10th percentile unit. Statistics are also tabulated in Appendix Tables A1-A3

Figure 3: p10p50 ratio

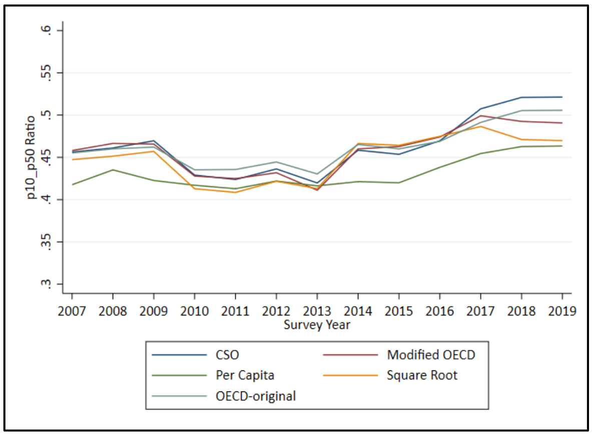
A. Household



B. Tax-Unit



C. Benefit-Unit

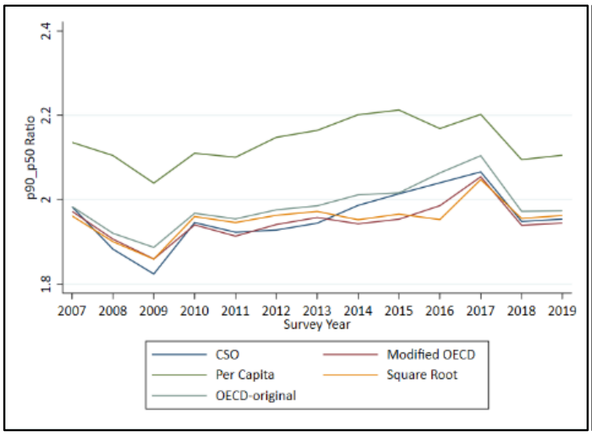


Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.

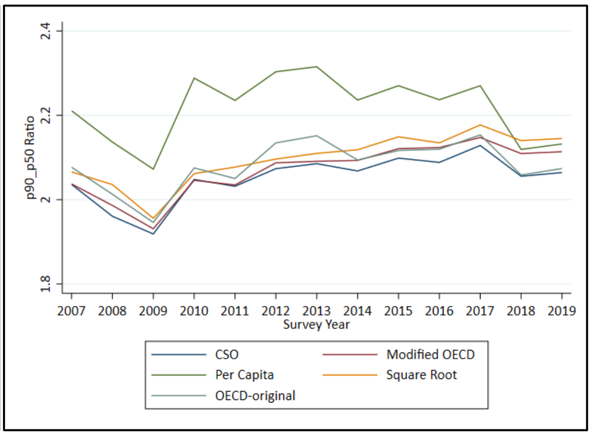
Notes: p10p50 ratios are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated over a population of households (A), tax-units (B) and benefit-units (C) and represent the ratio of income of the 10th percentile unit relative to the 50th percentile/median unit. Statistics are also tabulated in Appendix Tables A1-A3.

Figure 4: p90p50 ratio

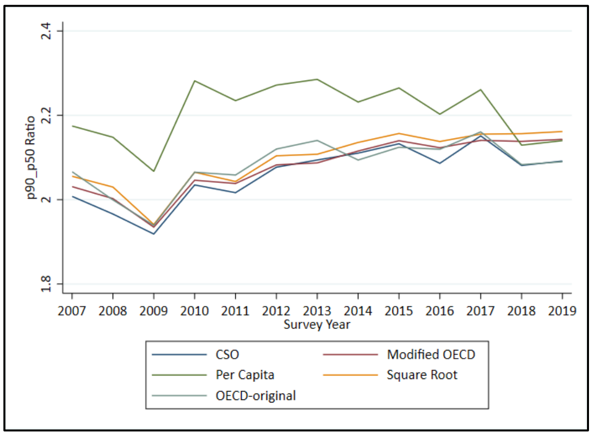
A. Household



B. Tax-Unit



C. Benefit-Unit



Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.
Notes: p90p50 ratios are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated over a population of households (A), tax-units (B) and benefit-units (C) and represent the ratio of income of the 90th percentile unit relative to the 50th percentile/median unit. Statistics are also tabulated in Appendix Tables A1-A3.

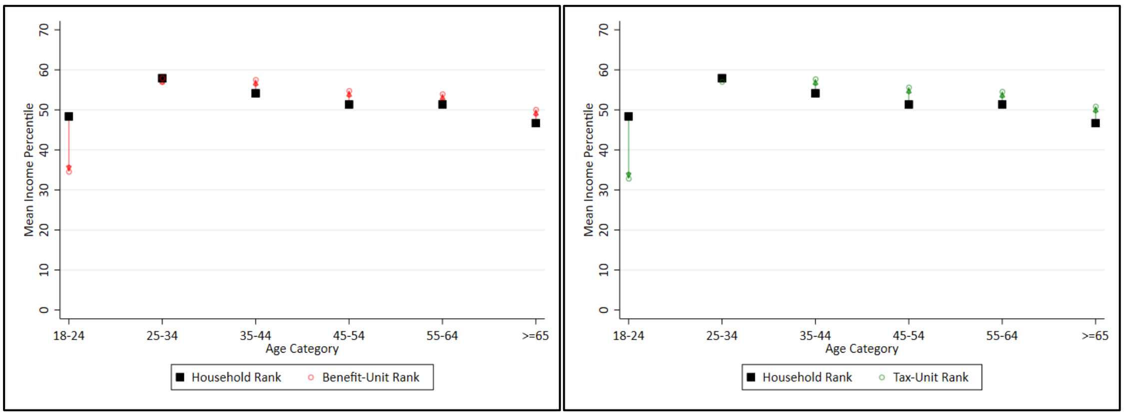
In Figure 5, we highlight the extent of the re-ranking of individuals at the household level, to those at the tax- and benefit-unit level. In Panels A and B of Figure 5, we can see that 18 to 24-year-olds tend to live in middle income households (on average, very close to the 50th percentile). The re-ranking at the tax-/benefit-unit level moves them close to the 33rd percentile in both distributions. Young people in this age group who are out-of-work tend to fall further down the tax-/benefit-unit income distribution; these out-of-work 18 to 24-year-olds tend to live in households just above the 30th percentile on average but they fall to just below the 20th percentile when moving to the tax-/benefit-unit. Their in-work peers tend to live in 60th percentile households and move to close to the 40th percentile at the tax-/benefit-unit level. The relative rank of 25 to 34-year-olds does not change from household, tax- and benefit-units on average. For all other age groups (35 to 44, 45 to 54, 55 to 64 and 65+), there are small increases in their rank going from the household to the tax-/benefit-unit level.

In Figure 6, we show formal regression coefficients from Equation 2 to establish the rank-rank relationship between household and benefit-/tax-units. These results are similar to those shown in Figure 5 but have the feature that they estimate the slope between household and smaller unit rankings while also capturing the level effect of moving from household to a smaller unit in the form of a constant in the estimated regression. There is a strong, positive correlation between household rankings and other units at the population level, 0.92 in the case of the benefit-unit and 0.90 for the tax-unit. These are similar magnitudes for the elderly (0.95 and 0.97 at the benefit and tax-unit level respectively) and for children (1.03 and 1.02 at the benefit/tax-unit level respectively).

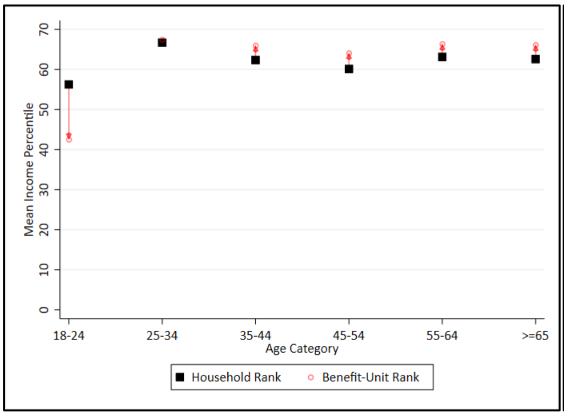
Despite this broadly strong relationship, there is substantial heterogeneity across age groups among the working age population. For 18 to 24-year-olds, the correlations are relatively weak and particularly so for those in-work. At the benefit-unit, the correlation is just 0.38 for those in-work and 0.58 for those out-of-work. The correlations are slightly smaller at the tax-unit level- 0.33 and 0.54. For those aged 25-34, the correlations are much stronger and closer to population averages. At the benefit-unit (tax-unit) level, for those in-work the coefficient is 0.87 (0.80) and 0.71 (0.60) for those out-of-work. For older age groups the regression coefficients tend to follow the population averages quite closely.

Figure 5: Re-ranking from household income distribution to tax-/benefit-units

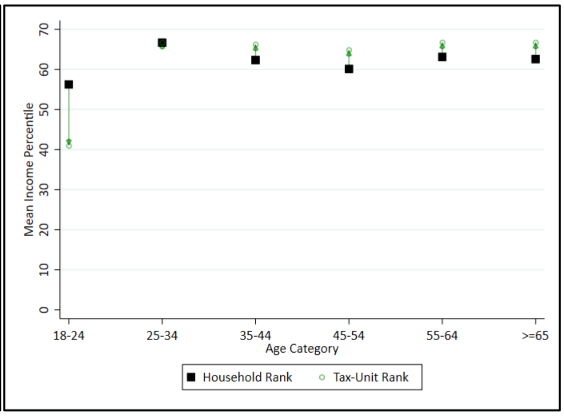
A. Benefit-Unit, All **B. Tax-Unit, All**



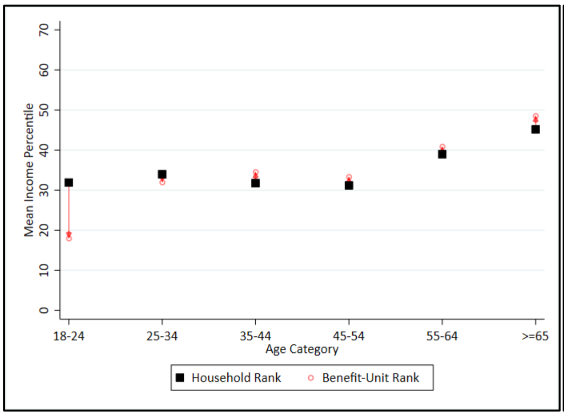
C. Benefit-Unit, In-work



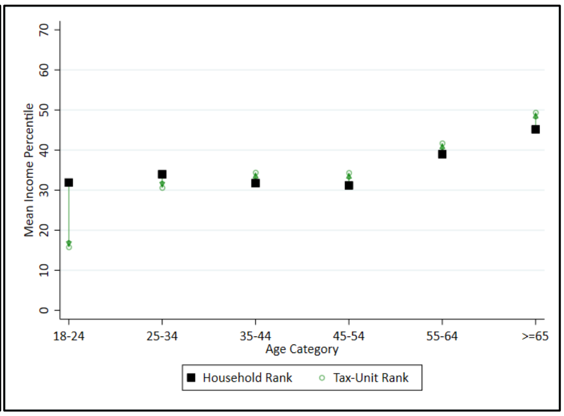
D. Tax-Unit, In-work



E. Benefit-Unit, Out of-work



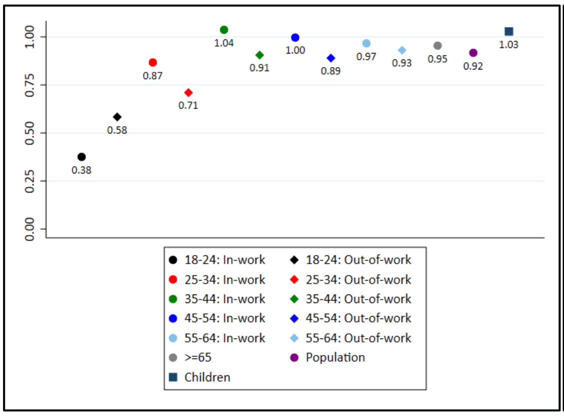
F. Tax-Unit, Out-of-work



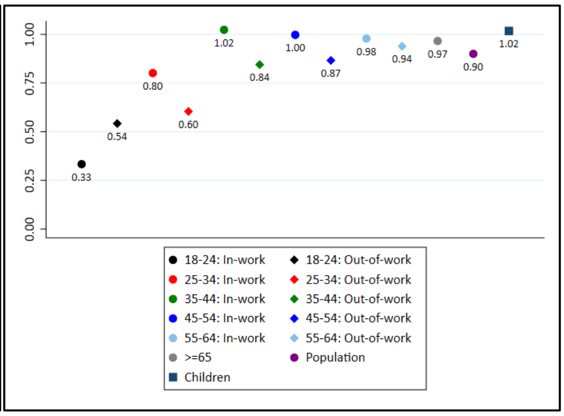
Source: Data from EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11 are pooled. Notes: These show the average income percentile in the household, benefit- and tax-unit income distributions for each demographic group listed. We exclude individuals in full-time education.

Figure 6: Rank-rank regression coefficients

A. Benefit-Unit



B. Tax-Unit



Source: Data from EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11 are pooled.

Notes: These show the regression coefficient of the household income percentile after being regressed on benefit- and tax-unit income percentile for each demographic group listed (see Equation 3).

3.2 Poverty

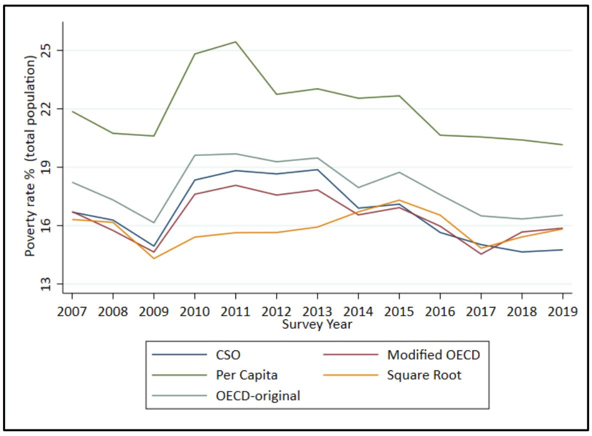
In the previous section we highlighted that inequality measures, p90p10 ratio and the Gini coefficient, were much higher at the tax-unit level, but that the choice of equivalence scale had only a marginal effect on estimates. Our findings for poverty, particularly the AROP rate, differ from this and the choice of equivalence scale emerges as an important consideration for poverty analysis. In Figure 7, we show the variation in the AROP rate, when different income-sharing units and equivalence scales are applied from 2007 to 2019. Overall, AROP rates are quite similar across all income-sharing units and results at the tax-unit do not differ substantially from household/benefit-unit level results as was seen in the case of the p90p10 ratio and Gini coefficient.

In terms of the household, the population level AROP rates shown in Figure 7 tend to be very sensitive to the choice of equivalence scale used. All scales show Irish AROP rates reached their lowest level in 2009 but the rate of poverty varies substantially- with estimates as high as 20.6 per cent for the per capita scale and as low as 14.3 per cent in the case of the square root scale. The CSO and OECD-modified scales tend to be quite similar, which is unsurprising given they assign similar weights to the additional members, while the OECD-original scales lead to higher rates of poverty.

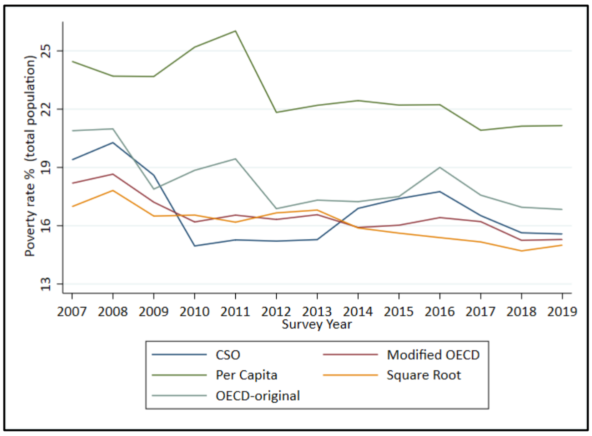
There is less variation in AROP rates when we examine the benefit- and tax-unit. For a given equivalence scale, AROP rates are comparable across household, benefit- and tax-unit level. For instance, in the case of the CSO scale, going from the household to the tax-unit reduces AROP rates by an average of 0.2 percentage points from 2007-2019. There is a similar effect for the benefit-unit whereby AROP rates increase slightly by 0.3 percentage points. These small average changes belie some relatively larger annual changes. For instance, in poverty rates were, 4.0 (3.2) percentage points higher at the tax-unit (benefit-unit) level than at the household once averaged over all equivalence scales. Overall, there are moderate effects of the unit of analysis on AROP rates, but the spread in AROP rates between equivalence scales within a given income-sharing unit tends to outweigh the spread in AROP rates between income-sharing units for a given scale. Interestingly, when we examine the at-risk-of-extreme-poverty (AROEP) rate, Figure 8, equivalence scales tend to converge and report very comparable results for a given income-sharing unit. This gives further evidence that the choice of equivalence scale is of unique importance to the AROP rate measure.

Figure 7: Poverty Rate, population

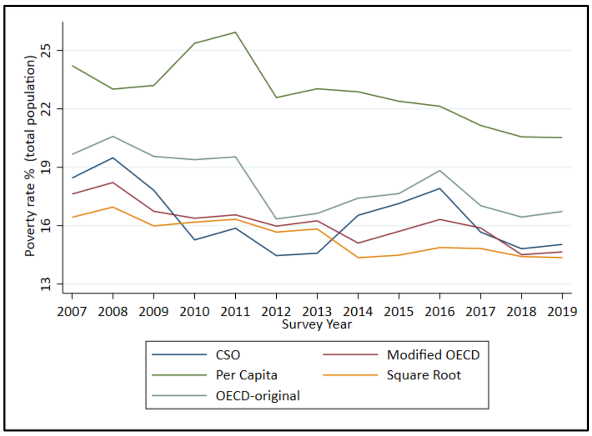
A. Household



B. Tax-Unit



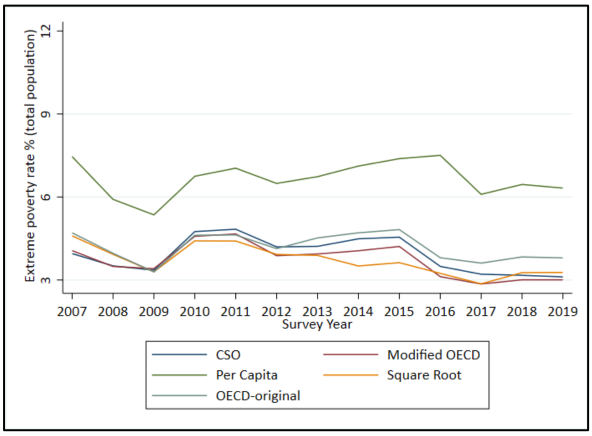
C. Benefit-Unit



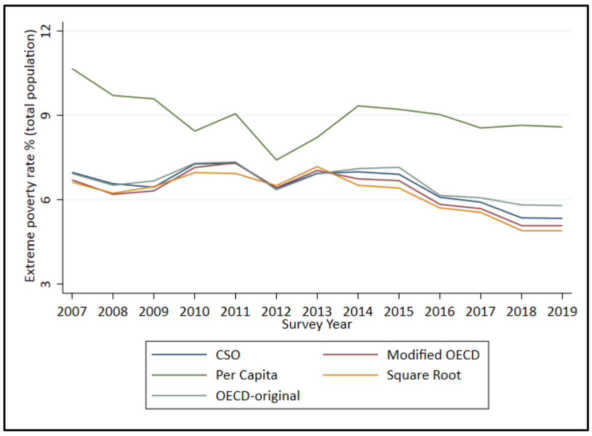
Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.
Notes: Income poverty rates or at-risk-of-poverty rates are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated as a headcount ratio of individuals living in households (A), tax-units (B) and benefit-units (C) below the poverty line, <60% of median unit equivalized disposable income. Statistics are also tabulated in Appendix Tables A4-A6.

Figure 8: Extreme Poverty Rate, population

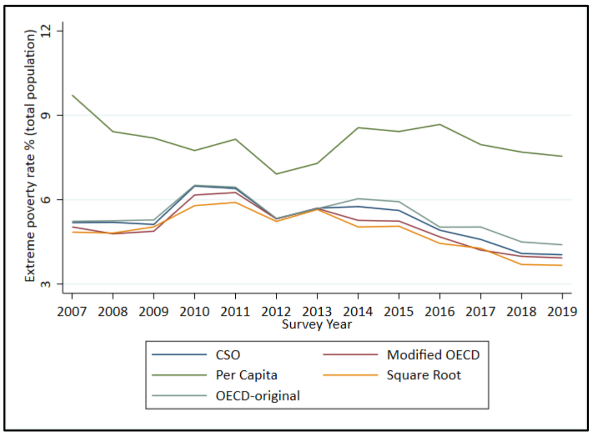
A. Household



B. Tax-Unit



C. Benefit-Unit



Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11.
Notes: Income poverty rates or at-risk-of-poverty rates are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC UDB file. Statistics are calculated as a headcount ratio of individuals living in households (A), tax-units (B) and benefit-units (C) below the poverty line, <60% of median unit equivalized disposable income. Statistics are also tabulated in Appendix Tables A4-A6.

While population level AROP rates are sensitive to the choice of equivalence scale, there appears to be a distinct lifecycle sensitivity to the choice of equivalence scale. In Appendix Figures A2-A4 we show AROP rates for children, working-age adults and the elderly across different units-equivalence scale combinations. From this we can establish that child and elderly poverty rate seem particularly sensitive to the choice of equivalence scale, especially at the household level. We summarize this observation in Figure 9 where we present AROP rates by ten-year age bands based on the income-sharing unit and the equivalence scale applied.[15] Poverty among children is considerably higher when

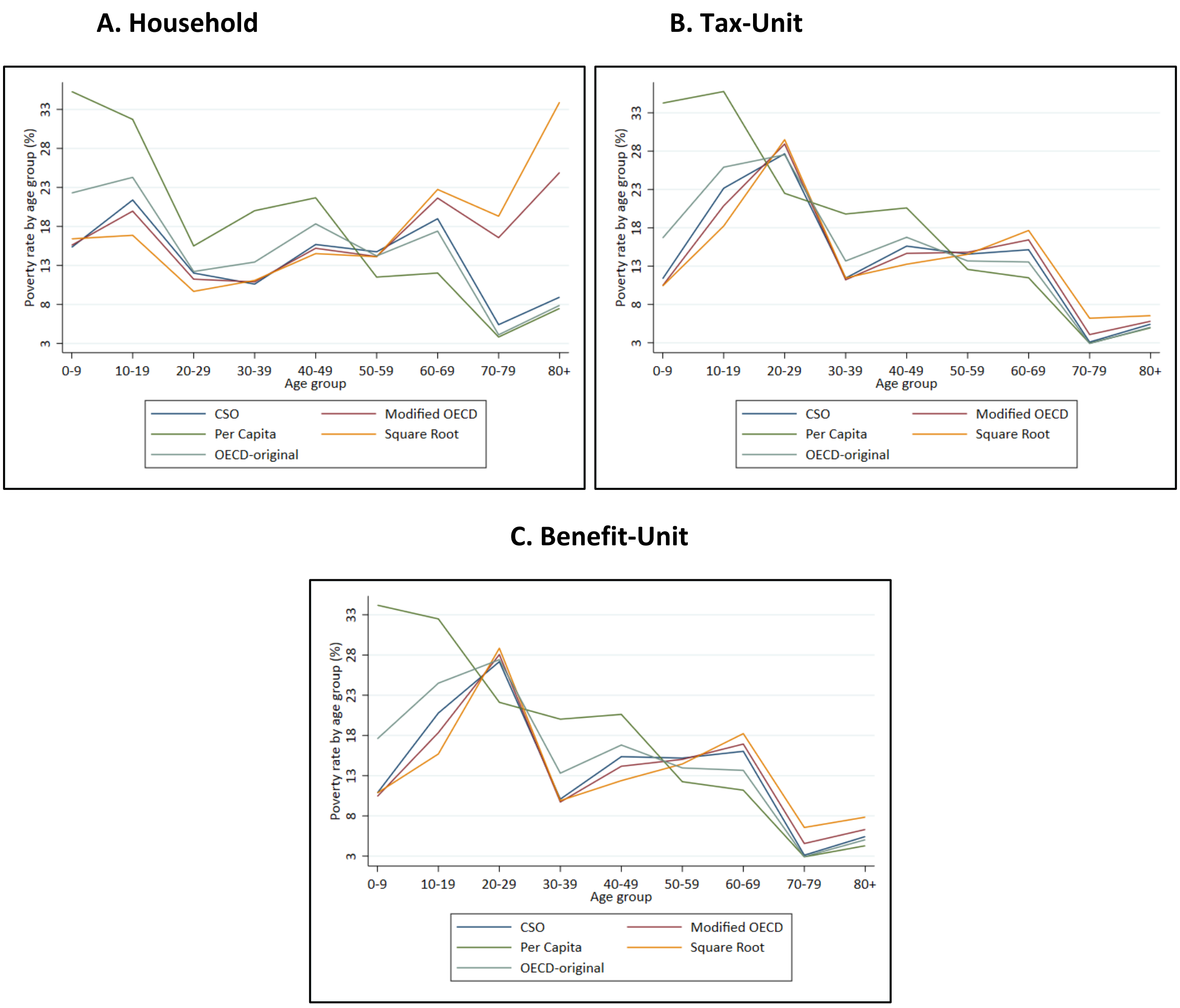
[15] In Appendix Tables A7-A9, we present the relevant variation of the AROEP rate by ten-year age groups with the results being quite similar with those of the AROP rate present in Figure 9.

the per capita scale is used –this is the case for households and tax-/benefit-units. There is also very substantial variation in AROP rates for children less than 10 years old across income-sharing units, indicating that for youngest children, the choice of equivalence scale is an important factor. The sensitivity of the child poverty rate to the choice of equivalence scale is highlighted by the spread of AROP rates at the household level. For instance, the AROP rate for children less than 10 years of age is 35.3 per cent when the per capita scale is used compared to 15.3 per cent when the CSO scale is applied. In comparison, AROP rates are very similar across all income-sharing unit; this seems sensible given that, for the majority of children, the household will equate to the tax-/benefit-unit. Young children seem to be unique in this context, and it is the case that for all other age groups, AROP rates differ depending on the income-sharing unit analysed.

There is also a rank-reversal effect in equivalence scales through the lifecycle at the household level. The per capita scale produces the lowest AROP rate for people above 50 years of age, while also producing the largest estimates of poverty for children. On the other hand, both the square root and OECD-modified scale produce the lowest AROP rates for children but the highest AROP rate for those aged over 60. For those aged between 30 and 50 years of age there is more commonality in the estimates, with the per capita, the OECD-original and the square root scales producing similar AROP rates, whereas the other two scales (square root and OECD-modified) produce higher poverty rates. Gelders (2021) reports similar dispersion in child and elderly poverty rates when examining the variation of household relative poverty in 32 countries in Africa and Asia according to alternative equivalence scales. One possible explanation for this observation is that the elderly individuals tend to live in smaller households, —elderly households are expected to have fewer children and thus be smaller (Gelders, 2021). This remark is observed in our data as well, with children living in households with 4.3 members on average, whereas the average members per household for individuals older than 60 is 1.8 (see Table A10 in the Appendix).

When examining AROP rates across income-sharing units, it is clear from Figure 9 that the tax-unit and the benefit-unit produce comparable results. In contrast, AROP rates at the household level tend to vary substantially for many ages categories compared to their tax-/benefit-unit levels. A notable difference is the rise in the AROP rate of young adults at sub-household levels, consistent with our earlier finding that adults aged 18 to 24-years-old tend to fall down the tax-/benefit-unit income distribution relative to their household rank. In 2019, AROP rates for those aged 20 to 29 ranged between 9.7 and 12 per cent across different equivalence scales at the household level. At the benefit-unit level these rise dramatically, with a range of 22.1 to 28.1 per cent. AROP rates at the tax-unit are marginally larger, with a range of 22.5 to 29.5 per cent. The other striking change is the convergence of AROP rates for the elderly, particularly those aged 70 or over, in the tax and benefit-unit results. As noted in Gelders (2021) elderly household-level AROP rates tend to be very sensitive to the choice of equivalence scale. We observe this in our household findings but see that elderly AROP rates are very insensitive to the choice of equivalence scale at the tax and benefit-unit level, and are very low, at close to 1 per cent for all scales for those aged 70 to 79. This is in stark contrast to the large spread of AROP rates at the household level, ranging from 3.8 to 19.3 per cent. This indicates that the variation in living conditions of elderly individuals may lead to different conclusions around their poverty status. Those over 70 also tend to have noticeably different AROP rates when moving from the household to the tax-/benefit-unit, but this only tends to occur when analysing the square root or modified OECD scale. This gives evidence that the currently dominant expert scale, the modified OECD scale, likely overstates the degree of elderly poverty. The degree of convergence in poverty estimates for the elderly at sub-household levels is astounding and indicates that there could be substantial confounding factors at the household level.

Figure 9: Poverty rate by ten-year age groups, 2019 results



Source: EUROMOD tax-benefit simulations using 2019 Irish tax-benefit rules and 2018 Irish EU-SILC UDB.
Notes: Income poverty rates or at-risk-of-poverty rates are calculated using simulated disposable income (market income less taxes plus net social welfare) based on calculations from the Irish policy systems in EUROMOD using the Irish EU-SILC

UDB file. Statistics are calculated as a headcount ratio of individuals in a given age bracket living in households (A), tax-units (B) and benefit-units (C) below the poverty line, <60% of median unit equivalized disposable income. Statistics are also tabulated in Appendix Tables A4-A6.

4. Discussion

Our results have highlighted the importance of equivalence scales and the relevant unit of analysis when measuring inequality and income poverty. Our research has concluded two important, general findings. Firstly, equivalence scales are particularly important for income poverty analysis, with population level AROP rates showing significant movement with the use of different scales at the household, benefit-unit and tax-unit level. For young children and the elderly, particularly those aged 60 or older, the choice of equivalence scale had a major impact on the conclusion of household poverty levels. Secondly, the unit of analysis is extremely pertinent for inequality metrics. There is a substantial increase in the level of inequality as measured by the Gini coefficient, going from the household to benefit-unit, and a further rise when going to the tax-unit. The first spike in inequality when analysing sub-household units arises from re-ranking of 18 to 24-year-olds, where those living as independent tax-/benefit-units e.g. not in education, tend to hold a lower position in the tax-/benefit-unit income distribution than in the household income distribution. A further increase in inequality occurs in the tax-unit concept as the income of cohabitating couples are independently assessed, which is not the case in the household-/benefit-unit. Income poverty rates of young adults were also significantly elevated when moving from the traditional household poverty calculation to the tax-/benefit-unit, with AROP rates rising from 9.7 to 12 per cent in 2019 (depending on the equivalence scale used) to 22.5 to 29.5 per cent at the tax-unit and 22.1 to 28.1 at the benefit-unit. We also note that elderly poverty rates tend to very insensitive to the choice of equivalence scale at the tax\benefit-unit. Taken together, the downranking of young adults from the household to tax-/benefit-unit income distributions and the subsequent rise in poverty rates for adults in their 20s indicates that the unit of analysis could have a significant impact on our interpretation of living standards for people at a transitional point in the lifecycle.[16]

In Figure 10 we demonstrate just how sensitive the AROP rates are different equivalization weights. We implement a simulation using the latest income data, from 2018 income data paired with the latest tax-benefit parameters from 2019, available in EUROMOD[17]. From these disposable incomes we then calculate Gini coefficients and AROP rates at the household level using 100 different hypothetical equivalization scales (all permutations of 0.1, 0.2. 0.3, 0.4…0.9, 1 for both child and adult equivalents),

[16] It should be noted though that 75% of individuals ages 20-29 in Ireland live with their parents and thus the household unit may be a better way of defining poverty for this group. For older individuals (above 70 years old) only 11% lives with their children.

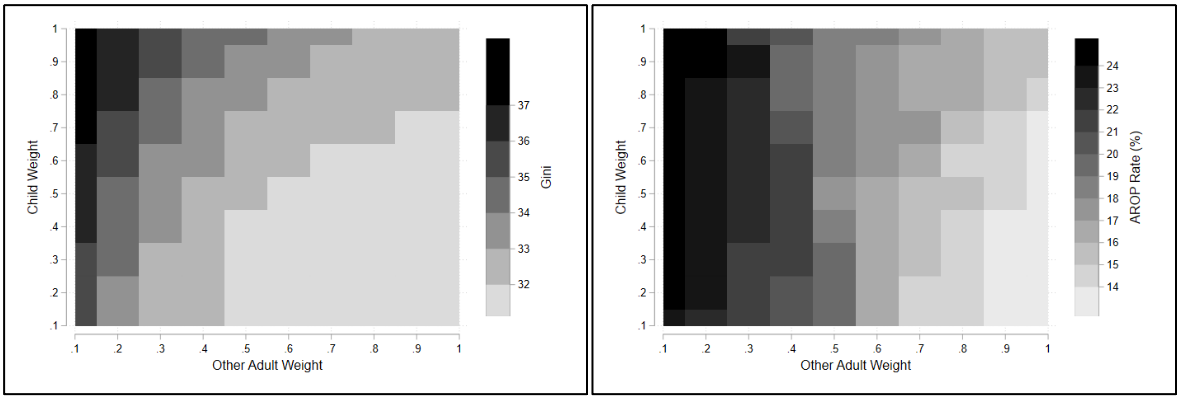
[17] We opted to exclude the 2020 tax-benefit parameters from the analysis as numerous discretionary policy changes were made to support household incomes in the wake of the COVID-19-related job losses.

we hold the household size relativity parameter constant at 1. Based on the logic of Equation 2, our preferred functional form for referencing expert equivalence scales: $(1 + \alpha(S_a - 1) + \beta S_k)^{\gamma}$, this amounts to allowing both α and β to vary discretely at values [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1] while holding γ=1 in all cases. Our primary interest in this thought experiment is to examine the partial effect of α and β on inequality and poverty.

To summarize our findings, we show a heatmap of the variation produced in Gini and AROP rates by all these hypothetical scales in Figure 10. Its apparent that there is much more variation in AROP rates due to permutations in child-adult weights. AROP rates are lowest at the highest values of adult weights and lowest values of child weights and tend to be less than 14 per cent. At moderate levels of adult weights, between 0.5 and 0.7, and moderate levels of child weights, 0.3-0.5, AROP rates range from 15.0 per cent to 19.5 per cent, with an average of 16.8 per cent. This sensitivity of the AROP rate is contrasted by the relative stability of the Gini coefficient, where a "stepped" pattern is evident in child-adult weights. The lowest Gini estimates are evident at medium to high levels of adult weights and low to medium levels of child weights. As is the case with the AROP rate, the Gini coefficient tends to be maximized as the child weight approaches 1 and the adult weight approaches 0.1. In Figure 11 we plot a sub-set of the results shown in Figure 10, so that the shape of the AROP rate and Gini coefficient in response to a *ceteris parabis* changes in adult and child weights can be more easily identified. For selected values of the child weight, 0.1 to 0.4, both inequality and poverty tend to decrease as the adult weight increases, with the rate of decrease flattening after a weight of 0.7. In contrast, inequality is increasing in the child weight, the increase is subtle at low levels of the child weight but increase quite rapidly at a weight of 0.4. There is no clear relationship between the poverty rate and the child weight, and the pattern of increasing values of the child weight seem very sensitive to the choice of initial adult weight, indicating that interaction effects between adult and child weights are also substantial.

Figure 10: Household level Gini and poverty rates using simulated equivalence scales, 2019 data

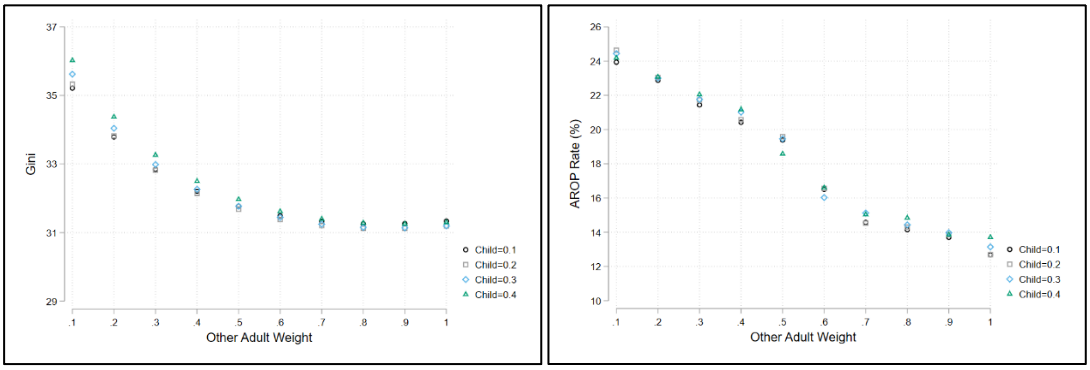
A. Gini **B. AROP Rate**



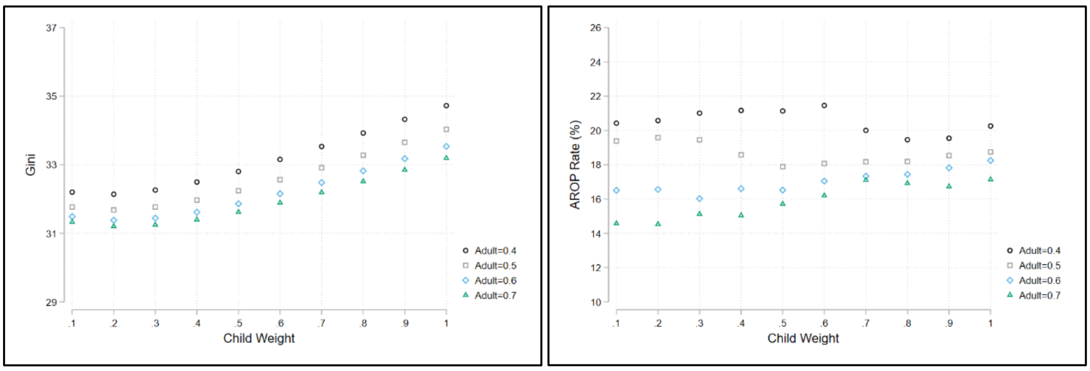
Source: EUROMOD tax-benefit simulations using 2019 Irish tax-benefit rules and 2018 Irish EU-SILC UDB.
Notes: We calculate Gini coefficients and poverty rates using 100 hypothetical equivalence scales based on the functional form defined in Equation 2: $(1 + \alpha(S_a - 1) + \beta S_k)^\gamma$. For all scales we hold the household relativity parameter, γ, as a constant at 1. We allow the adult weight, α and the child weight, β to vary discretely at values [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1].

Figure 11: Selected Gini and poverty rates using simulated equivalence scales, 2019 data

A. Gini, varying adult weight (α) **B. AROP Rate, varying adult weight (α)**



C. Gini, varying child weight (β) **D. AROP Rate, varying child weight (β)**



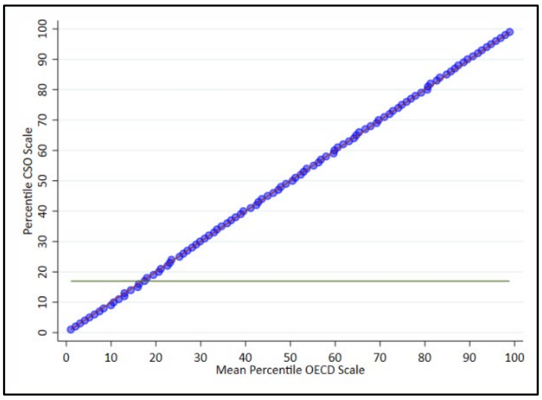
Source: EUROMOD tax-benefit simulations using 2019 Irish tax-benefit rules and 2018 Irish EU-SILC UDB.
Notes: We calculate Gini coefficients and poverty rates using 100 hypothetical equivalence scales based on the functional form defined in Equation 2: $(1 + \alpha(S_a - 1) + \beta S_k)^\gamma$. For all scales we hold the household relativity parameter, γ, as a constant at 1. We allow α and β to vary discretely at values [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1]. In Panel A and B we

display the Gini coefficient and poverty rate for varying α from 0.1 to 1 for selected values of β. In Panel C and D we display the Gini coefficient and poverty rate for varying β from 0.1 to 1 for selected values of α.

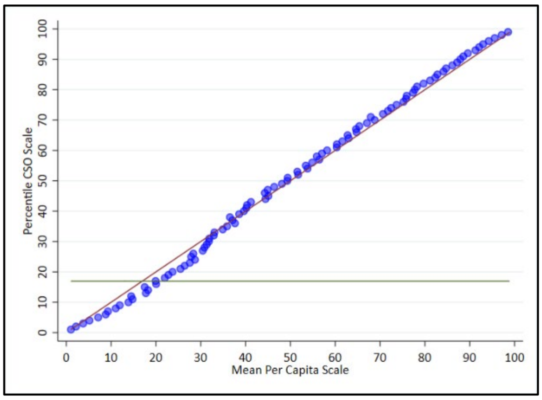
We can reconcile these findings by examining Figure 12, which shows a scatterplot of the mean centile ranks of households from 2007-2019, using the CSO equivalence scale, against these same household ranks using the square root, per capita, OECD-original and modified scales. A 45-degree line in each of the plots shows the extent to which the equivalence scales cause re-ranking effects along the income distribution. For instance, in plot A, there is very little deviation from the 45-degree line between mean household ranks using the CSO scale or OECD-modified scale –implying that households that were on average located in the 10^{th} centile under the CSO equivalized income distribution tend to be located close to the 10^{th} centile under the OECD-modified equivalized income distribution. This is also the case with the OECD-original scale, but there are noticeable differences between the CSO scales and both the square root and per capita scales in the ranking of low-income household close to the poverty line (the average household level poverty rate from 2007-2019 is shown as a horizontal line). In both cases, the most substantial re-ranking effects occur at the bottom of the income distribution. The scatter points are to the right of the 45-degree line at the bottom of the income distribution, indicating that low-income households move slightly up the per capita and square root equivalized income distribution compared to the distribution generated using the CSO scale. There is less re-ranking at the very bottom of the income distribution however e.g. $<5^{th}$ centile, which explains why we tend to notice little change in AROEP measures as opposed to AROP rates. Across all scales, there is very little movement from household income centile ranks from the middle to the top of the income distribution. From this observation we conclude that while the process of equivalization represents a non-monotonic income transformation, variation in equivalence scales tend to be non-monotonic at the bottom of the income distribution, particularly close to the poverty line, and approximately monotonic at the middle and top of the distribution. This reconciles our finding that statistics such as the Gini coefficient, which summarize the entire income distribution are less sensitive to the choice of equivalence scale than the AROP rate which is a low-income specific statistic and is a function of distance from the median income household.

Figure 12: Re-ranking across household income percentiles from equivalization scales 2007-2019

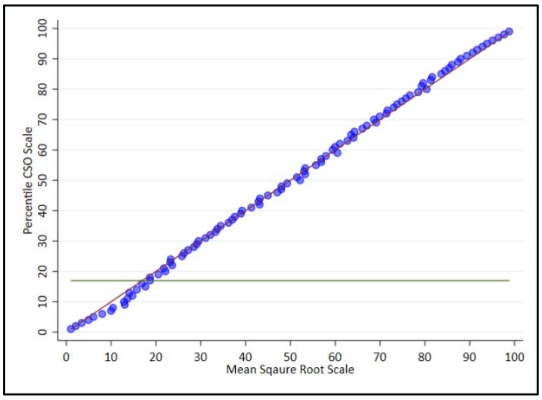
A. OECD-Modified



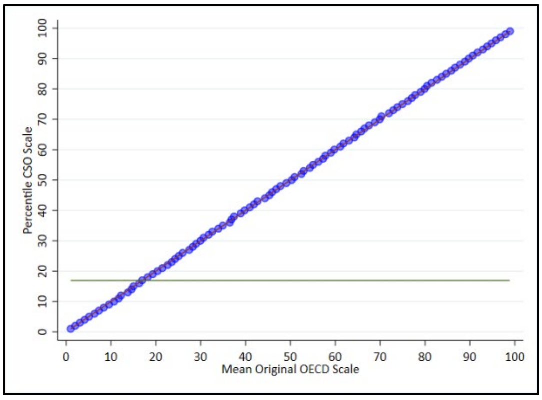
B. Per Capita



C. Square Root



D. OECD-Original



Source: Data from EUROMOD tax-benefit simulations using system-year combinations as per Appendix table A11 are pooled. Notes: Red-line is a 45-degree line indicating a perfect match between household income ranking with the CSO scale and the other examinable scales. In each graph the average income ranking of households under the Irish national CSO scale is plotted against the corresponding average rank for the OECD, per capita, square root and OECD original scale. Data are from 2007-2019 Euromod systems. The horizontal line represents the average household poverty rate from 2007-2019 using the CSO equivalence scale.

5. Conclusion

Our research has shed light on the importance of equivalence scales for at-risk-of-poverty calculations and the sensitivity of the Gini coefficient to different income-sharing assumptions within households. We use Ireland as a case study, but our results have significant general implications for applied public economists and policy makers. We find that equivalence scales have a major impact on household level poverty. This is concerning, particularly given the large range of estimates produced for young children and elderly across different scales. Our simulation results show that over a range of commonly observed adult-child equivalence weights –0.5 to 0.7 for adults and 0.3 to 0.5 for children–, at-risk-of-poverty rates in 2019 ranged from 15.0 per cent to 19.5 per cent, with an average of 16.8

per cent. Our findings also suggest that inequality and poverty rates are most sensitive to the choice of the adult weight, with both poverty and inequality decreasing as the size of the adult weight increases. This variance represents a challenge to public economist, who should be conscious of how sensitive income poverty is to the choice of equivalence scale. This is not an easily remediable issue either, as a strictly dominant equivalence scale is difficult, if not impossible to identify. The lack of consensus in optimal equivalence scales in the Irish context is highlighted by the use of three different scales from three different statistical bodies: the Irish national scale used by the Irish Central Statistics Office, the square root scale used by the OECD and the OECD-modified scale used by Eurostat.

We also find that inequality systematically rises at sub-household levels, with the Gini coefficient rising by an average of 4 percentage points (13 per cent) and 2.8 percentage points (9 per cent) at the tax and benefit-units relative to the household. Our analysis shows that young adults, those aged 18 to 24-years-old, have their position in the income distribution significantly distorted when moving from the household to sub-household level; 18 to 24-years-olds tend to live in middle income households but are downgraded to the bottom-third at the tax-/benefit-unit level. This re-ranking effect also has a significant effect on our understanding of income poverty levels amongst young adults, with at-risk-of-poverty rates more than doubling at the tax/benefit-unit as compared to the household level.

Public economists should be particularly aware that the at-risk-of-poverty measure, when calculated at the traditional household level is very sensitive to the value of equivalence scales, particularly for children and elderly. We suggest that authors report multiple estimates for these groups so as to get a sense of the range of estimated poverty. Equivalence scales are less important for calculating the Gini coefficient however. We show that different equivalence scales tend to be non-monotonic at the bottom of the income distribution, but approximately monotonic at the middle and top. Therefore, low-income specific statistics, like at-risk-of-poverty rates tend to have the largest variation in response to equivalence scales.

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Appendix

Table A1: Inequality statistics by equivalence scale, household level

	CSO	OECD-Modified	Per capita	Square root	OECD-Original
			Gini		
2007	0.3093	0.3111	0.3275	0.3171	0.3124
2008	0.3039	0.3048	0.3250	0.3101	0.3076
2009	0.2898	0.2906	0.3130	0.2960	0.2940
2010	0.3037	0.3052	0.3274	0.3103	0.3086
2011	0.3026	0.3040	0.3271	0.3089	0.3077
2012	0.3030	0.3030	0.3262	0.3053	0.3070
2013	0.3045	0.3044	0.3279	0.3066	0.3086
2014	0.3059	0.3069	0.3246	0.3097	0.3086
2015	0.3095	0.3106	0.3277	0.3134	0.3121
2016	0.3073	0.3093	0.3239	0.3137	0.3096
2017	0.3053	0.3077	0.3218	0.3127	0.3079
2018	0.3116	0.3158	0.3264	0.3236	0.3144
2019	0.3135	0.3177	0.3280	0.3255	0.3162
			p90p10		
2007	3.9917	4.1064	4.6051	4.2513	4.0816
2008	3.8100	3.9351	4.3434	4.0752	3.8987
2009	3.5104	3.6752	4.1688	3.8417	3.6839
2010	3.7582	3.7185	4.6149	3.9906	3.9139
2011	3.7629	3.7110	4.6423	3.9871	3.9054
2012	3.7897	3.8263	4.6446	4.0575	3.9127
2013	3.8137	3.8332	4.7077	4.0608	3.9630
2014	3.7456	3.8174	4.5722	4.0013	3.8864
2015	3.8418	3.9029	4.6433	4.0574	3.9358
2016	3.8590	3.9284	4.5474	3.9843	3.9679
2017	3.8742	3.9854	4.3916	4.1245	3.9070
2018	3.6817	3.8887	4.1653	4.0206	3.7438
2019	3.7099	3.9209	4.1923	4.0715	3.7606
			p10p50		
2007	0.4968	0.4803	0.4638	0.4614	0.4860
2008	0.4941	0.4845	0.4846	0.4663	0.4925
2009	0.5195	0.5059	0.4892	0.4839	0.5122
2010	0.5177	0.5218	0.4573	0.4911	0.5028
2011	0.5110	0.5156	0.4525	0.4880	0.5004
2012	0.5088	0.5073	0.4624	0.4838	0.5050
2013	0.5098	0.5107	0.4597	0.4857	0.5010
2014	0.5304	0.5089	0.4815	0.4879	0.5176
2015	0.5242	0.5006	0.4765	0.4845	0.5123
2016	0.5286	0.5055	0.4769	0.4901	0.5200
2017	0.5332	0.5154	0.5015	0.4965	0.5386
2018	0.5292	0.4987	0.5030	0.4863	0.5268
2019	0.5267	0.4959	0.5022	0.4820	0.5248

			p90p50		
2007	1.9832	1.9725	2.1359	1.9616	1.9836
2008	1.8827	1.9064	2.1048	1.9005	1.9203
2009	1.8238	1.8593	2.0393	1.8591	1.8869
2010	1.9457	1.9402	2.1102	1.9599	1.9678
2011	1.9227	1.9136	2.1005	1.9457	1.9544
2012	1.9280	1.9411	2.1479	1.9630	1.9759
2013	1.9443	1.9577	2.1643	1.9722	1.9854
2014	1.9865	1.9428	2.2015	1.9524	2.0115
2015	2.0140	1.9537	2.2125	1.9658	2.0162
2016	2.0400	1.9857	2.1685	1.9528	2.0634
2017	2.0658	2.0543	2.2023	2.0477	2.1042
2018	1.9483	1.9392	2.0950	1.9553	1.9724
2019	1.9539	1.9445	2.1055	1.9625	1.9736

Table A2: Inequality statistics by equivalence scale, tax-unit level

	CSO	OECD-Modified	Per capita	Square root	OECD-Original
			Gini		
2007	0.3519	0.3559	0.3640	0.3617	0.3530
2008	0.3469	0.3513	0.3580	0.3572	0.3478
2009	0.3345	0.3386	0.3476	0.3441	0.3358
2010	0.3466	0.3497	0.3640	0.3545	0.3495
2011	0.3457	0.3487	0.3635	0.3533	0.3487
2012	0.3464	0.3507	0.3587	0.3561	0.3477
2013	0.3490	0.3532	0.3616	0.3584	0.3504
2014	0.3457	0.3502	0.3565	0.3555	0.3464
2015	0.3492	0.3537	0.3595	0.3591	0.3498
2016	0.3453	0.3501	0.3557	0.3561	0.3460
2017	0.3438	0.3489	0.3532	0.3549	0.3444
2018	0.3459	0.3520	0.3553	0.3601	0.3470
2019	0.3475	0.3536	0.3568	0.3617	0.3486
			p90p10		
2007	5.2534	5.3655	6.0483	5.4052	5.3616
2008	4.8907	5.0062	5.7276	5.2219	4.9026
2009	4.8503	4.9968	5.5215	5.2373	4.8381
2010	6.3670	6.3591	5.8516	6.5140	6.2264
2011	6.1914	6.2547	5.7620	6.3548	6.0290
2012	5.6498	5.9856	5.5196	6.2395	5.6186
2013	6.1824	6.6235	5.8646	6.9368	6.0179
2014	5.4499	5.5621	5.7726	5.7409	5.3863
2015	5.5345	5.6730	5.9153	5.8028	5.4931
2016	4.9235	5.1041	5.5872	5.1132	4.9462
2017	4.8155	4.8826	5.3542	5.0825	4.8198
2018	4.2929	4.3825	4.9087	4.6128	4.4652

2019	4.3254	4.3752	4.9195	4.6011	4.4408
			p10p50		
2007	0.3876	0.3797	0.3656	0.3822	0.3874
2008	0.4009	0.3968	0.3730	0.3899	0.4106
2009	0.3956	0.3864	0.3753	0.3734	0.4022
2010	0.3216	0.3217	0.3911	0.3165	0.3333
2011	0.3282	0.3253	0.3880	0.3269	0.3401
2012	0.3670	0.3487	0.4173	0.3360	0.3799
2013	0.3373	0.3157	0.3948	0.3041	0.3575
2014	0.3795	0.3763	0.3874	0.3690	0.3888
2015	0.3792	0.3739	0.3838	0.3703	0.3853
2016	0.4242	0.4161	0.4004	0.4175	0.4285
2017	0.4420	0.4398	0.4240	0.4284	0.4468
2018	0.4788	0.4813	0.4317	0.4640	0.4610
2019	0.4772	0.4831	0.4334	0.4662	0.4670
			p90p50		
2007	2.0362	2.0373	2.2110	2.0659	2.0770
2008	1.9606	1.9863	2.1366	2.0358	2.0128
2009	1.9187	1.9309	2.0724	1.9559	1.9460
2010	2.0479	2.0459	2.2883	2.0618	2.0753
2011	2.0318	2.0349	2.2355	2.0773	2.0503
2012	2.0735	2.0873	2.3033	2.0963	2.1347
2013	2.0854	2.0910	2.3152	2.1097	2.1516
2014	2.0681	2.0931	2.2362	2.1184	2.0941
2015	2.0985	2.1209	2.2702	2.1491	2.1166
2016	2.0884	2.1236	2.2370	2.1347	2.1196
2017	2.1286	2.1474	2.2702	2.1772	2.1536
2018	2.0556	2.1094	2.1192	2.1401	2.0586
2019	2.0643	2.1137	2.1321	2.1450	2.0738

Table A3: Inequality statistics by equivalence scale, benefit-unit level

	CSO	OECD-Modified	Per capita	Square root	OECD-Original
			Gini		
2007	0.3349	0.3394	0.3463	0.3452	0.3359
2008	0.3343	0.3393	0.3452	0.3449	0.3353
2009	0.3214	0.3260	0.3344	0.3313	0.3228
2010	0.3386	0.3423	0.3543	0.3466	0.3413
2011	0.3377	0.3413	0.3539	0.3455	0.3405
2012	0.3360	0.3402	0.3478	0.3445	0.3373
2013	0.3380	0.3421	0.3501	0.3463	0.3394
2014	0.3338	0.3386	0.3429	0.3431	0.3342
2015	0.3374	0.3423	0.3461	0.3469	0.3377
2016	0.3353	0.3412	0.3426	0.3470	0.3355
2017	0.3306	0.3363	0.3388	0.3420	0.3312

2018	0.3346	0.3419	0.3407	0.3499	0.3352
2019	0.3362	0.3435	0.3421	0.3516	0.3368
			p90p10		
2007	4.4002	4.4338	5.2076	4.5956	4.5393
2008	4.2636	4.2928	4.9359	4.4967	4.3459
2009	4.0852	4.1545	4.8914	4.2471	4.1958
2010	4.7436	4.7816	5.4716	5.0013	4.7445
2011	4.7581	4.7975	5.4125	5.0010	4.7251
2012	4.7605	4.8226	5.3834	4.9890	4.7690
2013	4.9895	5.0762	5.4894	5.1028	4.9735
2014	4.6032	4.5986	5.2969	4.5785	4.5006
2015	4.7012	4.6240	5.3934	4.6462	4.6178
2016	4.4432	4.4783	5.0267	4.5025	4.5196
2017	4.2395	4.2885	4.9739	4.4303	4.3977
2018	3.9946	4.3415	4.6011	4.5775	4.1221
2019	4.0122	4.3672	4.6179	4.6005	4.1333
			p10p50		
2007	0.4563	0.4581	0.4176	0.4473	0.4552
2008	0.4611	0.4665	0.4352	0.4514	0.4601
2009	0.4696	0.4657	0.4226	0.4570	0.4622
2010	0.4290	0.4279	0.4170	0.4129	0.4353
2011	0.4238	0.4249	0.4129	0.4085	0.4356
2012	0.4363	0.4318	0.4220	0.4217	0.4446
2013	0.4197	0.4112	0.4163	0.4130	0.4304
2014	0.4585	0.4600	0.4213	0.4665	0.4653
2015	0.4536	0.4628	0.4199	0.4642	0.4600
2016	0.4695	0.4741	0.4382	0.4748	0.4690
2017	0.5074	0.4992	0.4545	0.4865	0.4913
2018	0.5210	0.4925	0.4628	0.4711	0.5053
2019	0.5213	0.4907	0.4634	0.4699	0.5057
			p90p50		
2007	2.0079	2.0310	2.1748	2.0556	2.0663
2008	1.9660	2.0025	2.1480	2.0299	1.9994
2009	1.9185	1.9348	2.0672	1.9411	1.9391
2010	2.0349	2.0461	2.2818	2.0651	2.0651
2011	2.0166	2.0384	2.2348	2.0430	2.0584
2012	2.0770	2.0824	2.2717	2.1041	2.1200
2013	2.0941	2.0872	2.2853	2.1077	2.1405
2014	2.1104	2.1154	2.2316	2.1357	2.0941
2015	2.1326	2.1399	2.2649	2.1570	2.1242
2016	2.0863	2.1233	2.2027	2.1379	2.1195
2017	2.1513	2.1407	2.2608	2.1554	2.1608
2018	2.0811	2.1383	2.1292	2.1565	2.0830
2019	2.0916	2.1431	2.1400	2.1616	2.0900

Table A4: Poverty statistics by equivalence scale, household level

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
2007	16.69	16.72	21.87	16.32	18.23
2008	16.28	15.75	20.74	16.17	17.32
2009	14.95	14.64	20.61	14.31	16.15
2010	18.34	17.61	24.82	15.41	19.61
2011	18.83	18.07	25.44	15.64	19.69
2012	18.66	17.57	22.75	15.65	19.28
2013	18.88	17.83	23.03	15.93	19.48
2014	16.90	16.55	22.54	16.71	17.96
2015	17.10	16.92	22.67	17.31	18.74
2016	15.65	15.97	20.65	16.54	17.59
2017	15.02	14.54	20.55	14.84	16.50
2018	14.65	15.67	20.40	15.42	16.34
2019	14.76	15.87	20.15	15.83	16.54
			At-risk-of-extreme-poverty rate		
2007	3.95	4.06	7.46	4.60	4.71
2008	3.51	3.49	5.92	3.93	3.97
2009	3.36	3.41	5.35	3.30	3.29
2010	4.75	4.58	6.75	4.41	4.62
2011	4.84	4.66	7.04	4.41	4.63
2012	4.20	3.88	6.49	3.93	4.13
2013	4.22	3.94	6.74	3.89	4.52
2014	4.49	4.06	7.12	3.51	4.71
2015	4.55	4.21	7.39	3.63	4.82
2016	3.49	3.12	7.51	3.24	3.81
2017	3.21	2.86	6.10	2.86	3.61
2018	3.17	3.01	6.45	3.27	3.83
2019	3.11	3.01	6.32	3.27	3.80
			At-risk-of-poverty rate, children		
2007	19.98	18.83	33.04	17.25	24.17
2008	19.32	18.00	32.32	18.16	23.45
2009	17.99	17.14	32.24	16.21	21.90
2010	21.98	20.59	39.19	16.82	27.34
2011	22.75	21.38	39.63	17.42	27.23
2012	20.66	18.80	33.35	17.00	24.17
2013	21.37	19.76	33.87	17.74	24.69
2014	20.09	19.30	34.97	18.54	24.27
2015	20.20	19.51	34.76	19.11	25.24
2016	19.77	19.83	32.74	19.73	24.86
2017	17.78	17.07	32.76	15.97	23.05
2018	18.67	18.33	35.15	16.80	23.80
2019	18.88	18.36	34.86	17.26	24.14
			At-risk-of-poverty rate, working age population		

2007	14.71	14.34	17.56	13.41	15.43
2008	14.23	13.31	16.43	12.81	14.37
2009	12.87	12.55	16.28	11.36	13.38
2010	17.17	16.48	20.48	14.46	17.07
2011	17.78	17.00	21.32	14.83	17.35
2012	17.97	16.92	19.87	14.31	17.80
2013	18.10	17.02	20.08	14.56	17.93
2014	17.21	16.68	20.30	15.97	17.27
2015	17.41	17.00	20.50	16.13	18.10
2016	15.36	15.74	18.25	15.01	16.43
2017	15.42	14.59	18.52	13.52	15.84
2018	14.41	14.05	17.38	13.32	15.37
2019	14.47	14.10	17.13	13.64	15.52
			At-risk-of-poverty rate, elderly		
2007	19.98	25.83	17.62	32.05	19.21
2008	21.44	25.28	18.36	32.14	20.24
2009	20.23	21.42	18.18	27.96	18.90
2010	16.18	16.88	14.60	17.46	15.33
2011	15.23	16.13	14.42	15.90	14.68
2012	17.89	18.37	14.30	20.03	16.24
2013	17.45	17.94	14.40	19.38	16.09
2014	8.40	9.93	6.84	16.43	7.71
2015	8.81	10.91	7.32	19.34	7.83
2016	8.26	8.85	6.61	17.22	7.76
2017	7.55	9.14	5.95	19.04	6.57
2018	7.96	18.15	5.92	22.62	6.43
2019	8.10	19.35	5.77	23.31	6.51

Table A5: Poverty statistics by equivalence scale, tax-unit level

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
2007	19.39	18.19	24.46	16.98	20.89
2008	20.28	18.65	23.70	17.81	20.99
2009	18.60	17.21	23.68	16.50	17.89
2010	14.96	16.19	25.19	16.55	18.85
2011	15.27	16.55	26.02	16.18	19.44
2012	15.21	16.32	21.83	16.66	16.88
2013	15.29	16.57	22.20	16.81	17.32
2014	16.89	15.91	22.44	15.89	17.24
2015	17.39	16.03	22.21	15.62	17.50
2016	17.76	16.42	22.23	15.39	19.00
2017	16.52	16.21	20.91	15.17	17.57
2018	15.64	15.25	21.13	14.70	16.95

2019	15.57	15.29	21.15	15.00	16.84
At-risk-of-extreme-poverty rate					
2007	6.97	6.71	10.67	6.62	6.93
2008	6.57	6.19	9.71	6.23	6.51
2009	6.44	6.31	9.59	6.46	6.67
2010	7.27	7.14	8.44	6.96	7.29
2011	7.30	7.31	9.06	6.93	7.34
2012	6.41	6.42	7.41	6.50	6.35
2013	6.94	7.04	8.22	7.18	6.92
2014	6.99	6.74	9.34	6.51	7.10
2015	6.90	6.68	9.21	6.41	7.15
2016	6.09	5.83	9.03	5.71	6.15
2017	5.91	5.68	8.55	5.55	6.07
2018	5.35	5.08	8.65	4.90	5.81
2019	5.34	5.08	8.59	4.90	5.79
At-risk-of-poverty rate, children					
2007	18.09	15.31	35.14	12.45	22.98
2008	19.37	16.32	35.90	14.12	22.50
2009	17.12	14.47	35.61	12.67	21.34
2010	13.61	11.73	37.40	12.15	22.37
2011	13.67	12.13	38.88	11.89	23.36
2012	13.45	10.94	30.76	11.69	18.85
2013	13.79	11.42	31.32	12.28	19.60
2014	14.99	12.16	33.27	11.57	20.56
2015	15.84	12.16	32.85	11.06	21.15
2016	16.56	13.82	33.55	11.51	22.17
2017	15.56	13.98	32.07	12.02	19.91
2018	15.68	13.70	34.86	11.91	19.99
2019	15.50	13.80	34.78	12.31	19.86
At-risk-of-poverty rate, working age population					
2007	20.07	19.14	20.74	18.32	20.41
2008	20.75	19.46	19.49	18.94	20.62
2009	19.09	17.99	19.58	17.56	16.29
2010	15.36	18.11	21.71	18.43	17.92
2011	15.89	18.54	22.42	18.19	18.46
2012	15.62	18.42	19.23	18.63	16.15
2013	15.61	18.62	19.58	18.68	16.58
2014	19.63	19.32	20.93	19.52	17.87
2015	20.04	19.48	20.73	19.23	18.02
2016	20.60	19.58	20.71	18.87	20.24
2017	19.16	19.33	19.61	18.42	19.16
2018	17.95	18.01	19.00	17.48	18.36
2019	17.92	18.02	19.04	17.72	18.23
At-risk-of-poverty rate, elderly					
2007	18.77	20.28	17.87	21.33	18.04
2008	19.65	19.53	19.11	20.15	19.42

2009	19.26	19.32	19.08	19.55	19.12
2010	15.95	16.07	15.30	16.40	15.58
2011	15.62	15.84	15.30	15.07	15.51
2012	17.00	17.05	15.75	17.15	16.40
2013	16.91	16.98	15.73	16.81	16.15
2014	7.22	6.88	6.51	6.94	6.84
2015	7.41	7.00	6.56	7.34	6.99
2016	6.30	6.41	5.54	6.56	6.11
2017	5.52	5.42	4.88	5.54	5.11
2018	4.68	5.28	4.43	7.11	4.47
2019	4.70	5.40	4.60	7.48	4.47

Table A6: Poverty statistics by equivalence scale, benefit-unit level

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
2007	18.44	17.62	24.22	16.43	19.66
2008	19.48	18.21	23.01	16.95	20.58
2009	17.81	16.74	23.20	15.99	19.56
2010	15.27	16.38	25.37	16.18	19.39
2011	15.87	16.55	25.93	16.33	19.53
2012	14.46	15.97	22.58	15.67	16.34
2013	14.58	16.25	23.03	15.83	16.63
2014	16.53	15.10	22.87	14.35	17.41
2015	17.14	15.71	22.39	14.48	17.65
2016	17.91	16.32	22.13	14.87	18.83
2017	15.67	15.88	21.15	14.82	17.02
2018	14.81	14.51	20.56	14.41	16.44
2019	15.03	14.65	20.52	14.36	16.73
			At-risk-of-extreme-poverty rate		
2007	5.18	5.03	9.72	4.85	5.23
2008	5.20	4.79	8.42	4.81	5.25
2009	5.12	4.88	8.19	5.03	5.28
2010	6.48	6.17	7.75	5.79	6.51
2011	6.40	6.25	8.15	5.90	6.44
2012	5.32	5.32	6.91	5.23	5.33
2013	5.70	5.69	7.29	5.65	5.68
2014	5.75	5.26	8.56	5.03	6.03
2015	5.61	5.24	8.42	5.05	5.93
2016	4.91	4.68	8.68	4.44	5.02
2017	4.59	4.21	7.96	4.27	5.03
2018	4.09	3.98	7.69	3.69	4.50
2019	4.04	3.93	7.54	3.66	4.40

At-risk-of-poverty rate, children					
2007	17.39	15.18	35.03	12.13	21.63
2008	18.67	15.78	34.55	12.87	22.13
2009	16.71	14.00	34.84	11.88	21.24
2010	14.01	11.88	37.82	11.48	23.56
2011	14.97	12.57	38.80	11.54	23.86
2012	12.93	11.56	31.55	11.04	18.87
2013	13.66	12.37	32.34	11.49	19.65
2014	15.76	11.97	34.60	10.10	22.13
2015	16.50	13.18	33.84	10.19	22.40
2016	17.89	15.08	33.50	10.99	22.84
2017	15.65	14.57	33.04	12.28	20.23
2018	15.41	13.81	34.33	13.00	20.43
2019	15.36	13.91	34.25	12.73	20.90
At-risk-of-poverty rate, working age population					
2007	18.70	17.99	20.30	17.07	18.92
2008	19.67	18.82	18.88	17.92	20.04
2009	17.90	17.33	19.07	16.92	18.83
2010	15.60	18.23	21.76	18.07	18.19
2011	16.20	18.32	22.29	18.34	18.37
2012	14.60	17.50	20.07	17.22	15.23
2013	14.52	17.63	20.46	17.28	15.41
2014	18.75	18.10	21.10	17.57	17.48
2015	19.34	18.48	20.63	17.72	17.72
2016	20.18	18.79	20.50	18.17	19.61
2017	17.72	18.47	19.54	17.54	18.06
2018	16.71	16.72	18.30	16.35	17.32
2019	17.09	16.78	18.27	16.30	17.60
At-risk-of-poverty rate, elderly					
2007	19.79	22.18	18.53	24.54	18.76
2008	20.39	20.59	19.66	21.22	20.07
2009	20.06	19.94	19.53	20.52	19.83
2010	16.46	16.70	15.63	16.78	16.07
2011	16.14	16.12	15.32	16.40	15.59
2012	17.21	17.64	15.84	17.70	16.71
2013	17.05	17.50	15.89	17.70	16.45
2014	7.05	6.84	6.37	7.40	6.80
2015	7.43	7.22	6.38	7.50	6.97
2016	6.76	6.77	5.86	6.93	6.43
2017	5.65	5.83	5.13	6.63	5.52
2018	4.77	5.49	4.44	8.05	4.54
2019	4.77	6.09	4.44	8.39	4.56

Table A7: AROP and AROEP rate by ten-year age groups, household unit (2019 data)

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
0-9	15.32	15.59	35.29	16.41	22.29
10-19	21.39	19.96	31.72	16.87	24.29
20-29	12.03	11.24	15.50	9.68	12.22
30-39	10.61	10.89	20.02	11.08	13.43
40-49	15.69	15.20	21.67	14.52	18.33
50-59	14.75	14.14	11.51	14.12	14.22
60-69	18.99	21.64	12.03	22.74	17.40
70-79	5.41	16.56	3.83	19.31	4.12
80+	8.94	24.92	7.49	33.94	7.89
			At-risk-of-extreme-poverty		
0-9	1.90	1.79	10.79	3.15	4.01
10-19	4.68	3.89	11.40	3.67	6.15
20-29	3.20	3.20	4.76	2.50	3.43
30-39	1.73	1.52	5.81	2.25	2.36
40-49	4.17	4.03	6.28	3.40	4.60
50-59	2.49	2.70	3.07	3.27	2.67
60-69	4.28	4.72	4.06	5.91	4.16
70-79	1.80	1.80	1.56	1.43	1.77
80+	3.25	3.49	1.70	4.16	3.25

Table A8: AROP and AROEP rate by ten-year age groups, tax-unit (2019 data)

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
0-9	11.36	10.45	34.27	10.41	16.66
10-19	23.16	20.87	35.78	18.22	25.91
20-29	27.66	28.93	22.50	29.50	27.53
30-39	11.44	11.22	19.80	11.46	13.67
40-49	15.61	14.66	20.59	13.25	16.76
50-59	14.56	14.81	12.57	14.54	13.68
60-69	15.14	16.42	11.48	17.65	13.54
70-79	3.09	4.07	2.94	6.20	2.91
80+	5.43	5.81	4.95	6.54	5.04
			At-risk-of-extreme-poverty		
0-9	2.02	1.98	12.17	2.83	3.64
10-19	9.08	7.51	15.97	6.21	10.09
20-29	12.03	13.71	11.79	13.93	12.39
30-39	3.94	3.94	7.93	4.47	4.27
40-49	4.58	4.08	7.01	2.96	4.82
50-59	3.86	3.33	4.37	3.23	3.84
60-69	5.38	5.07	5.03	5.02	5.22

70-79	1.19	1.01	1.13	1.01	1.19
80+	2.87	3.18	1.88	3.18	2.54

Table A9: AROP and AROEP rate by ten-year age groups, benefit-unit (2019 data)

	CSO (%)	OECD-Modified (%)	Per capita (%)	Square root (%)	OECD-Original (%)
			At-risk-of-poverty rate		
0-9	10.85	10.41	34.19	10.85	17.58
10-19	20.79	18.35	32.49	15.70	24.50
20-29	27.17	28.05	22.12	28.85	27.42
30-39	10.08	9.72	20.02	9.90	13.31
40-49	15.36	14.17	20.62	12.38	16.81
50-59	15.18	15.02	12.25	14.45	13.96
60-69	16.03	16.93	11.19	18.23	13.66
70-79	3.12	4.56	2.91	6.56	2.94
80+	5.43	6.31	4.29	7.84	5.04
			At-risk-of-extreme-poverty		
0-9	1.27	1.23	11.19	1.33	2.17
10-19	4.75	3.72	12.34	2.61	5.74
20-29	12.25	13.93	11.96	14.29	12.51
30-39	1.75	1.78	6.57	2.03	2.06
40-49	3.40	3.21	6.07	2.09	3.60
50-59	3.51	2.89	4.19	2.99	3.48
60-69	5.22	5.04	4.87	4.88	5.22
70-79	1.19	1.19	1.13	1.01	1.19
80+	2.87	3.18	1.88	3.18	2.54

Table A10: Size of income-sharing unit (2019 data)

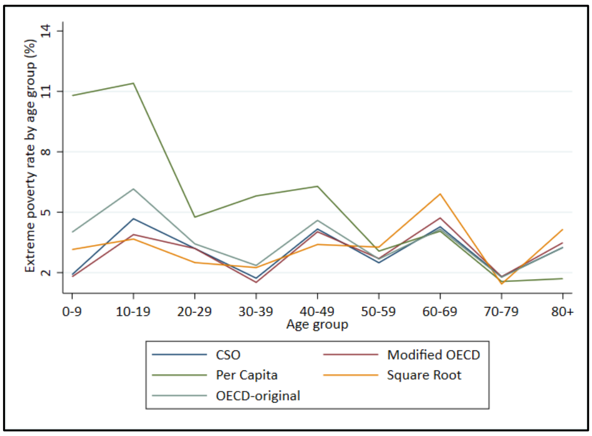
	Household unit	Tax-unit	Benefit-unit
0-9	4.16	3.93	4.05
10-19	4.40	3.80	3.99
20-29	3.78	1.61	1.70
30-39	3.30	2.71	2.97
40-49	3.55	3.13	3.27
50-59	3.17	2.53	2.57
60-69	2.13	1.77	1.78
70-79	1.80	1.59	1.60
80+	1.59	1.36	1.37
Total	3.34	2.89	2.78

Table A11: Tax-benefit systems and Irish EU-SILC data years used

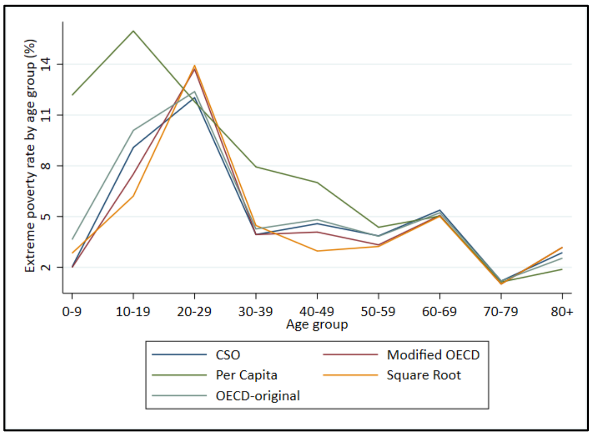
Tax-benefit system	SILC Data Used in Simulations
2007	2007
2008	2008
2009	2008
2010	2010
2011	2010
2012	2012
2013	2012
2014	2015
2015	2015
2016	2016
2017	2017
2018	2018
2019	2018

Figure A1: AROEP by age group, 2019 data

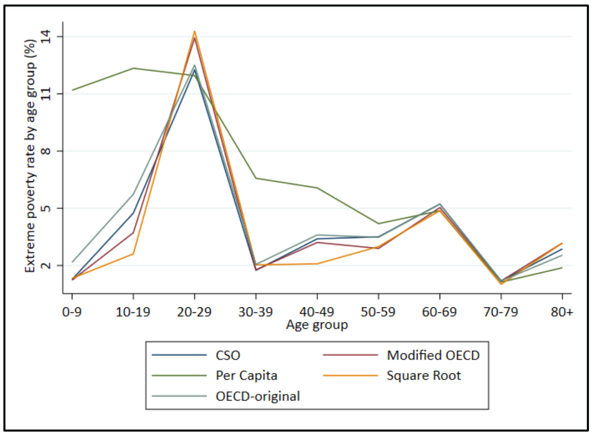
A. Household



B. Tax-Unit



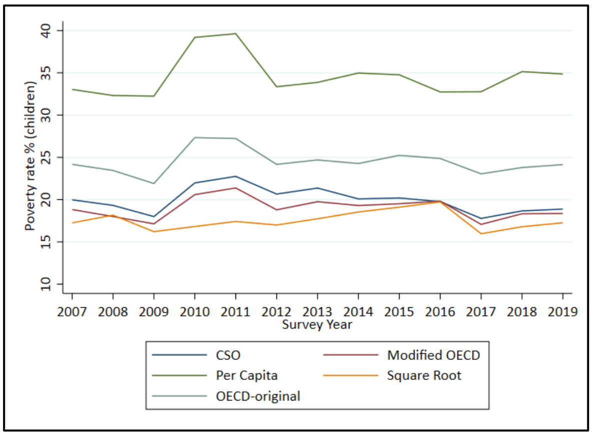
C. Benefit-Unit



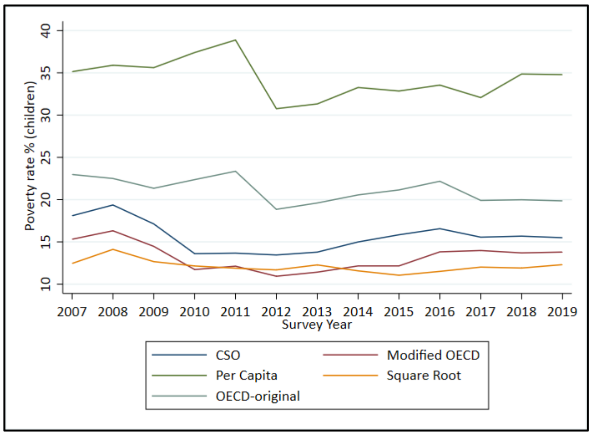
Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix Table A11.

Figure A2: Child Poverty Rate

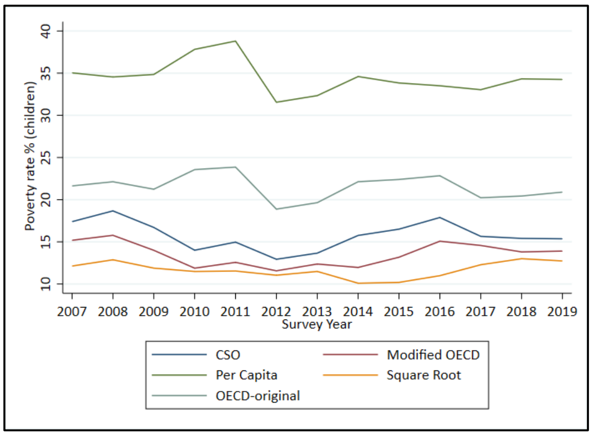
A. Household



B. Tax-Unit



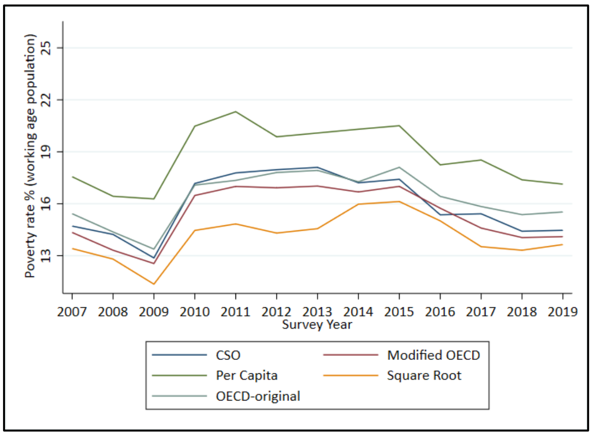
C. Benefit-Unit



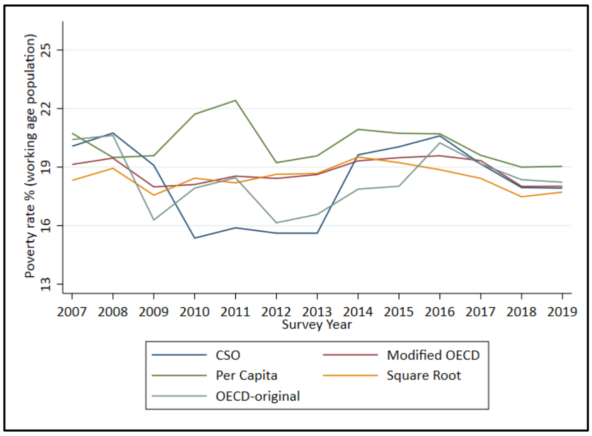
Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix Table A11.

Figure A3: Working-Age Poverty Rate

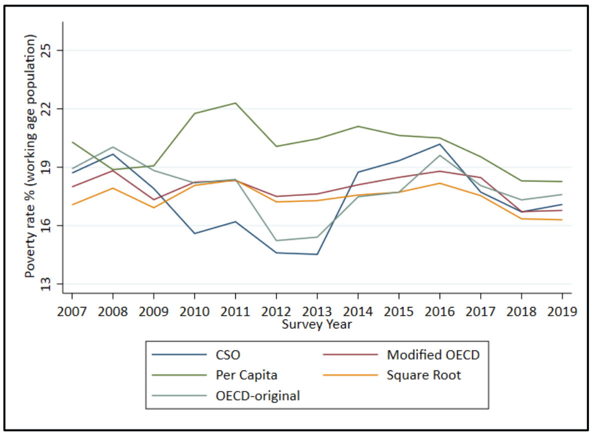
A. Household



B. Tax-Unit



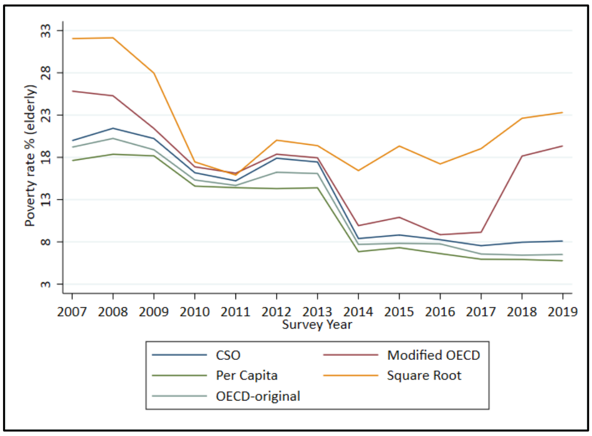
C. Benefit-Unit



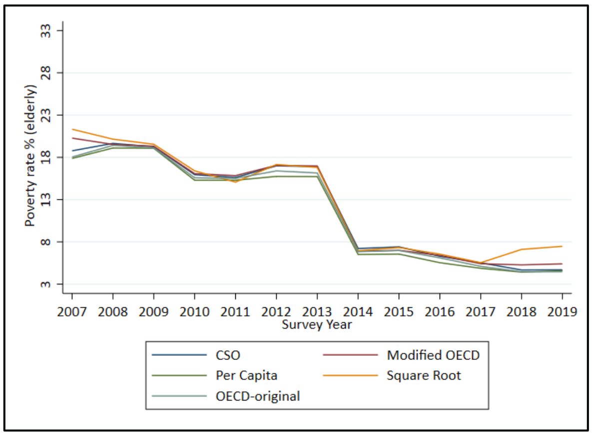
Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix Tables A11.

Figure A4: Elderly Poverty Rate

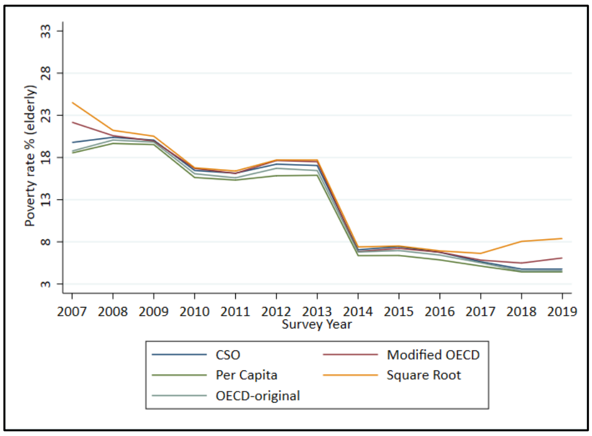
A. Household



B. Tax-Unit



C. Benefit-Unit



Source: EUROMOD tax-benefit simulations using system-year combinations as per Appendix Tables A11.