National Institute of Economic and Social Research

THE EVOLUTION OF TAX IMPLICIT VALUE JUDGEMENTS, REDISTRIBUTION AND INCOME INEQUALITY IN THE UK: 1968 TO 2015

Justin van de Ven[1,2]
Nicolas Hérault[1]

[1] Melbourne Institute of Applied Economic and Social Research, the University of Melbourne, Australia
[2]National Institute of Economic and Social Research

NIESR Discussion Paper No. 510

Date: 14 October 2019

National Institute of Economic and Social Research

About the National Institute of Economic and Social Research

The National Institute of Economic and Social Research is Britain's longest established independent research institute, founded in 1938. The vision of our founders was to carry out research to improve understanding of the economic and social forces that affect people's lives, and the ways in which policy can bring about change. Over eighty years later, this remains central to NIESR's ethos. We continue to apply our expertise in both quantitative and qualitative methods and our understanding of economic and social issues to current debates and to influence policy. The Institute is independent of all party political interests.

National Institute of Economic and Social Research
2 Dean Trench St
London SW1P 3HE
T: +44 (0)20 7222 7665
E: enquiries@niesr.ac.uk
niesr.ac.uk
Registered charity no. 306083

This paper was first published in October 2019

The evolution of tax implicit value judgements, redistribution and income inequality in the UK: 1968 to 2015

Justin van de Ven and Nicolas Hérault

Abstract

An issue of interest in the literature that explores the drivers of inequality is the distributional bearing of tax and transfer policy, where an important theme concerns changes in the relative treatment of alternative population subgroups. We develop an empirical approach for quantifying the value judgements implicit in the relative treatment of demographic subgroups by a tax and transfer system. We apply this approach to UK data reported at annual intervals between 1968 and 2015, documenting remarkable improvements in tax and transfer treatment enjoyed by some population subgroups – particularly families with children and age pensioners – relative to the wider population. We show that accounting for the changing value judgements implicit in tax and transfer policy provides a fresh perspective on the evolution of income inequality and redistribution; one that departs from the prevailing view that UK inequality stopped rising from the early 1990s.

Keywords: equivalence scale, inequality, redistribution, horizontal equity

JEL Classifications: D31, H23, I38

Acknowledgements

Van de Ven would like to thank John Muellbauer for formative discussions concerning the merits of tax implicit (equivalence) scales. We also thank Stephen Jenkins and Guyonne Kalb for comments on earlier drafts. The authors assume responsibility for any errors or omissions made.

Contact details

Justin Van de Ven (J.Vandeven@niesr.ac.uk), National Institute of Economic and Social Research, 2 Dean Trench Street, London SW1P 3HE

The evolution of tax implicit value judgements, redistribution and income inequality in the UK: 1968 to 2015*

Justin van de Ven[†,‡] and Nicolas Hérault[†]

May, 2019

Abstract

An issue of interest in understanding the drivers of inequality is the incidence of tax and transfer policies on population subgroups. We develop an empirical approach for quantifying the value judgements implicit in the relative treatment of demographic subgroups by a tax and transfer system. We apply this approach to UK data reported at annual intervals between 1968 and 2015. This analysis quantifies significant improvements in the relative tax and transfer treatment enjoyed by families with children and age pensioners, relative to the wider population. We find that accounting for the changing value judgements implicit in tax and transfer policy produces measures of rising income inequality between 1990 and 2015, by 9 Gini points for private income and 12 Gini points for disposable income. This is in contrast to widely-known measures of income inequality equivalised using the OECD scale, which stabilised following steep increases in inequality during the 1980s.

Key words: equivalence scale, inequality, redistribution, horizontal equity.

JEL Classifications: D31, H23, I38.

* Van de Ven would like to thank John Muellbauer for formative discussions concerning the merits of tax implicit (equivalence) scales. We also thank Stephen Jenkins and Guyonne Kalb for comments on earlier drafts. The authors assume responsibility for any errors or omissions made.

‡ NIESR, London, UK

† Melbourne Institute of Applied Economic and Social Research, the University of Melbourne, Australia.

1 Introduction

Income inequality in most high-income countries has increased appreciably since the 1970s, motivating renewed interest in the drivers of distributional trends. One factor that has attracted intense research interest is the role of tax and transfer policy, where an important theme concerns changes in the relative treatment of alternative population subgroups. Population subgroups can be distinguished over a wide range of features, and there has been a long trend among OECD countries toward less progressive income tax rates and more tightly targeted welfare benefits.[1] We develop a new analytical approach to reveal and quantify the shifts in relative treatment of alternative population subgroups by the UK tax and transfer system during the last half century. We then provide the first distributional analysis explicitly accounting for these changing value judgements implicit in tax and transfer policy.[2] The results provide a new perspective on the evolution of inequality and redistribution in the UK.

It is generally recognised that income inequality rose appreciably in most OECD countries during the three decades from the 1980s (see, e.g., Tóth 2014, OECD 2008, or Morrelli *et al*. 2015). A large literature has explored the reasons for the rise in income inequality.[3] One of the key findings is that the redistributive power of tax and transfer systems has been declining (Atkinson 2015, p. 65, OECD 2011, p. 18). This decline has been attributed to the combination of a trend away from highly progressive income tax rates, with significant drops in top marginal income tax rates (e.g. Scheve and Stasavage, 2016) and the reduced generosity of social

[1] For reviews of historical trends in tax and transfer policy, see OECD (2011) and Atkinson (2015).

[2] Value judgements in the current paper refer to beliefs concerning the relative demands of one family type, relative to another. Beliefs concerning 'demands' associated with a family may vary with the analytical perspective – for example, the demands of one family type may be considered greater than another when considering their respective consumption needs, but equal when evaluating their net tax burdens.

[3] See, e.g., Machin (2001) for a critical appraisal in support of skills-biased technological change, and Atkinson (2000b) for an opposing view. See Atkinson (2005) for a critique of the focus on globalisation as an explanation for widening wage inequality, and Atkinson (2015) and Ravallion (2017) for updated discussions.

transfers. In a detailed study of OECD countries, Immervoll and Richardson (2011) show that the effects of the temporal variation of tax and transfer systems have not applied evenly across demographic population subgroups. Specifically, "Changes in tax burdens and benefit entitlements were mostly "regressive" for single individuals and childless families in particular […]. Changes for families with children appeared less "regressive" (or more "progressive") […]. A few countries (e.g., Australia, United Kingdom) appeared successful at protecting low-income families with children from losing ground relative to higher income groups" (op cit, p. 67). This temporal heterogeneity in the treatment of alternative demographic subgroups is often cited as an explanatory factor underlying the evolution of redistribution.

Horizontal equity – the principle that equals should be treated equally – is a long-standing foundation of welfare economics, applicable since at least Walras. Musgrave (1959, p. 160) described horizontal equity as "perhaps the most widely accepted principle of equity in taxation". In light of the shifts in relative treatment of alternative demographic subgroups that are discussed above, we are left with two likely conclusions: views regarding who is equal to who have substantively altered through time; and/or that treating equals equally no longer underpins design of transfer systems. This study presents new empirical evidence, estimating the scale of shifts in relative treatment by the UK tax and transfer system described by survey microdata during the last half century.

The existing literature that explores temporal variation of inequality and redistribution focusses on measures of income that are equivalised using scales that are assumed to be independent of the policy environment. This approach is consistent with the view that changes in tax-transfer treatment are un-related to the definition of 'equals'; that policy makers accept that any changes they implement to taxes or social transfers may alter the horizontal (in)equity of the status-quo. It seems reasonable to argue, however, that in context of mounting budgetary constraints, policy makers may revise their views concerning the relative sacrifices implied for

alternative demographic subgroups of a decline in social transfers, while at the same time accepting that some inequity is an inevitable product of policy reform.[4]

This study consequently considers two related questions: How have the value judgements implicit in UK tax and transfer policy evolved through time? And, how does accounting for the value judgements implicit in tax and transfer policy influence the analysis of income inequality and redistribution in the UK?

A number of factors motivate our focus on the UK as a case study. A relatively long time-series of comparable microdata are publicly available for the UK that report detailed measures of household demographics and income at annual intervals between 1968 and 2015. The UK also experienced a large increase in inequality between the 1970s and 2010s, both in absolute terms and relative to other high-income countries.[5] The bulk of this increase occurred within an isolated window during the 1980s. Furthermore, UK tax and transfer policy has been reported to have played a crucial role in off-setting rising private income inequality, especially since the 1990s, with rising social transfers to families with children and the elderly cited as important underlying factors (e.g. Brewer and Wren-Lewis, 2016).

The first contribution of this paper is to build on the new method proposed in van de Ven *et al*. (2017) to shed light on the evolution of value judgements implicit in UK tax and transfer policy, in the form of estimated tax implicit (equivalence) scales. To the best of our knowledge, this is the first study to estimate tax implicit scales exclusively on survey data and to consider their evolution through time. We find evidence of substantial (and statistically significant)

[4] e.g. Piketty (2014), p. 20. See also Prest (1960) on the use of equal sacrifice to operationalise the concept of vertical equity in taxation.

[5] The GINI Project (http://www.gini-research.org/articles/home) reports Gini coefficients of equivalised disposable income for a sample of 30 high-income countries between 1980 and 2010 (inclusive). These data indicate that the UK, with an increase of 8.1 percentage points, experienced the second largest increase in inequality during the sample period of any country in the EU15 plus Australia, Canada, and the U.S. (after Sweden). The un-weighted average increase across this sample of countries was 4.4 percentage points, with only Spain reporting a reduction in inequality.

variation in the value judgements implicit in tax and transfer policy, with increasingly favourable treatment in later years of families with children and the elderly, relative to households comprised exclusively of healthy, working-age adults. The estimated tax implicit scales allow us to quantify these shifts in value judgements.

Our second contribution is to explore the distributional implications of contemporaneous shifts in social value judgements. We find that accommodating the evolution of value judgements exacerbates the rise in private income inequality since the 1990s and depresses associated measures of redistribution. These two shifts generate a 6-percentage point increase in the Gini coefficient of disposable income inequality in the two decades to 2015, in sharp contrast to the flat profiles for inequality measured with respect to income equivalised using the OECD scale. The reasoning that underlies these results is clear: although the UK transfer system during the last two decades has adjusted to shield some population groups from the rise in private income inequality, it has done so unevenly – neutralising the distributional effects of changes in relative tax treatment consequently provides an alternative perspective of underlying trends in transfer system progressivity and market income inequality.

Section 2 provides historical context for the study. Data and methods are described in Section 3, and results are reported in Section 4. Section 5 concludes.

2 Tax and Transfer Policy, Value Judgements, and the Income Distribution

The UK (direct) transfer system is comprised of three key elements: income taxes; non-means-tested contributory social insurance; and non-contributory means-tested social transfers. Accessible reviews are produced by the Institute for Fiscal Studies; see Pope and Waters (2016) on the UK tax system, and Hood and Norris-Keiller (2016) on the social transfer system.

Figure 2.1: Fiscal aggregates in the UK

Source: Government receipts reported by Office for National Statistics (ONS) code ANBY. Taxes on income and wealth reported by ONS code NMZJ. Social transfer expenditure reported by Institute for Fiscal Studies (IFS), *Fiscal Facts*. GDP reported by ONS code YBHA.

The basic composition of government receipts displayed remarkable stability during the seven decades to 2015. Figure 2.1, for example, reports that government receipts were broadly 35% of GDP between 1950 and 2016, while the share of receipts collected from income and wealth taxes remained steady at approximately one third. Underlying this broad stability were two key shifts in policy that altered the implicit value judgements and redistributive effects of the UK tax and transfer system.

First, there was a sustained trend toward reduced progressivity of income taxes. The UK income tax system takes a standard progressive multi-step form assessed on a (joint) household basis prior to April 1990, and on an individual basis thereafter. During the six decades to 2007, the minimum threshold on taxable income was typically increased at a rate just above price

growth, resulting in substantial downward bracket creep with respect to earnings.[6] At the same time, the top rate of marginal tax was reduced, from a peak of 97.5% in 1951 to 40% in 2009 (see Appendix A.2, Figure A.2, for detail).

Secondly, there were important shifts in the scale and targeting of UK social transfer payments. Figure 2.1 indicates that, in contrast to the relatively flat profile of government revenues between 1950 and 2015, social transfer expenditure as a share of GDP almost tripled, from 4 to 11 per cent.[7] Contemporaneous changes to the targeting of transfer payments are a principal focus of the current study, and it is to these that we now turn.

2.1 Social transfer reforms

Maximum rates of payment of selected social transfers are reported in Figure 2.2 (additional detail is reported in Appendix A.2). The figure displays key payments to population subgroups that are the focus of our empirical analysis (Section 4), distinguishing households by the number and age of (healthy) members. All series are reported for the maximum period over which comparable data could be found, and all rates are adjusted to 2016 prices.

Starting with the series reported for unemployment transfers, Figure 2.2 indicates that the maximum rate of (means-tested) payment increased steadily between 1948 and 1972, from £40 to £70 per week. In the 44 years since 1972, however, (corresponding to the period of our empirical analysis) the real value of unemployment transfers remained approximately unchanged, with the rate of payment for a single adult in 2016 equal to £73.10 per week.

[6] Real earnings growth averaged 2.4 percentage points per annum during the same period.

[7] The rise in social transfer expenditure reported for the latter half of the 20th century continued a trend that began late in the 19th century. Lindert (1994), for example, reports that expenditure on welfare and age pensions was equal to 0.7% of GNP in 1890, rising to 1.6% of GNP by 1930. Still further back, Lindert (1998) reports that there was a long and gradual increase between 1688 and 1821, when expenditure on poverty relief peaked at 2.7% of GDP. This trend was reversed by reforms introduced in 1834 (the 'New Poor Law'), after which expenditure on poverty relief declined, and was equal to 0.7% of GDP by 1880.

People above state pension age[8] are eligible to two key transfer schemes in the UK; a contributory 'age pension' and a means-tested 'income support' payment. Figure 2.2 reports maximum rates payable under each of these schemes for single pensioners for the period 1948 to 2016 inclusive. The figure indicates that, between 1948 and 1970, these age-related payments were almost identical to the maximum rate of unemployment transfers payable to single people.

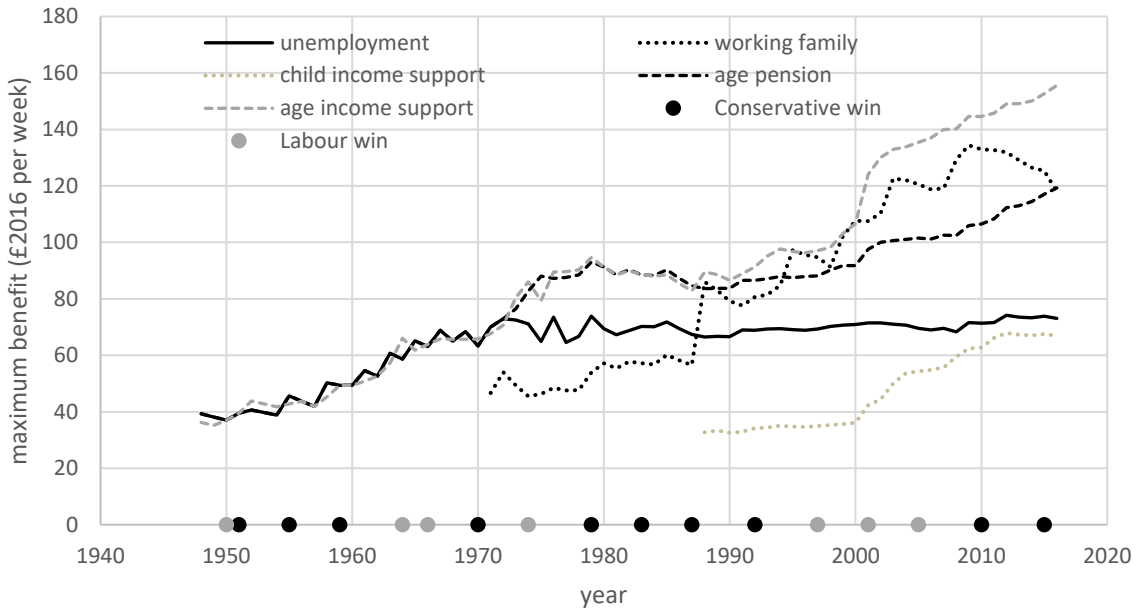
Whereas the real value of unemployment transfers remained approximately unchanged between 1972 and 2016, the real value of age-related payments have continued to climb (with the exception of the decade 1980-1990, Thatcher's term as Prime Minster).[9] Furthermore, the withdrawal (claw-back) rate imposed on age income support was reduced in 2003 from 100 to 40 per cent, while it has remained at 100 per cent for unemployment support. Hence, the population above state pension age has benefited from a sustained trend of preferential treatment by the UK benefits system throughout most of the last half century.

The final set of statistics reported in Figure 2.2 are for child-related transfers. These social transfers take two key forms in the UK: child-specific allowances to rates of means-tested income support for families on very low incomes; and transfers for low-to-middle income families delivered through various tax credits. Payment rates for selected examples of each of these types of social transfer are reported in the figure.

[8] State pension age in the UK between 1948 and March 2010 was 60 for women and 65 for men. From April 2010, the pension age for women has increased by one month every two months, reaching 63 in April 2016, while that for men has remained fixed at 65.

[9] Prior to 1979, age-related social transfers were typically up-rated by the higher of prices and earnings and were up-rated by prices between 1979 and 1987. From 2011 pensions have been up-rated by the so-called 'triple lock', equal to the higher of wage growth, price growth, or 2.5% per annum.

Figure 2.2: Timeseries variation of payment rates by transfer scheme



Source: Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. All payment rates derived from Institute for Fiscal Studies (IFS) *Fiscal Facts*. Dots show changes of government, by elected party.

Notes: 'Unemployment': Unemployment transfer for man or single women over 18 between 1948 and 1995, Jobseekers Allowance for single person 25+ between 1996 and 2016. 'Age pension': standard single person rates for the basic state pension. 'Age income support': Support Benefit single householder rate between 1948 and 1987, Income Support adult rate 25+ and pensioner premium between 1988 and 2003, Guarantee Credit for single person between 2004 and 2016. 'Working family': payments for single adult working 30 hours per week with one child aged 11 years payable under the Family Income Supplement between 1971 and 1987, the Family Credit between 1988 and 1998, the Working Families Tax Credit between 1999 and 2002, and the Working Tax Credit and Child Tax Credit between 2003 and 2016. 'Child income support': Income Support allowance for a dependent child aged 11 between 1988 and 2016.

The payment rates for families with children reported in Figure 2.2 – in common with those of people above state pension age and in contrast to unemployment benefits – describe substantial real growth, especially following introduction of the Family Credit in 1988. Indeed, working family benefits display the fastest growth of any of the reported benefits over the sample period since 1972, even accounting for the real decline observed since 2010. These statistics reflect the prominence of families in the policy platforms put forward by the two principal political parties in the UK during recent decades.

The trends discussed above can be understood as reflecting changing revenue needs in context of evolving social priorities, including perceptions about what is distributionally fair.

Later in this paper we present new measures for the scale of the implied shifts in value judgements, and use the new measures to explore associated distributional implications. The distributional implications of the shifts in focus of the transfer system have, however, been previously explored using well established statistical methods, and it is to that literature that we now turn.

2.2 Distributional effects of transfer policy reforms

A popular method for exploring the distributional effects of transfer policy, sometimes referred to as the 'direct payments approach', uses decomposition methods to analyse variation described by time-series data. Actual payments studies for the UK typically find that the contribution of taxes and social transfers to disposable income inequality displayed a high degree of stability during the four decades to 2010.[10]

Jones *et al*. (2009), for example, decompose inequality by considering the dispersion of increasingly encompassing definitions of income reported by the Office for National Statistics. They find that the influence of direct taxes on disposable income inequality varied fairly smoothly between 1977 and 2009, within -2 and -4 (Gini) percentage points. Although Jones *et al.* (2009) find more substantial time-series variation for the redistributive effects of cash benefits during their same period, the authors attribute this mostly to the effects of the economic cycle. These observations lead Jones *et al*. to conclude that "the tax system as a whole played a relatively small role in changes to post-tax income inequality over this period" (op cit, p. 42).

In a similar vein, Brewer and Wren-Lewis (2016) consider the role of taxes and transfers underlying the evolution of income inequality, distinguishing the period 1978 to 1991 when inequality in Great Britain (excluding Northern Ireland) rose precipitously, from the period

[10] Similar conclusions based on alternative time-periods and decomposition methods are found by Jenkins (1995), Goodman *et al*. (1997), and Kenworthy and Smeeding (2013) for US.

1991 to 2008 when disposable income inequality was relatively stable. With respect to the former of these periods, the authors report that the rise in inequality during the 1980s was predominantly attributable to changes in the labour market, with social transfers having little bearing on time trends (consistent with Jones *et al*). For the latter period, they find that diverse factors brought an end to the rise in inequality; while earnings inequality continued to increase beyond 1991, it did so at a reduced rate, and was off-set by increasing redistribution delivered through income taxes and the introduction of tax credits.

The results reported in the direct payments literature consequently appear to run counter to the substantive changes to tax and transfer policies discussed in the remainder of this section. Many results also appear to run directly counter to policy changes; for example, Brewer and Wren-Lewis report that the redistributive effect of income taxes increased between 1978 and 1991, despite the coincident decline in tax progressivity. They also report that social transfers to pensioners and households with children increased disposable income inequality between 1991 and 2008. This regressive effect is found despite the fact that social transfers for both of these population subgroups were made more generous during the same time period, in part to combat child and pensioner poverty.

A common explanation for the surprising nature of some results reported in the direct payments literature is that the associated statistics reflect the influence of a wide range of factors that extend beyond evolving tax and transfer policy. It is well known, for example, that a rise in private income inequality will imply a rise in redistributive effect of the tax and transfer system if policy remains unchanged. Similarly, Brewer and Wren-Lewis (2016) note that "although changes to the structure of the benefit system considered in isolation would have reduced inequality, the large fall in the number of workless families meant the benefit system became less effective at reducing inequality" (op cit, p. 303).

The difficulties associated with interpretation of distributional statistics based purely on survey data have motivated use of simulation methods to consider 'what if' questions concerning the distributional implications of changes to tax and transfer policy. 'What if' analyses typically find that changes in tax and transfer policy had a more pronounced impact on evolving income inequality in the UK than reported in the 'actual payments' literature. A seminal study by Johnson and Webb (1993), for example, reports that changes to tax and transfer policy between 1979 and 1988 can explain a substantively larger share of the rise in UK disposable income inequality over that period (43-51 per cent, depending on the inequality measure) than changes in either the earnings distribution (18-23 per cent), or rates of economic activity (28-29 per cent); see also Clark and Leicester (2004), and Adam and Browne (2010).

In contrast, what if studies of the period 1997 to 2011 generally report that increased redistribution of the transfer system almost exactly off-set rises in private income inequality over the same period, supporting the findings of Brewer and Wren-Lewis (2016); e.g. Brewer *et al*. (2004), Bargain (2012), Hills *et al*. (2014). [11]

Taken together, the existing literature suggests two distinct episodes for the role of tax and transfer policy underlying the evolution of UK income inequality since the 1970s. Prior to the 1990s, reforms to tax and transfer policy reduced progressivity in a way that approximately off-set the rise in redistributive effect that would have been observed due to the coincident increase in private income inequality. In contrast, since the 1990s progressivity of the tax and transfer system has approximately increased to exactly off-set the rise in disposable income inequality that would otherwise have been observed due to rising inequality of market incomes. This

[11] These results are sensitive to assumptions concerning temporal indexing of tax and benefits policy, see also Clark and Leicester (2004), Adam and Browne (2010). As discussed in Section 2.2 and Appendix A.2, rates of up-rating have varied substantively since the 1970s, complicating identification of appropriate assumptions to make in this regard.

interesting and nuanced description is only made clear by the alternative analytical perspectives that have been taken.

3 Data and Empirical Methods

"Providing a comprehensive account of inequality trends requires both good analytical tools and good data" (Jenkins, 1995, p. 57). This study is made possible by a long series of detailed microdata, and an analytical approach that is designed to consider the evolution of income inequality from a fresh perspective.

3.1 Data sources

The principal data sources for the study are the Living Costs and Food Survey (LCF), the Expenditure and Food Survey (EFS), the Family Expenditure Survey (FES), and the Family Resources Survey (FRS, including the accompanying Household Below Average Income, HBAI, subfiles).[12] All of these surveys report detailed information concerning household demographics and income for annual snap-shots of the UK population cross-section. Furthermore, all of the surveys report responses to survey questionnaires, administered to stratified, clustered, random samples of households drawn throughout each year from the Post Office's list of addresses for the UK, and participation in each survey was voluntary. The surveys were accessed via standard *End User Licenses* from the UK Data Archive to facilitate replicability of reported results.

The FES was introduced in 1957, and was superseded by the EFS from 2001, which was superseded by the LCF from 2008. All three surveys report the same information for the characteristics explored in this study at annual intervals throughout the period 1968 to 2015

[12] For FRS details, see National Centre for Social Research et al. (2017). For HBAI subfile, see Department for Work and Pensions (2017). For LCF details, see Department for Environment, Food and Rural Affairs, ONS (2019). For EFS details, see Department for Environment, Food and Rural Affairs, ONS (2009). For FES details, see ONS (2002).

(inclusive, at the time of writing), which defines the period of the analysis. These three surveys are consequently referred to collectively throughout the remainder of the paper as the LCF.

The LCF is our primary data source because it provides the longest consistent time-series information concerning the distribution of household incomes in the UK. The LCF is also the data source used by the Office for National Statistics for its regular statistical bulletin, *Effects of taxes and benefits on UK household income*. Nevertheless, the LCF has some important drawbacks for an analysis of inequality, which is why we also report the full set of results based on the FRS (see Appendices D.5 and E.2).

The FRS was introduced in 1992, and data available through the UK Data Archive report at annual intervals between 1993 and 2015 (at the time of writing).[13] The FRS data have two key advantages for an analysis of the income distribution, relative to the LCF. First the sample sizes reported by the FRS are typically over three times those reported by the LCF, suggesting that the survey is likely to provide better distributional coverage of the population; this is one of the reasons why the FRS was originally introduced. Secondly, derived variables reported for the FRS (via the HBAI subfiles) are designed to address undercoverage of (voluntary) survey samples of top incomes (see Burkhauser *et al.* 2018 for a detailed description). These advantages are materially important, given that preliminary analysis of the LCF microdata indicated that income distributional measures have been substantively affected by top-coding since 2006 (see Appendix A).[14]

The purpose of a tax and transfer system is to define the net payments between government and individual 'income units' during a single 'income period'. This study defines the 'income unit' as the household, and the 'income period' as one week. These terms of reference reflect

[13] The FRS provides data for the UK from 2002, when the original sample for Great Britain was extended to include Northern Ireland.

[14] This top-coding is not evident in the Secure Access variant of the survey, which is available from 2006.

the data reported by the surveys upon which the analysis is based and are in common with the vast majority of research on income inequality in the UK and are in line with recommendations by international organisations such as the Canberra Group (The Canberra Group 2001). We are concerned with distributional differences between 'private incomes' that exclude all direct government transfers (denoted 'original income' by the ONS, or 'market income' by the OECD) and 'disposable incomes' equal to private incomes plus net direct government transfer payments (denoted 'net income' by the OECD). All income measures ignore in-kind social transfers, indirect taxes, and housing costs.

Measures of household private and disposable income per week were identified from each survey, and the sample was censored to omit any household with negative private or disposable income. We also omitted any household with zero private and disposable income (0.05% of the LCF pooled sample, and 0.28% of the FRS sample). All financial statistics were discounted to 2016 prices using the National Accounts final consumption expenditure deflator (YBGA).[15] Further details concerning the data used and associated validation checks are reported in Appendix B.

3.2 Empirical methods

3.2.1 Identifying tax implicit value judgements

The first challenge associated with this study is the empirical identification of the value judgements implicit in the evolving tax system (note that the term 'tax' is used here to refer to the net payment between the government and a household implied by the tax and transfer

[15] From the financial year ending 2016, the Office for National Statistics stopped using the final expenditure consumption deflator, in preference for the Consumer Prices Index including owner-occupiers' housing costs (CPIH). The average difference between the annual rates of inflation implied by these two price indices between 1977 and 2015/16 is 0.2 percentage points. The final expenditure consumption deflator is used here, as it provides a consistent series for our entire sample period.

system as a whole). The positive correlation that is commonly assumed between welfare and disposable income, *ceteris paribus*, implies that value judgements are a feature of the basic functioning of a tax system. Van de Ven *et al*. (2017) present a theoretical framework for measuring these value judgements in terms of 'tax implicit scales'. A tax implicit scale is defined as the proportional adjustment to the disposable income of any given household that is required to obtain the disposable income of a household with a reference set of characteristics that is of equal 'merit for tax purposes' to the given household. The authors propose the following two normative conditions for identifying a tax implicit scale:

Condition HE (Horizontal Equity): Any two income units of equal tax merit in the presence of a tax must also have equal merit if, *ceteris paribus*, all taxes were set to zero.

Condition TI (Tax Independence): Relative merit for tax purposes is independent of the tax function (system).

An implication of conditions HE and TI is that any two households of equal tax merit will have the same average (effective) tax rate. If the average tax rate of a household with reference characteristics varies monotonically with private income and covers the range of average tax rates of all households in the population, then conditions HE and TI will uniquely identify the tax implicit (equivalence) scale of any household with non-zero private income. This is the basis of the approach used here to measure tax implicit value judgements.

A fully specified function describing a tax implicit scale would need to include as arguments all characteristics that influence the tax and transfer payments of any household. In the UK, as in most OECD countries, this spans a very large set of characteristics, including age, demographics, labour status, health conditions, income sources, and asset holdings. The function would also need to respond to characteristics beyond those explicitly referred to by tax

policy, to reflect, for example, take-up of social transfers and tax evasion. Explicit definition of such a function is impractical, which motivates the methodology that we employ here.

The first problem is to identify a set of characteristics to assume for reference households. Most of the discussion in the study focusses on reference households defined as single adults without children, aged 25 to 59, and not in receipt of own-business income or social transfers for disability or sickness. Reference households are then fully defined for the analysis by adding the relationship between private and disposable income (hereafter referred to as the tax function) to which they were subject.

The tax function of reference households in any given year was estimated using a (weighted) fractional polynomial regression (see Royston and Altman, 1994)[16] on data pooled over the three-year window centred about the given year, for the sample of households conforming to the limited set of characteristics as described in the preceding paragraph. This sample was censored prior to estimation to omit any household with disposable income under £60 per week (2016 prices, approximately equal to 85% of the value of unemployment benefits throughout the sample period). Statistical uncertainty of all estimates was evaluated via 100 bootstrap replications, drawn using the repeated half-sample method proposed by Saigo *et al*. (2001).[17] Although the pooling and censoring of data improved precision of the regressions, they had little bearing on associated point-estimates (see Appendices D.3 and D.4).

Given the estimated tax functions for reference households, a unique tax implicit scale was evaluated for each household following the approach suggested by van de Ven *et al*. (2017). If the private income of any given household was equal to zero, then the tax implicit scale of the

[16] The regression was undertaken using 'fp' Stata routine, adopting the default condition for the 'powers' option, and setting 'dimension(3)'. The motivation for this modelling choice is discussed in Appendix D.1.

[17] The repeated half-sample method was implemented in Stata by the 'rhsbsample' command. Its use is motivated by the objective to account for the clustered sample design of the survey data, where full details of the clustering are unknown. Results were not sensitive to the alternative of bootstrap randomised resampling (using the 'bsample' command).

household was set equal to the ratio of the household's disposable income to the disposable income of reference households with zero private income in the year the household was observed. Otherwise, the tax implicit scale was set equal to the ratio of the household's private income to the private income of reference households with the same average effective tax rate as the household.

The household-specific tax implicit scales obtained as described above provide a coherent basis for equivalising incomes for the distributional analysis reported in Section 4.2 (discussed further below). Exploring the implications of tax implicit scales for selected household subgroups required evaluation of associated summary statistics. These summary statistics were evaluated for 11 household types, distinguished by their number of adults and state pension age status, number of children, number of workers and the presence of self-employed or disabled members. Tax functions for each of these subgroups were evaluated in the same way as for reference households, and these were used to calculate subgroup-specific tax implicit scales. Section 4.1 reports these summary statistics for 7 selected subgroups, and the remaining 4 groups are reported in Appendix D.2.

3.2.2 Analysing the evolution of inequality and progressivity

The approach that we adopt for our distributional analysis takes as its starting point conventional analyses based on Gini measures of income equivalised using the modified OECD scale. Inequality is measured on an individual basis, reflecting the view that each person merits equal representation (e.g. Danziger and Taussig, 1979). Redistribution is equal to the Gini of private incomes minus the Gini of disposable incomes. Redistribution tends to increase, *ceteris paribus*, with the dispersion of private incomes and the progressivity (the rate of increase of average effective tax rates with private income, e.g. Lambert, 1999) and size of the tax and transfer system.

The ‘conventional’ analysis described above provides a high-level statistical summary of inequality and redistribution that abstracts from potentially complex interactions at the disaggregated level. In this study we explore the influence of evolving tax and transfer policy on inequality, by using tax implicit scales to equivalise incomes. This shift in methodology raises important issues of interpretation that we discuss here.

The (modified) OECD scale measures differences in household needs implied by the number and age of household members, as broadly inferred from expert opinion (de Vos and Zaidi, 1997). Using the OECD scale to equivalise incomes aims to reduce the population to a comparable basis in terms of relative needs. In contrast, tax implicit scales reflect the relative merits of alternative households for tax purposes. Using a tax implicit scale to equivalise incomes consequently aims to reduce the population to a comparable basis in terms of relative tax merit; but what does that mean?

In general, the higher is a household’s tax implicit scale, the more favourably it is treated by the tax and transfer system (defined in terms of average effective tax rates).[18] But reported differences in tax and transfer payments between households may be due to reporting error. There is, for example, evidence to suggest that households exhibit a tendency to under-report receipt of some social transfers (e.g. Brewer and O’Dea, 2012, and Ralph and Manclossi, 2016; see discussion in Appendix B.4). In a conventional analysis of redistribution where incomes are equivalised using the OECD scale (or any other scale evaluated independently of tax and transfer policy), under-reporting of social transfers will tend to exaggerate equivalised disposable income inequality and dampen associated measures of redistribution.

[18] This holds whenever average effective tax rates are non-decreasing in private income for reference households.

In contrast, under-reporting of transfers is likely to generate a *downward* bias for inequality measures of income equivalised using a tax implicit scale. The reason for this can be inferred from the above discussion: A household group for which transfer payments are under-reported will be described as having received unfavourable treatment by the transfer system, and will consequently be assigned a relatively small tax implicit scale. A small tax implicit scale will tend to inflate equivalised measures of private and disposable income, dampening associated measures of inequality and redistribution (if measured relative to disposable income inequality). Measurement bias of any sort is undesirable, so that it is unclear which of the two forms referred to here is preferable; in any event it is useful to be aware of such biases when interpreting results.

Greater normative detail concerning the relative merits of alternative forms of equivalisation can be obtained by considering cases in which the data provide an accurate description of reality. Where reported differences in tax treatment accurately reflect the circumstances of households, then it is useful to consider the potential reasons for reported differences. If disparities in tax treatment were attributable to random factors, then it would be difficult to justify their use as a basis for equivalisations for distributional analysis. But one of the goals of modern tax and transfer systems is that payments to and from the government should be objective and predictable. Other common reasons why a survey may (accurately) report disparities in tax treatment include behavioural responses such as imperfect take-up of social transfers or tax avoidance/minimisation, and eligibility conditions imposed by transfer schemes. These considerations raise interesting normative issues for distributional analyses.

Consider the incidence of imperfect take-up of social transfers. The conventional approach for redistributive analysis treats non-take-up of transfers identically to non-eligibility. This seems sensible in contexts where administrative hurdles or social stigma act as severe impediments to receipt of transfer payments. It seems less sensible, however, in contexts where

take-up is more a question of access to private resources or a conscious decision in context of a short-term income shock (Paukkeri, 2017). Where the incidence of non-take-up is closely related to the private resources available to a household, then it would seem desirable to dampen the bearing of non-take-up on measures of equivalised income inequality. This objective is consistent with the adjustments implied by the tax implicit scales.

A final point of interpretation associated with the form of equivalisation that we discuss here concerns the property of *Independence of Base* (IB; Blackorby and Donaldson, 1993, Lewbel, 1989), which is satisfied by most equivalence scales currently in common use (e.g. modified OECD, square-root of family size, McClements, 1977, Binh and Whiteford, 1990). One reason for the enduring popularity of IB, despite the associated controversy,[19] is that it makes a distributional analysis insensitive to the choice of the scale reference unit. This property is usually lost when incomes are equivalised using tax implicit scales, as these scales rarely satisfy IB (e.g. van de Ven *et al*., 2017).

It may be inferred from the above discussion that the effect of the chosen reference unit on income inequality when a tax implicit scale is used for equivalisation depends on the degree of progressivity of the tax and transfer schedule for the reference unit, relative to the wider population: A reference unit with a relatively progressive rate structure will dampen measured inequality of both private and disposable equivalised income, and vice versa.[20] In practice, the progressivity of the tax and transfer system is often similar for substantive population subgroups, which will tend to mitigate the sensitivity of equivalised inequality to the choice of

[19] For empirical evidence rejecting IB, see Blundell and Lewbel (1991), and Pashardes (1995) using parametric methods, and Blundell et al. (1998), and Pendakur (1999) using semi-parametric methods. Dickens et al. (1993), test the IB hypothesis in the context of linear and non-linear demand models. More recent studies (Donaldson and Pendakur 2006, 2003, Koulovatianos et al. 2005, De Ree et al. 2013 and Biewen and Juhasz 2017) report evidence that equivalence scales are decreasing in income.

[20] This implication is derived from interpretation of a tax implicit scale as a proportional mapping of all members of a population onto the tax function of reference units. Appendix C clarifies the point with reference to a simple example.

reference unit. Results reported in Section 4 provide one example of the extent to which this is true for the UK context.

4 Results

This section reports our analysis of the evolving value judgements implicit in UK tax and transfer policy, before discussing associated implications for measures of inequality and redistribution.

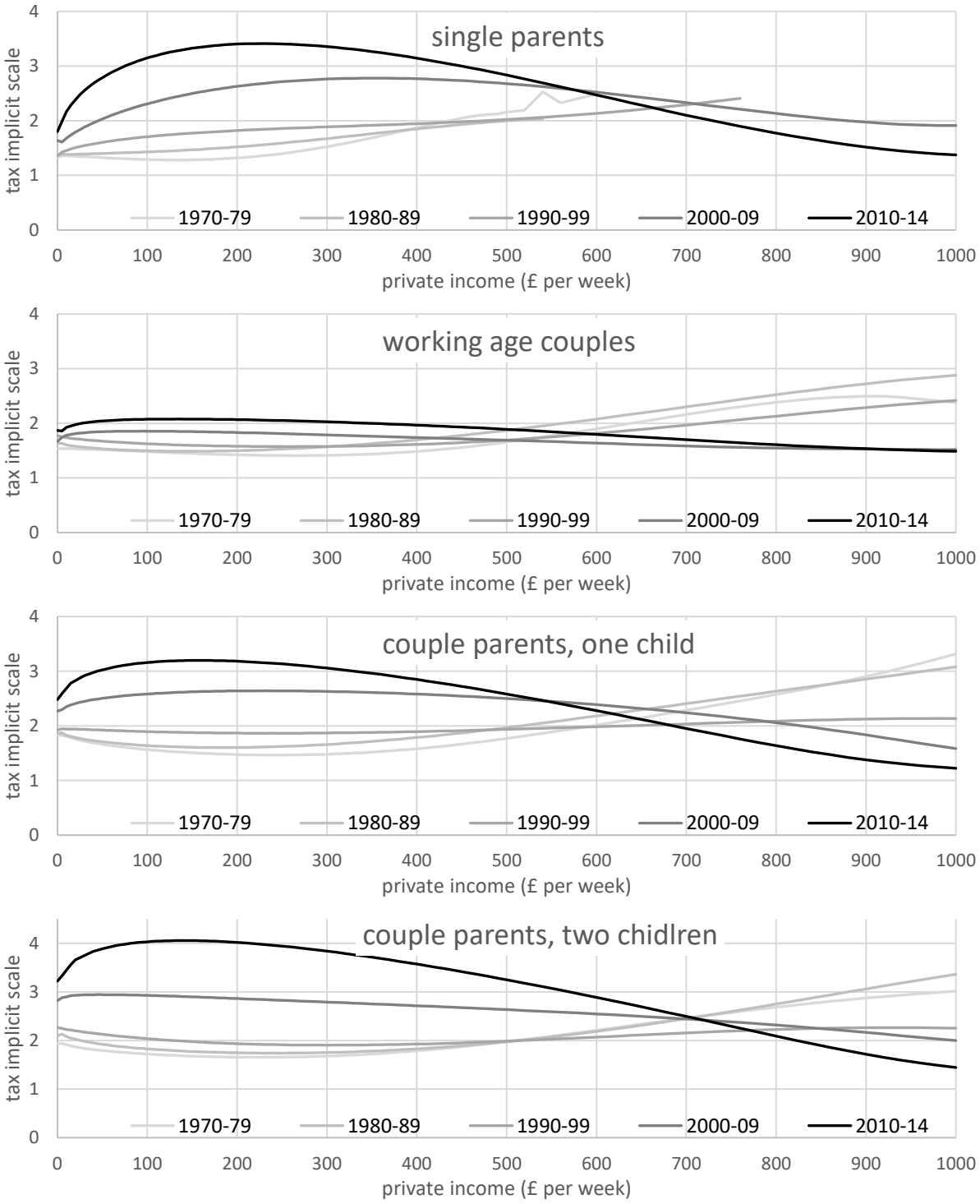
4.1 Evolution of tax implicit value judgements

Estimated tax implicit value judgements are reported here for population subgroups distinguished by age and number of household members, as discussed in Section 3.2. Analysis focusses on households with private incomes between £0 and £1000 per week, which captured the bottom four quintiles of the UK population in 2015/16.[21] All scales are measured relative to single adults without children (more fully defined in Section 3). Qualitatively similar results were also obtained assuming working aged couples as the reference unit; see Appendix D.6. All estimates for tax implicit scales reported in this section are based on LCF data; see Appendix D.5 for analysis using the FRS.

Estimated tax implicit scales for working-age households are reported in Figure 4.1. One of the most striking impressions made by this figure is the temporal variation of the relationship with income that is evident across all four sets of reported scales. The nature of this trend-shift can be broken down into three key components.

[21] The upper bound imposed on private income for the analysis reported in this section is below the top-coding of LCF income data, which censors the top 4% of households by disposable income from 2006. Average 'original income' of households in the 4th quintile was £53,792 per annum in 2015/16; ONS (2017), Table 4.

Figure 4.1: Tax implicit scale estimates; working-age population, 1970 to 2014



Source: Authors' calculations using Living Cost and Food Survey data (LCF, EFS, and FES)

Notes: Tax implicit scales measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Single parents: same as single adult, but with one child aged 13 or under. Working age couple: same as single adult, but with two individuals aged under 60 and over 13 and with disposable income worth at least £100 per week. Couple, one/two child(ren): same as couple, but with one/two child(ren) aged 13 or under. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Each series reports arithmetic averages of year specific tax implicit scales over the respective decade, where the scales for each year were evaluated on data pooled over three consecutive years.

Starting at zero private incomes, estimated tax implicit scales of families with children are found to have increased for all population subgroups between 1970 and 2014, with most of the shift having occurred since 2000. During the period 1970-99, it is surprising to note that the estimated tax implicit scales at zero private incomes approximately correspond to the (modified) OECD scale:[22] 1.0 for single adults without children (the reference population); 1.3-1.4 for single adults with one child; 1.5-1.8 for couples without children; 1.8-1.9 for couples with one child; and 1.9-2.3 for couples with two children.

However, since the 2000s this correspondence has broken. Between the 1990-99 averages reported for families with zero income in Figure 4.1, and the 2010-14 averages, estimated tax implicit scales for working aged couples increased by 0.09, for single parents by 0.44, for couples with one child by 0.55, and for couples with two children by 0.96. These shifts are striking, implying much higher weights for children than is typical for equivalence scales estimated on consumption needs. As discussed in Section 2, this reflects a deliberate shift in policy in favour of low-income families with children, especially following the election of New Labour in 1997 (Brewer and Wren-Lewis, 2016).

Secondly, the tax implicit scales for later years – especially 2010 to 2014 – tend to rise with low to modest private incomes, rather than falling at a low gradient as they did in the 1970s and 1980s. This reflects the shift in emphasis of the UK transfer system in favour of in-work benefits (including tax credits) for low income families. The basic motivation for this shift in policy was to improve labour incentives toward the bottom of the income distribution for families with children, recognising the additional hurdles to employment that child-rearing implies.

[22] The OECD scale assigns a value of 1 to the household reference person, 0.5 to each member over age 13, and 0.3 to each member aged 13 and under.

The third key feature of the trend in tax implicit scales observed for working-age households since the 1990s is the reversal in the relationship with private incomes above approximately £300 per week. Whereas tax implicit scales between 1970 and 1999 reported in Figure 4.1 tend to rise with private incomes above £300 per week, they fall with higher income in more recent years. The decline in tax implicit scales evident in more recent data is driven by the shift from joint to individual income tax assessment implemented in 1990, and the withdrawal of means-tested benefits.

It is interesting to note that, at £1000 per week, there is little distinction between the level of the tax implicit scales displayed in Figure 4.1 for all five population subgroups (including single working age adults) in the 2010-14 data. This observation suggests a shift in (implicit) social value judgements toward the view that household demographics become less pertinent for evaluating tax and transfer payments toward the top of the private income distribution.

Moving to the pension-age population, the tax implicit scale estimates reported in Figure 4.2 present a stark contrast to those for the working-age population. Taken together, the two panels reported in Figure 4.2 indicate a pronounced shift of the UK tax and transfer system in favour of households with members above state pension age, relative to single working-age adults (the reference group). The figure suggests that this shift applied fairly consistently, both through time, and across the private income distribution.

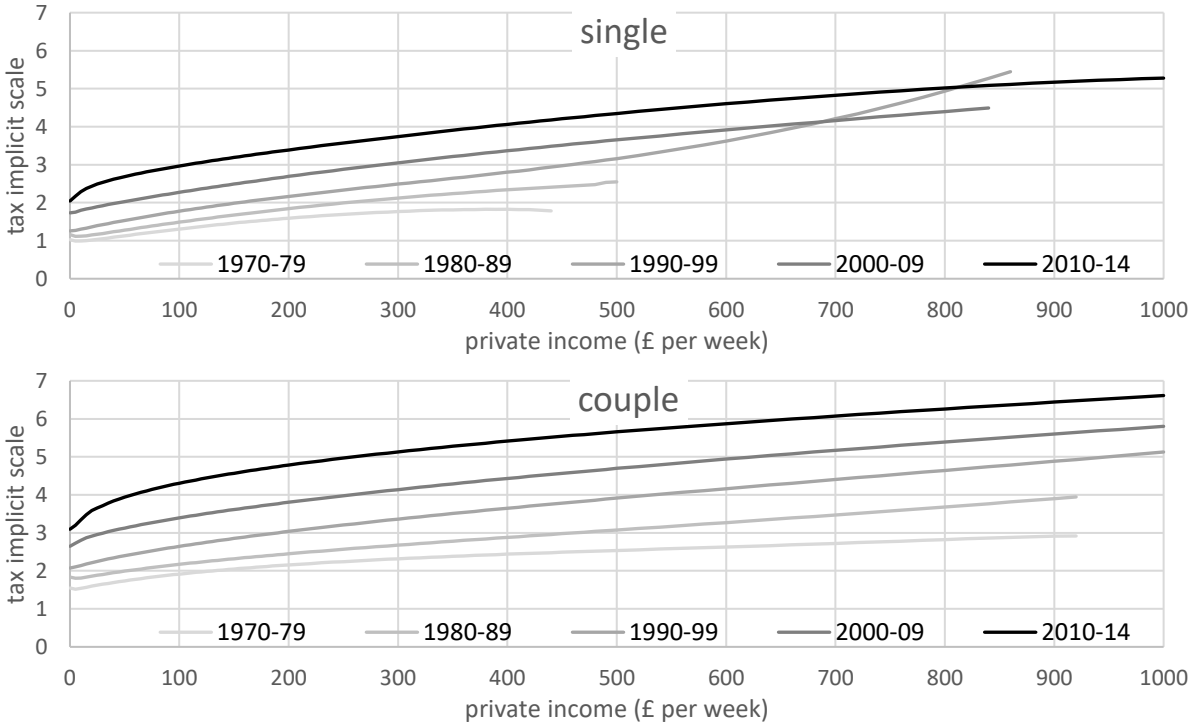
Between 1970-1979 and 2010-2014, the tax implicit scales estimated for both single and couple pensioners more than doubled at all measures of private income considered here. To put the results in perspective, by 2010-2014, the average tax implicit scale estimated for pensioner couples with private income of £900 per week was 6.4. This implies that these pensioner couples were subject to the same average effective tax rates as single working-age adults without children earning (only) £140 per week. In contrast, the same pensioners would, given the tax implicit scales estimated for 1970-1979, have been treated equivalently to single

working age adults with private income of £310 per week. These are evidently strong temporal shifts in social value judgements.

The substantive increases in tax implicit scales reported for the pensioner population reflect the increases in generosity of state retirement benefits, relative to unemployment benefits, discussed in Section 2. They also reflect maturing of the state pension system, which would have improved the relationship between private and disposable income of the population above state pension age, even if policy had remained broadly unchanged.

One of the most important factors underlying the improvements in tax-transfer treatment of families with children and people over state pension age, relative to the wider population, has been a concerted effort in the UK to reduce rates of poverty (see, e.g. *Budget Report* 2001, Section 5).

Figure 4.2: Tax implicit scale estimates; pension-age population, 1970 to 2014



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure 4.1. Single pensioners, defined as households comprised of single adult aged 65+. Couple pensioners defined as households comprised of two adults, at least one of whom is aged 65+.

The *Households Below Average Income* periodical of the Department for Work and Pensions, for example, reports that, in 1996/97 when New Labour first came to power, 19 per cent of all individuals lived in poor households (i.e. with less than 60 per cent of contemporary median household income). At that time, poverty rates were highest among single parents (46 per cent), followed by single female pensioners (32 per cent), and single male pensioners (23 per cent). The substantive increases in benefits that were subsequently introduced for these population subgroups appear to have had a pronounced effect; by 2015/16, the poverty rate among single parents was 26 per cent, single female pensioners 24 per cent, and single male pensioners 19 per cent, relative to 16 per cent for the full population.

If the reforms to benefit rates were primarily focussed upon poverty relief, then that raises the question of why benefit rates were not increased for the population more generally. One likely candidate is that targeting benefit delivery to selected population subgroups helps to limit the costs to the public purse. If a limited account of budgetary implications is the principal explanation for the targeted adjustment to benefit rates, then the changes in implicit value judgements described by the tax implicit scales reported here are likely to have been largely an unintended consequence of associated reforms. In that case, the current analysis may help to improve design of transfer policy by clarifying the changes in value judgements implicit in alternative policies.

However, it seems reasonable to suppose that at least some of the trend shifts in tax implicit scales described in this section reflect changing views concerning the relative merits of alternative population subgroups. Interpreted from this perspective, the scales provide an interesting perspective of contemporary shifts in social preferences. We now turn to consider how accounting for the value judgements implicit in tax and transfer policy influences an analysis of income inequality and redistribution in the UK.

4.2 Evolution of inequality and redistribution

This section reports measures of dispersion based on the Gini coefficient calculated using LCF data, as described in Section 3.2. Unless otherwise stated, qualitatively similar results to those reported here were obtained when evaluated on FRS data (Appendix E.2), and using alternative measures of inequality (Appendix E.3).

Three sets of equivalence scales are considered for analysis: the modified OECD scale; individual specific tax implicit scales (described in Section 3.2); and a 'restricted' set of tax implicit scales. The assumed reference unit for equivalisation is single working aged adults without dependent children, consistent with Section 4.1. Sensitivity of results to the assumed reference unit is reported in Appendix E.4.

The tax functions (describing disposable income as a function of private income) estimated for reference households, upon which the tax implicit equivalence scales depend, cover up to the 99th percentile of year-specific equivalised private incomes evaluated for the full population using the OECD scale. Disposable incomes for reference households with private incomes between the 99th percentile and an upper threshold worth £3000 per week in 2015 (adjusted in all other years for 2% per annum real wage growth) were imputed using the year-specific policy parameters of UK income taxes and national insurance contributions. These terms of reference permitted individual tax implicit scales to be evaluated for 99% of the pooled LCF household sample, and 96% of the pooled FRS population. Sensitivity to the method of estimating tax functions for reference units is reported in Appendix E.5.

The (individual-specific) tax implicit scales vary over a wide range of characteristics in addition to the numbers and ages of household members that describe the OECD scale. The restricted tax implicit scales were evaluated by taking year-specific averages over the unrestricted tax implicit scales within demographic subgroups, distinguishing the numbers of

household members aged 13 and under, and those aged 14 and over (in common with the OECD scale).[23] The restricted scales – which are base independent (income invariant) by construction – consequently represent an intermediate between the tax implicit and OECD scales, providing a measure of the bearing that time variation in the tax implicit relativities associated with household demographics have had on distributional statistics.

The top panel of Figure 4.3 reports year-specific point estimates for measures of inequality of equivalised private and disposable incomes, and the bottom panel reports associated measures of redistribution. Confidence intervals for the point estimates are omitted from Figure 4.3 to avoid excess clutter (see Appendix E.1, Figure E.4).

The distributional statistics based on the OECD scale that are reported in Figure 4.3 are well known (e.g. Appendix A.1). In brief, these statistics indicate that both private and disposable income inequality in the UK rose sharply in the two decades to 1990. Equivalised private income inequality increased by 14 Gini (percentage) points during this period, while disposable income inequality increased by 10 points, with 4 points off-set by increased redistribution. Thereafter, income inequality and redistribution based on the OECD scale have approximately stabilised, with inequality of both equivalised private and disposable income drifting down by approximately 3 Gini points during the 25 years to 2015 in the figure.[24]

Distributional statistics evaluated on income equivalised using tax implicit scales provide some fascinating insights compared with the well-known backdrop described in the preceding paragraph. Starting with the set of statistics based on 'restricted' tax implicit scales, there is

[23] Averages taken over 15 subgroups comprised of single adults with 0, 1, or 2 or more children, couples with 0, 1, 2, or 3 or more children, 3 adults with 0, 1, or 2 or more children, 4 or more adults with 0, or at least one child, and pensioner households with 1, 2, or 3 or more adults. These subgroups each account for at least 1 per cent of the pooled population sample in the LCF; see Appendix E.1 for details.

[24] Some of the decline in private income inequality described by the LCF since 2006 is due to top-coding of incomes, which depresses inequality by between 2 and 3 percentage (Gini) points (e.g. see Figure B.1). Gini coefficients for private and disposable income equivalised using the OECD scale evaluated from FRS data remain approximately unchanged over the period 1994-2015; see Figures E.4 and E.5.

virtually no statistical difference with measures of income inequality based on the OECD scale throughout the period 1968 to 2000. This result is alluded to in Section 4.1, by the close correspondence between the OECD and tax implicit scales at zero private income, by the fairly flat profiles of tax implicit scales with incomes, and by the temporal stability of tax implicit scales between 1970 and 2000, relative to later years.

However, from 2000 a widening disparity appears between measures of inequality evaluated on income equivalised using the OECD and the restricted tax implicit scales, with the latter series remaining level to 2015 while the former drifts downward in Figure 4.3. This shift corresponds with the substantive variation of tax implicit relativities that are reported in Section 4.1 for the 2000s and 2010s, relative to the preceding three decades.

As discussed previously, UK transfer policy increasingly discriminated in favour of families with children on modest incomes and people over state pension age during the sample period, and particularly since 2000. The greater generosity of treatment of these targeted population subgroups implies higher measures of equivalised disposable incomes when the equivalence scale used is time and income invariant (like the OECD scale). This will tend to depress equivalised income inequality, to the extent that the targeted population groups were concentrated toward the bottom of the income distribution (e.g. Brewer and Wren-Lewis, 2016).

In contrast, increased generosity of tax treatment of discrete population subgroups will be reflected by higher tax implicit scales, relative to the wider population, which off-set the coincident rises in disposable incomes when used for equivalisation. Put another way, an *increase in the generosity* of the tax and transfer treatment of a given tax unit (e.g. single parents) will generally imply that the unit is considered equal, for the purpose of evaluating a

tax implicit scale, to a *less well-off* reference unit (e.g. single working aged adult) than they would have been in the absence of the increased generosity.[25]

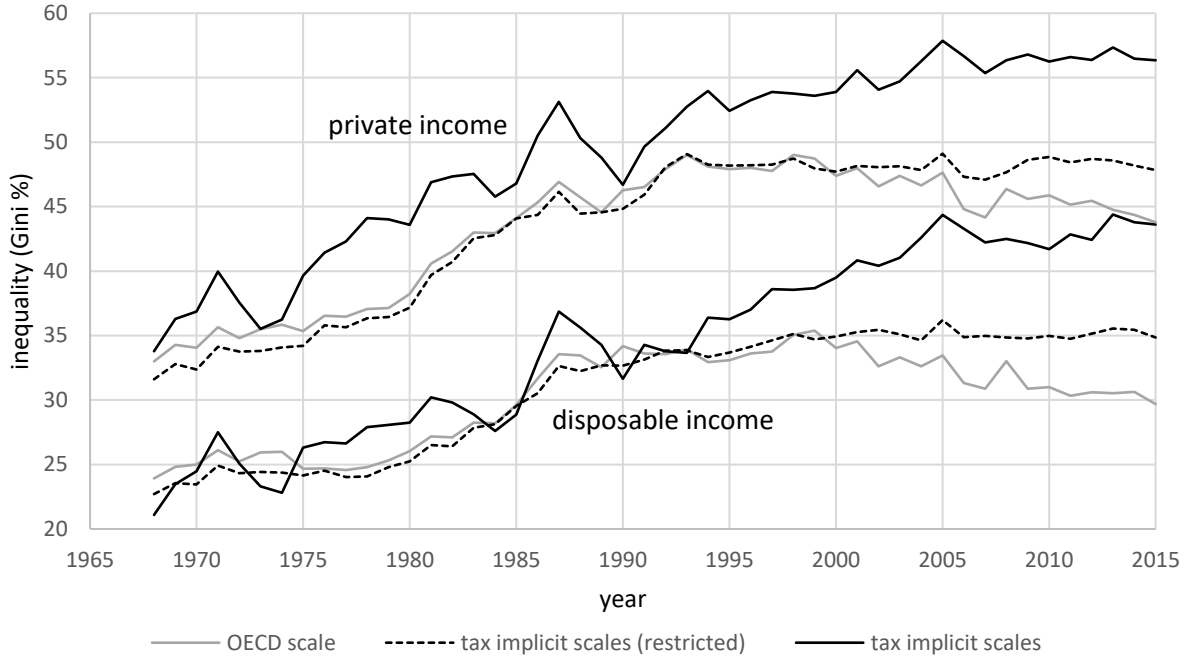
Hence, the increase in generosity of transfer benefits to selected population subgroups implemented during the 1990s and 2000s is reflected in the distributions of income equivalised using tax implicit scales by an increased population density toward the lower end of the distribution, resulting in higher measures of inequality and lower measures of redistribution. As the use of demographic targeting by the UK transfer system increased during the 2000s and 2010s, so too did the wedge between measures of equivalised income inequality based on the OECD and tax implicit scales.

Figure 4.3 indicates that relaxing the limitations imposed on the restricted tax implicit scales have a number of important effects on the reported measures of dispersion. Although all three scales generate similar trends for inequality of equivalised private and disposable incomes between 1970 and 1990, measures of inequality tend to be higher when incomes are equivalised using the (unrestricted) tax implicit scales. Between 1970 and 1990, the average gap is 4.2 Gini points for inequality of equivalised private incomes, and 0.9 points for disposable incomes, with the difference between these two averages reflected in higher measures of redistribution of income equivalised using the tax implicit scales (average 3.2 Gini points).

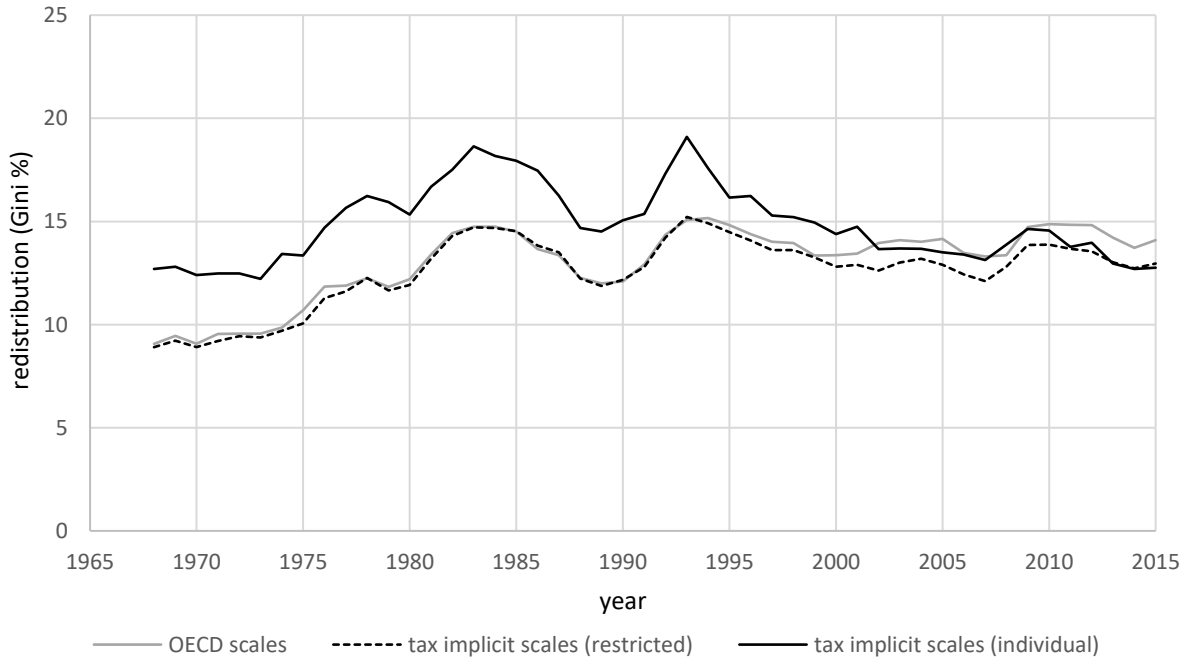
The gaps referred to in the preceding paragraph exist between measures of inequality based on the tax implicit scales and both the OECD and restricted tax implicit scales. The implication is that these differences in equivalised income inequality are driven by differences in the individual-specific tax implicit scales, within the subgroups over which the restricted scales are averaged.

[25] This is because the increased generosity will imply a lower average effective tax rate, and average effective tax rates tend to increase with private income.

Figure 4.3: Distributional statistics by year, and equivalence scale



Panel A: Inequality



Panel B: Redistribution

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: All inequality statistics report Gini coefficients as percentages. Household equivalised incomes of individuals weighted by survey weights. Equivalisation calculated using the (modified) OECD scale, household specific tax implicit scales (as described in Section 3.2, with single adult households as reference), and restricted tax implicit scales evaluated as year-specific averages of the unrestricted tax implicit scales over population subgroups distinguished by numbers of household members aged 13 and under and 14 and over.

Furthermore, the tax implicit scales are associated with more volatile profiles for inequality of equivalised income between 1970 and 1990, and greater statistical uncertainty (Figure E.4), than either of the two alternative scales reported in Figure 4.3. This finding is unsurprising, given that the OECD scales are fixed and the variation of the restricted tax implicit scales is muted, relative to the individual specific scales (which are also evaluated with uncertainty).

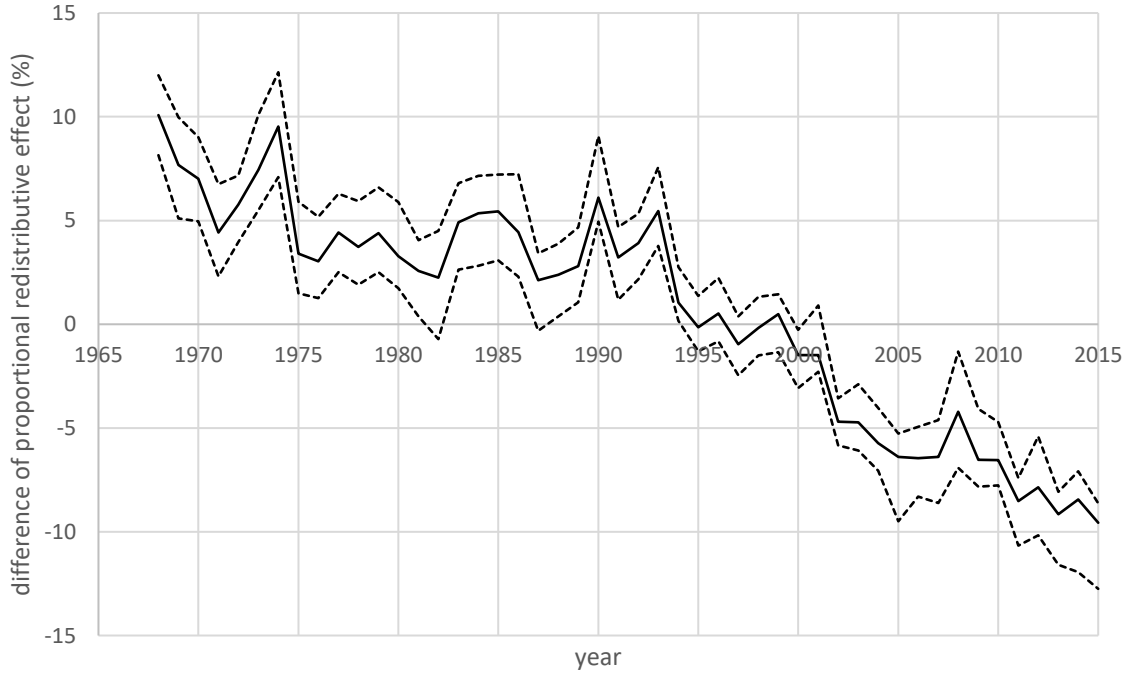
Finally, inequality of both private and disposable income equivalised using tax implicit scales rises throughout the period 1990 to 2015, in contrast to the 3 Gini point reduction observed for incomes equivalised using the OECD scale. The inequality of private incomes equivalised using tax implicit scales rose by 10 Gini points, and of disposable incomes by 12 Gini points. The rise observed for equivalised disposable income inequality is particularly notable, being larger than the increase observed for the same series between 1968 and 1990 (11 Gini points), and implying a fall in redistribution despite the coincident rise in private income inequality.

The average gap between the measures of income inequality based on the restricted and unrestricted tax implicit scales widened from 1990. This suggests that the increase in inequality measures late in the time series based on the (unrestricted) tax implicit scales can be attributed (in part) to associated temporal changes in the relationships of the scales with income.

As discussed in Section 4.1, changes to means-testing of benefits, and the shift from joint to individual income tax assessment transformed the relation between tax implicit scales for the working age population and income between 1990 and 2015. From fairly flat profiles that were increasing toward very high incomes, tax implicit scales for the working aged population took a hill shaped profile, with relatively high values at modest incomes, decreasing toward higher incomes. The combination of relatively high tax implicit scales at the low end of the income distribution, and low equivalence scales at the high end of the distribution tend to exaggerate measures of equivalised income inequality.

Statistics reported in Figure 4.4 are designed to clarify the relative decline in redistributive effect identified when incomes are equivalised using tax implicit rather than the OECD scale. This figure reports the excess of the ratio of redistribution to private income inequality evaluated for incomes equivalised using tax implicit scales, to those equivalised using the OECD scale. Figure 4.4 reveals that the redistributive effect measured in terms of tax implicit scales exceeded the OECD scale by approximately 5 percent between 1968 and 1990. This ratio is reported to have fallen throughout the period between 1990 and 2015, ending the sample period at a deficit of 10 percent.

Figure 4.4: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. See notes to Figure 4.3. Dotted lines indicate 90% confidence intervals of bootstrap point estimates.

To the extent that the shifts in relative tax and transfer treatment reflect genuine shifts in popular sentiment concerning relative needs, then the analysis reported here provides a new perspective of the influence of the shifts in sentiment on measures of inequality and redistribution. To the extent that they do not, then the temporal shifts in tax implicit scales reported in Section 4.1 provide new insights into how recent reforms to UK transfer policy have distorted the relative tax treatment of demographic subgroups. Either way, the analysis contributes important new insights concerning the redistributive role of the evolving tax and transfer system in the UK.

5 Conclusions

This study uses tax implicit scales to (i) reveal the evolution of value judgements implicit in UK tax and transfer policy, and (ii) show how accounting for those value judgements influences an otherwise standard analysis of inequality and redistribution. We find that tax implicit scales distinguishing households by the number and age of household members have varied substantively during the half-century to 2015. Households with at least one member above state pension age have benefitted substantively from the maturation of the state pension system, in addition to favourable ad-hoc adjustments to policy. These changes are reflected in the estimated tax implicit scales, which have approximately doubled in value between the 1970s and 2010-14 across a broad range of incomes, relative to single working-age adults without dependent children.

In contrast, tax implicit scales estimated for the working age population suggest associated value judgements were broadly stable during the 1970s and 1980s. During that time, scales for the working age population without any private income closely resemble the (modified) OECD scale, which assigns a value of 1.0 to the first adult in a household, 0.5 for each additional

member aged 14 or over, and 0.3 for each member aged 13 or under. These scales are found to increase at higher incomes, especially relative to single adults without children.

The tax implicit scales estimated for the working age population describe a radical shift in the value judgements implicit in UK tax and transfer policy during the 25 years to 2015. We distinguish three key features of this shift.

First, families with children and low incomes enjoyed substantial improvements in treatment, reflecting a deliberate shift in policy. The estimated net transfer payments received by single adults with one child and no private income, for example, increased by over 30% between 1995 and 2014, relative to otherwise similar single adults without children.

Secondly, the tax implicit scales (relative to single adults without children) for later years – especially 2010 to 2014 – tend to initially rise with private income, up to around half of median household income, rather than falling as in period 1970 to 1989. This reflects the shift in emphasis of the UK transfer system in favour of in-work benefits, designed to improve labour incentives toward the bottom of the income distribution.

Finally, estimated tax implicit scales are found to decline with private income above half the household median, and there is little difference between point estimates of the tax implicit scales reported for any of the working-age population subgroups with private incomes of £1000 per week. This is interpreted as a shift in (implicit) social value judgements, toward the view that household demographics become less pertinent for evaluating tax and transfer payments toward the top of the private income distribution.

We find that accommodating the changing value judgements implicit in tax and transfer policy described above has an interesting bearing on measures of inequality and redistribution. Measures of equivalised income inequality based on tax implicit scales increase over the two decades to 1990 in a similar fashion to measures based on the OECD. Whereas measures of equivalised income inequality and redistribution based on the OECD scale stabilised during the

two and a half decades to 2015, income inequality continued to climb throughout the sample period when equivalised using tax implicit scales. Furthermore, measures of redistribution of income equivalised using tax implicit scales fell between 1990 and 2015, despite the coincident rise in private income inequality.

Our results suggest two alternative extreme interpretations, assuming that they are not driven by measurement error, and that horizontal equity (the requirement that equals should be treated equally) is an objective underlying UK tax and transfer policy. The first interpretation assumes that the UK government implements tax and transfer policy reforms that conform to the principle of horizontal equity. In that case, the tax implicit scales that we report quantify evolving value judgements concerning the definition of relative equals. Accommodating these evolving value judgements in a distributional analysis, our results indicate that inequality has increased throughout the last half century, and that redistribution has declined during the two decades to 2015, in stark contrast to most of the existing literature.

The second interpretation assumes that recent changes to UK tax and transfer policy have not conformed to the principle of horizontal equity. It might be, for example, that limiting the increase in benefits to specific population subgroups, especially during the 2000s, was a politically expedient method for containing the burden on the public purse of desired poverty relief. In that case, the tax implicit scales that we report quantify the distortions to horizontal equity associated with recent tax and transfer policy reforms.

This is the first study to explore the influence on a distributional analysis of the value judgements implicit in tax and transfer policy, and as such there remain a wide range of subjects for further research. A primary question concerns which of the two alternative interpretations of our results most accurately describes the practical context. This question could be explored by considering the extent to which the value judgments of the estimated tax implicit scales are in agreement with views held by the public or government. Alternatively, to what extent do the

tax implicit scales estimated from survey data reflect the value judgements explicitly described by tax and transfer policy? How do the scales implicit in tax and transfer systems of other countries compare with those of the UK? The value judgements implicit in tax and transfer policy seem to us to be an under-utilised information source that can be readily exploited in context of contemporary micro-data sources.

References

Aronson, J.R., Johnson, P. and Lambert, P.J. (1994), "Redistributive effect and unequal income tax treatment", *Economic Journal*, 104, pp. 262-70.

Aronson, J.R. and Lambert, P.J. (1994), "Decomposing the Gini coefficient to reveal vertical, horizontal and reranking effects of income taxation", *National Tax Journal*, 47, pp. 273-94.

Atkinson, A.B. (2015), *Inequality*. Harvard University Press: Cambridge MA.

Atkinson, A.B. (2005), "Is rising income inequality inevitable? A critique of the transatlantic consensus". In Cornia, G.A., Pohjola, M. & Shorrocks, A., *Wider Perspectives on Global Development*. UNU-WIDER: Helsinki.

Atkinson, A.B. (2000a), "Distribution of Income and Wealth". In Halsey, A. & Webb, J. (eds) *Twentieth-Century British Social Trends*. Macmillan: London.

Atkinson, A.B. (2000b), "The changing distribution of income: Evidence and explanations", *German Economic Review*, 1, pp. 3-18.

Atkinson, A.B. (1979), "Horizontal equity and the distribution of the tax burden". In Aaron, H.J. & Boskins, M.J. (eds) *The Economics of Taxation*. Brookings Institution: Washington DC

Atkinson, A.B. and Micklewright, J. (1983), "On the reliability of income data in the Family Expenditure Survey 1970-1977", *Journal of the Royal Statistical Society (Series A)*, 146, pp. 33-61.

Atkinson, A.B. and Salverda, W. (2005), "Top incomes in the Netherlands and the United Kingdom over the 20th century", *Journal of the European Economic Association*, 3, pp. 883-913.

Bargain, O. (2012), "The distributional effects of tax-benefit policies under New Labour: A decomposition approach", *Oxford Bulletin of Economics and Statistics*, 74, pp. 856-874.

Barrett, G., Levell, P. and Milligan, K. (2015), "A comparison of micro and macro expenditure measures across countries using differing survey methods". In Carroll, C.D., Crossley, T.F. and Sabelhaus, J. (eds.), *Improving the Measurement of Consumer Expenditures*. University of Chicago Press: Chicago.

Biewen, M. and Juhasz, A. 2017. "Direct Estimation of Equivalence Scales and More Evidence on Independence of Base." *Oxford Bulletin of Economics and Statistics*, 79, pp. 875–905.

Binh, T. N. and Whiteford, P. (1990), Household equivalence scales: New Australian estimates from the 1984 Household Expenditure Survey", *Economic Record*, 66, pp. 221-234.

Blackorby, C. and Donaldson, D. (1993), "Adult-equivalence scales and the economic implementation of interpersonal comparisons of well-being", *Social Choice and Welfare*, 10, pp. 335–361.

Blundell, R., Duncan, A. and Pendakur, K. (1998), "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Applied Econometrics*, 13, pp. 435–461.

Blundell, R. and Etheridge, B. (2010), "Consumption, income and earnings inequality in Britain", *Review of Economic Dynamics*, 13, pp. 76–102.
Blundell, R. and Lewbel, A. (1991), "The information content of equivalence scales", *Journal of Econometrics*, 50, pp. 49–68.
Brewer, M. and O'Dea, C. (2012), "Measuring living standards with income and consumption: evidence from the UK", *IFS Working Paper* W12/12.
Brewer, M. and Wren-Lewis, L. (2016), "Accounting for Changes in Income Inequality: Decomposition Analyses for the UK, 1978–2008", *Oxford Bulletin of Economics and Statistics*, 78, pp. 289-322.
Burkhauser, R.V., Hérault, N., Jenkins, S.P. and Wilkins, R. (2018), "Survey under-coverage of top incomes and estimation of inequality: What is the role of the UK's SPI adjustment?", *Fiscal Studies*, 39(2), 213-240.
Danziger, S. and Taussig, M.K. (1979), "The income unit and the anatomy of income distribution", *Review of Income and Wealth*, 25, pp. 365-375.
De Ree, J., Alessie, R. and Pradhan, M. (2013), "The price and utility dependence of equivalence scales: Evidence from Indonesia." *Journal of Public Economics*, 97, pp. 272–281.
De Vos, K. and Zaidi, A. (1997), "Equivalence scale sensitivity of poverty statistics for the member states of the European Community", *Review of Income and Wealth*, 43, pp. 319-333.
Department for Environment, Food and Rural Affairs, Office for National Statistics (2009), *Expenditure and Food Survey, 2007*, [data collection], UK Data Service, *2nd Edition*, Accessed 9 May 2019. SN: 6118, http://doi.org/10.5255/UKDA-SN-6118-1
Department for Environment, Food and Rural Affairs, Office for National Statistics (2019), *Living Costs and Food Survey, 2015-2016*, [data collection], UK Data Service, *3rd Edition*, Accessed 9 May 2019. SN: 8210, http://doi.org/10.5255/UKDA-SN-8210-5
Department for Work and Pensions (2017).,*Households Below Average Income, 1994/95-2015/16*. [data collection]. *10th Edition.* UK Data Service. SN: 5828, http://doi.org/10.5255/UKDA-SN-5828-8
Dickens, R., Fry, V. and Pashardes, P. (1993), "Nonlinearities and equivalence scales", *Economic Journal*, 103, pp. 359–368.
Donaldson, D. and Pendakur, K. (2006), "The Identification of Fixed Costs From Consumer Behavior." *Journal of Business & Economic Statistics*, 24, pp. 255–265.
Donaldson, D. and Pendakur, K. (2003), "Equivalent-expenditure functions and expenditure-dependent equivalence scales." *Journal of Public Economics*, 88, pp. 175–208.
Goodman, A., Johnson, P. and Webb, S. (1997), *Inequality in the UK*. Oxford University Press: Oxford.
Hills, J. (2007), "Ends and means: The future roles of social housing in England", *CASEreport* 34.
Hills, J. (2004), *Inequality and the State*. Oxford University Press: Oxford.
Hood, A. and Norris Keiller, A. (2016), "A survey of the UK benefit system", *IFS Briefing Note* BN13.
Immervoll, H. and Richardson, L. (2011), "Redistribution policy and inequality reduction in OECD countries: What has changed in two decades?", *OECD Social, Employment and Migration Working Papers*, 122.
Jenkins, S.P. (1995), "Accounting for inequality trends: Decomposition analyses for the UK, 1971-1986", *Economica*, 62, pp. 29-63.
Johnson, P. and Webb, S. (1993), "Explaining the growth in UK income inequality: 1979-1988", *Economic Journal*, 103, pp. 429-435.

Jones, F., Annan, D. and Shah, S. (2009), "The redistribution of household income 1977 to 2006/07", *Economic & Labour Market Review*, 3, pp. 31-44.
Kenworthy, L. and Smeeding, T. (2013), "Growing inequalities and their impacts in the United States", GINI Country Report *United States*.
Koulovatianos, C., Schröder, C. and Schmidt, U. (2005), "On the income dependence of equivalence scales." *Journal of Public Economics*, 89, pp. 967–996.
Lambert, P.J. (1999), "Redistributional effects of progressive income taxes", In Silber, J. (ed.) *Handbook on Income Inequality Measurement*. Springer Science: New York.
Lewbel, A. (1989), "Household equivalence scales and welfare comparisons", *Journal of Public Economics*, 39, pp. 377–391.
Lindert, P.H. (1998), "Poor relief before the Welfare State: Britain versus the Continent, 1780-1880", *European Review of Economic History*, 2, pp. 101-140.
Lindert, P.H. (1994), "The rise of social spending, 1880-1930", *Explorations in Economic History*, 31, pp. 1-37.
Machin, S. (2001), "The changing nature of labour demand in the new economy and skill-biased technology change", *Oxford Bulletin of Economics and Statistics*, 63, pp. 753-776.
McClements, L.D. (1977), "Equivalence scales for children", *Journal of Public Economics*, 8, pp. 191-210.
Musgrave, R.A. (1959). *The Theory of Public Finance*. McGraw-Hill: London.
National Centre for Social Research, Office for National Statistics, Social and Vital Statistics Division, Department for Work and Pensions (2017), *Family Resources Survey, 2015-2016*. [data collection]. UK Data Service. SN: 8171, http://doi.org/10.5255/UKDA-SN-8171-1
OECD (2011), *Divided We Stand. Why Inequality Keeps Rising*. OECD: Paris
OECD (2008), *Growing Unequal? Income Distribution and Poverty in OECD Countries*. OECD: Paris.
ONS (2017), *The Effects of Taxes and Benefits on Household Income, 2015/16 Reference Tables*. Office for National Statistics: London.
ONS (2016), *A guide to sources of data on earnings and income*. Office for National Statistics: London.
ONS (2002), *Family Expenditure Survey, 2000-2001*, [data collection], UK Data Service, Accessed 9 May 2019. SN: 4490, http://doi.org/10.5255/UKDA-SN-4490-1
Pashardes, P. (1995), "Equivalence scales in a rank-3 demand system" *Journal of Public Economics*, 58, pp. 143–158.
Pendakur, K. (1999), "Semiparametric estimates and tests of base-independent equivalence scales", *Journal of Econometrics*, 88, pp. 1–40.
Piketty, T. (2014), *Capital in the Twenty-First Century*. Belknap Press: Cambridge, MA.
Pope, T. and Waters, T. (2016), "A survey of the UK tax system", *IFS Briefing Note* BN09.
Prest, A. (1960), *Public Finance in Theory and Practice*. Weidenfeld and Nicolson: London.
Ralph, J. and Manclossi, S. (2016), "Living Costs and Food Survey", *National Statistics Quality Review*: Series 2, Report 3.
Ravallion, M. (2017), "Inequality and globalization: A review essay", ECINEQ Working Paper Series, 2017/435.
Royston, P. and Altman, D.G. (1994), "Regression using fractional polynomials of continuous covariates: Parsimonious parametric modelling", *Applied Statistics*, 43, pp. 429–467.
Saigo, H., Shao, J. and Sitter, R.R. (2001), "A repeated half-sample boostrap and balanced repeated replications for randomly imputed data", *Survey Methodology*, 27, pp. 189-196.
Scheve, K. and Stasavage, D. (2016), *Taxing the Rich: A History of Fiscal Fairness in the United States and Europe*. Princeton University Press: Princeton.

The Canberra Group (2001), *Expert Group on Household Income Statistics: Report and Recommendations*. Ottawa.

Tóth, I.G. (2014), "Revisiting grand narratives of growing inequalities: Lessons from 30 country studies". In Nolan, B., Salverda, W., Checchi, C., Marx, I., McKnight, A., Tóth, I.G. and van de Werfhorst, H.G. (eds), *Changing Inequalities and Societal Impacts in Rich Countries: Thirty Countries' Experiences.* Oxford University Press: Oxford.

Van de Ven, J. (2011), "Expenditure and disposable income trends of UK households: Evidence from micro-data", *National Institute Economic Review*, 218, pp. R44-R57.

Van de Ven, J., Hérault, N. and Azpitarte, F. (2017), "Identifying tax implicit equivalence scales", *Journal of Economic Inequality*, 15, pp. 257-276.

Yitzhaki, S. (1983), "On an extension of the Gini inequality index", *International Economic Review*, 24, pp. 617-628.

Appendix A: Supplementary Background Context

Appendix A.1: Evolution of inequality and redistribution in the UK

Figure A.1 displays previously published summary statistics for income inequality in the UK, expressed in terms of the Gini coefficient. Three of the series displayed in the figure – those starting in 1977 – describe the evolution of inequality and of the redistributive effect of the UK tax-transfer system, as reported by the Office for National Statistics (ONS). The fourth series reports statistics calculated by the Institute for Fiscal Studies (IFS), and is a useful addition because it covers a considerably longer time period (starting in 1961), and provides a closer approximation to the analytical approach adopted for this study.[26]

Figure A.1 indicates that income inequality in the UK rose sharply during the 1980s, relative to the two decades covered on either side of this window. The ONS series indicate that private income inequality increased by 8.5 Gini (percentage) points between 1978 and 1990, and that disposable income inequality increased by 10.2 Gini points during the same period. Although the series reported by the ONS does not extend prior to 1977, there is good reason to suppose that the late 1970's marked a trough in UK income inequality. The IFS statistics, for example, indicate a downward drift in disposable income inequality from 26 Gini points in the early 1960s to 24 Gini points in the late 1970s. Furthermore, although population representative microdata were only collected in the UK from 1957, analyses of tax records indicate that the Gini coefficient fell from 43 percent in 1938 to 32 percent in 1977 and the share of income going to the top 1% fell by more than two-thirds between 1920 and 1980, from 19 to 6 percent

[26] The ONS statistics were evaluated entirely on data from the Living Costs and Food survey (LCF, and its forerunners), and are weighted by household. In contrast, the IFS statistics are evaluated on LCF data to 1993, and Family Resources Survey and Household Below Average Income (HBAI) data from 1994, and are weighted by individual. Only the HBAI includes an adjustment based on tax data to better capture top incomes. We discuss measurement issues in Section 3.2.

(e.g. Atkinson, 2000a, Atkinson and Salverda, 2005, and Atkinson, 2015; see also Atkinson and Voitchovsky, 2011 on the distribution of earnings).

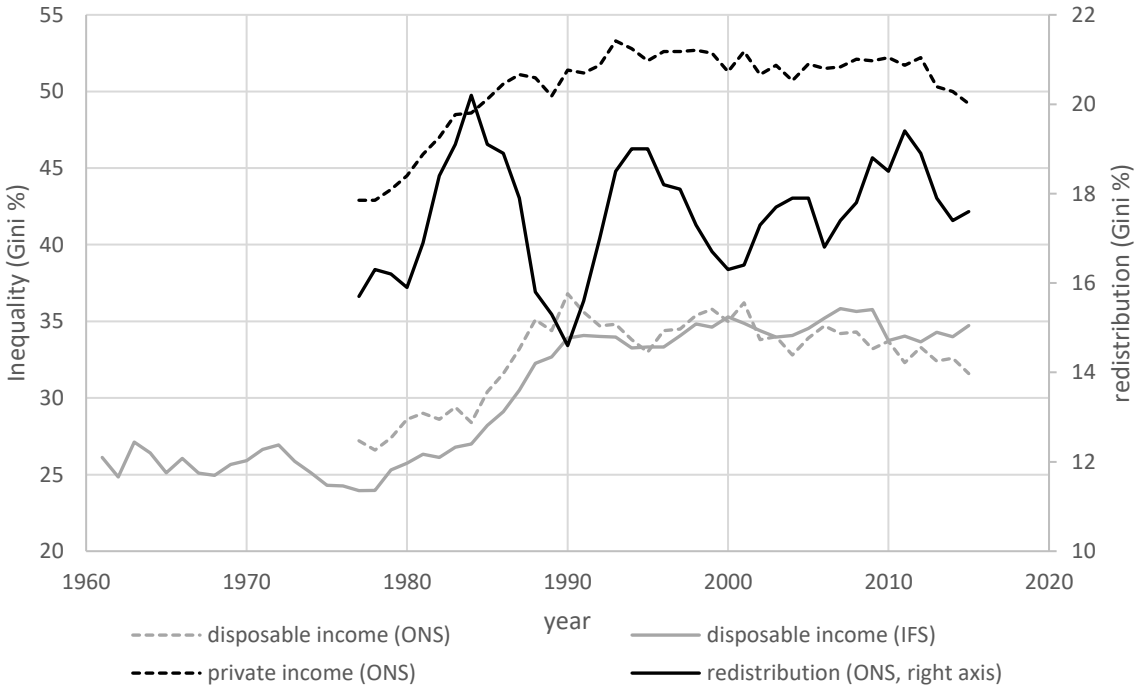
The measures of private and disposable income inequality reported by the ONS display similar time-series variation during the sample period. Figure A.1 indicates that the two series rose together between 1977 and 1990, were approximately stable during the 15 years to 2005, before showing some decline in the decade to 2015. It is notable that the decline in disposable income inequality reported for the most recent decade by the ONS is not evident in the series reported by the IFS (which were evaluated on data from a different survey that includes an adjustment for the undercoverage of top incomes and uses the individual rather than household as the unit of analysis). The overall similarity in trends between private and disposable income inequality highlights the role of factors other than the tax-transfer system in shaping inequality. For example, the rise in inequality reported between 1979 and 1990 coincides with the term of the Thatcher government, when important reforms were enacted to liberalise the capital and labour markets.[27]

Nevertheless, Figure A.1 also provides clear evidence of the important influence that tax and transfer policy has had on disposable income inequality in the UK. This is most obviously indicated by the fact that inequality of private income inequality is on average more than one and a half times as high as disposable income inequality during the sample period. The figure also indicates that changes in redistributive effect had an important bearing on the time-series variation of income inequality. This is emphasised by the observation that measured redistribution was lowest during the sample period at the end of the Thatcher government,

[27] On the role of the 'boom' of inequality of earnings underlying the rise in disposable income inequality during the 1980s, see Blundell and Etheridge (2010). Other labour-market factors cited as important in the rise of income inequality during the 1980s include rising unemployment and self-employment income; e.g. Jenkins (1995).

despite the substantial rise in private income inequality to 1990.[28] Furthermore, redistribution policy appears to have been an important factor depressing inequality since 1990, as measured by the ONS; of the 5.2 percentage point fall in disposable income inequality reported between 1990 and 2015, 3.0 percentage points are attributable to an increased redistributive effect of tax and transfer policy.

Figure A.1: Inequality and redistribution of equivalised household income by year



Source: ONS series reported in *Household Disposable Income and Inequality in the UK: financial year ending 2016*, Reference Table 11. IFS series reported in *Living standards, poverty and inequality in the UK: 2017*.

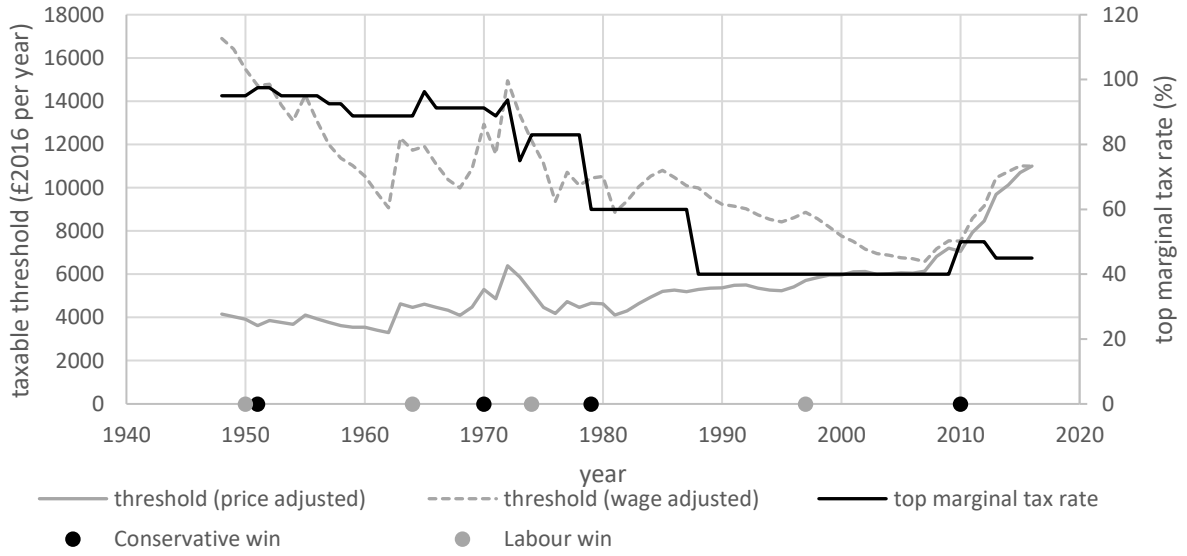
Notes: All measures based on the Gini coefficient, evaluated on household income equivalised using the modified OECD scale. Calendar years reported to 1993, and financial years (beginning in April) from 1994. 'Redistribution' series reports the excess of private income inequality to disposable income inequality. ONS statistics based on Living Costs and Food (LCF, and forerunner) surveys, reported at annual intervals. IFS statistics based on LCF survey data to 1993, and Family Resources Survey and Household Below Average Income data thereafter. ONS statistics cover all households in the UK. IFS statistics are at the individual level covering Great Britain before 2002/02 and to the UK thereafter.

[28] All else being equal, measured redistribution should rise with inequality of private income.

Appendix A.2: Tax and transfer policy reforms

Income tax policy reforms have been implemented in an ad-hoc fashion, generally being set by the prevailing government at budget time. Figure A.2 displays the minimum income thresholds on which no tax was assessed, and the top marginal income tax rates applicable in each year. These parameters were selected to provide a broad description of how UK income tax progressivity has evolved through time. [29]

Figure A.2: Timeseries variation of minimum income tax thresholds and higher marginal rates of income tax

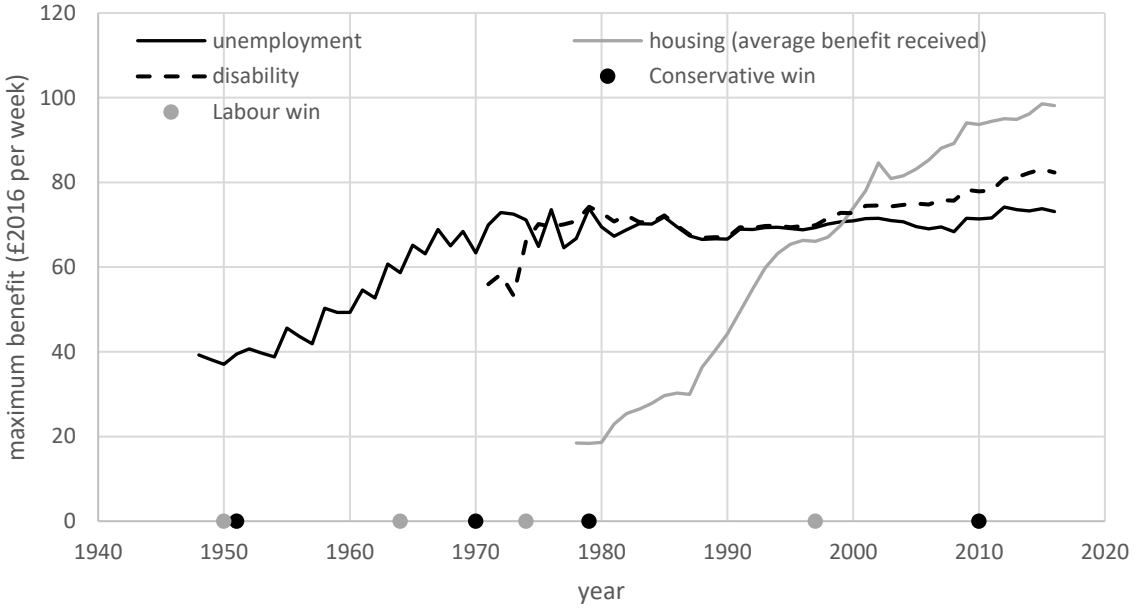


Source: Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Wage growth adjusted using ONS code KGQ2. Rates and thresholds for income tax and surplus tax prior to April 1973 derived from HM Treasury *Tax benefit reference manual: 2009-2010 edition*. Rates and thresholds for income tax from April 1973 derived from HM Revenue and Customs *Table A.2*. These rates exclude surcharges on investment income.

Notes: The UK income tax system takes a standard progressive multi-step form, assessed on a joint basis prior to April 1990, and on an individual basis thereafter. 'Threshold' defines minimum earnings necessary for a single employee without children or any other income source to incur a tax burden. Prior to 1973, the taxable threshold has been adjusted to account for earned income relief. 'Higher marginal tax rate' defines the marginal tax rate above the highest threshold of the top of the multi-step function. Prior to 1973, this marginal rate is comprised of both income and surplus tax rates. Surplus taxes were abolished from April 1973. Tax schedules for selected years based on authors' calculations. The average private income of non-retired households in the top decile by equivalised disposable income in 2015/16 was £120000 per annum (£2300 per week). Graph omits allowance for investment income surcharge of 15% applicable between 1978 and 1983.

[29] This decline in income tax progressivity is also reflected by contemporaneous variation of national insurance contributions, which have been earnings related since 1975.

Figure A.3: Timeseries variation of payment rates by transfer scheme



Source: Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Housing benefits reported by the Department for Work and Pensions *Benefit expenditure and caseload tables 2017*. All other payment rates derived from Institute for Fiscal Studies (IFS) *Fiscal Facts*. Dots show changes of government, by elected party.

Notes: 'Unemployment': Unemployment transfer for man or single women over 18 between 1948 and 1995, Jobseekers Allowance for single person 25+ between 1996 and 2016. 'Housing': average Housing Benefit per recipient. 'Disability': Attendance Allowance higher rate.

Figure A.3 reports time evolution of housing and disability benefits, along-side unemployment benefits that are discussed in Section 2. This figure indicates that average payments per recipient for housing benefit increased strongly from the late 1970s, more than doubling in real terms between 1987 and 1996 alone (corresponding to deregulation of rent controls and the recession of the early 1990s). Housing benefit is the principal support payment to subsidise rental costs for people on low incomes, so that its rise will have depressed disposable income inequality. The change in payment rates also suggests a clear shift in the importance attached to housing needs by the tax and transfer system.

However, the changes in payment rates for housing benefit provide a useful case study for the potential pit-falls associated with analysing shifts in any developed transfer system. Housing assistance for low income people in the UK has been provided sporadically via public housing

(a 'supply-side' in-kind benefit) and rent assistance (a 'demand-side' direct payment), and only rent assistance is discussed above. There was a pronounced shift in the UK from the 1970s to the 2000s from supply-side (public housing) to demand-side (rent assistance) subsidies. The Hills Review (2007), for example, reports that the share of supply-side subsidies in total housing relief provided in England declined from 82 per cent in 1975 to 34 per cent in 2003. Accounting for shifts of this sort in the delivery of welfare benefits is rarely a simple matter, complicating distributional analyses of disposable income that omit in-kind transfers.[30]

The UK transfer system includes a broad range of schemes to support people affected by disability or sickness. A key component of this system since 1970 has been a payment that provides a non-taxable, non-contributory, non-means-tested state subsidy for living and mobility costs that increase in respect of the recognised severity of a disability.[31] Figure A.3 displays time-series variation for the 'higher' rates of payment for single adults provided by the 'living component' of the disability support payments referred to above. This figure reflects the fact that social transfer rates to support people affected by disabilities have tended to vary in a similar fashion to unemployment transfers since 1970, with disability transfers showing weak real growth in excess of unemployment transfers from the mid-1990s.[32]

[30] After Housing Costs measures of income are also imperfect, as these do not account for shifts in the quality of housing services. Hills (2004) consequently conjectures that the best distributional measure for people on low incomes is an intermediate between Before and After Housing Costs incomes.

[31] This component has been called the Personal Independence Payment (PIP) since 2013. The PIP replaced the Disability Living Allowance, which was introduced in 1992 to integrate the Mobility and Attendance Allowances that were introduced in 1970.

[32] Similar time variation can be found for means-tested disability transfer payments provided by Income Support and Employment Support Allowance, and for Incapacity / Invalidity Benefits.

Appendix B: Data and Definitions

Appendix B.1: Survey descriptions

Living Costs and Food Survey

The Family Expenditure Survey (FES) was introduced in 1957, and reports detailed information regarding demographics, income, and expenditure for a cross-sectional sample of households in the United Kingdom. Although the FES was superseded by the Expenditure and Food Survey (EFS) in 2001, and by the Living Costs and Food Survey (LCF) in 2008, the basic structure of the survey regarding the characteristics of concern in this study has remained largely intact from 1968. Reference throughout this paper is consequently made to the LCF whenever discussing the time-series data provided by these three data sources (the FES, EFS, and LCF). Data from the LCF are used for construction of the UK National Accounts and are also the basis for the weights used to evaluate official inflation indices.

The LCF is collected on a continuous basis and has reported data at annual intervals since 1961.[33] The sample size of the survey was approximately doubled in 1967, and data are considered in this study from 1968. The unit of analysis in the survey is the household, defined as any group of people who share the same living accommodation, that is a living room or sitting room, or share meals together or have common housekeeping. Households are selected at random from the Post Office's list of addresses (for Great Britain, excluding the Scottish Isles and the Isles of Scilly; Northern Ireland is sampled through the Valuations and Lands Agency list), and participation is voluntary. All individuals aged 16 and over in participating households are asked to keep a diary of expenditure covering a two-week period, with children aged 7 to 15 also being asked to keep a simplified diary since 1998. Regular expenditure,

[33] The reporting period was changed from calendar years to financial years (starting in April) in 1993, back to calendar years in 2006, and then back to financial years for the 2015/16 survey.

demographic, and income data are recorded at a household interview, and retrospective information is collected on expenditure of selected large and infrequent purchases.

Family Resources Survey

The Family Resources Survey (FRS) was introduced by the Department for Work and Pensions (DWP) in October 1992, in response to the perceived limitations of the Living Costs and Food Survey (LCF) and the General Lifestyle Survey for analysing household incomes in the UK. The FRS reports detailed information regarding household demographics and income for a cross-section of households in the United Kingdom. Although the FRS omits detail concerning household expenditure that is reported by the LCF, it includes finer detail concerning income sources, for samples that are typically more than three times those reported by the LCF. Similar to the LCF, the FRS is a clustered, stratified random sample of UK households based on postcode sectors, is collected on a continuous basis, and participation in the survey is voluntary. The FRS is used by the DWP for departmental modelling of the transfer system, and to produce its periodical *Households Below Average Income*. The FRS is also the survey source for the cross-sectional element of the European Union Statistics on Income and Living Conditions (EU-SILC).

We use the FRS and the accompanying subfiles of derived income variables called the Households Below Average Income (HBAI) dataset. The HBAI subfiles are constructed by the DWP and available as a distinct series through the UK Data Archive. This series is specifically designed to deliver inter-temporally comparable definitions for selected variables and is referred to by the Office for National Statistics as "the foremost source of UK data and information about household net income and poverty" (ONS, 2016, p. 17).

Appendix B.2: Variable construction

All variables explored in this study were extracted from survey data files obtained from the UK Data Archive using Stata "do" files, which are available from the authors upon request.

Living Costs and Food Survey

Individual ages (a005, reported at annual intervals subject to top-coding), were used to identify the numbers of adults and children in each household, where adults were defined as any individual aged 14 or over. This definition of adulthood reflects explanatory variables for the modified OECD scale. Indicators of the number of employed, and self-employed, members are also evaluated for each household (a206, a221, p047, p037, a202, a203).

Measures of private income were evaluated by aggregating up employee wages (codes p008, p011, p015), own-business income (p037, p047), investment income (p048), private pension income (p049), and other income (p050). Disposable income was evaluated by adding private income and aggregate social transfers (p031, p032, p033), and subtracting income taxes and National Insurance contributions (p029, p063, p067, p075, p079). Variable construction at the individual level for private income and social transfers were validated against survey measures of gross income (p051), and disposable income was validated against the associated survey aggregate (p177). Furthermore, aggregate household disposable income was checked against the same measure reported by the survey at the household level (p389, p277, p274, p67269, p204, p267269, p267).

Disability social transfers were identified separately for each household, as these provide a useful indicator for interpreting tax implicit scales. This is complicated by the fact that disability transfer payments in the UK have gone through a series of reforms. Personal independent payments replaced disability living allowance in 2013, which replaced mobility and attendance allowances in 1992. Employment and support allowance replaced incapacity

benefit in 2011, which replaced invalidity benefit in 1995. Aggregate household disability social transfers are evaluated by summing up individual scheme values reported by the survey (p026, p009, p032, b403, b405, b421, b417, b418, b340, t361, p016, p023). All income measures were converted to 2016 prices using the National Accounts final consumption expenditure deflator (YBGA).

Family Resources Survey

As for the LCF, individual ages (age80, age) reported at annual intervals subject to top-coding, were used to identify the numbers of adults and children in each household, where adults were defined as any individual aged 14 or over. Indicators of the number and presence of employed, and self-employed, were also computed for each household using information on employment status (empstati), hours worked (tothours) and the presence of employment and self-employment income (esgjobhh, esgrsehh).

Measures of household private income (esmkinchh) include employee wages (esgjobhh), own-business income (esgrsehh), investment income (esginvhh), private pension income (esgocchh), and other income (esmischh). Disposable income (esninchh) adds private income and aggregate social transfers, inclusive of tax credits, (esbenihh, espribhh), and subtracts income taxes, National Insurance contributions, domestic rates and council tax, contributions to occupational pension schemes, all maintenance and child support payments, parental contributions to students living away from home and student loan repayments (DWP 2017:15). There is no separate variable for taxes, which we imputed by taking the difference between gross and disposable income (esninchh – esginchh). The measures of private and disposable income evaluated from the HBAI are similar to those derived from the LCF, except that they include the cash value of certain forms of income in kind, including free school meals. We infer the receipt of disability transfers by using the FRS derived variable (hhdisben).

Appendix B.3: Consistency checks

Two forms of consistency check were performed on the extracted data for the LCF and FRS: The time-series of the mean for each extracted variable was plotted and visually screened for discontinuities; and income distribution statistics were compared against statistics reported by government agencies. Finally, summary measures of income dispersion were compared between the LCF and FRS

Living Costs and Food Survey

Year specific averages for the variables extracted from the LCF are reported in Table B.1. We identify one substantive break in our cleaned data series, for the average number of children per household, which falls discontinuously from 1995 to 1996. This discontinuity coincides with introduction of survey weights and is not evident in unweighted averages.

Summary statistics for the distribution of private and disposable income extracted from the LCF were checked for consistency by comparing them against associated statistics reported by the Office for National Statistics (ONS) in its statistical bulletin, *Effects of taxes and benefits on UK household income*. The ONS series reports data from 1977 to 2015. The ONS does not report statistics for data prior to 1977, to ensure consistency of the time series. Personal correspondence with the ONS (10/11/2017) suggested that the ONS have not considered data prior to 1977 due to resource constraints associated with ensuring data comparability, rather than more fundamental issues associated with comparing FES surveys pre- and post-1977. Although income data reported by the FES prior to 1977 were subject to substantive criticism, they remain a valuable source of information (e.g. Atkinson and Micklewright, 1983), motivating their inclusion in this study.

Gini coefficients for measures of household income equivalised using the OECD modified scale are reported in Figure B.1. This figure indicates that the Gini coefficients associated with

private and disposable income extracted from the LCF closely match those reported by the ONS prior to 2005, but are systematically lower in all years between 2006 and 2015. Although the ONS and LCF data series reported in Figure B.1 are based on the same underlying LCF microdata, differences in methods of calculation result in the variation between the respective series that is described by the figure. Whereas the LCF series is based upon current weekly measures of income reported by the survey, the ONS series are based on annualised measures of income adjusted to account for periods of non-employment. Furthermore, the LCF series is based upon data available from the UK Data Service, which are subject to censoring, whereas the ONS series is based upon uncensored microdata.

Figure B.2 provides a clearer indication of the influence of censoring on the distributions of income extracted from the LCF. As in Figure B.1, the two panels of Figure B.2 indicate a close correspondence between the ONS and LCF data series up to 2005. From 2006, however, the share of the highest quintile of households ranked in terms of equivalised disposable incomes falls discontinuously, with respect to both private and disposable income.

Table B.1: Year specific averages of household characteristics; LCF data

year	adults	kids	eldest	workers	self-emp	disbld	private income	disposable income	sample
1968	2.219	0.741	51.27	1.338	0.115	0.04	381.73	361.04	7183
1969	2.205	0.754	51.42	1.328	0.132	0.04	391.27	364.24	7008
1970	2.183	0.762	51.03	1.327	0.130	0.04	395.86	365.38	6391
1971	2.170	0.729	51.20	1.299	0.134	0.04	394.84	366.36	7239
1972	2.171	0.746	50.64	1.302	0.125	0.02	405.96	384.92	7017
1973	2.140	0.684	51.67	1.282	0.117	0.04	424.56	399.97	7124
1974	2.134	0.700	51.39	1.278	0.125	0.04	418.98	391.59	6695
1975	2.131	0.681	51.27	1.270	0.108	0.04	419.95	372.22	7203
1976	2.116	0.632	51.38	1.238	0.098	0.05	399.91	354.76	7203
1977	2.132	0.630	51.18	1.242	0.105	0.06	392.78	356.95	7196
1978	2.117	0.600	51.23	1.228	0.097	0.08	402.68	374.50	7001
1979	2.098	0.604	51.13	1.225	0.101	0.06	399.64	377.30	6776
1980	2.114	0.599	51.14	1.231	0.103	0.06	413.20	386.02	6944
1981	2.145	0.584	51.27	1.190	0.115	0.06	412.65	387.40	7524
1982	2.118	0.577	50.83	1.119	0.080	0.07	394.78	373.47	7428
1983	2.096	0.562	51.00	1.076	0.090	0.06	389.97	367.06	6973
1984	2.093	0.528	51.61	1.080	0.089	0.06	393.86	368.83	7081
1985	2.073	0.524	51.38	1.083	0.092	0.06	415.42	385.56	7012
1986	2.037	0.516	50.94	1.072	0.094	0.06	430.25	405.31	7178
1987	2.034	0.499	50.86	1.080	0.109	0.06	454.67	424.66	7396
1988	2.021	0.495	51.37	1.091	0.117	0.07	480.40	441.62	7265
1989	2.005	0.504	51.00	1.089	0.117	0.07	481.75	444.16	7410
1990	1.967	0.508	51.23	1.083	0.116	0.08	506.08	463.18	7046
1991	1.946	0.476	51.41	1.030	0.112	0.09	496.39	458.28	7056
1992	1.951	0.499	51.06	1.007	0.109	0.08	476.06	447.54	7418
1993	1.962	0.515	51.03	0.984	0.105	0.10	472.05	447.72	6979
1994	1.926	0.498	50.78	1.005	0.108	0.12	487.65	455.89	6853
1995	1.923	0.517	51.31	0.993	0.107	0.13	488.51	456.41	6797
1996	1.946	0.437	51.35	1.039	0.117	0.13	503.79	474.43	6415
1997	1.936	0.432	51.39	1.043	0.098	0.14	528.54	493.72	6409
1998	1.935	0.430	51.58	1.060	0.105	0.14	559.27	516.96	6630
1999	1.894	0.420	51.32	1.037	0.096	0.14	580.29	537.93	7097
2000	1.933	0.421	51.67	1.089	0.098	0.15	601.16	556.05	6637
2001	1.955	0.421	51.98	1.121	0.101	0.14	650.68	601.49	7473
2002	1.965	0.417	52.09	1.124	0.106	0.15	641.28	600.95	6927
2003	1.948	0.409	52.26	1.109	0.101	0.14	646.48	602.64	7048
2004	1.976	0.411	52.56	1.132	0.105	0.15	665.19	621.07	6798
2005	1.958	0.400	52.62	1.106	0.104	0.14	665.79	619.17	6785
2006	1.965	0.400	52.71	1.116	0.113	0.14	628.66	596.06	6645
2007	1.958	0.389	52.67	1.106	0.110	0.13	640.25	606.27	6136
2008	1.968	0.384	52.93	1.123	0.108	0.15	643.16	615.10	5843

Continued next page.

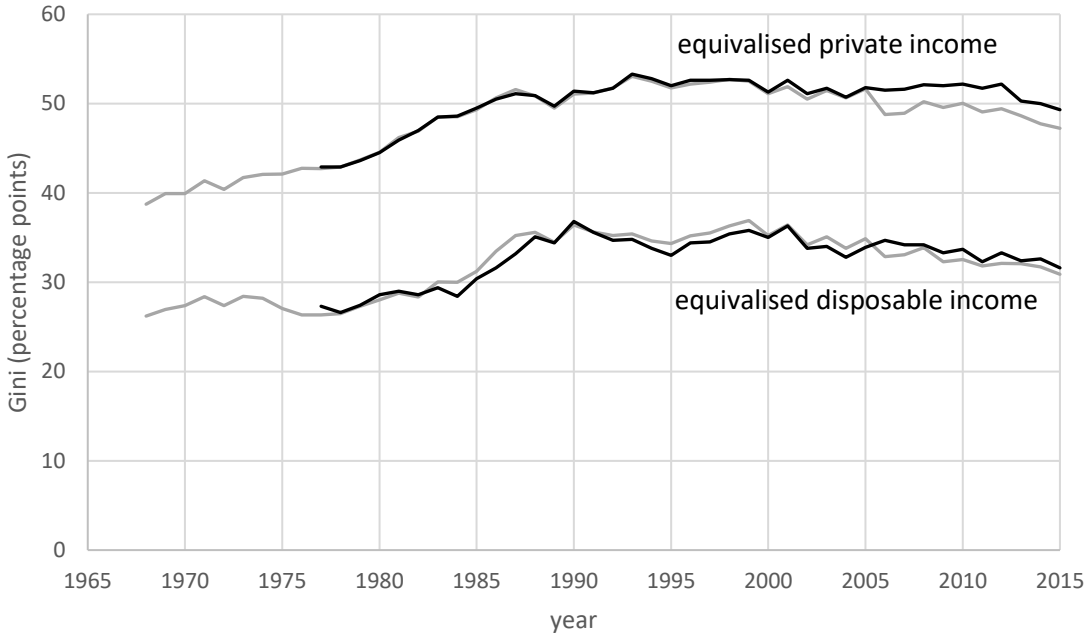
Table B.1: Year specific averages of household characteristics; LCF data (contd.)

year	adults	kids	eldest	workers	self-emp	disbld	private income	disposable income	sample
2009	1.951	0.383	52.76	1.098	0.108	0.14	610.48	595.00	5822
2010	1.953	0.378	52.91	1.076	0.116	0.14	604.60	594.93	5263
2011	1.965	0.387	52.98	1.089	0.119	0.13	614.21	601.07	5691
2012	1.953	0.385	53.08	1.082	0.114	0.13	598.82	592.27	5593
2013	1.966	0.392	53.46	1.108	0.122	0.12	616.57	607.79	5144
2014	1.991	0.404	53.60	1.128	0.120	0.13	643.88	636.59	5133
2015	1.956	0.395	53.58	1.122	0.121	0.13	643.00	636.27	4912

Source: Authors' calculations using data from the Living Costs and Food Survey (LCF), Expenditure and Food Survey (EFS), and Family Expenditure Survey (FES). Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Notes: adults = all household members aged 14 and over, kids = all members aged under 14. eldest = age in years of oldest household member. workers = number of adults employed. self-emp = proportion of households with at least one adult self-employed. disbld = proportion of households in receipt of disability transfers. private income and disposable income measured in £2016 per week. Breaks identified visually are reported in red. Break identified for average number of children per household, between 1995 and 1996 is attributed to introduction of survey weights from 1996.

Figure B.1: Gini coefficients of equivalised household income by year and data source

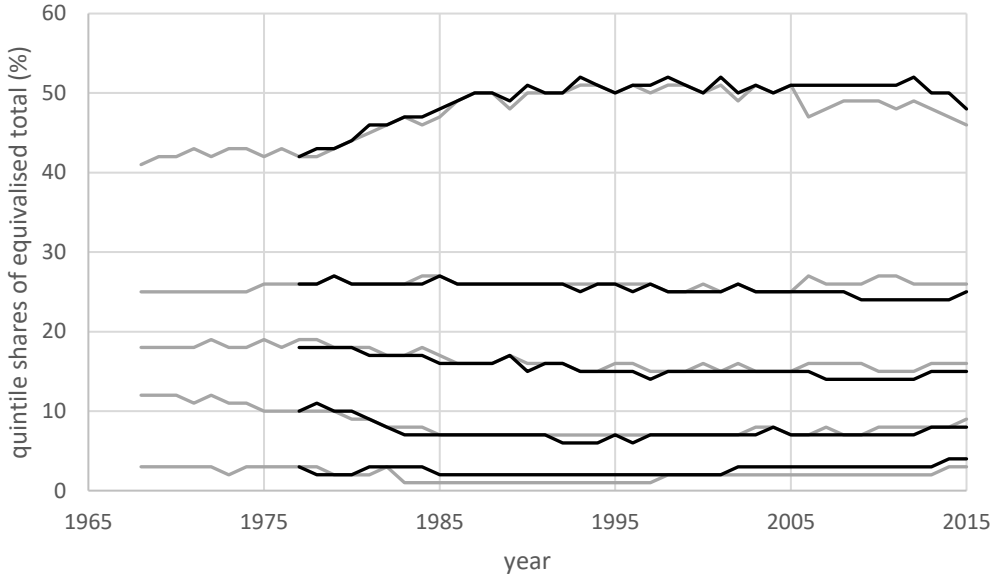


ONS reported summary statistics in black, LCF summary statistics in grey

Source: ONS statistics reported in statistical bulletin *Effects of Taxes and Benefits on Household Income, 2015/16*, Reference Table 11. LCF summary statistics based on authors' calculations from LCF microdata.

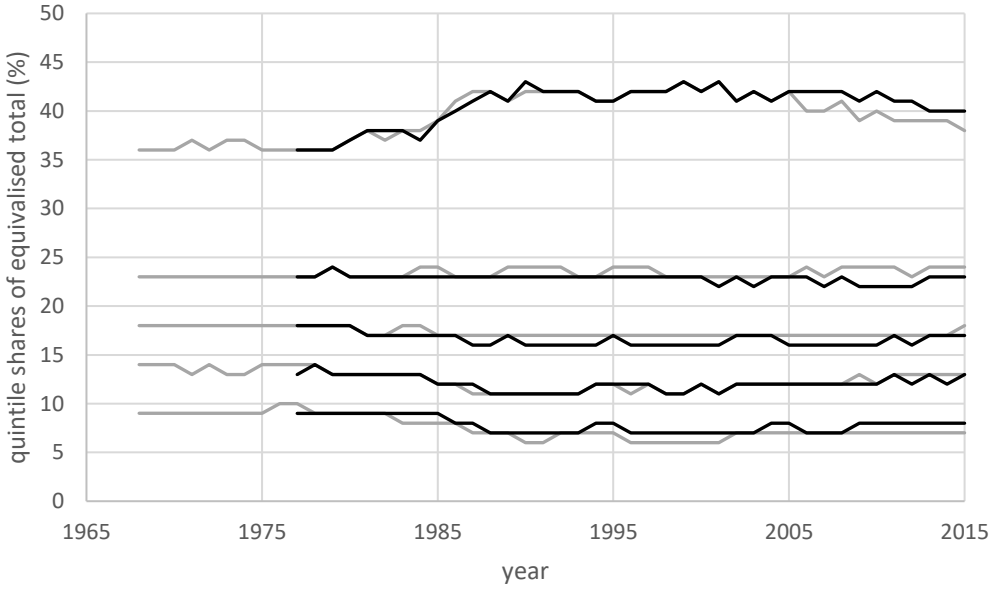
Notes: ONS series reported between 1977 and 2015; LCF series based on data reported at annual intervals between 1968 and 2015/16 inclusive. Household income equivalised using the modified OECD scale. Data weighted by household. Survey weights included from 1996.

Figure B.2: Income shares of equivalised disposable income quintiles by year and data source



ONS reported summary statistics in black, LCF summary statistics in grey

Panel A: Private income



ONS reported summary statistics in black, LCF summary statistics in grey

Panel B: Disposable income

Source: ONS statistics reported in statistical bulletin *Effects of Taxes and Benefits on Household Income*, *2015/16*, Reference Table 29. LCF summary statistics based on authors' calculations from LCF microdata.

Notes: ONS series reported between 1977 and 2015; LCF series based on data reported at annual intervals between 1968 and 2015/16 inclusive. Household income equivalised using the modified OECD scale. Quintiles based on household ranked by equivalised disposable income. Survey weights included from 1996.

Family Resources Survey

Year specific averages for the variables extracted from the FRS are reported in Table B.2. Comparing Tables B.1 and B.2 reveals that the two surveys imply very similar year specific averages for all characteristics. The most systematic differences between the two surveys are reported for: the average numbers of adults employed, which are systematically higher in the LCF (by 2.4 percentage points on average); and the proportion of households with at least one adult self-employed, which are systematically higher in the FRS (by 0.9 percentage points). Statistics for the proportion of households in receipt of disability transfers – while of comparable magnitude to those reported by the LCF – display a 2.5 percentage point fall between 2007 and 2008 that appears out of step with the remainder of the time-series. We have been unable to find an explanation for this fall.

Year specific averages for private income reported by the LCF and FRS are almost identical in the two surveys up to 2005 and are systematically lower (by an average of £58 per week) from 2006. The decline in private income reported by the LCF from 2006, relative to the FRS, is consistent with the top-censoring of the LCF that is discussed above. Similar relative variation about 2005/2006 is also described by the LCF and FRS year-specific averages reported for disposable income. However, it was surprising to find that the LCF year specific averages for disposable income are almost identical to those evaluated on data extracted from the FRS from 2006, but are systematically higher than the FRS series in years up to 2005 (by £33 per week on average). This surprising variation was traced to the adjustments applied to obtain the HBAI (Households Below Average Income) dataset, which systematically lower year-specific averages for disposable income reported by the FRS (by £32 per week on average).

Summary statistics for the distribution of disposable income extracted from the FRS were checked for consistency by comparing them against associated statistics reported by the Department for Work and Pensions in its periodical, *Households Below Average Incomes*. These statistics are reported in Figure B.3, and although they are not based on precisely the same adjustments for inflation, they indicate a very close match between the statistics calculated on the extracted microdata and those reported by the Department.

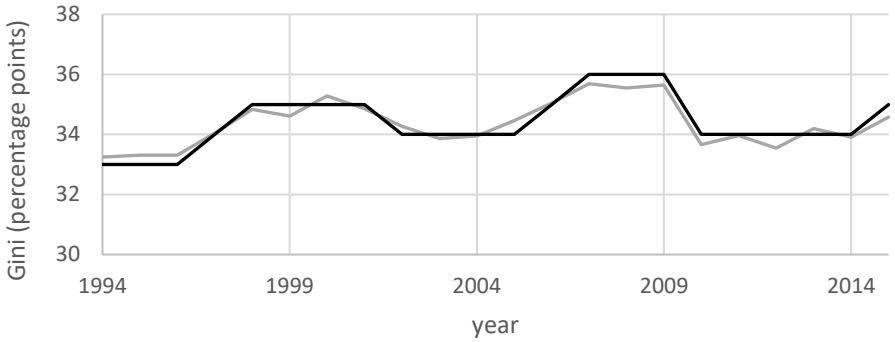
Table B.2: Year specific averages of household characteristics; FRS data

year	adults	kids	eldest	workers	self-emp	disbld	private income	disposable income	sample
1994	1.952	0.437	51.09	1.011	0.114	0.13	477.68	442.17	26198
1995	1.938	0.434	51.08	1.009	0.114	0.15	485.46	441.55	26156
1996	1.931	0.428	51.23	1.024	0.115	0.15	497.46	452.06	25513
1997	1.920	0.424	51.20	1.044	0.117	0.15	523.76	467.97	23427
1998	1.912	0.420	51.35	1.038	0.115	0.15	551.34	486.93	22856
1999	1.901	0.416	51.35	1.040	0.111	0.15	564.55	497.86	24931
2000	1.900	0.411	51.40	1.047	0.110	0.15	603.95	525.60	23747
2001	1.919	0.414	51.59	1.068	0.114	0.15	633.89	554.85	25260
2002	1.950	0.406	51.80	1.081	0.114	0.16	635.11	559.54	28637
2003	1.945	0.407	51.87	1.077	0.112	0.16	635.16	560.74	28786
2004	1.948	0.400	51.94	1.081	0.115	0.17	657.83	574.06	27963
2005	1.952	0.395	52.09	1.090	0.119	0.16	662.52	581.03	27955
2006	1.956	0.388	52.18	1.086	0.116	0.16	678.66	589.91	25690
2007	1.960	0.384	52.20	1.089	0.122	0.16	702.07	607.42	24905
2008	1.958	0.383	52.17	1.082	0.117	0.13	691.57	608.12	25000
2009	1.956	0.385	52.25	1.062	0.118	0.13	681.05	606.55	25112
2010	1.956	0.383	52.49	1.054	0.120	0.14	657.50	591.08	25281
2011	1.971	0.380	52.51	1.082	0.122	0.14	667.80	595.71	20693
2012	1.963	0.381	52.82	1.067	0.123	0.14	659.76	594.19	20126
2013	1.942	0.380	53.02	1.076	0.126	0.13	678.91	607.85	20056
2014	1.941	0.387	53.16	1.092	0.129	0.13	694.77	621.62	19466
2015	1.934	0.386	53.20	1.077	0.124	0.13	708.34	631.70	19241

Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series. Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

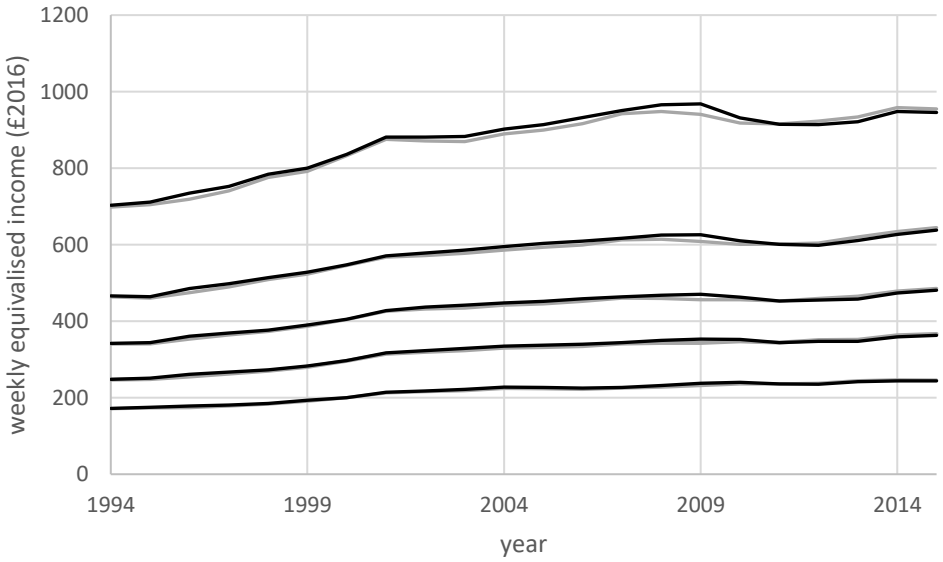
Notes: adults = all household members aged 14 and over, kids = all members aged 13 and under. eldest = age in years of oldest household member. workers = number of adults employed. self-emp = proportion of households with at least one adult self-employed. disbld = proportion of households in receipt of disability transfers. private income and disposable income measured in £2016 per week. Breaks identified visually are reported in red. Drop in proportion of households in receipt of disability transfers between 2007 and 2008 remains unexplained.

Figure B.3: Distributional statistics for equivalised household disposable income by data source



DWP reported summary statistics in black, FRS summary statistics in grey

Panel A: Gini coefficients



DWP reported summary statistics in black, FRS summary statistics in grey

Panel B: Quintile medians

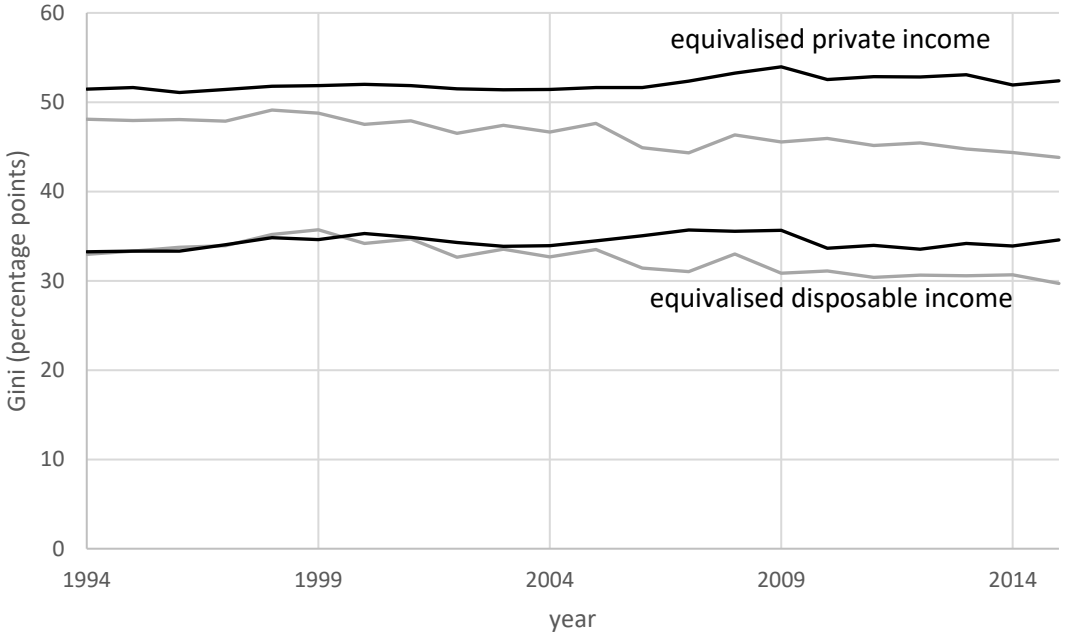
Source: DWP statistics reported in *Households Below Average Income, 1994/95 to 2015/16*, Income Distribution Timeseries Tables 2.1ts and 2.2ts. FRS summary statistics based on authors' calculations from FRS microdata, HBAI series. Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.
Notes: Household income equivalised using the modified OECD scale. Data weighted by individual.

Preliminary distributional comparisons between the LCF and FRS

Figure B.4 reports Gini coefficients of equivalised private and disposable household income evaluated from the microdata extracted from the LCF and FRS. This figure indicates a very

close correspondence between the Gini measures evaluated from the two surveys for disposable income up to 2005. From 2006, disposable income inequality evaluated from the LCF is systematically below that evaluated from the FRS, by 3.6 percentage points on average. This discrepancy is attributable to the top-coding of high incomes reported by the LCF (as discussed above), as well as to the HBAI adjustment to top incomes that allowed for a better capture of rising top income shares in the mid-2000's (see Burkhauser *et al.*, 2018).

Figure B.4: Gini coefficients of equivalised household income by year and data source

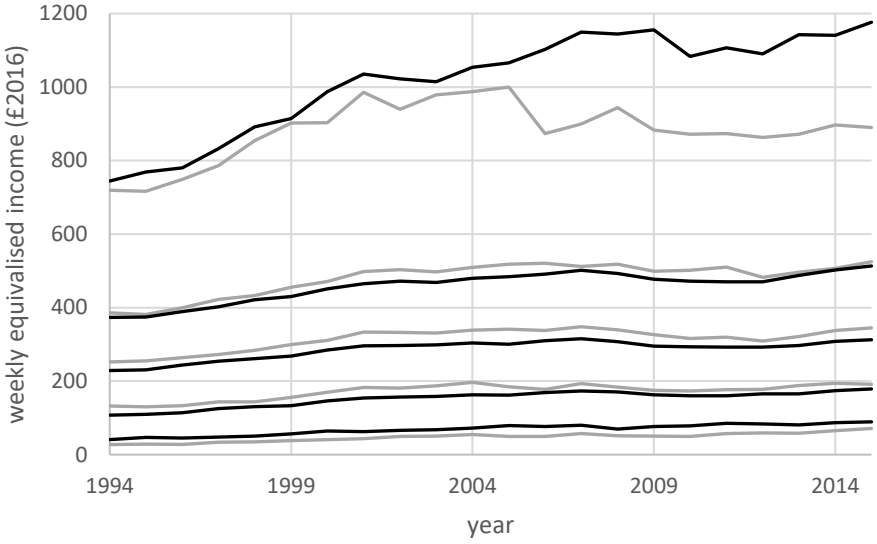


Source: Authors' calculations using microdata from the Living Costs and Food (LCF) survey and Family Resources Survey (FRS), HBAI series.
Notes: Household income equivalised using the modified OECD scale. Data weighted by individual.

In contrast, the Gini coefficients reported for private income using data from the LCF are lower than those evaluated from FRS data throughout the sample period. This discrepancy widens noticeably from 2005 to 2006, consistent with the top-coded LCF data. Nevertheless, the differences in Gini measures between 1994 and 2005 – at 3.8 percentage points – are substantial. Given the relatively close correspondence of Gini coefficients reported for disposable incomes, the differences between the dispersions reported for private incomes imply that the redistributive effect of the UK tax and transfer system is approximately 20% higher when measured using the FRS than the LCF. Approximately 1.5 percentage points of this 3.8-point difference is attributable to imputations associated with the HBAI series (based on statistics evaluated from the raw FRS data, not reported here), leaving a gap of 2.3 percentage points attributable to survey methodology not further explained.

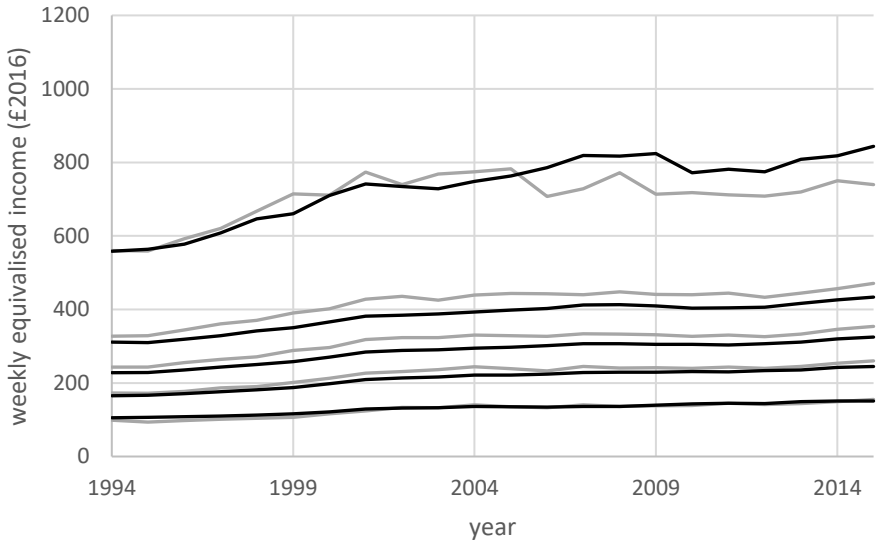
Further detail concerning the distributional differences evaluated from FRS and LCF income data is provided in Figure B.5. The top panel of Figure B.5 indicates that the lower inequality of equivalised private incomes reported by the LCF, relative to the FRS, is primarily attributable to the way that the LCF captures the top of the income distribution. This is consistent with adjustments made to the base FRS data to capture the incidence of high-income individuals in the construction of the HBAI series. Otherwise the two panels of Figure B.5 indicate a fairly close correspondence between the distributions of private and disposable incomes reported by the FRS and LCF, with the LCF tending to report slightly higher incomes in the middle of the distribution.

Figure B.5: Quintile averages of equivalised household income by year and data source



FRS statistics in black, LCF statistics in grey

Panel A: Private income



FRS statistics in black, LCF statistics in grey

Panel B: Disposable income

Source: Authors' calculations using microdata from the Living Costs and Food (LCF) survey and Family Resources Survey (FRS), HBAI series. Prices adjusted using the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Notes: Household income equivalised using the modified OECD scale. Data weighted by individual, quintiles evaluated with respect to disposable income.

Appendix B.4: Tests for representativeness

A key concern for this study is the extent to which the survey data we consider provide a representative reflection of the UK population. The representativeness of both the LCF and FRS is imperfect by construction. People in institutions – including retirement homes, the military, and prison – are omitted from both sample pools, as are people with no fixed address (the homeless). Furthermore, rates of (voluntary) participation have generally been declining. In the case of the FRS, this decline is relatively slight, falling from just under 70% in the early 1990's, to just under 60% in the most recently available waves. However, in the case of the LCF, the response rate was approximately 70% during the 1970s and 1980s and has declined since the early 1990s; in 2015/16 (the most recent data) the participation rate was 46% of the eligible sample. Declining survey response rates are a feature that has been reported for comparable surveys in other (Anglo-Saxon) countries; see, e.g., Barrett *et al*. (2015) and van de Ven (2011) for discussion.

The decline in participation rates coincides with declines in the sample sizes reported by the LCF and FRS. Between 1968 and 2003, the LCF reported data for approximately 7,000 households, but this has since fallen fairly consistently with time, and in 2015 data were reported for just under 5,000 households. Similarly, the reported sample for the FRS was around 26,000 households in the early 1990's and has since fallen to just under 20,000 households in the most recent waves (5,000 of the fall for the FRS is a result of a deliberate reduction in the sample implemented in 2011). Hence, the decline in participation rates implies increased statistical uncertainty associated with summary statistics evaluated from both surveys. More concerning, however, is that participation has been found in past surveys to be distributed non-uniformly across the population.

Foster (1996), for example, compares the characteristics of households responding to the 1991 FES with information derived from the 1991 Census, and finds that response was lower than average in Greater London, higher in rural areas, and that the response rate tended to increase with the age of the household reference person. Low response rates were also found for ethnic minorities, the lower educated, self-employed, and the manual social class. These differences in response rates will influence summary statistics evaluated using the survey wherever they are not neutralised by associated sample weights (necessarily true prior to introduction of weights for the LCF in 1996/97). Sample weights for the LCF were updated by comparing LCF response against the 2001 Census, and a review of the LCF weights in light of the recent decline in survey participation is currently being undertaken by the 2011 Census non-response linkage project. Similar up-dating of grossing weights has also been undertaken for the FRS.

One approach to consider how successfully survey weights off-set non-random survey participation in respect of reported income is to consider the coverage by each survey of National Account aggregates. This is useful because the measures of income reported by the National Accounts are based on very different data sources to the LCF and FRS; for example, wages and salaries are supplied as an aggregate by HM Revenue and Customs for inclusion in the National Accounts, and interest income is supplied by the Bank of England. The National Accounts data are consequently not subject to the same concerns as a random sample survey in which response is voluntary, like the LCF and FRS.

Statistics comparing the LCF, FRS and National Accounts aggregates for disposable income of the household sector are reported in Figure B.6. Panel A of this figure reveals a sustained downward trend in the ratio of per-capita disposable income reported by the LCF to that reported by the National Accounts between 1968 and 1996. In contrast, response rates to the

LCF were broadly stable during much of this period, suggesting that survey response was not driving the decline in coverage.

In contrast, coverage rates of income reported in the National Accounts by the LCF are reported to have recovered by approximately 5 percentage points in the two decades since 1995. The timing of the start of this recovery coincides with introduction of sample weights with the LCF, and the recovery is most immediately apparent on a weighted basis; between 1995 and 1999 the (weighted) coverage ratio increased from 66 to 74 percentage points. Nevertheless, a recovery in the coverage rate is also reported on an unweighted basis, so that there is little to distinguish the weighted from the unweighted series by the end of the sample period.

The increase reported for coverage rates in the unweighted series, in context of the coincident decline in response rates, suggests that survey non-response was concentrated among those with low incomes. That the same rise is not reported for the weighted series, suggests that the LCF weights have successfully off-set the distortion of average disposable incomes implied by the concentration of non-response toward the bottom of the income distribution.

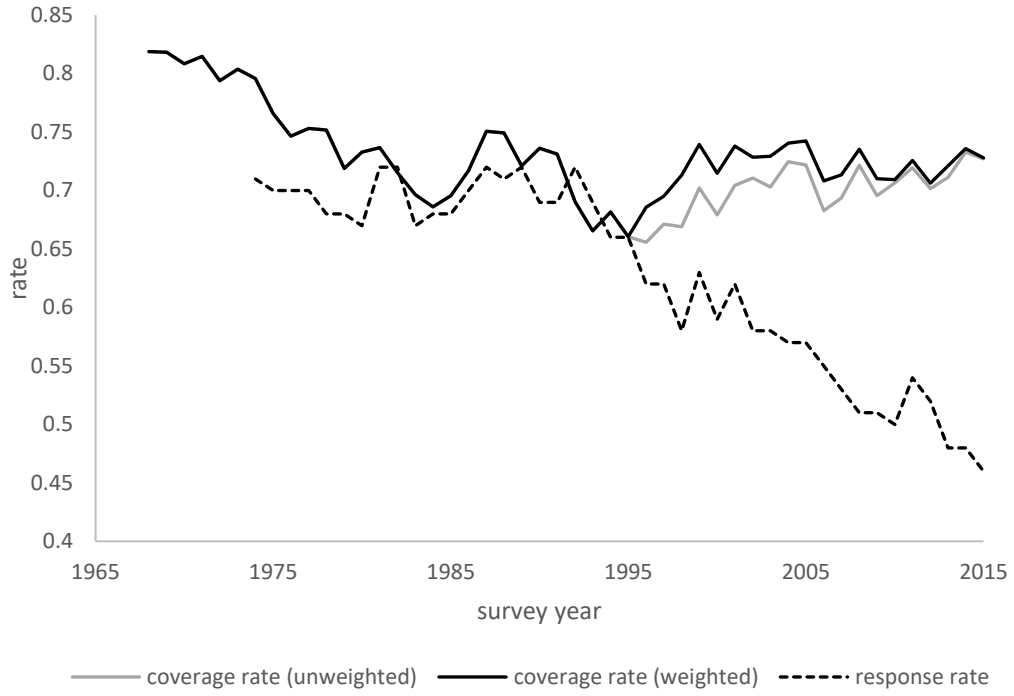
Statistics reported in Panel B of Figure B.6 describe a somewhat more concerning picture for the FRS than for the LCF discussed above. Specifically, the time variation reported for the coverage rate is approximately a reflection of that reported for the response rate; the correlation coefficient between the two series is -0.91. This suggests that the FRS grossing weights have not successfully off-set distortions to average household incomes implied by concentration of survey non-response among low income households.[34] Although the importance of this issue is less acute for the FRS – the response rate to the FRS is substantively higher than, and fell by

[34] Non-response among low income households will tend to increase average household incomes reported by the survey, if not off-set by sample weights, which is consistent with the rise in coverage rates reported in the figure.

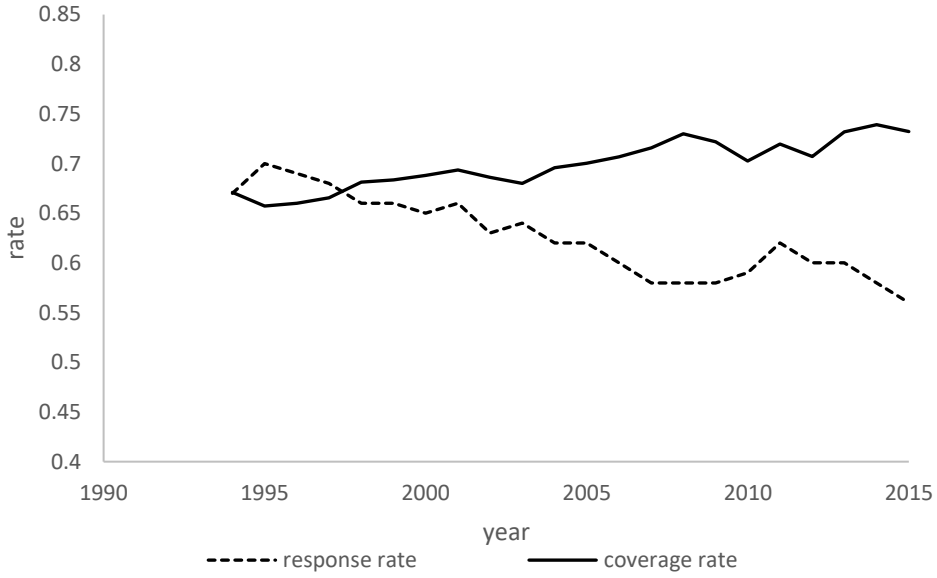
approximately half of the decline reported for the LCF – it is nevertheless an issue that should be taken into account when interpreting the results obtained.

Finally, a number of dedicated studies have considered the representativeness of the LCF and FRS. The most recent review of the LCF conducted by the ONS is reported by Ralph and Manclossi (2016), which conveniently uses the FRS as a comparator. One aspect explored by Ralph and Manclossi (2016) of relevance for the current study is the analysis of under-reporting of income, work that the ONS based on an earlier study of the LCF and FRS conducted by Brewer and O'Dea (2012). Importantly, these studies suggest that the LCF and FRS both tend to under-report the incidence of selected social transfers. In this regard, Ralph and Manclossi (2016) single-out Pension Credit, Disability Living Allowance, Attendance Allowance, and Employment Support Allowance as conspicuously under-represented by the two surveys. Similar evidence of under-reporting for these transfer payments is reported by Brewer and O'Dea (2012), who also report results suggesting that Income Support and Tax Credits are understated by the LCF and FRS. Brewer and O'Dea (2012) undertake an in-depth analysis of the distributional implications of these issues.

Figure B.6: LCF and FRS sample response rates and coverage rates of disposable income reported in the National Accounts, by survey year



Panel A: Living Costs and Food Survey (LCF)



Panel B: Family Resources Survey (FRS)

Source: Survey response rates for LCF derived from Barrett *et al*. (2015) between 1974 and 2009, and survey technical reports between 2010 and 2015. Response rates for the FRS derived from survey technical reports. Coverage rates for disposable income based on authors' calculations.

Notes: Coverage rates describe ratios of per-capita measures of disposable income reported by the LCF and FRS to those reported by the National Accounts. National Accounts figures based on historical series for variables QWND (disposable income of households and non-profit institutions) and EBAQ (population aggregate) reported in 2017. LCF and FRS statistics based on measures of disposable income and household members, as described in Appendix B.2. FRS statistics do not include Northern Ireland prior to 2002.

Appendix B.5: Summary of relevant survey changes

We list here changes in survey methodology of which we are aware that may influence this analysis.

Living Costs and Food Survey

- Data are held by the UK Data Service at annual intervals from 1961
    - Data for 1961-1963 are available from the UK Data Service, but are reported using a substantively different file and variable structure than later years. Furthermore, attempts to extract meaningful data from these sets were unsuccessful, motivating their exclusion from the analysis.
    - Data for 1964-1967 are not publicly available, being held by the Data Service for archival purposes only, due to missing coding information.
- Family Expenditure Survey (FES) available from the UK Data Service reporting data for calendar years at annual intervals from 1968. This sample includes a random sample for Great Britain, and a sample for Northern Ireland (drawn from the Northern Ireland Family Expenditure Survey). The survey was administered by the Department of Employment.
- A change in coding of social transfers from 1972.
- In 1986 there was a change in database administration for the survey
- Responsibility for the survey was taken over by the Central Statistical Office in 1989.
- A change in coding of taxes from 1992.
- A change in coding for employee wages from 1993.
- Data reported for calendar years to 1993, amended to financial years (beginning in April) from 1993/94.
- Computerised personal interviewing was introduced in April 1994.

- Survey weights were introduced in 1996/97; sample statistics prior to that year are consequently unweighted. Weights based on comparison between 1991 Census and FES data.
- The Northern Ireland Family Expenditure Survey discontinued and replaced by a dedicated sample in the (UK) Family Expenditure Survey. The Northern Ireland population over-sampled in the FES by a factor of (approximately) 5.
- FES merged with the National Food Survey from April 2001, to form the Expenditure and Food Survey (EFS). Coincident change in methodology for measuring consumption.
- Data reported for financial years to 2005/06, and for calendar years from 2006.
- Secure Access variant of the LCF (EFS) made available from 2006
    - Top-coding of income appears to have had a more pronounced impact on data reported under the standard End User License of the survey from 2006.
- Reported weights updated in response to match between 2001 Census and EFS data from 2007.
- EFS renamed the Living Costs and Food Survey (LCF) from 2008, when it became part of the Integrated Household Survey (IHS). Collection of data on income and expenditure underwent little discontinuity over this transition.
- From January 2010, the Northern Ireland sample used for the LCF was reduced to a sample proportionate to the Northern Ireland population relative to the rest of the UK
- Data reported for calendar years to 2014, and for financial years from 2015/16 when the LCF ceased being included as part of the IHS.

Family Resources Survey

- FRS introduced in October 1992, reporting data for Great Britain for financial years from 1993/1994.
- Coding change for business income from 1995.
- Tax Credits included in measure of social transfers from 1999.
- Sample for Scotland extended north of the Caledonian Canal from 2001/02.
- Sample for Scotland doubled from 2002/03.
- Sample population extended to include Northern Ireland from 2002/03.
- Reported adult ages top-coded to 80 years from 2002/03.
- Definition of grossing weights altered from 2002/03.
- Sample population reduced by 5000 households from 2011.
- Changes in the HBAI adjustments to top incomes due to the non-indexation of the income thresholds determining eligibility for adjustment until 2009/2010.

Appendix C: Distributional Sensitivity to the Tax Implicit Scale Reference Unit

The influence of the reference unit on measures of inequality of income equivalised using tax implicit scales can be explored with reference to a stylised population comprised of two subgroups, A and B. Members of group $i \in \{A, B\}$ receive a social transfer V_i, and are subject to a marginal tax rate on all private income of t_i. Suppose that the tax schedule of group A is more progressive than that of group B, with $V_A > V_B, t_A > t_B$. As an extreme example, suppose that $t_A = 1.0$, so that the tax schedule for group A is fully equalising (at disposable income V_A). In this case, adopting A as the reference population will give a tax implicit scale for each member of B equal to their disposable income divided by V_A. This tax implicit scale will consequently imply complete equality of the equivalised disposable income distribution (at V_A).

The extent to which equivalised private income would also be equalised in the above example is inversely related to the progressivity of the tax schedule for B. If the tax schedule for B is distributionally neutral ($V_B = 0$), then the distribution of equivalised private income for all members of B would also be reduced to complete equality (within group B, at value $V_A/(1 - t_B)$). In contrast, if the tax schedule for B is fully equivalising (in common with that of A), then the distribution of equivalised private income for all members of B would be the same as the unequivalised distribution (subject to the proportional adjustment V_A/V_B).

Appendix D: Tax Implicit Value Judgements

Appendix D.1: Empirical support for analytical approach

Evaluating the value judgements implicit in tax and transfer policy using tax implicit scales requires micro data that describe demographics, private and disposable incomes for each income unit (household). As tax implicit scales generally do not conform to Independence of Base (IB), it also requires data describing household circumstances over the full range of incomes that are of interest. This second demand is made more exacting for survey data sources, as finer descriptions for 'household types' are considered for analysis, and as heterogeneity of tax and transfer treatment within household types increases. These considerations influenced the empirical methodology adopted for this study.

Capturing the relationship between private and disposable income is complicated by the fact that the relationship exhibits discrete changes in gradient, especially toward the bottom of the distribution where means-tested benefits are exhausted. Experimentation revealed that the changes in curvature described by the relationship between private and disposable income could be accommodated by kernel smoothers (e.g. the 'lpoly' Stata routine) by varying bandwidths by private income. This approach, however, was difficult to implement for all years, population subgroups, and data sources considered in the study because there was no objective criterion for defining the assumed bandwidths, and changes in bandwidth sometimes produced discontinuities in estimated relationships.

We found that the fractional polynomial – as implemented by the 'fp' Stata routine setting the dimension parameter to 3 – is able to obtain a close reflection of the relationship between private and disposable incomes described by the survey data explored in this study. The principle drawback of the approach, however, is that it can imply an implausible relationship where the survey data are sparse. This issue is most pronounced at very low, but positive,

private incomes, where the fractional polynomial has a tendency to generate a relationship exhibiting a local trough, and at high private incomes, where curvature can vary substantively with the sample. This places an additional burden on the sample sizes considered for estimation.

The sample sizes of alternative household types described by the survey data are reported in Tables D.1 and D.2. Table D.1 indicates that LCF cross-sectional sample sizes are relatively small for single parents (particularly early in the sample period), for disabled singles, and for couples with and without children (particularly late in the sample period). For couples, the decline in samples sizes reported by more recent surveys is due both to the decline in the total sample reported by the LCF, and to a rise in two-earner households; analysis here focuses on single-earner households to simplify inter-household comparisons. The relative sample sizes reported for population subgroups by the FRS are qualitatively similar to the LCF, although the absolute numbers reported by the FRS are substantively larger as discussed in Section 3.1 and Appendix B.

Intertemporal variation of the tax and transfer policies explored here exhibits auto-regression, as discussed in Section 2.2. This auto-regression motivated the choice to pool data from three consecutive survey years to improve estimates for the relationship between private and disposable incomes. The estimated tax functions for all population subgroups in all years were compared against scatter-plots of the raw survey data for the respective year. Examples of these plots are reported below for single adults and couples. The household types reported below are of particular interest, as they are assumed as alternative reference units for the analysis. The full set of plots is available from the authors upon request.

Table D.1: Year specific sample sizes by household type; LCF data

year	single adults	single 1 child	disabled single	couple	couple 1 child	couple 2 children	single pensioners	couple pensioners
1968	298	26	13	312	354	376	603	737
1969	264	23	18	283	313	364	609	732
1970	235	32	13	241	280	313	559	686
1971	288	39	19	302	326	332	659	767
1972	301	33	9	305	331	335	639	732
1973	312	33	21	272	242	288	769	811
1974	286	40	17	213	261	273	679	772
1975	329	40	16	237	268	353	793	773
1976	364	36	18	282	257	338	793	849
1977	343	50	25	258	256	297	766	809
1978	356	53	29	280	240	287	785	794
1979	384	62	24	226	247	258	809	758
1980	335	58	16	247	235	272	833	735
1981	385	66	17	278	243	291	859	833
1982	446	74	28	283	293	392	853	784
1983	418	96	25	300	276	350	801	774
1984	445	65	21	308	275	316	836	733
1985	460	75	26	262	269	315	834	757
1986	462	100	32	277	242	283	855	770
1987	520	113	21	268	224	296	920	764
1988	524	99	37	255	203	248	889	785
1989	517	115	37	268	227	227	865	810
1990	542	135	38	221	177	205	897	713
1991	543	116	42	270	189	232	924	668
1992	623	120	64	288	189	248	921	781
1993	562	139	69	300	194	203	833	740
1994	605	127	75	232	190	204	796	607
1995	598	142	87	243	186	197	752	615
1996	547	146	85	236	165	193	666	570
1997	581	169	103	233	157	164	668	563
1998	583	146	103	230	135	159	677	587
1999	708	170	114	241	166	161	751	592
2000	665	126	125	200	96	138	661	616
2001	683	179	154	229	131	158	768	691
2002	609	154	118	197	122	137	679	698
2003	639	162	123	218	125	134	724	651
2004	586	140	130	177	133	119	704	646
2005	594	133	142	212	134	122	735	673
2006	579	147	124	173	120	126	701	681
2007	503	134	100	192	108	107	611	637
2008	499	109	122	154	95	101	614	621

Continued next page.

Table D.1: Year specific sample sizes by household type; LCF data (cont.)

year	single adults	single 1 child	disabled single	couple	couple 1 child	couple 2 children	single pensioners	couple pensioners
2009	510	105	120	162	121	94	581	636
2010	430	96	109	156	92	93	586	546
2011	473	123	127	146	100	86	578	662
2012	413	96	96	176	119	108	609	670
2013	385	86	79	140	77	85	582	684
2014	360	88	98	158	68	93	548	693
2015	390	71	100	119	79	82	509	620

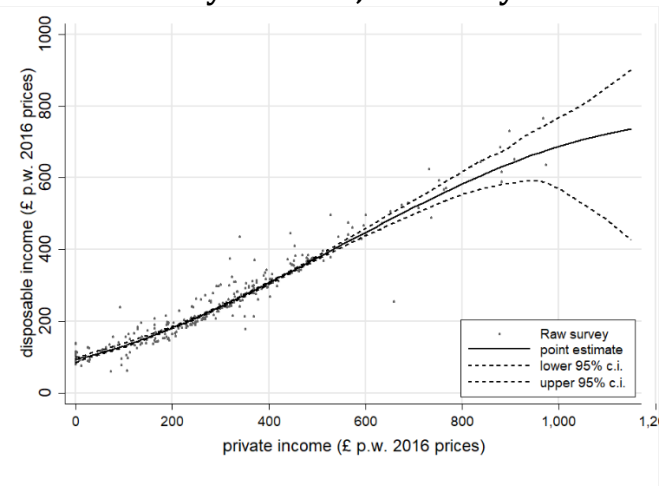
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: single adults = households with one adult, aged 25-59, with disposable income worth at least £60 per week (2016 prices), not in receipt of disability or own-business income, and without children. Single 1 child = same as single adult, but with one child aged 13 or under. Disabled single = same as single adult, but with disability income. Couple = same as single adult, but with two adult members, disposable income worth at least £100 per week, and up to one adult identified as working. Couple 1/2 child(ren) = same as couple, but with 1/2 child(ren). Single pensioner = same as single adult but aged 65+. Couple pensioner = same as couple, but with eldest member aged 65+.

Table D.2: Year specific sample sizes by household type; FRS data

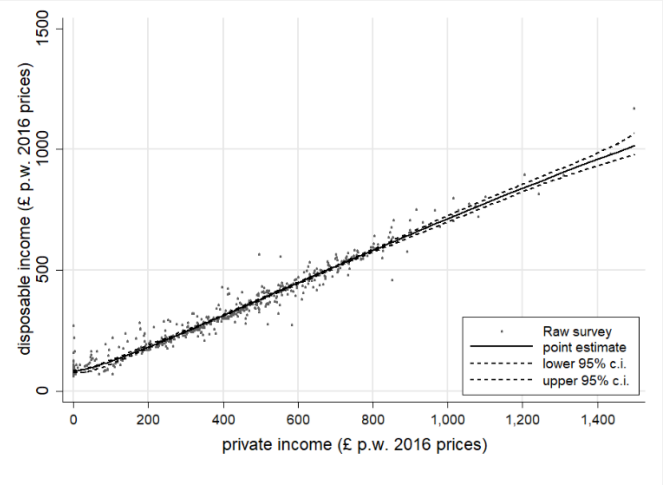
year	single adults	single 1 child	disabled single	couple	couple 1 child	couple 2 children	single pensioners	couple pensioners
1994	2202	617	322	853	577	715	3307	2443
1995	2267	615	378	829	541	607	3154	2172
1996	2232	601	417	799	449	593	3101	2086
1997	2049	533	368	717	421	498	2634	1980
1998	2023	510	363	699	431	459	2573	1984
1999	2203	549	440	755	453	509	2791	2179
2000	2146	551	406	710	398	496	2590	2116
2001	2262	585	433	749	481	489	2664	2211
2002	2576	660	588	874	526	575	2995	2440
2003	2614	659	580	834	545	562	2943	2562
2004	2490	644	605	748	549	510	2843	2481
2005	2469	632	621	782	489	486	2904	2455
2006	2301	570	563	729	474	484	2555	2409
2007	2202	554	580	706	446	432	2643	2225
2008	2401	588	348	810	476	454	2527	2331
2009	2450	594	393	911	461	459	2519	2469
2010	2346	536	401	824	487	475	2506	2513
2011	1955	457	324	689	370	354	2015	2080
2012	1822	451	371	620	324	382	2150	2117
2013	1801	409	306	614	346	332	2201	2178
2014	1710	408	289	570	294	330	2131	2224
2015	1710	410	379	579	310	308	2200	2153

Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series.
Notes: As for Table C.1.

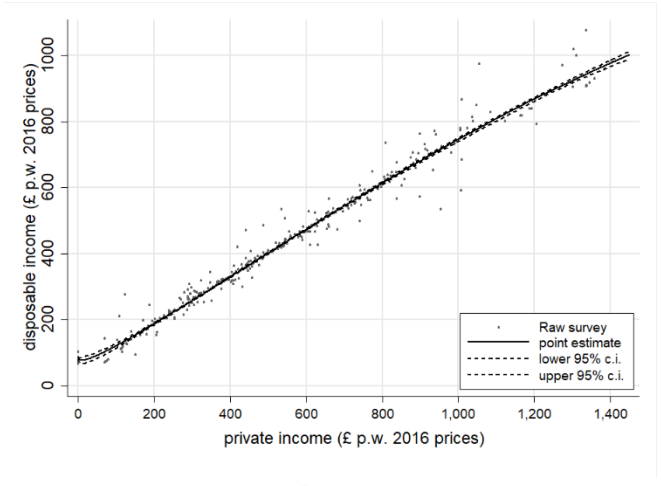
Figure D.1: Relationship between private and disposable income of single adults described by LCF data, selected years



Panel A: 1974



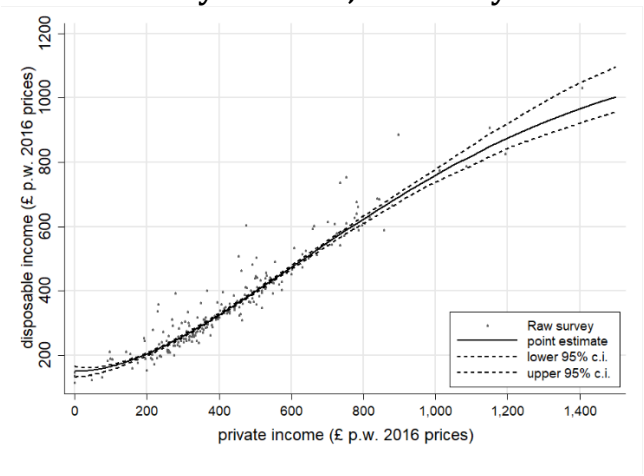
Panel B: 1994



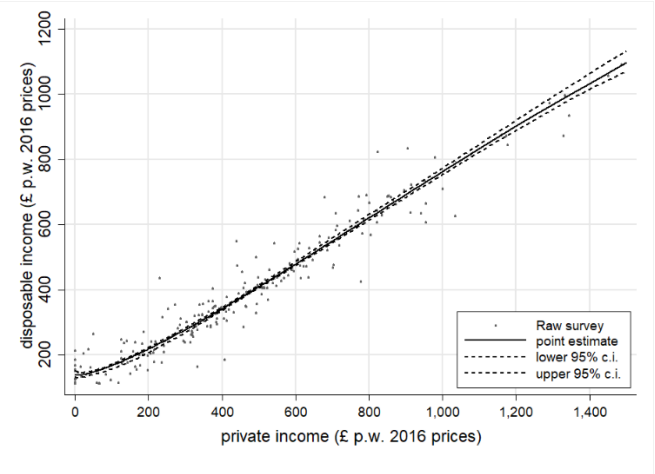
Panel C: 2014

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: Sample limited to households with one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Smoothed functions estimated by fractional polynomial regression on pooled data for three years centred about reference year. 95% confidence intervals estimated from 100 bootstrap replications.

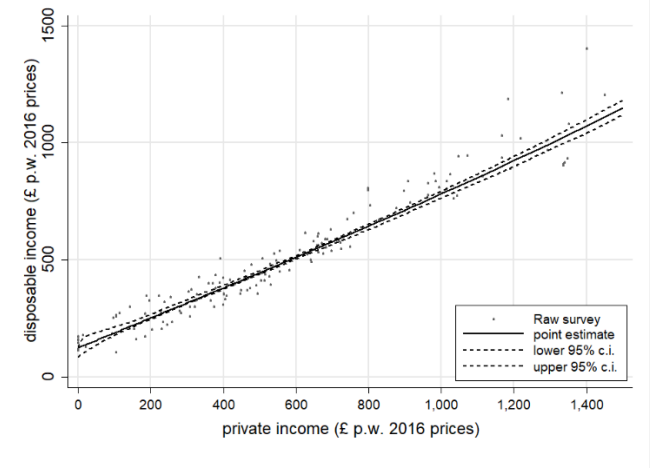
Figure D.2: Relationship between private and disposable income of adult couples described by LCF data, selected years



Panel A: 1974



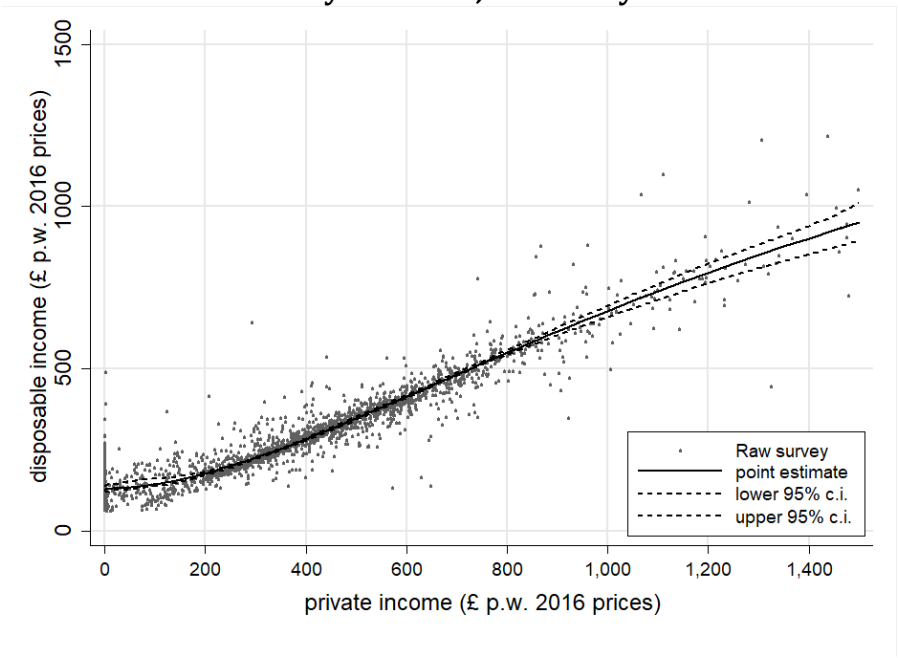
Panel B: 1994



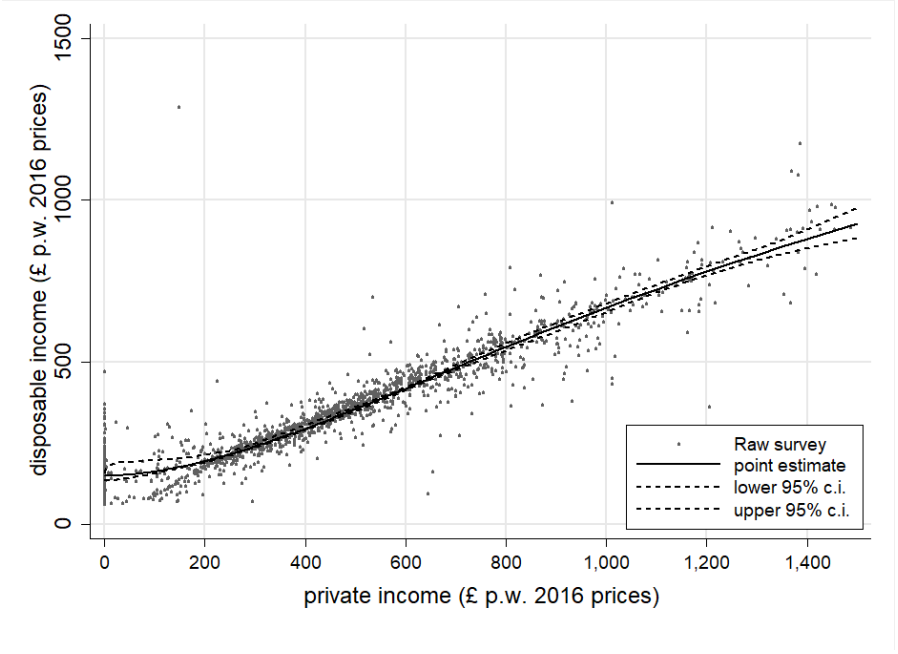
Panel C: 2014

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.1.

Figure D.3: Relationship between private and disposable income of single adults described by FRS data, selected years



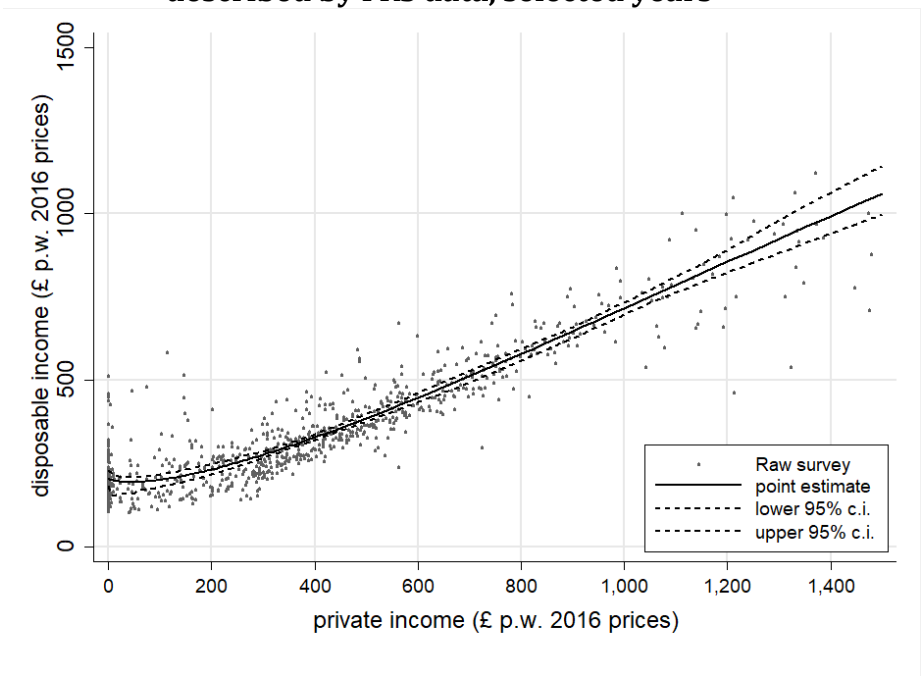
Panel A: 1995



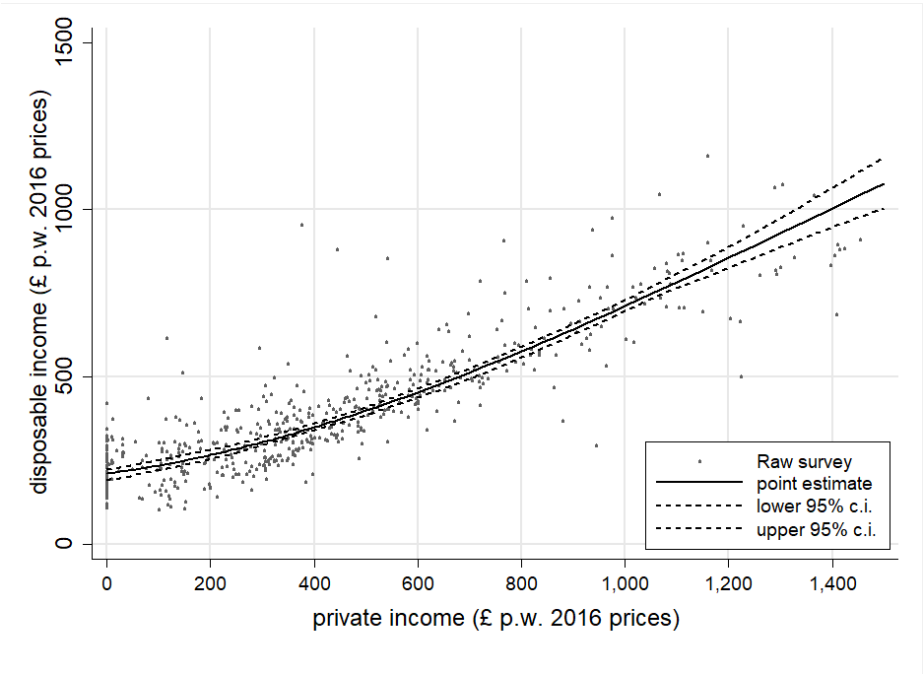
Panel B: 2014

Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series.
Notes: As for Figure D.1.

Figure D.4: Relationship between private and disposable income of adults couples described by FRS data, selected years



Panel A: 1995



Panel B: 2014

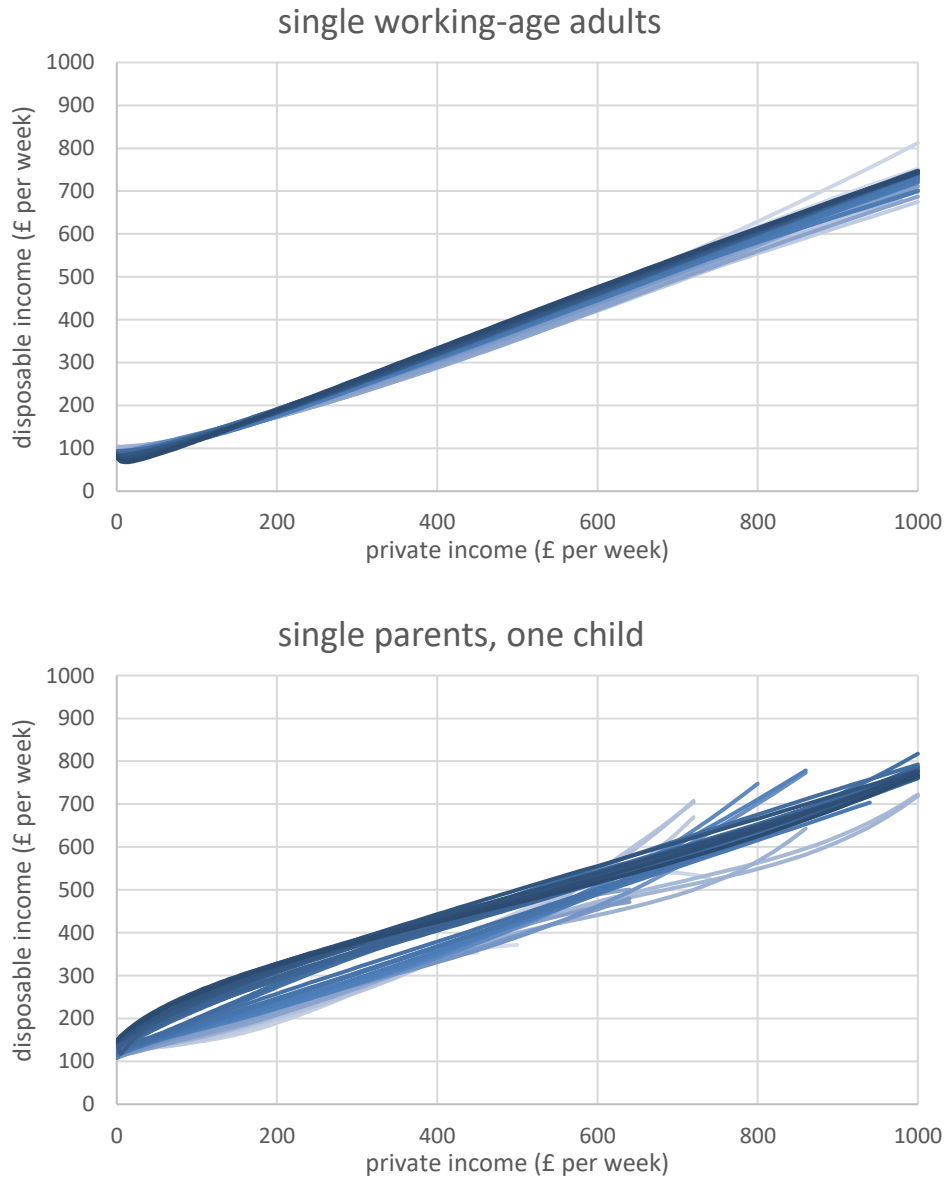
Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series.
Notes: As for Figure D.1.

Appendix D.2: Supplementary statistics for principal tax implicit scale estimates

Estimated tax and transfer functions

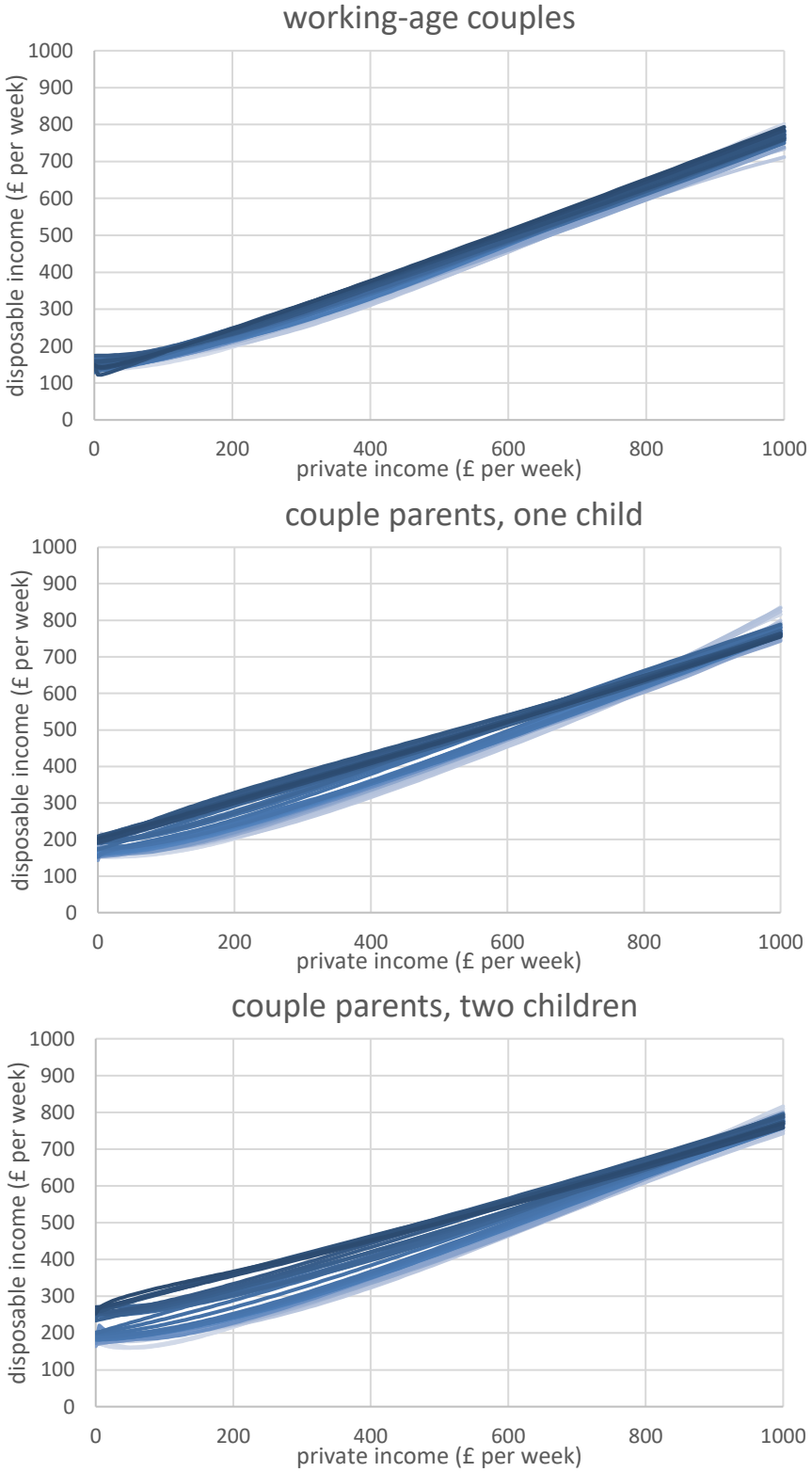
This appendix reports point estimates for disposable income as a function of private income for all years and population subgroups discussed in Section 4.1.

Figure D.5: Estimated relationships between private and disposable income for single adults of working age by sample year, 1969 to 2014



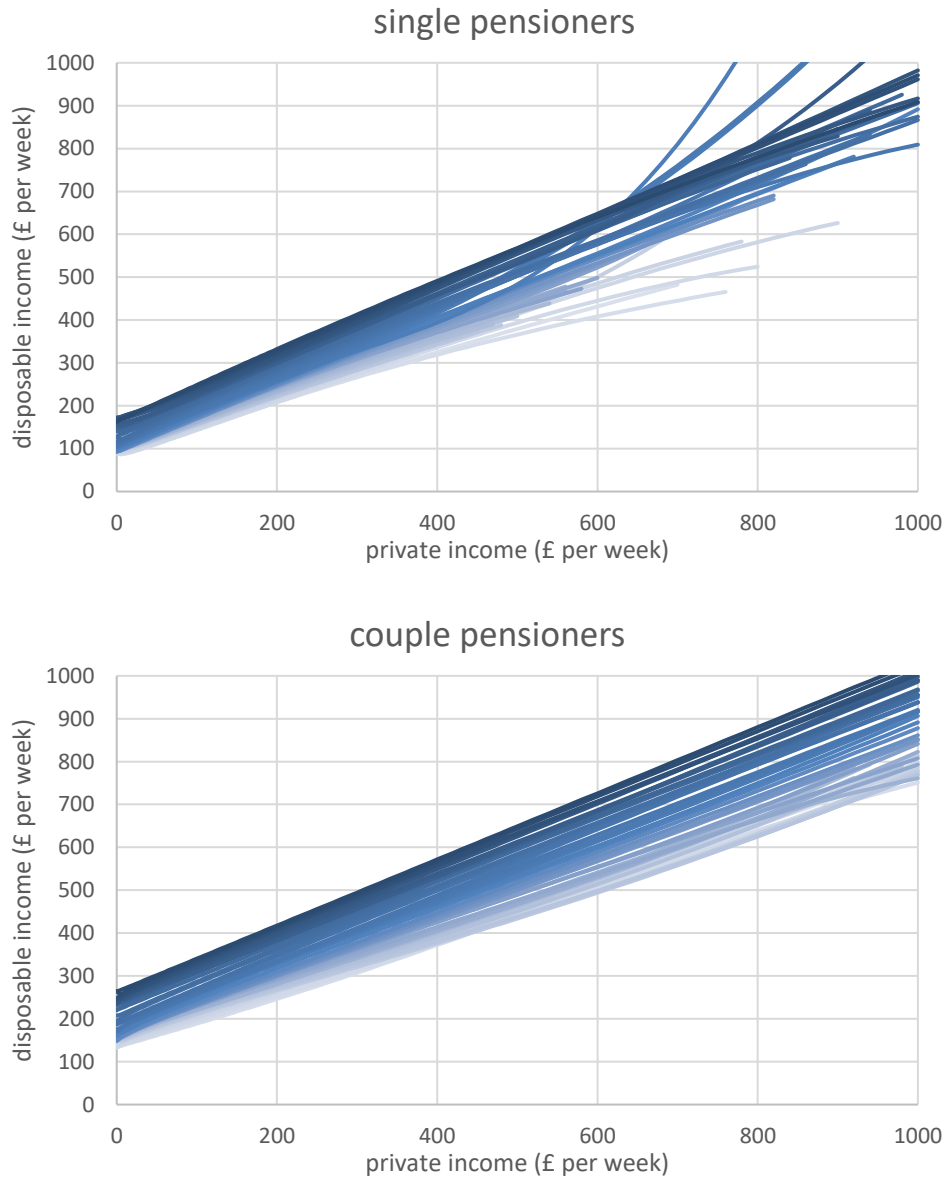
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: Relationships between private and disposable income estimated using fractional polynomial regressions, via the 'fp' Stata routine setting the dimension parameter to 3. Relationship for any given year evaluated on pooled data from three consecutive years centred about given year. Schedules estimated for more recent years presented in darker shading. single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Single parents = same as single adult, but with one child aged 13 or under. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Figure D.6: Estimated relationships between private and disposable income for working-age couples by sample year, 1969 to 2014



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.5. Couple, no children same as single adult, but with two individuals aged under 60 and over 13, and disposable income worth at least £100 per week. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under.

Figure D.7: Estimated relationships between private and disposable income for pension-age households by sample year, 1969 to 2014

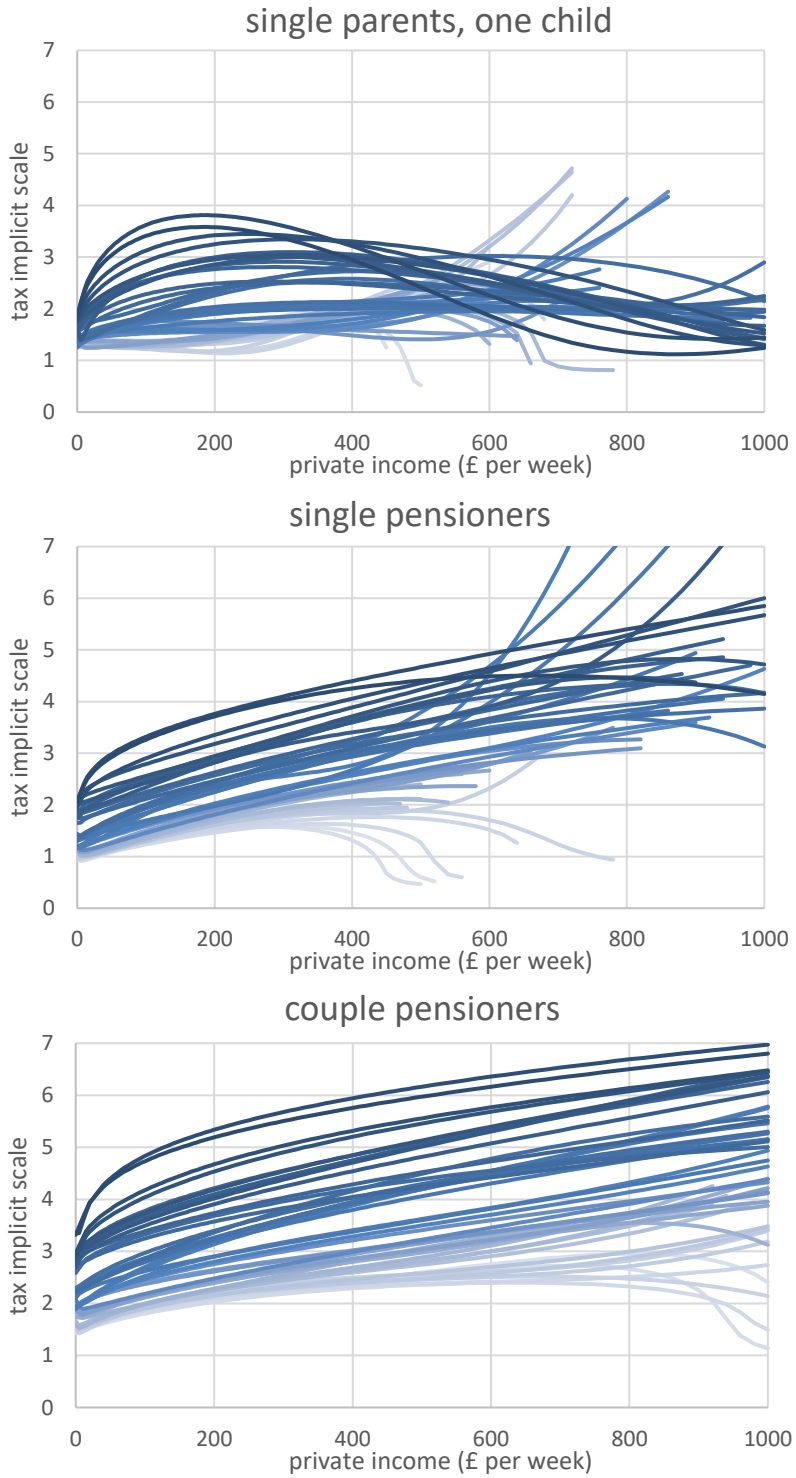


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.5. Single pensioners, defined as households comprised of single adult aged 65+. Couple pensioners defined as households comprised of two adults, at least one of whom is aged 65+.

Full set of point-estimates for tax implicit scales

This appendix reports point estimates for tax implicit scales as a function of private income for all years and population subgroups discussed in Section 4.1.

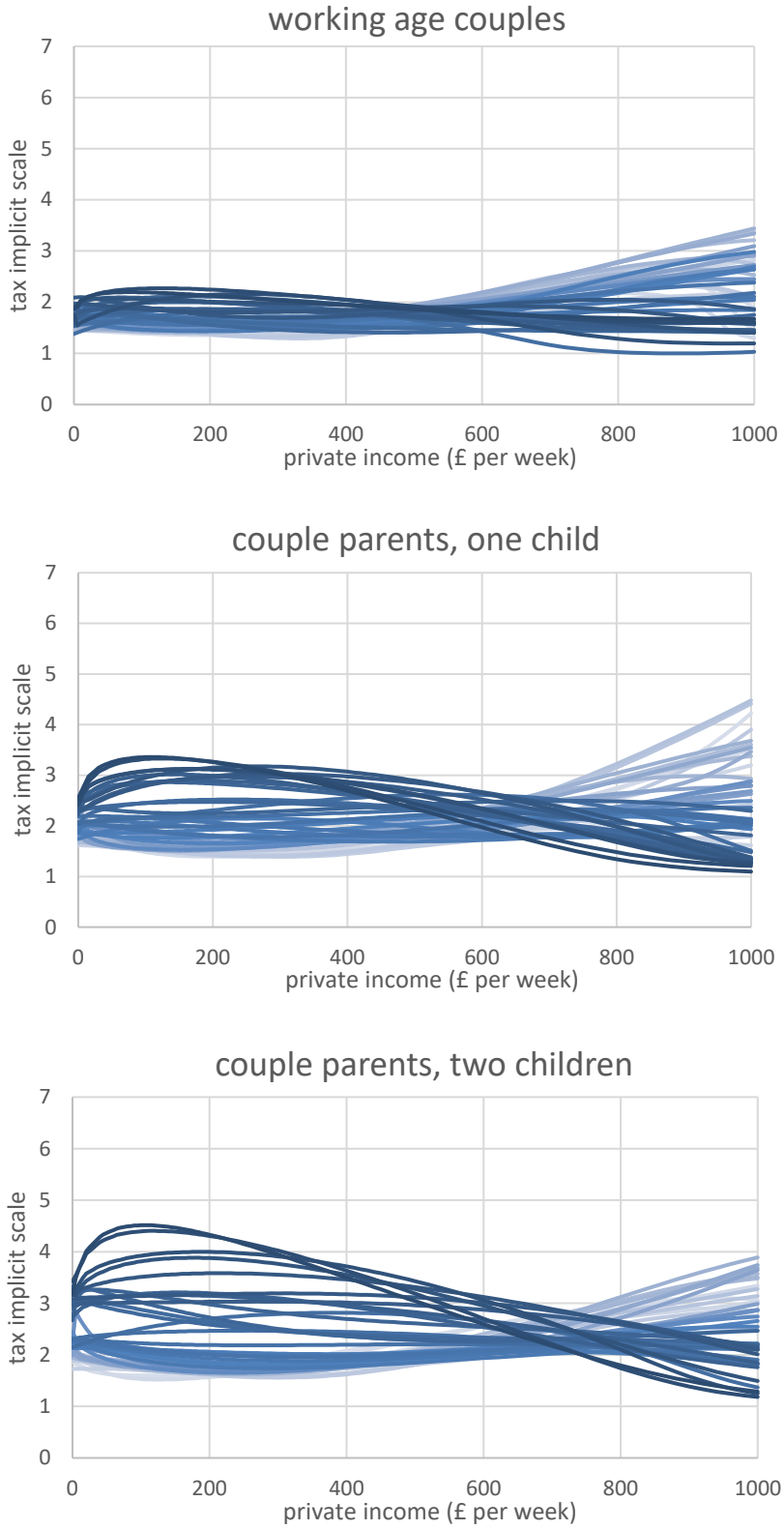
Figure D.8: Point-estimates for tax implicit scales by household type and sample year, 1969 to 2014



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).

Notes: Tax implicit scales measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Single parents = same as single adult, but with one child aged 13 or under. Pensioners identified as households with at least one member aged 65+. Tax implicit scales estimated separately for each year, on pooled data from three consecutive years centred about given year. Estimates for more recent years presented in darker shading.

Figure D.9: Point-estimates for tax implicit scales by household type and sample year, 1969 to 2014



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Couple, no children same as single adult, but with two individuals aged under 60 and over 13, and disposable income worth at least £100 per week. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under.

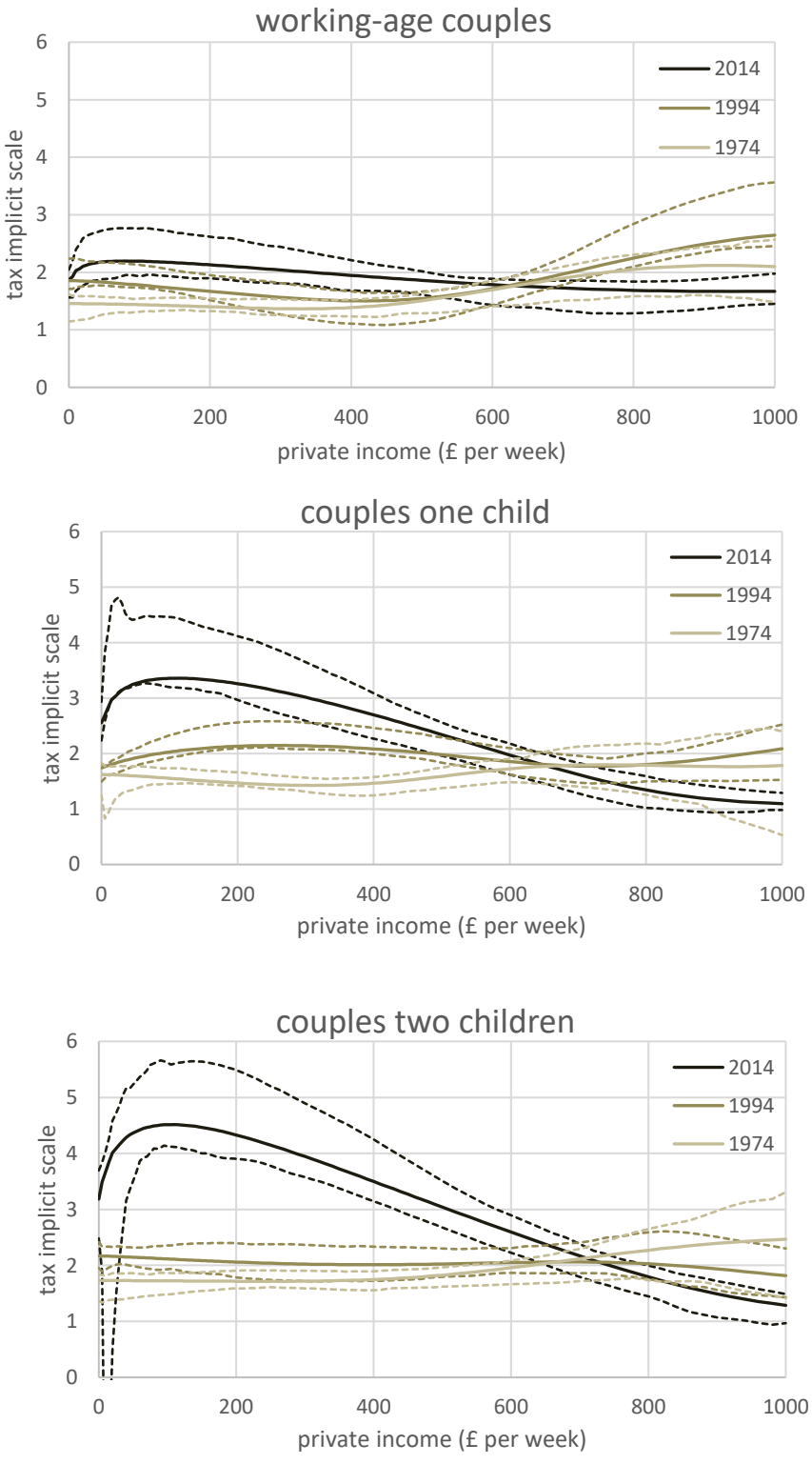
Statistical dispersion of estimated tax implicit scales

This appendix reports 90% confidence intervals about point estimates for tax implicit scales as a function of private income for all population subgroups in selected years discussed in Section 4.1.

Figure D.10: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Dotted lines indicate 90% confidence intervals of bootstrap point estimates. Estimates for more recent years presented in darker shading.

Figure D.11: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year

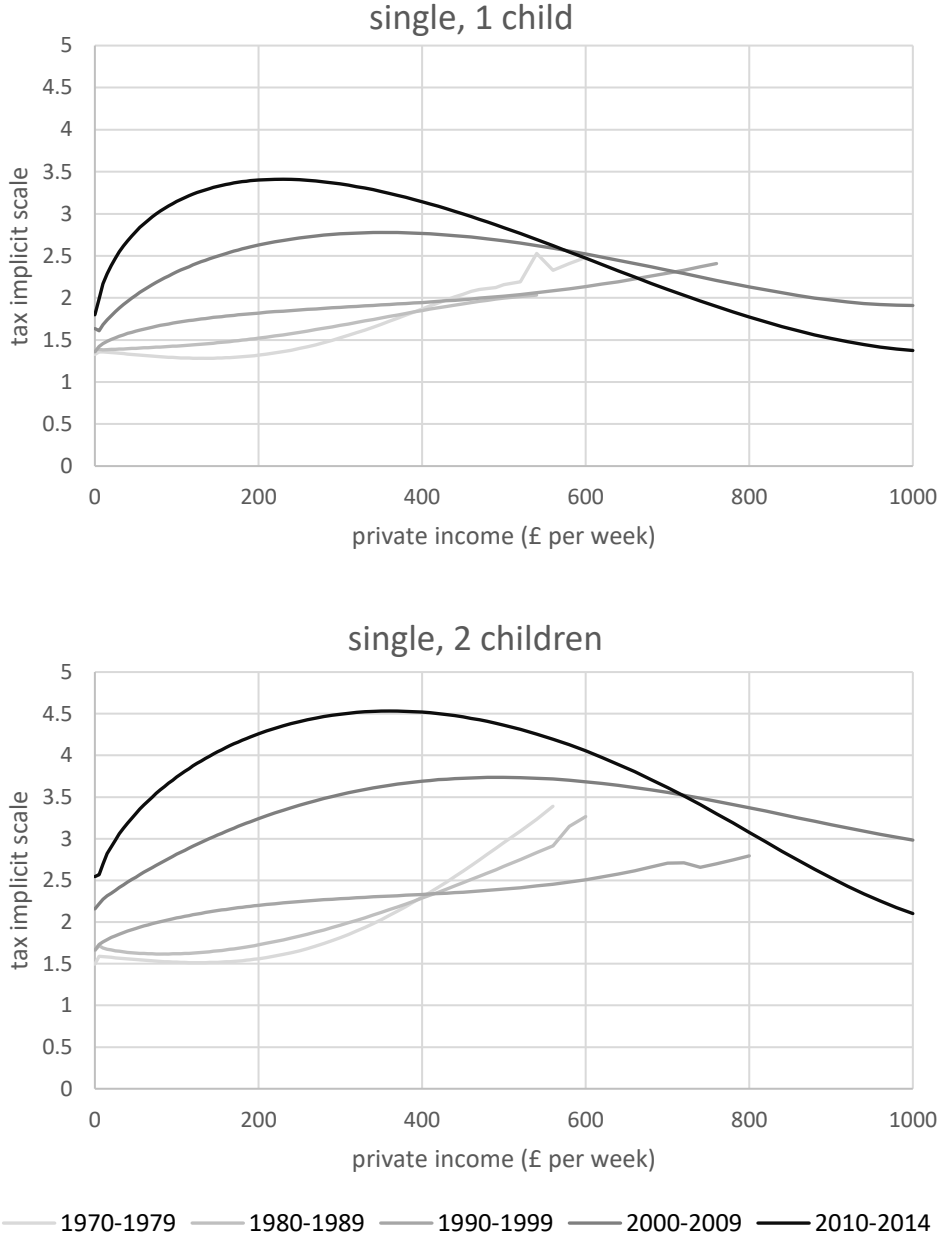


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.10. Couple, no children same as single adult, but with two individuals aged under 60 and over 13, and disposable income worth at least £100 per week. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under.

Scales for supplementary household characteristics

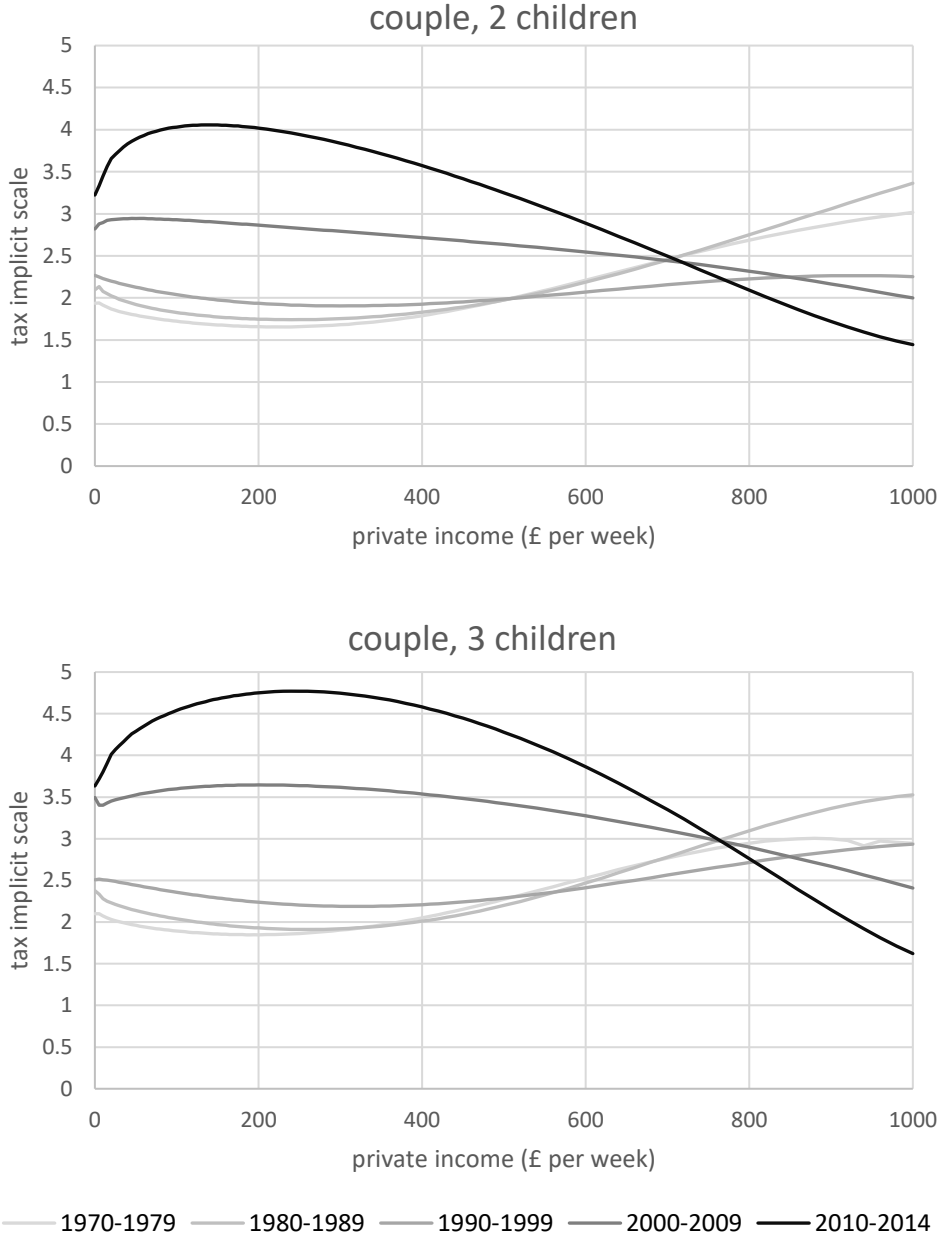
This appendix reports tax implicit scales estimated for population subgroups beyond those reported in Section 4.1. Estimates reported for families with children indicate evidence of trend variation with the number of dependent children. Relaxing the restriction of working-age couples to include two earner families is shown to have little impact on estimated tax implicit scales. Estimates reported for single adults in receipt of disability benefits indicate a trend toward more favourable treatment of this population subgroup at measures of private income under £500 per week, relative to single working-age adults. This is in contrast to the relative stability of disability benefits discussed in Appendix A.2.

Figure D.12: Tax implicit scale estimates for single parents



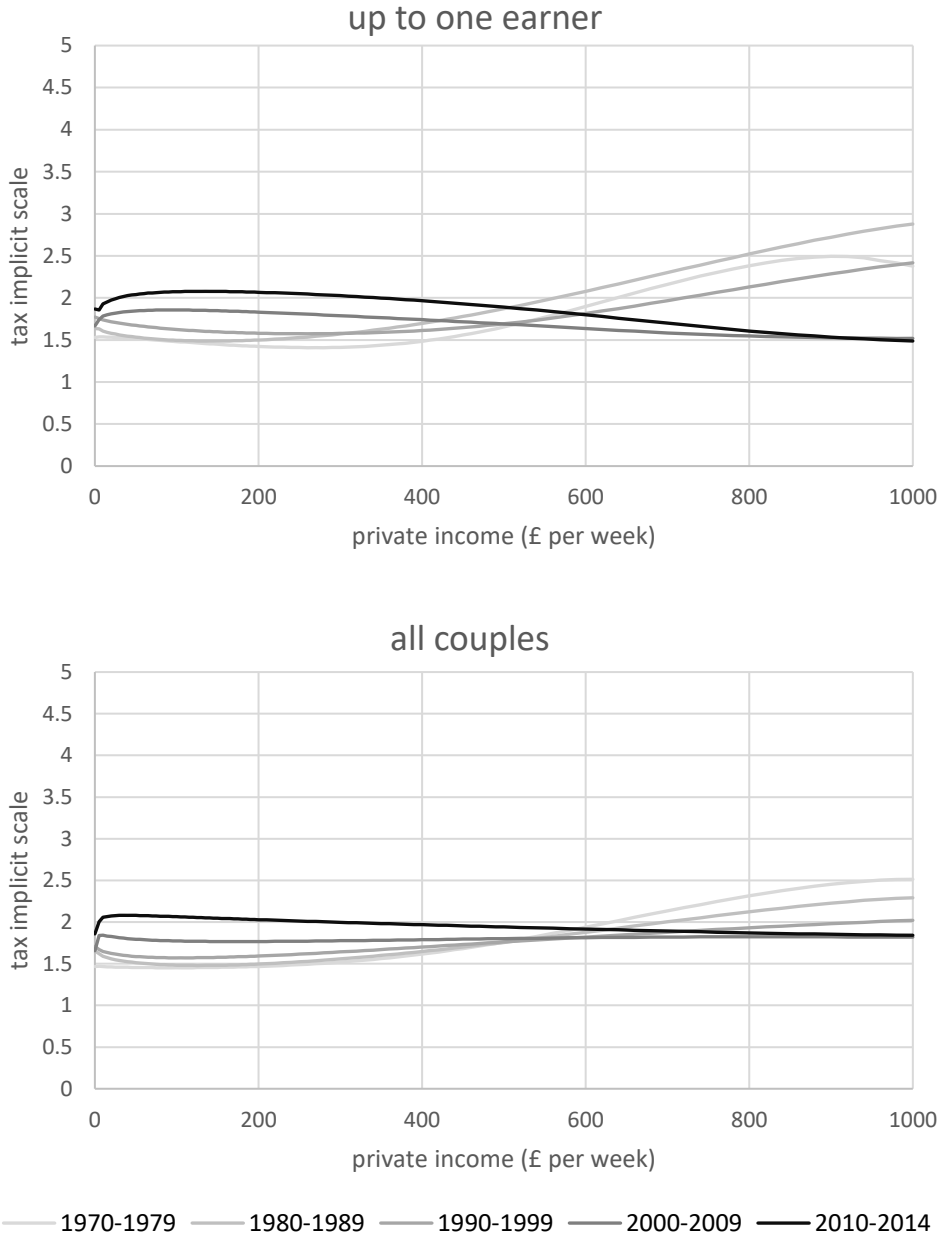
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Singles, 1 child reported in Section 4.1 and included here for comparison.

Figure D.13: Tax implicit scale estimates for couple parents



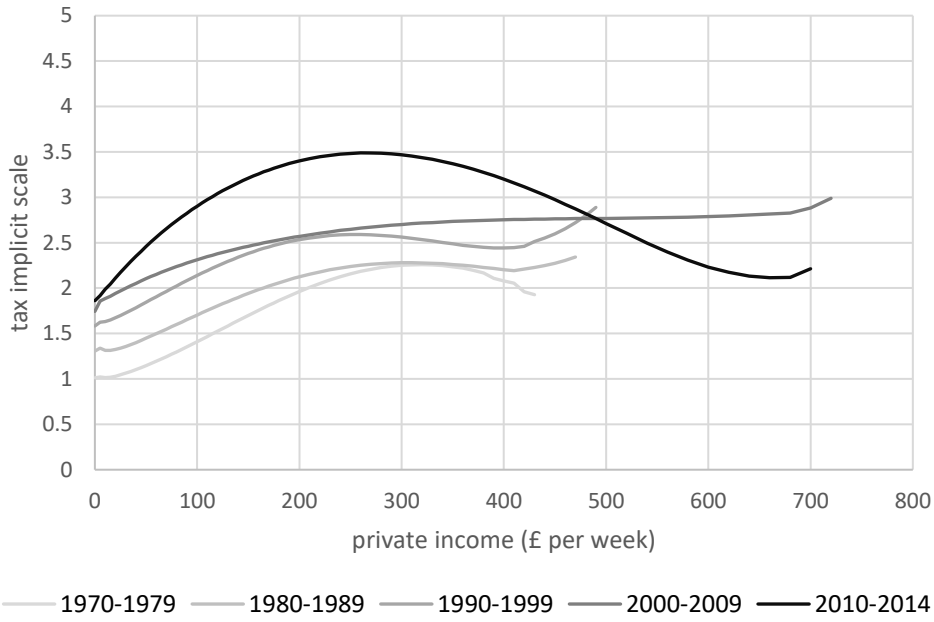
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Couples, 2 children reported in Section 4.1 and included here for comparison.

Figure D.14: Tax implicit scale estimates for working-age couples with children



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Couples with up to one earner reported in Section 4.1, and included here for comparison.

Figure D.15: Tax implicit scale estimates for single adults affected by disability



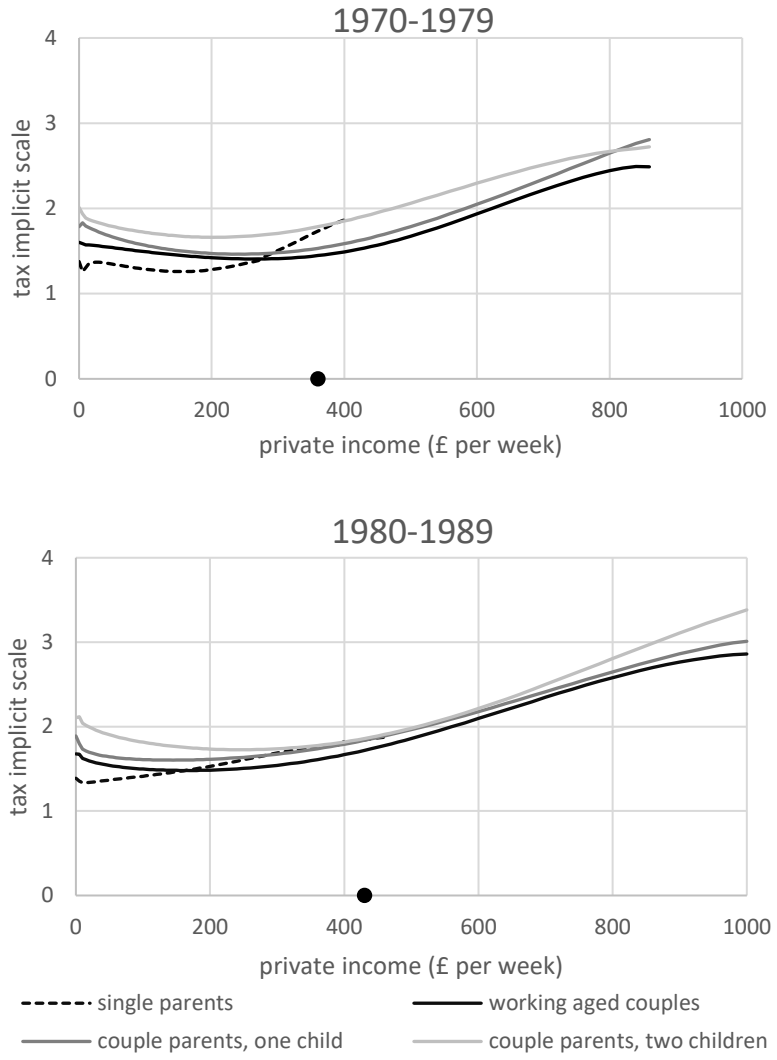
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Statistics are for single adults without children, aged under 60 years, with at disposable income of at least £60 per week, in receipt of disability benefits, and not in receipt of own-business income.

Appendix D.3: Sensitivity to pooling across sample years

This appendix reports estimates of tax implicit scales calculated on data reported for individual survey years (un-pooled data). Comparing Figures D.16 to D.18 with Figures 4.1 and 4.2 reveals that pooling across sample years had little impact on point estimates for tax implicit scales. Pooling of year specific data does, however, have an important bearing on the dispersion of point estimates, as indicated by comparing Figures D.19 and D.20 with D.10 and D.11.

Similar statistics to those reported here were also obtained by pooling over five years of data (results available from the authors upon request).

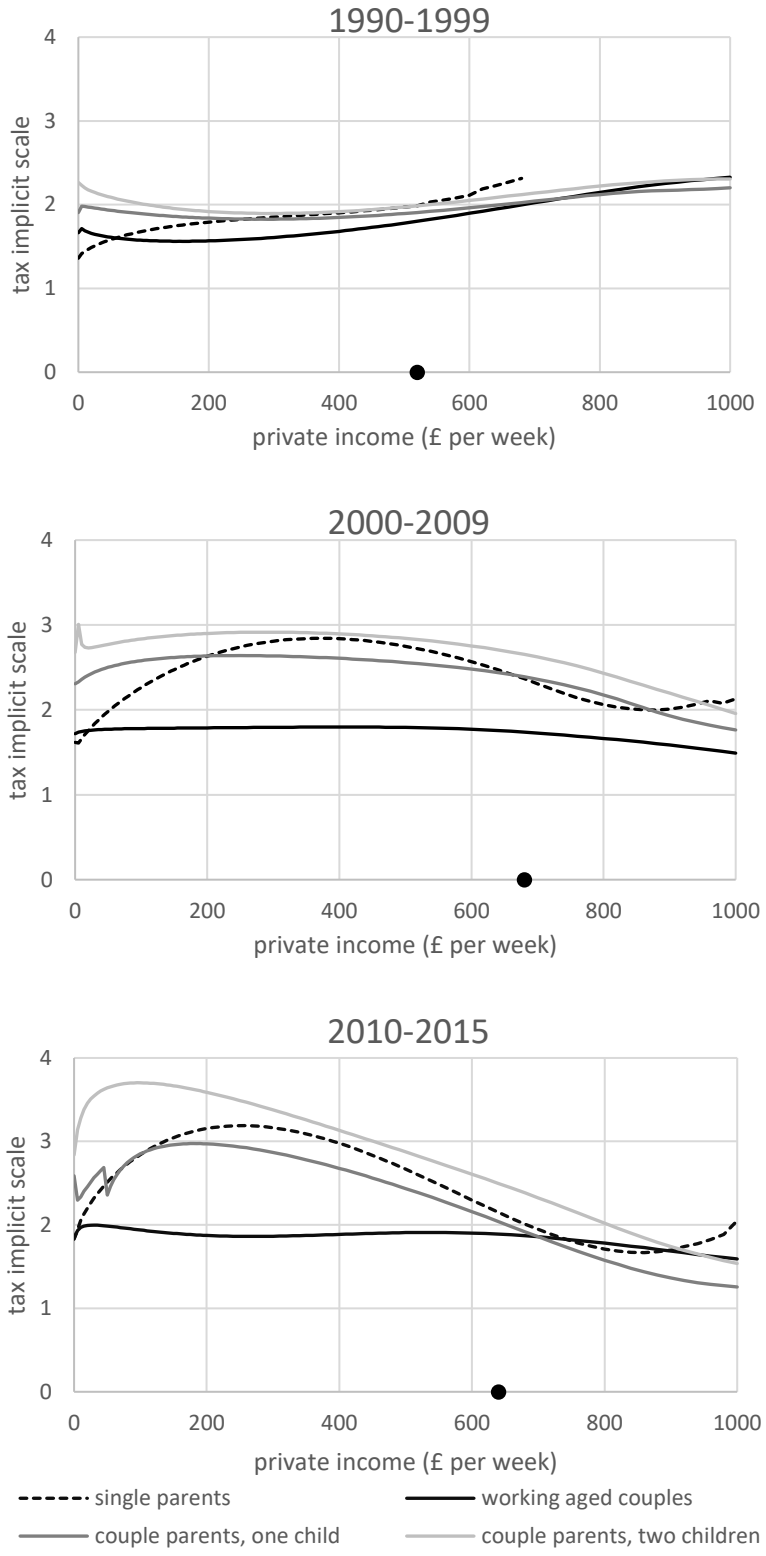
Figure D.16: Tax implicit scale estimates; working-age population, 1970 to 1989; estimates evaluated on data for individual survey years (un-pooled)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)

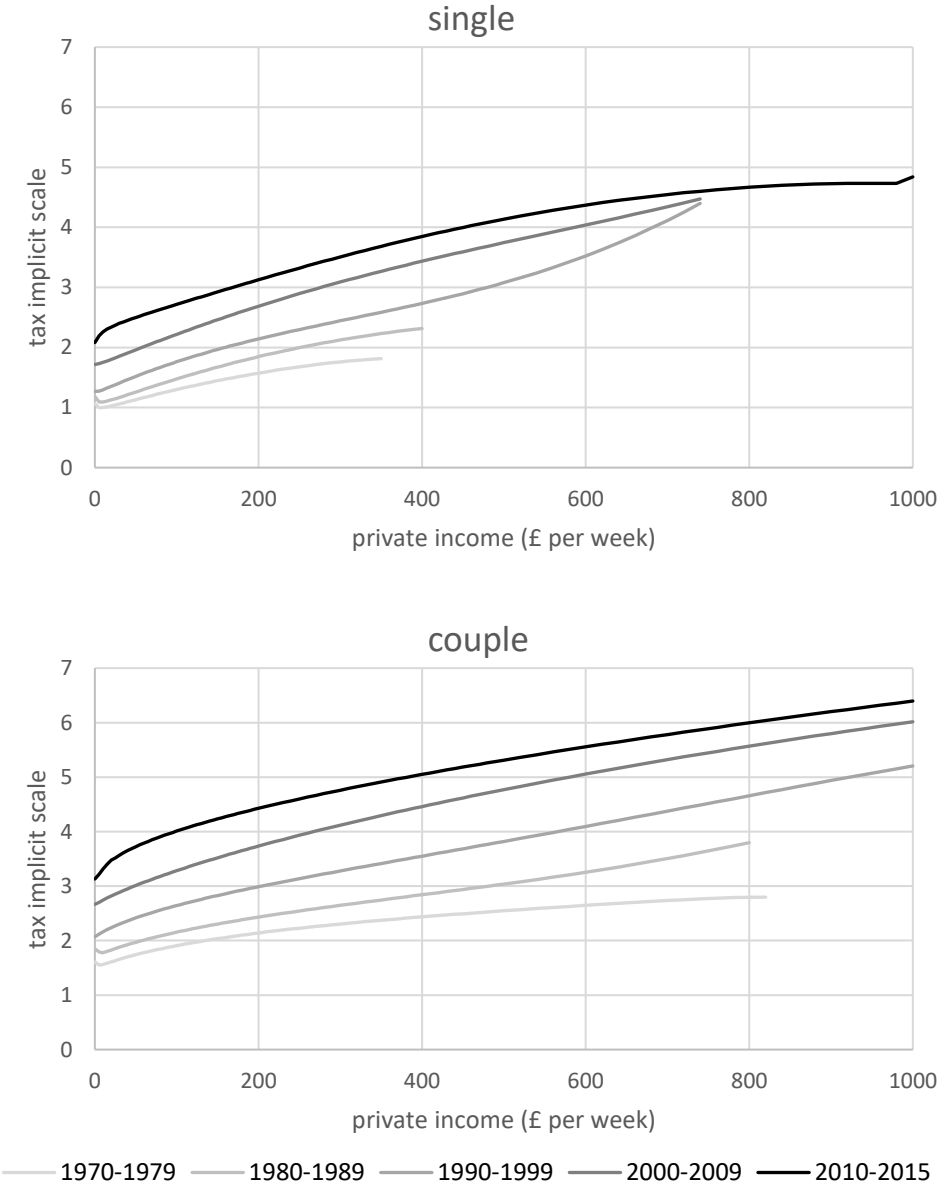
Notes: Tax implicit scales measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Single parents = same as single adult, but with one child aged 13 or under. Couple, no children same as single adult, but with two individuals aged under 60 and over 13 and with disposable income worth at least £100 per week. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under. Median income = median household private income. Median income reported as black dot on horizontal axis, equal to values reported for 1977 and 1985. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Tax implicit scales estimated separately for each year as described in Sections 3.2 and 4.1 and averaged over 10-year intervals.

Figure D.17: Tax implicit scale estimates; working-age population, 1990 to 2014; estimates evaluated on data for individual survey years (un-pooled)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)
Notes: As for Figure D.16. Median income values reported for 1995, 2005, and 2012.

Figure D.18: Tax implicit scale estimates; pension-age population, 1970 to 2014; estimates evaluated on data for individual survey years (un-pooled)

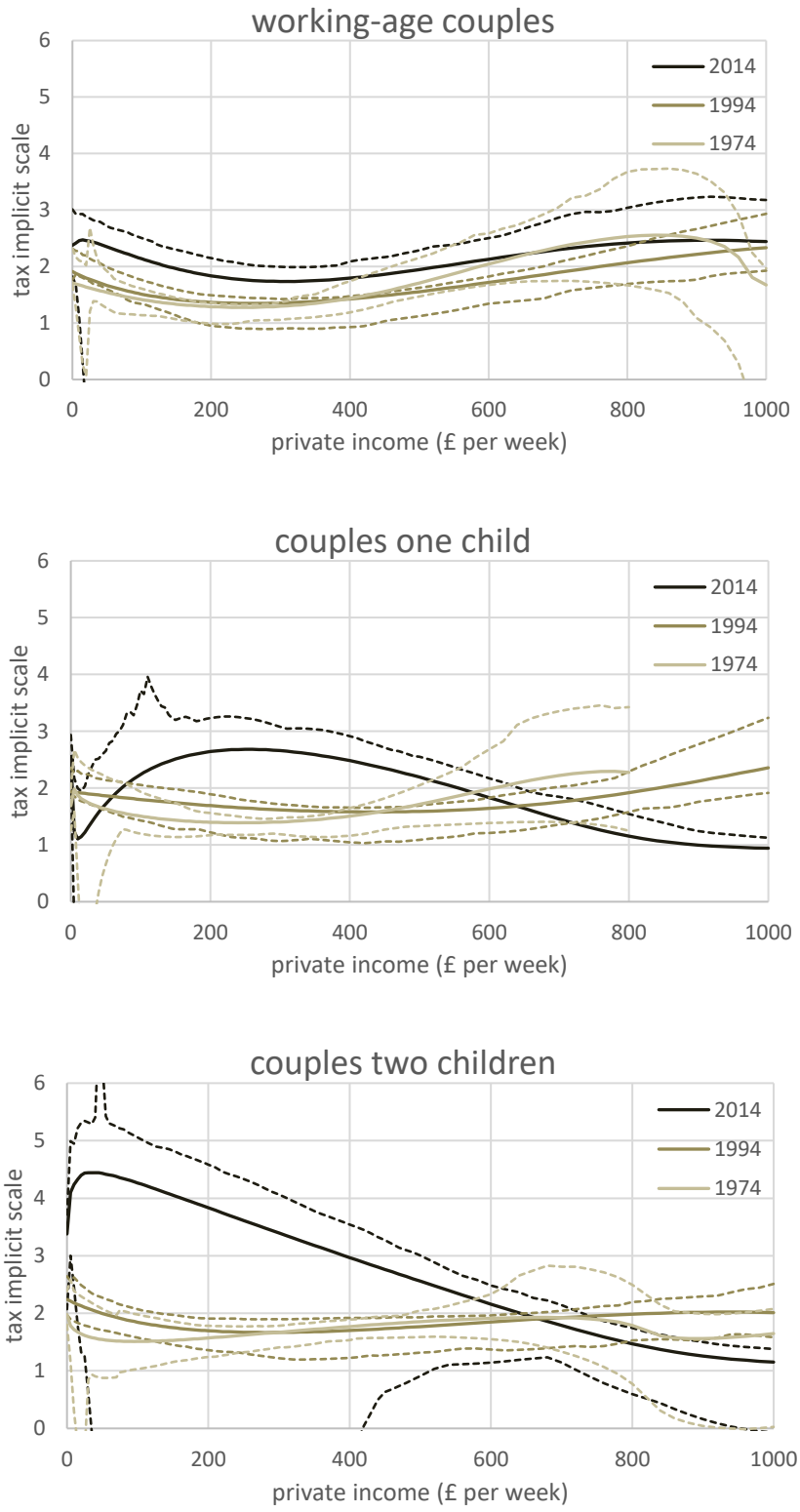


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.16. Single pensioners, defined as households comprised of single adult aged 65+. Couple pensioners defined as households comprised of two adults, at least one of whom is aged 65+.

Figure D.19: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.8. Dotted lines indicate 90% confidence intervals of bootstrap point estimates. Estimates for more recent years presented in darker shading.

Figure D.20: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year



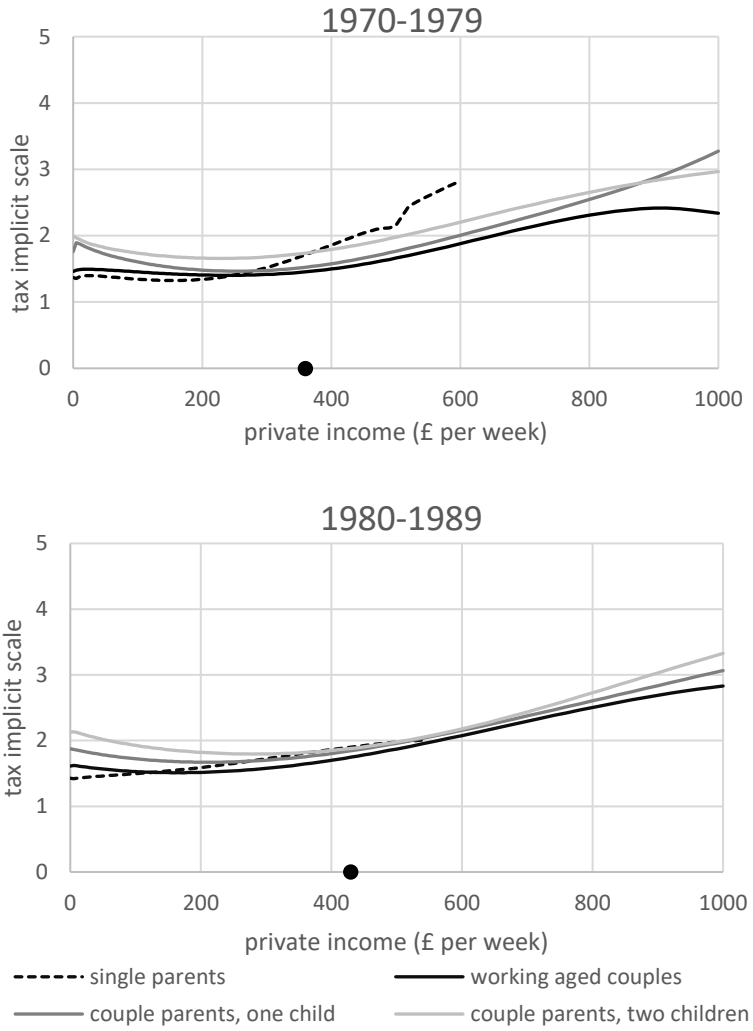
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.10. Couple, no children same as single adult, but with two individuals aged under 60 and over 13, and disposable income worth at least £100 per week. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under.

Appendix D.4: Sensitivity to truncation of sample population

Between 1969 and 2008, estimates for tax implicit scales are broadly insensitive to censoring of working-age households that report disposable incomes under the safety-net defined by the (real) value of unemployment benefits. This can be seen by comparing Figures 4.1 and 4.2 with Figures D.21 and D.22. However, whereas point estimates for tax implicit scales of the working age population between 2009 and 2014 are also broadly insensitive to censoring with respect to disposable income, censoring substantively reduces associated confidence intervals. This can be seen in Figures D.23 and D.24.

The substantive increase in confidence intervals on uncensored data that is evident from 2009 is attributable to the nature of incomes reported for working-age single adults toward the bottom of the distribution. Specifically, the proportion of households reporting disposable income equal to private income toward the bottom of the income distribution increased appreciably following the Great Recession. Representative data for this shift are reported in Figure D.25. These data indicate that the fraction of single working-age adults with private income under £200 per week who reported disposable income equal to private income increased from 12% in 2008 to 34% in 2014. This shift is sufficient to generate bootstrapped resamples that generate two distinctively different estimates for the relationship between private and disposable income for the population; one in which the relationship at low incomes is approximately flat, and another that drops sharply at private incomes just above zero; associated statistics are reported in Figure D.26. It is this statistical dichotomy that is responsible for the wide standard errors, which is omitted by censoring disposable incomes below the welfare safety-net.

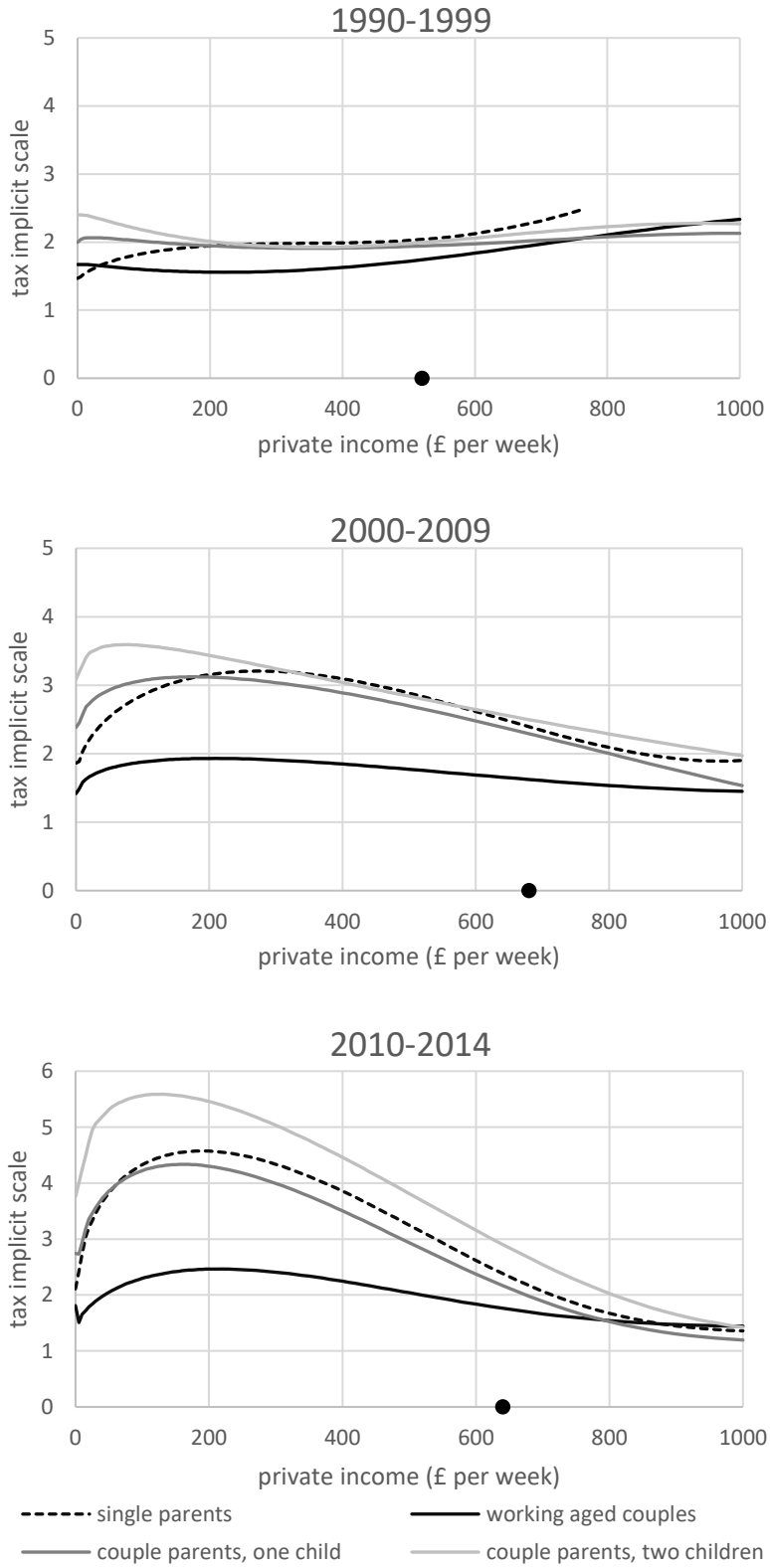
Figure D.21: Tax implicit scale estimates; working-age population, 1970 to 1989; households with disposable income under welfare safety-net not censored out



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)

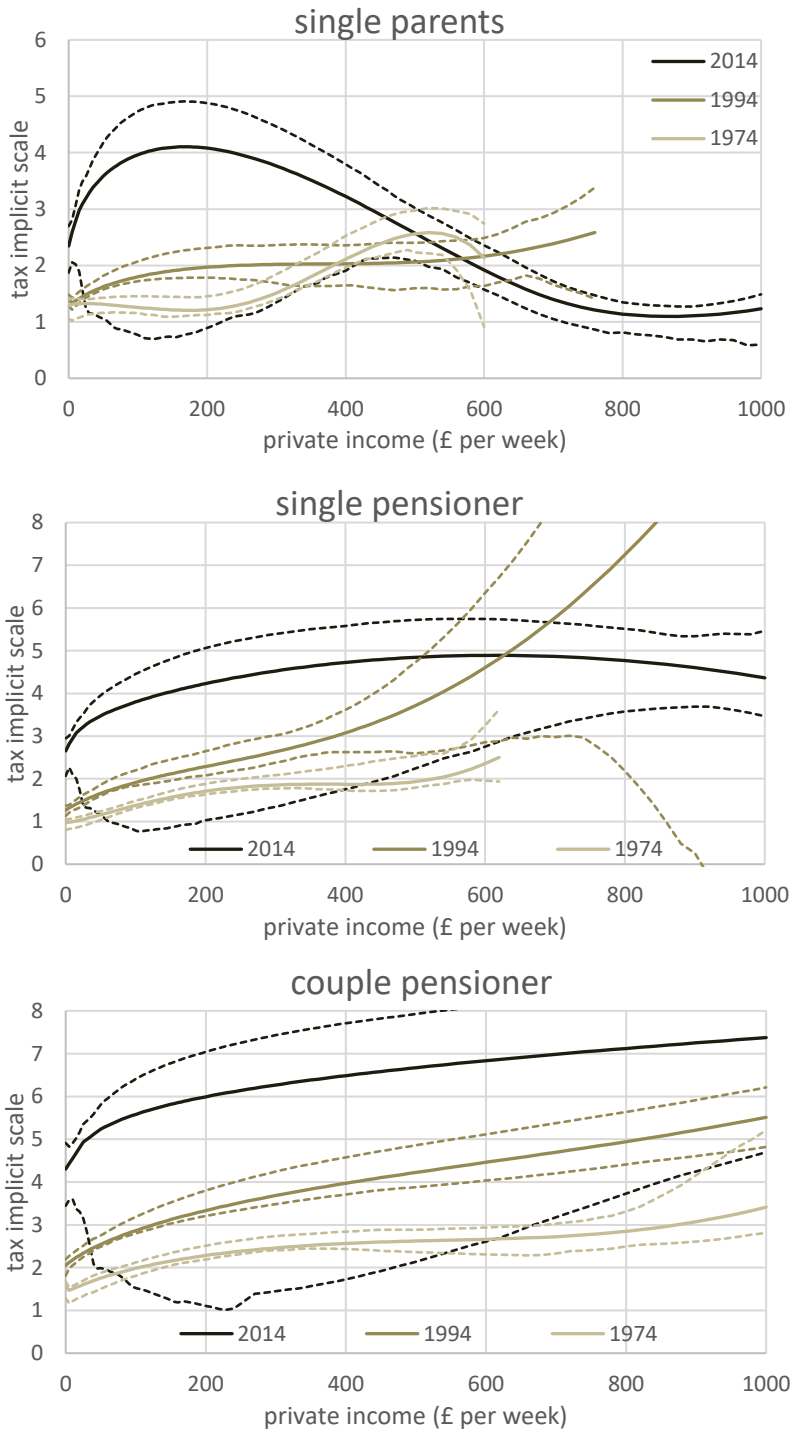
Notes: Tax implicit scales measured relative to single adult households, comprised of one adult, aged 25-59, not in receipt of disability or own-business income, and without children. Single parents = same as single adult, but with one child aged 13 or under. Couple, no children same as single adult, but with two individuals aged under 60 and over 13. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under. Median income = median household private income. Median income reported as black dot on horizontal axis, equal to values reported for 1977 and 1985. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Tax implicit scales estimated separately for each year, on pooled data from three consecutive years centred about given year and averaged over intervals as indicated.

Figure D.22: Tax implicit scale estimates; working-age population, 1990 to 2014; households with disposable income under welfare safety-net not censored out



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)
Notes: As for Figure D.19. Median income values reported for 1995, 2005, and 2012.

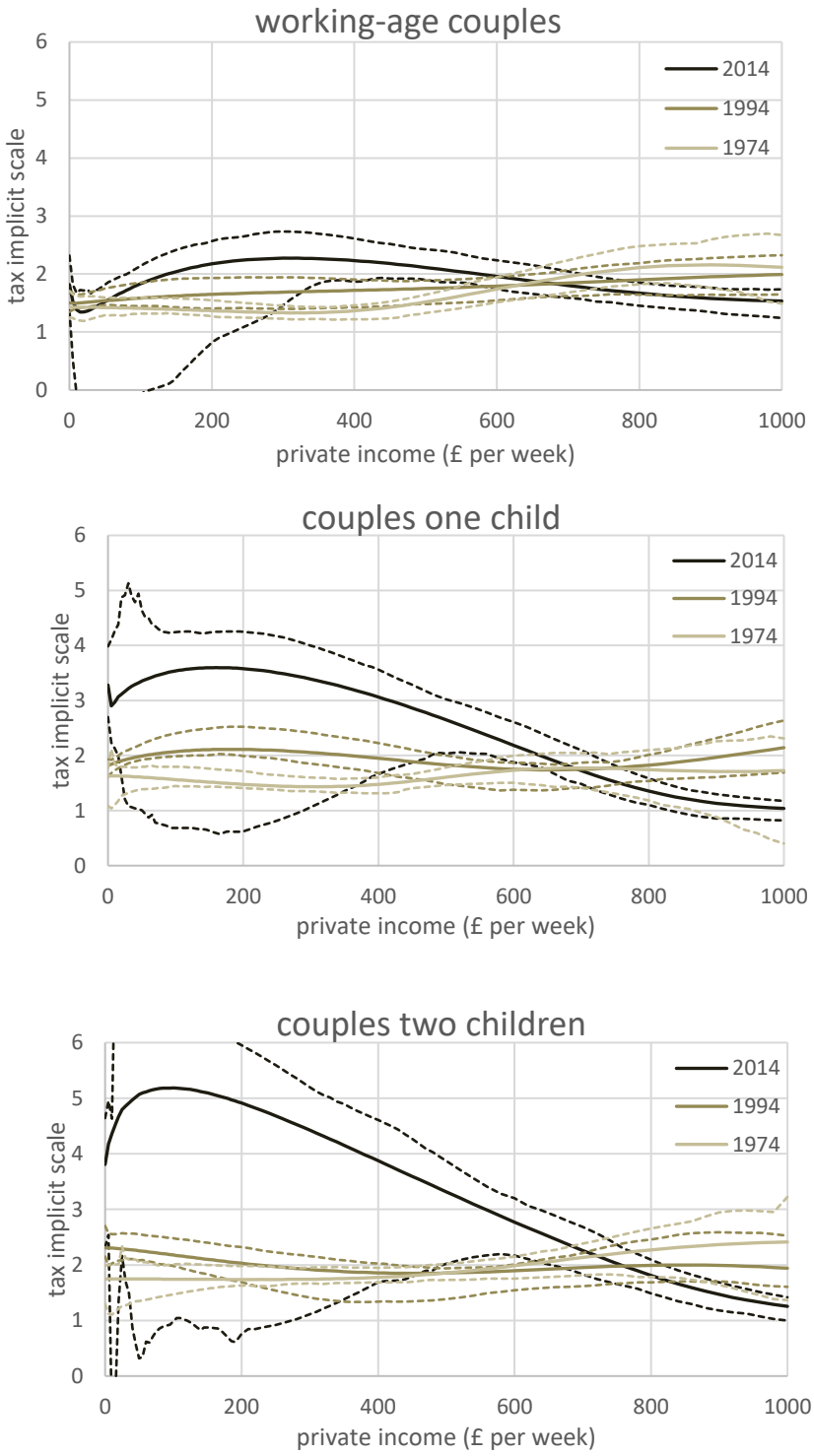
Figure D23: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).

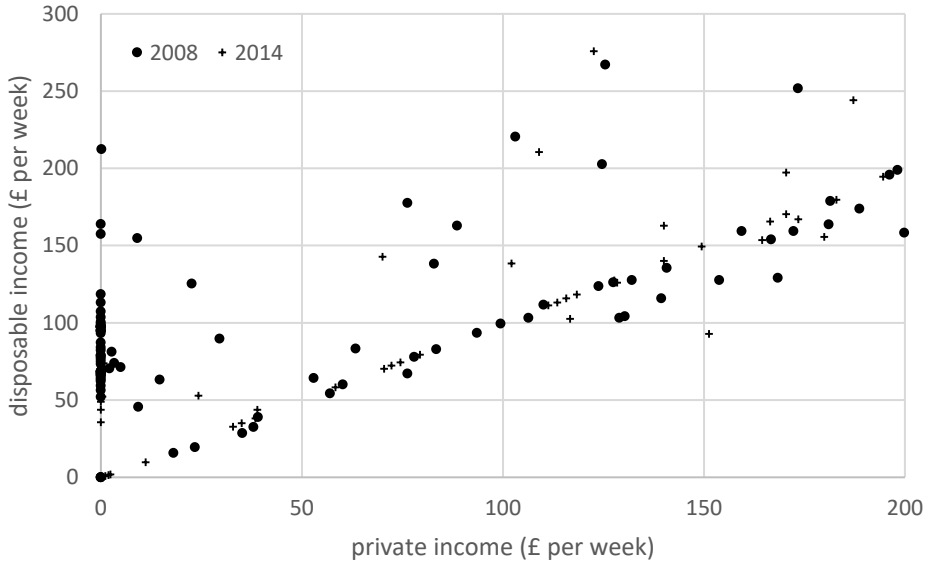
Notes: Tax implicit scales measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Single parents = same as single adult, but with one child aged 13 or under. Pensioners identified as households with at least one member aged 65+. Tax implicit scales estimated separately for each year, on pooled data from three consecutive years centred about given year. Dotted lines indicate 90% confidence intervals of bootstrap point estimates. Estimates for more recent years presented in darker shading.

Figure D.24: Point-estimates and 90% confidence intervals for tax implicit scales by household type and sample year



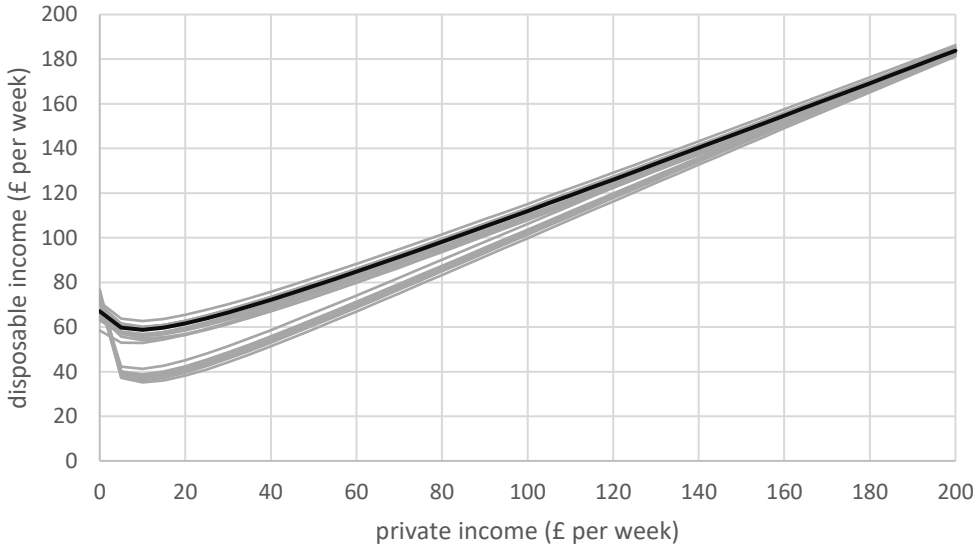
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.21. Couple, no children same as single adult, but with two individuals aged under 60 and over 13. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under.

Figure D.25: Scatter plot of private relative to disposable income reported by single working age adults, by survey year



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: Data for households comprised of one adult, aged 25-59, not in receipt of disability or own-business income, and without children. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Figure D.26: Estimated relationships between private and disposable income for single adults of working age for 2014; survey sample (in black) and first 20 bootstrap re-samples (in grey)

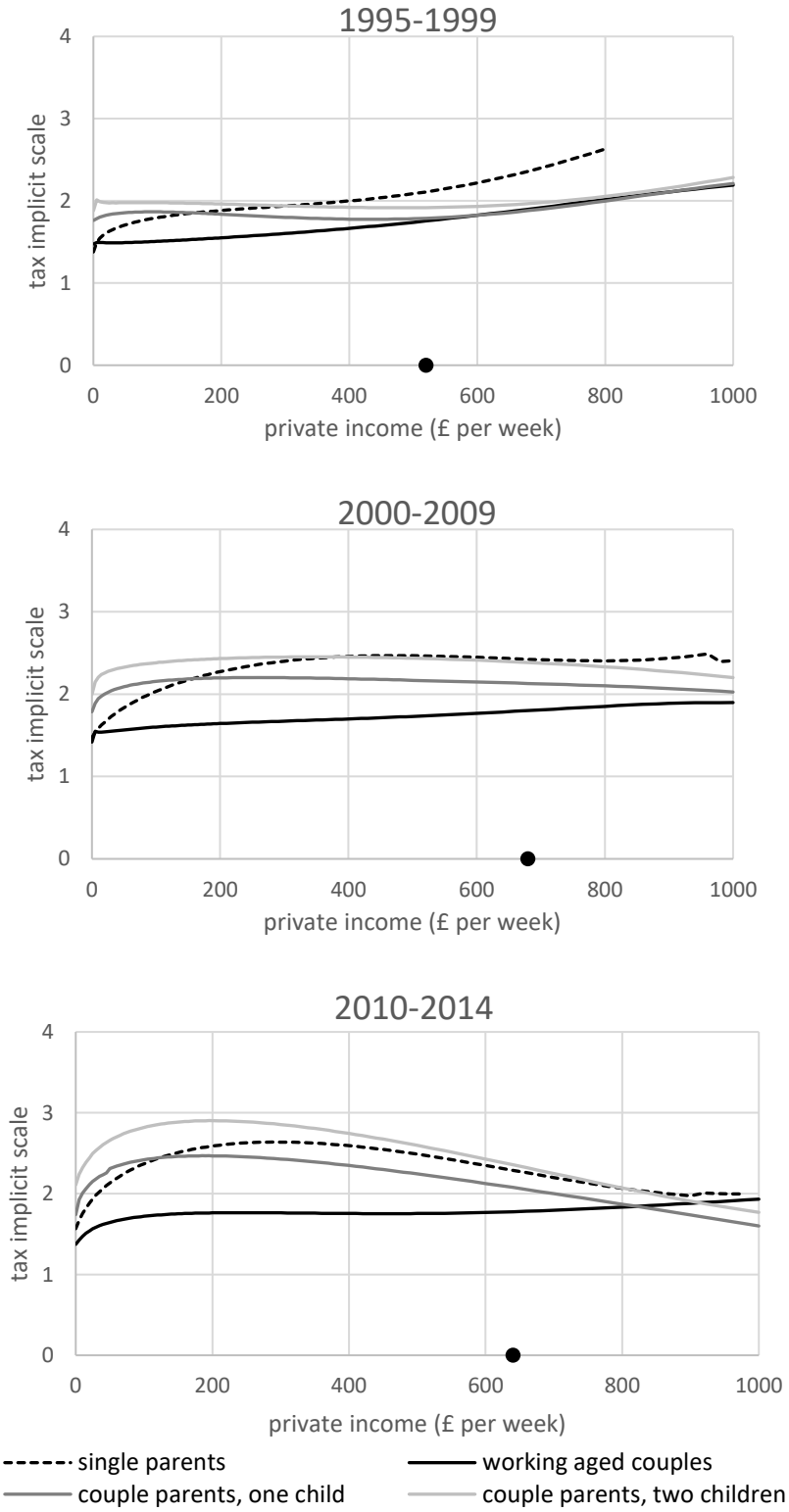


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: Relationships between private and disposable income estimated using fractional polynomial regressions, via the 'fp' Stata routine setting the dimension parameter to 3. Relationship evaluated on pooled data from three consecutive years centred about given year. Single adult households, comprised of one adult, aged 25-59, not in receipt of disability or own-business income, and without children. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Appendix D.5: Sensitivity to survey data source

Tax implicit scales for the working-age population are similar when estimated using either the Living Costs and Food Survey (LCF) or Family Resources Survey (FRS). This is revealed by comparing Figure D.27 with Figure 4.1. In contrast, tax implicit scales for the population over state pension age display much less temporal variation when estimated from the FRS than the LCF data; comparing Figures D.28 and 4.2. The differences reported in this respect are attributable to substantively different relationships between private and disposable incomes described for working-age households by the two surveys. Figures D.29 and D.30 describe these differences between survey data for single working-age people without children between 2013 and 2015, which are representative of the differences for working-age people more generally.

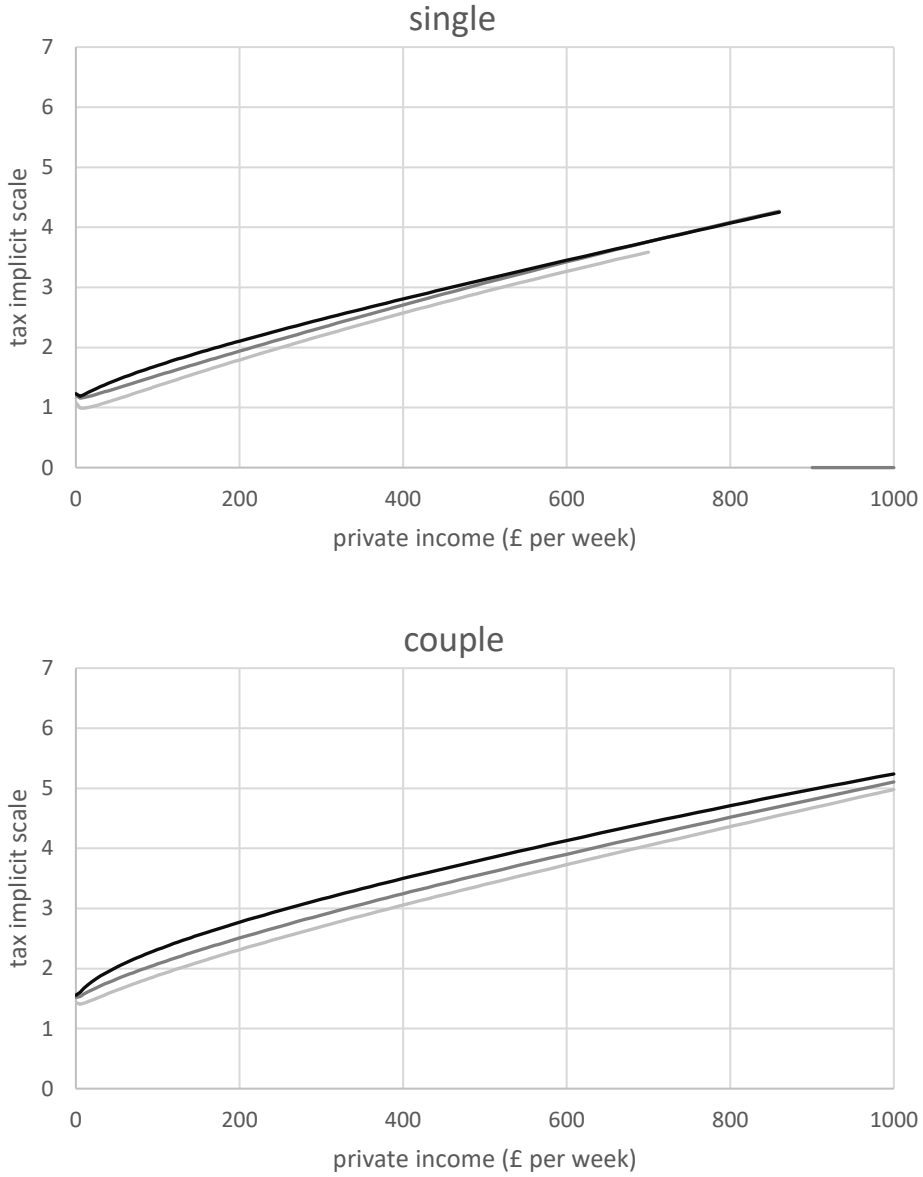
Figure D.27: Tax implicit scale estimates; working-age population, 1995 to 2014; estimates based on data from the Family Resources Survey



Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series, and median household private income reported by ONS (2017)

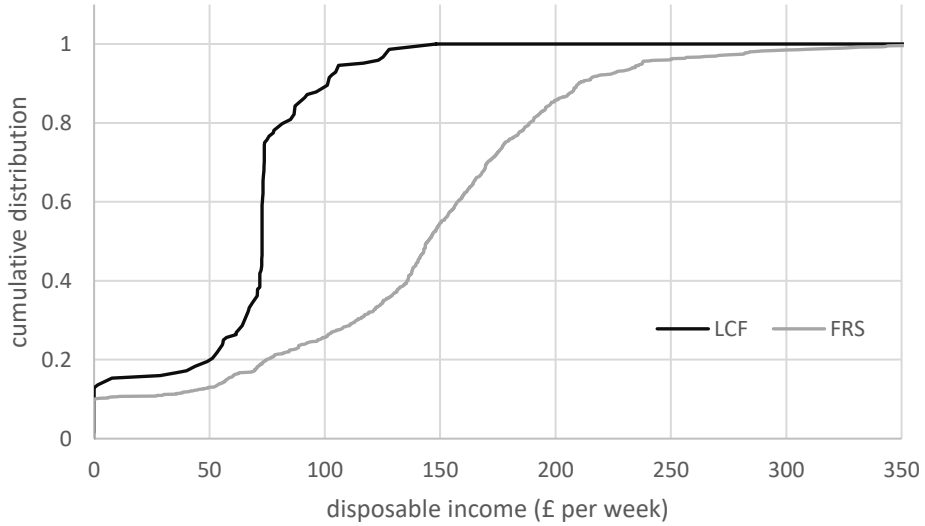
Notes: As for Figure 4.1. Median income values reported for 1995, 2005, and 2012.

Figure D.28: Tax implicit scale estimates; pension-age population, 1970 to 2014; estimates based on data from the Family Resources Survey



Source: Authors' calculations using data from the Family Resources Survey (FRS), HBAI series.
Notes: As for Figure 4.1. Single pensioners, defined as households comprised of single adult aged 65+. Couple pensioners defined as households comprised of two adults, at least one of whom is aged 65+.

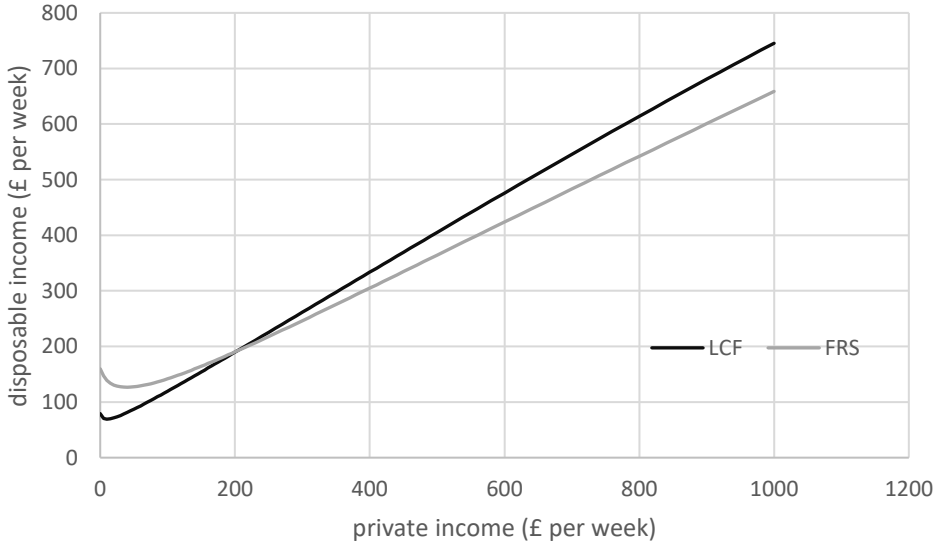
Figure D.29: Cumulative distribution of disposable income for single working-age adults with zero private income by data source; 2013-2015



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF), and the Family Resources Survey (FRS), HBAI series

Notes: Data for households comprised of one adult, aged 25-59, not in receipt of disability or own-business income, and without children. Figure reports weighted cumulative distribution. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

Figure D.30: Estimated relationships between private and disposable income for single adults of working age by data source, 2013-2015



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF), and the Family Resources Survey (FRS), HBAI series

Notes: Relationships between private and disposable income estimated using fractional polynomial regressions, via the 'fp' Stata routine setting the dimension parameter to 3. Relationship evaluated on pooled data from three consecutive years. Data for households comprised of one adult, aged 25-59, not in receipt of disability or own-business income, and without children. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA.

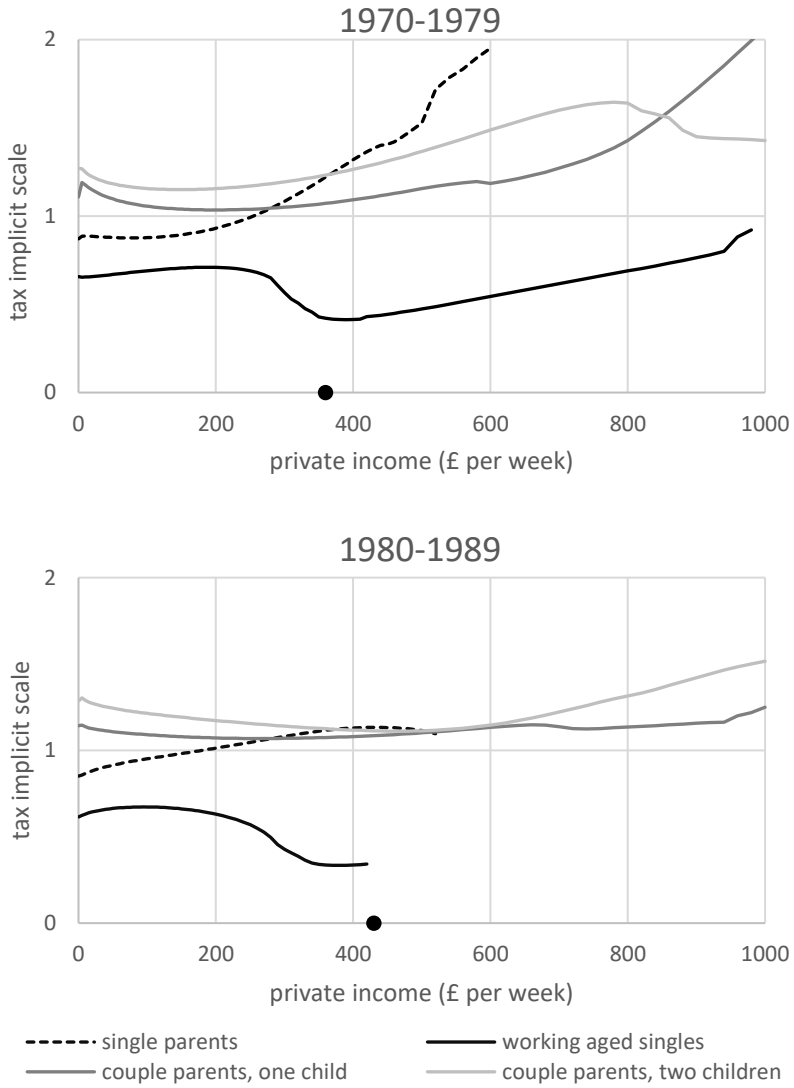
Appendix D.6: Sensitivity to reference unit

This appendix reports tax implicit scales estimated with working-age couples as reference units, in place of single adults. The transformations involved in shifting from a single adult to couple reference unit could be inferred directly from Figures 4.1 and 4.2. Note, however, that direct comparisons between the figures reported here and those in Section 4.1 are complicated by the base dependence of the tax implicit scales.

Where an equivalence scale satisfies base independence (independent of income), then exchanging one reference unit for another involves multiplying all scales by a fixed factor, equal to the reciprocal of the original scale value for the new reference unit. Although a similar calculation can be used to approximate the associated adjustments for a base dependent scale, the transformations for a precise translation are more involved.

Consider, for example, the tax implicit scale for pensioner couples with private income of £660 per week between 2010 and 2014. When single adults are the assumed reference unit, then Figure 4.2 reports that their tax implicit scale is (approximately) 6. Dividing £660 by 6, gives equivalised income of £110 per week. Exchanging as the reference unit for the tax implicit scale couples without children in place of single adults can be done by identifying the private income of couples (the new reference unit) at which the scale reported in Figure 4.2 implies equivalised income of £110 per week; this is £230 per week (with a scale in Figure 4.2 of 2.0). Hence, the tax implicit scale of pensioner couples with private income of £660 per week is 2.9 (= 660 / 230) when couples without children are taken as the reference unit.

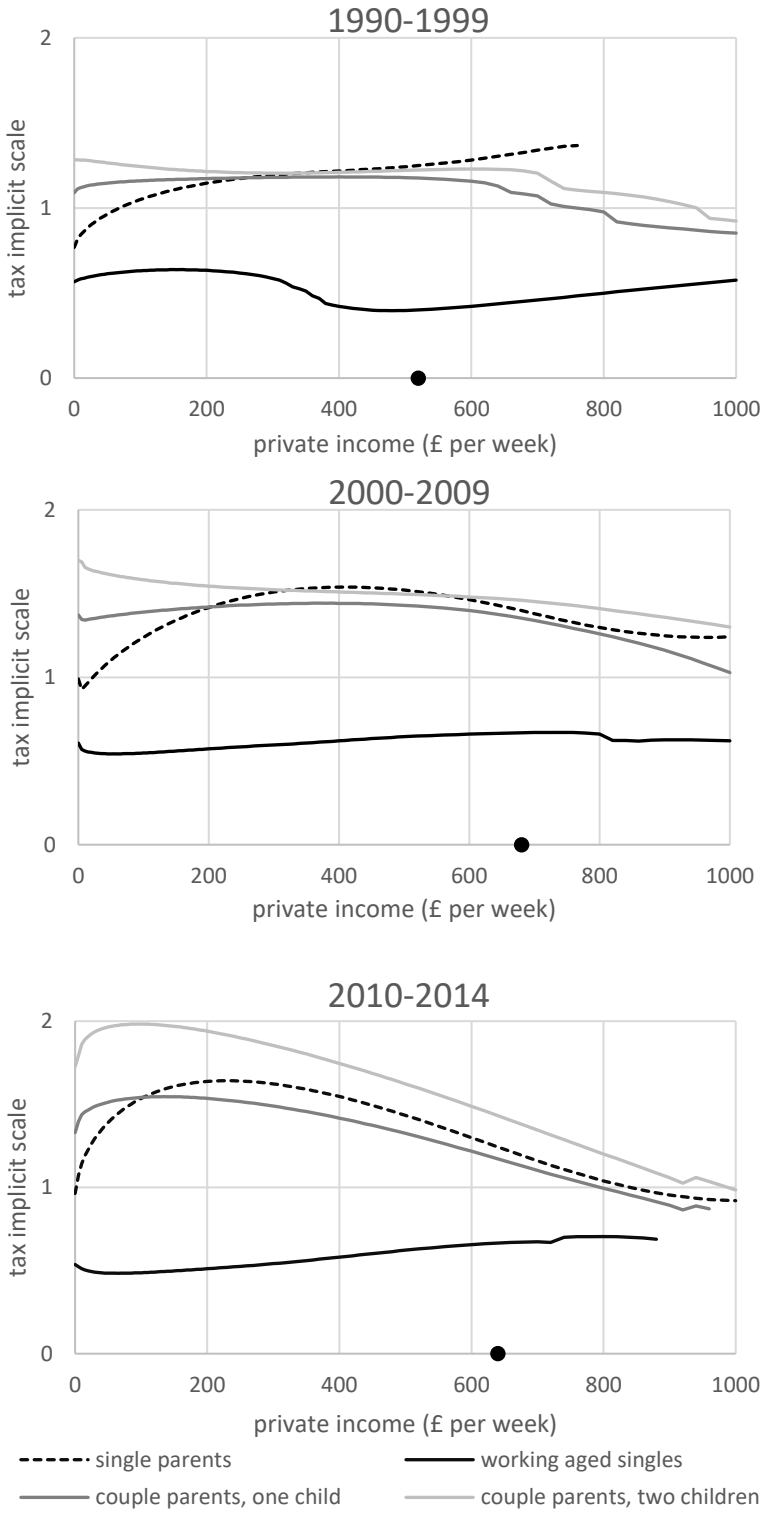
Figure D.31: Tax implicit scale estimates for working-age population, 1970 to 1989; estimates assume working-age couple as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)

Notes: Tax implicit scales measured relative to working-age couple households, comprised of two adults aged 25-59, with disposable income worth at least £100 per week, not in receipt of disability or own-business income, and without children. Single adults = same as working-age couples, but with one adult and disposable income worth at least £60 per week. Single parents = same as single adult, but with one child aged 13 or under. Couple, one/two child(ren) same as couples, but with one/two child(ren) aged 13 or under. Median income = median household private income. Median income reported as black dot on horizontal axis, equal to values reported for 1977 and 1985. All financial statistics adjusted to 2016 prices by the National Accounts final consumption expenditure deflator, Office for National Statistics code YBGA. Tax implicit scales estimated separately for each year, on pooled data from three consecutive years centred about given year.

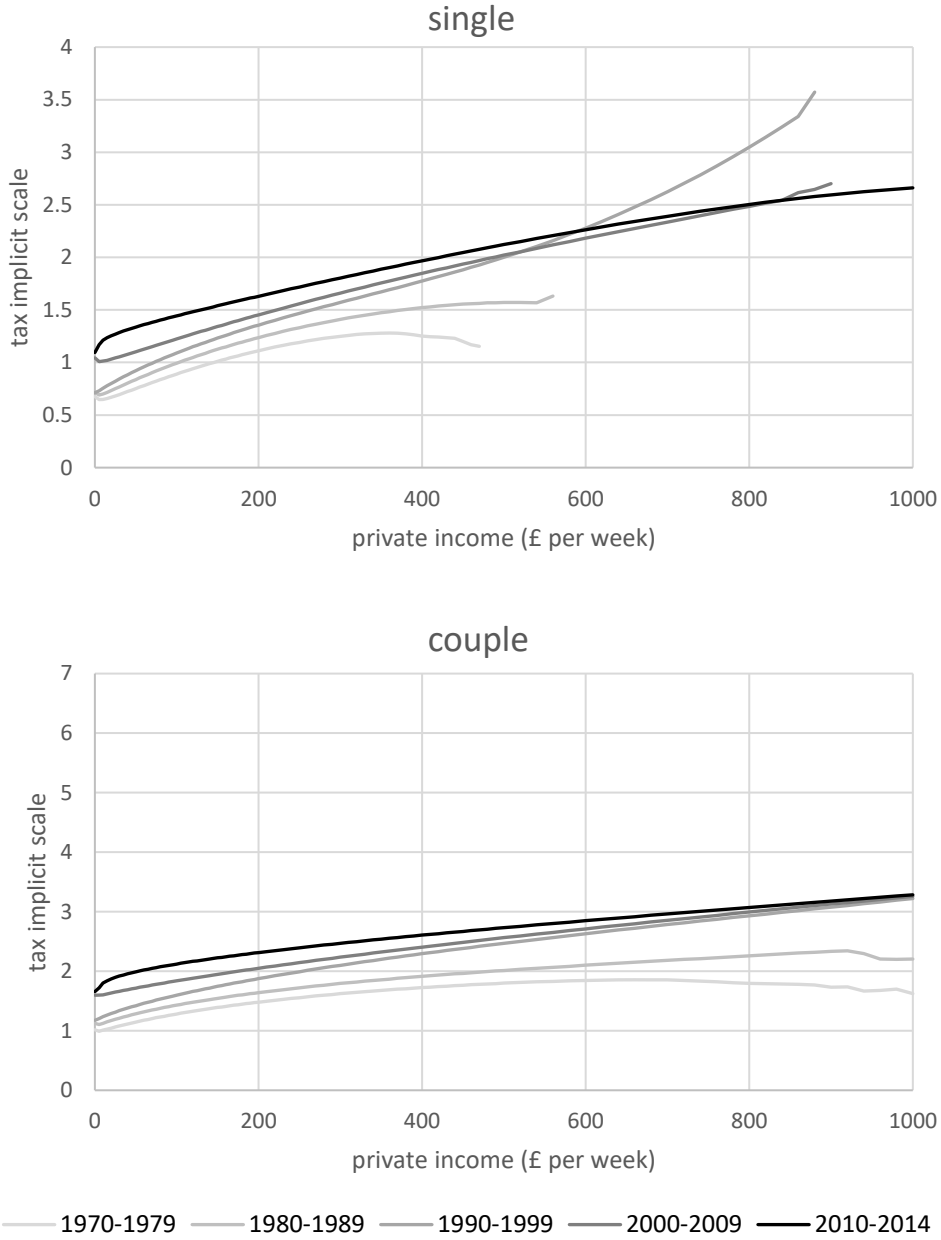
Figure D.32: Tax implicit scale estimates for working-age population, 1990 to 2014; estimates assume working-age couple as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), and median household private income reported by ONS (2017)

Notes: As for Figure D.31. Median income values reported for 1995, 2005, and 2012.

Figure D.33: Tax implicit scale estimates for pension-age population, 1970 to 2014; estimates assume working-age couple as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES).
Notes: As for Figure D.31. Single pensioners, defined as households comprised of single adult aged 65+. Couple pensioners defined as households comprised of two adults, at least one of whom is aged 65+.

Appendix E: Inequality and Progressivity

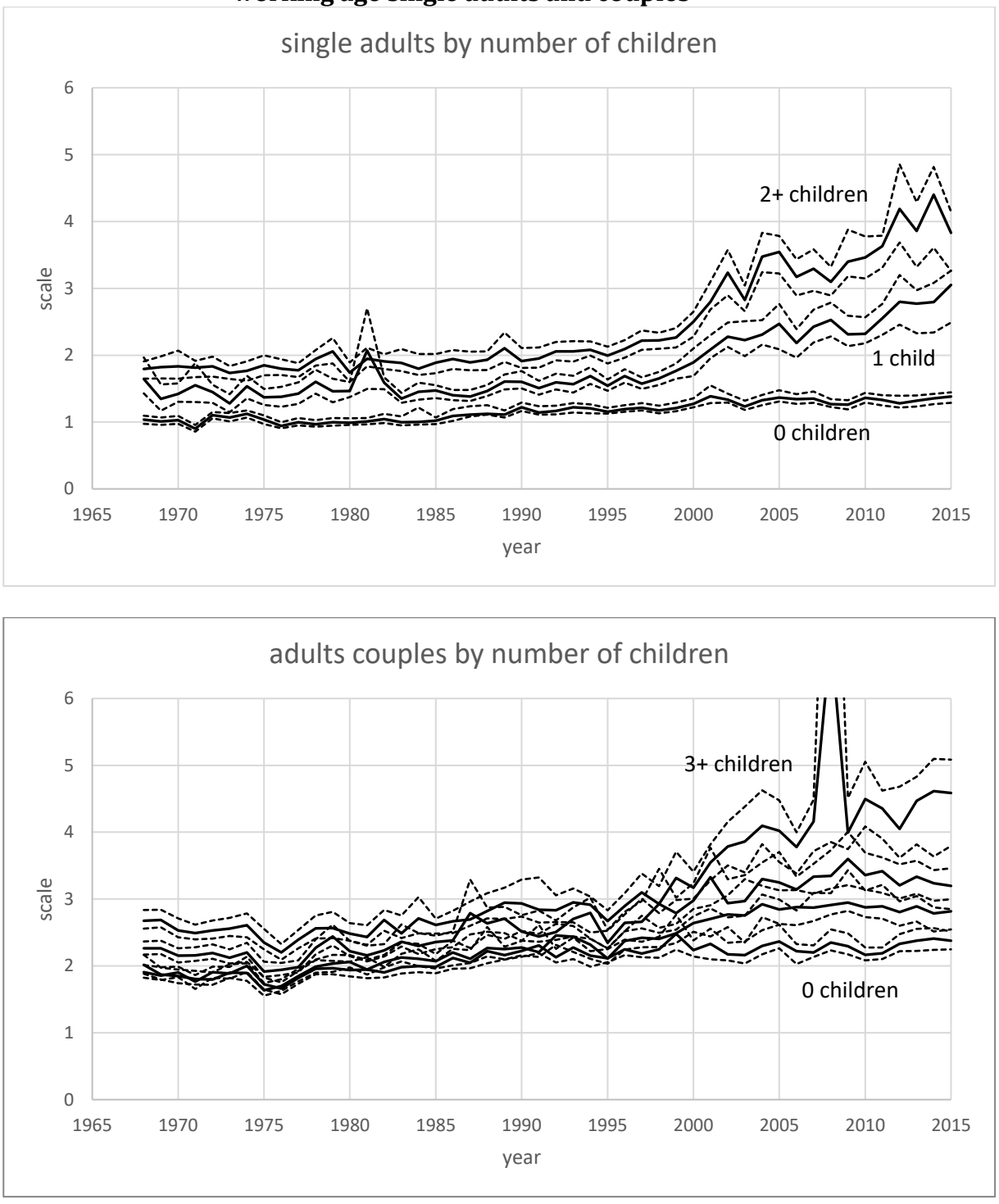
Appendix E.1: Supplementary statistics for principal distributional analysis

Table E.1: Demographic distribution of pooled survey population (%)

	children							
	0	1	2	3	4	5	6	all
adults	adults aged 59 and under							
1	9.8	1.6	1.2	0.4	0.1	0.0	0.0	13.2
2	15.4	7.0	8.8	2.7	0.7	0.2	0.0	34.8
3	5.4	2.8	1.1	0.4	0.1	0.0	0.0	9.9
4	3.1	1.1	0.4	0.1	0.0	0.0	0.0	4.8
5	0.6	0.3	0.1	0.0	0.0	0.0	0.0	1.1
6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	adults aged 60 and over							
1	14.4	0.0	0.0	0.0	0.0	0.0	0.0	14.4
2	17.2	0.1	0.0	0.0	0.0	0.0	0.0	17.4
3	2.7	0.2	0.1	0.0	0.0	0.0	0.0	3.1
4	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.9
5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
all	69.7	13.4	11.8	3.7	1.0	0.2	0.1	99.9

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES), 1968-2015.
Notes: Adults defined as individuals 14 and over, children as 13 and under. Households of individuals aged 59 and under reported in top panel, and those of individuals 60 and over reported in bottom panel.

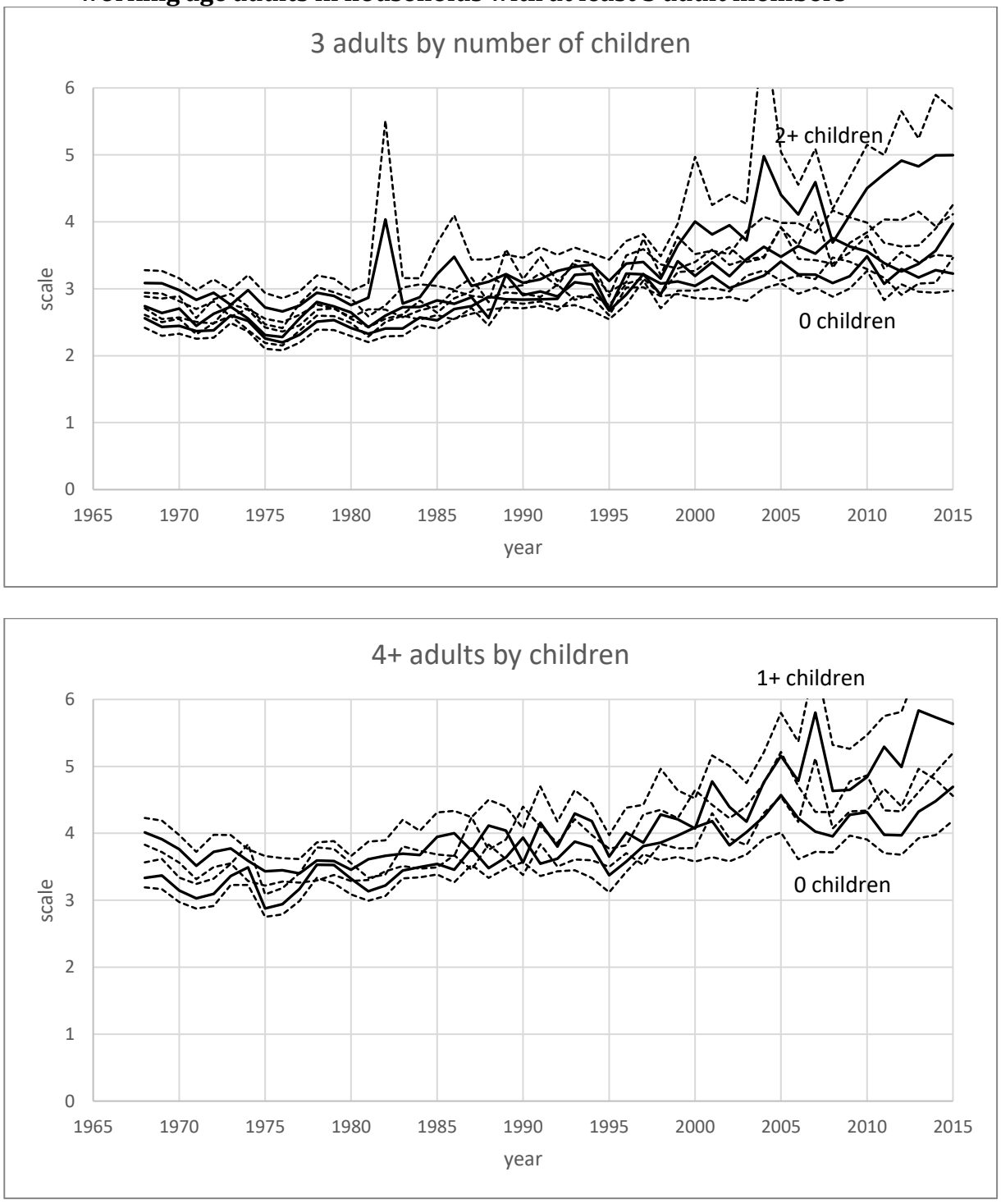
Figure E.1: Year specific averages of tax implicit scales by demographic subgroups; working age single adults and couples



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Individual specific tax implicit scales averaged over population subgroups, by survey year. Adults defined as individuals aged 14 and over, and children as 13 and under. Averages taken over population aged under age 60. Individual specific scales estimated as described in Section 3.2. 90% confidence intervals reported with dashed lines.

Figure E.2: Year specific averages of tax implicit scales by demographic subgroups; working age adults in households with at least 3 adult members

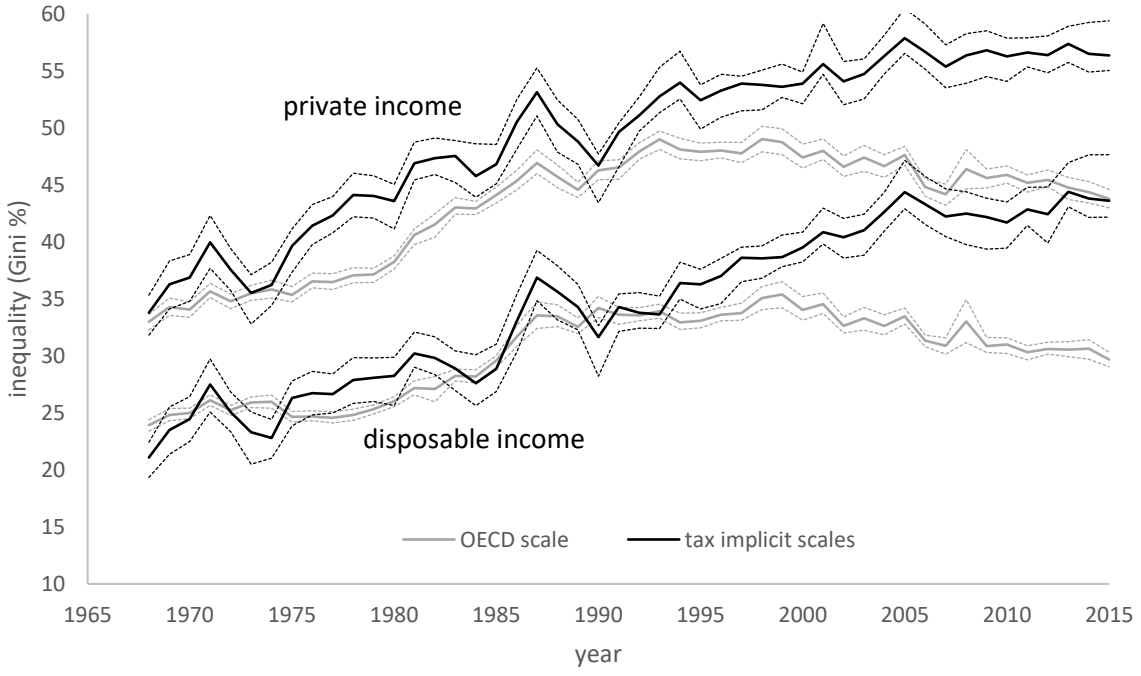


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: See Figure E.1.

Figure E.3: Year specific averages of tax implicit scales by demographic subgroups; state pension age adults

Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: See Figure E.1.

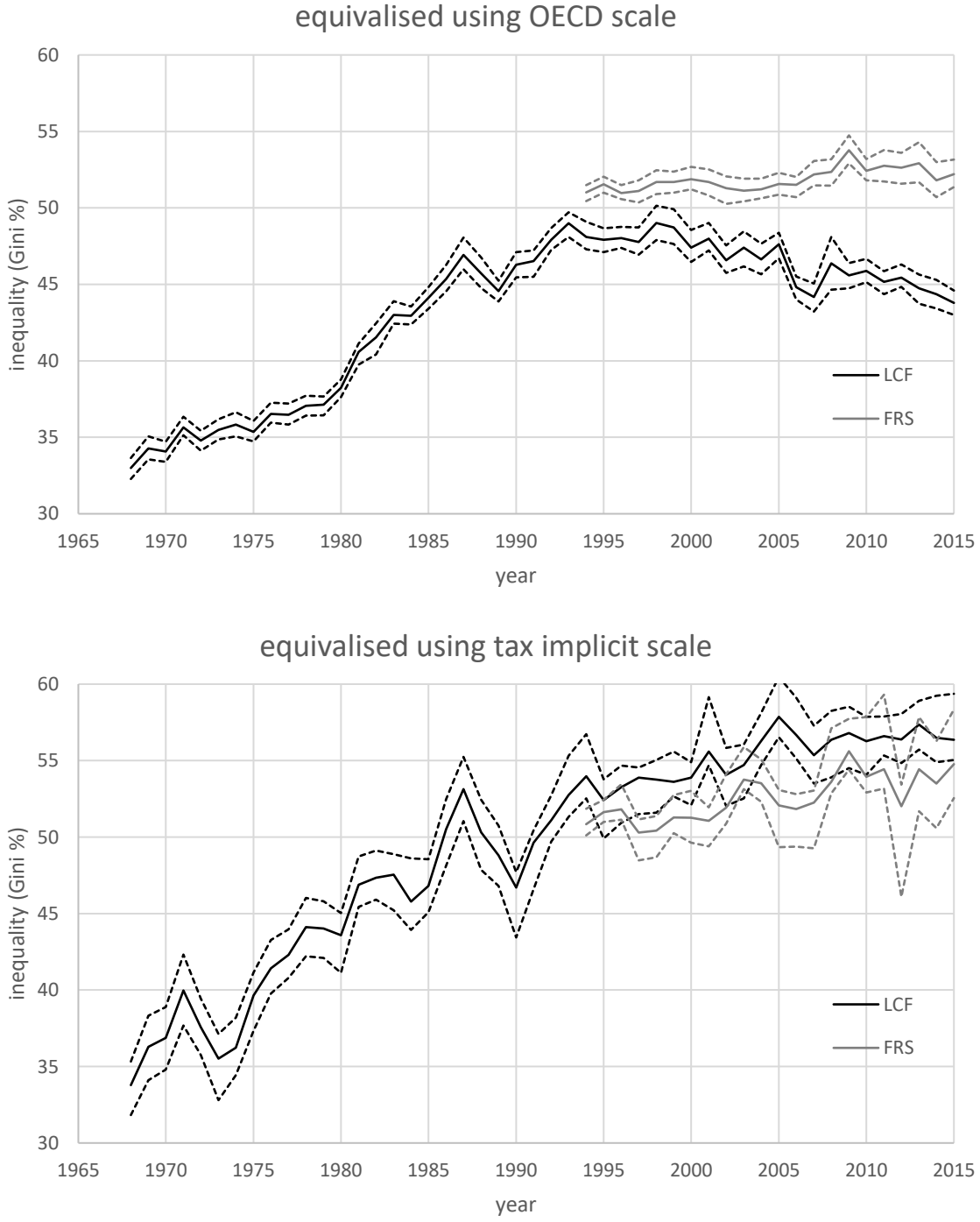
Figure E.4: Income inequality by year, and equivalence scale



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: See Figure 4.3. Dotted lines indicate 90% confidence intervals.

Appendix E.2: Sensitivity to data source

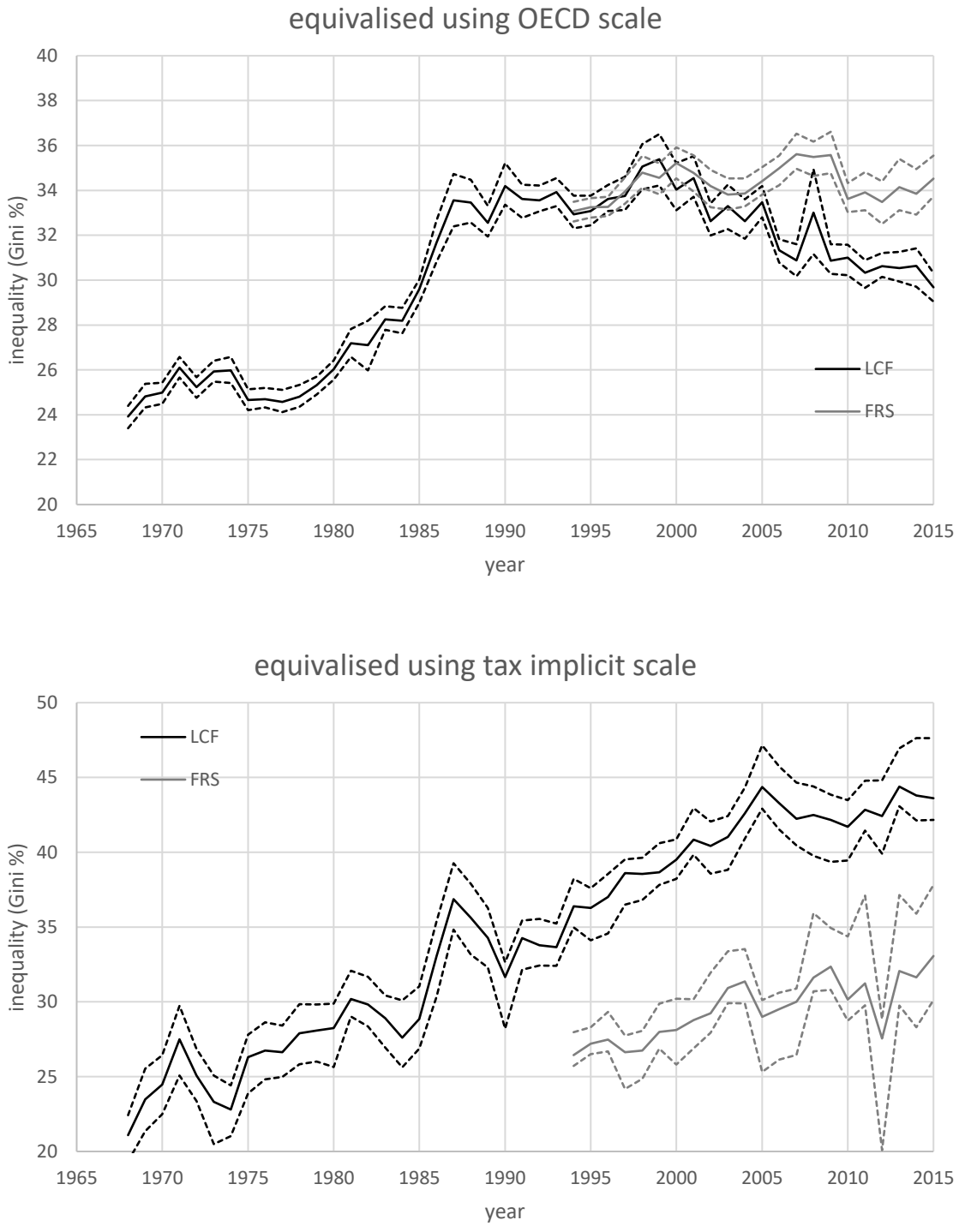
Figure E.5: Inequality of equivalised private income and associated confidence intervals by year, data source, and equivalence scale



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

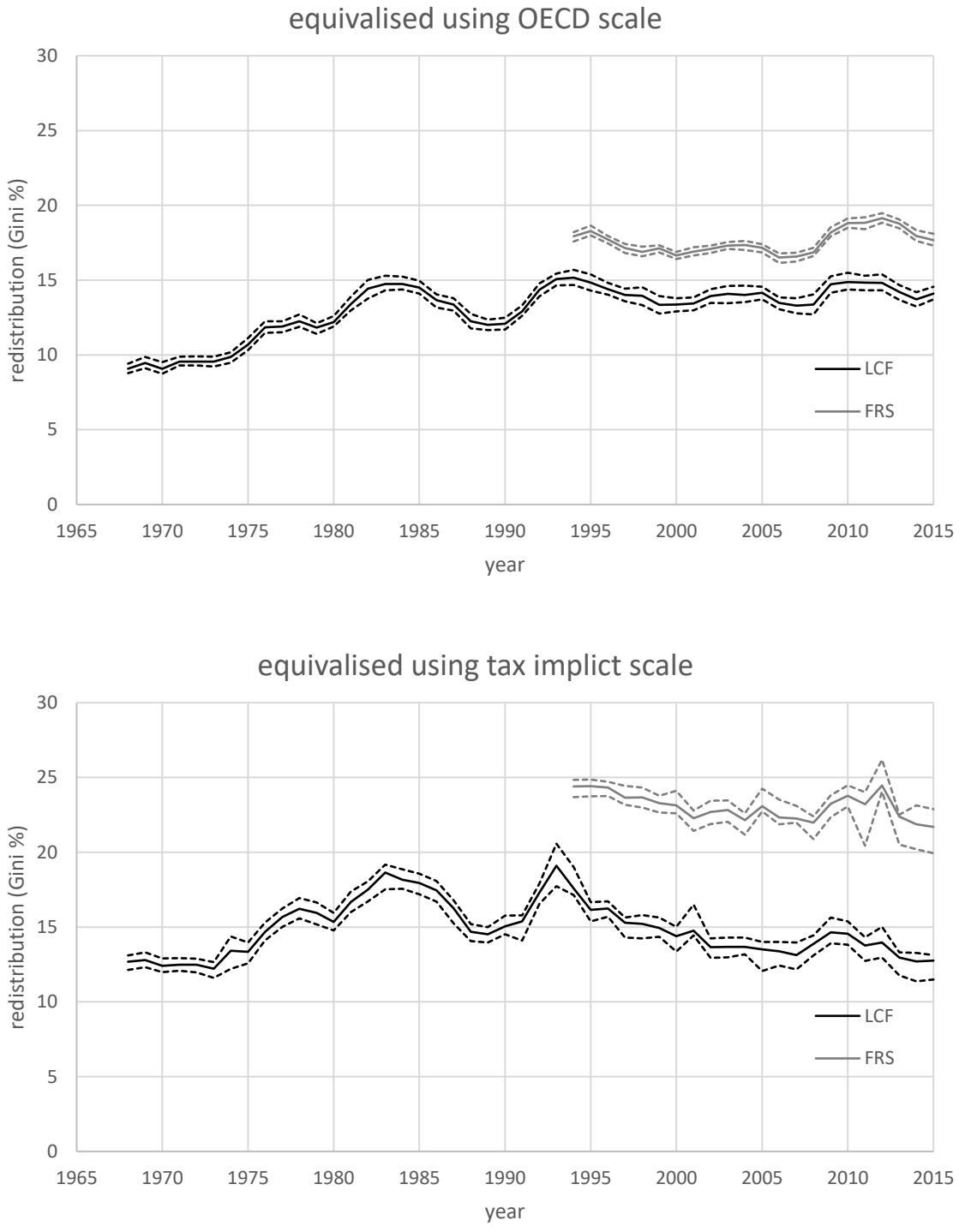
Notes: As for Figure E.4. The FRS tends to indicate higher inequality levels than the LCF, in part due to the SPI adjustment implemented in the FRS to better capture top incomes.

Figure E.6: Inequality of equivalised disposable income and associated confidence intervals by year, data source, and equivalence scale



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: As for Figure E.5.

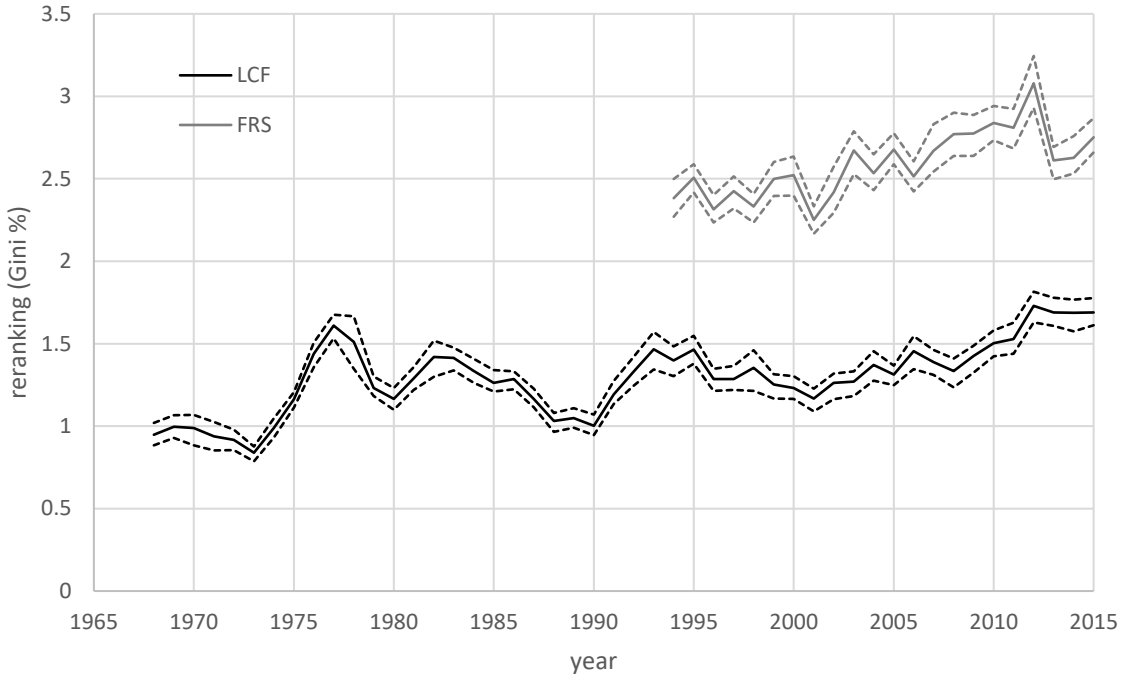
Figure E.7: Redistribution of household equivalised income and associated confidence intervals by year, data source, and equivalence scale



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.5.

Figure E.8: Reranking of equivalised income by year and data source



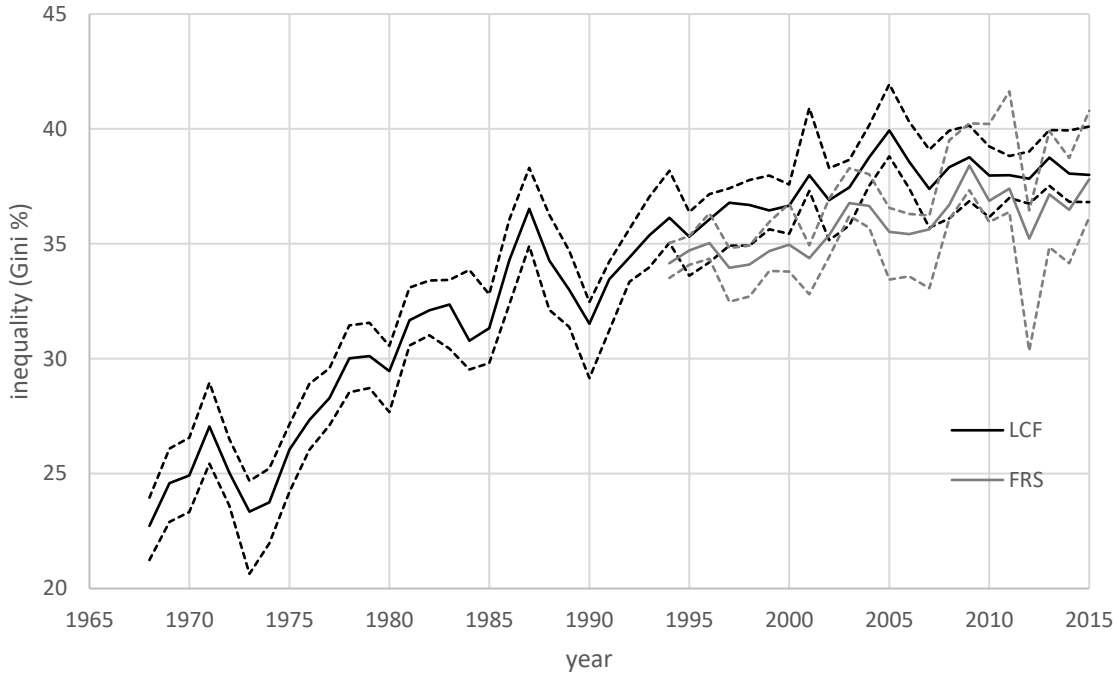
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: Reranking evaluated as Gini coefficient of disposable income less the concentration index of disposable income ranked by private income. All measures of income equivalised using the OECD scale.

Appendix E.3: Sensitivity to definition of inequality

This appendix reports sensitivity of results to alternative assumptions concerning the degree of inequality aversion. The analysis focusses on results derived using the extended Gini index, as discussed in Yitzhaki (1983). Two values of inequality aversion are considered, v = 1.5 and 4.0, which describe excess sensitivity to bottom end and top end population weighting respectively; a value of v = 2.0 obtains the standard Gini index that is discussed in the remainder of this paper, and v = 1.0 describes indifference to inequality.

Extended Gini, low inequality aversion variant (v = 1.5)

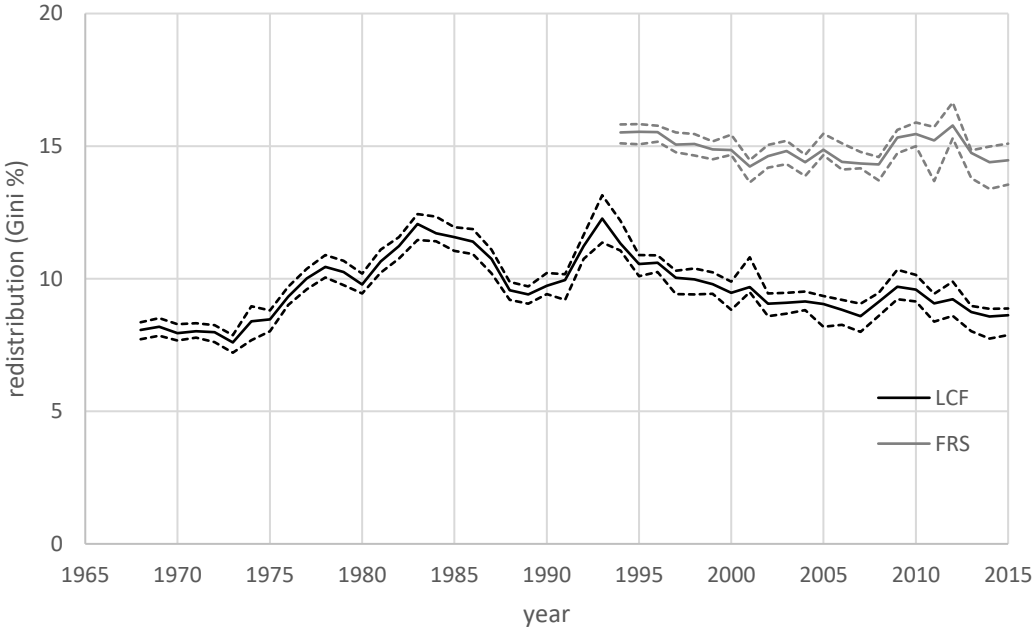
Figure E.9: Inequality of equivalised private income by year, data source, and equivalence scale; low inequality aversion variant (v = 1.5)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: All inequality statistics report extended Gini coefficients as percentages, with inequality aversion parameter *v* = 1.5. Household equivalised incomes weighted by survey weights and the number of household members. Equivalisation calculated using individual specific tax implicit scales, evaluated as described in Section 3.2, and measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Dotted lines indicate 90% confidence intervals of bootstrap point estimates.

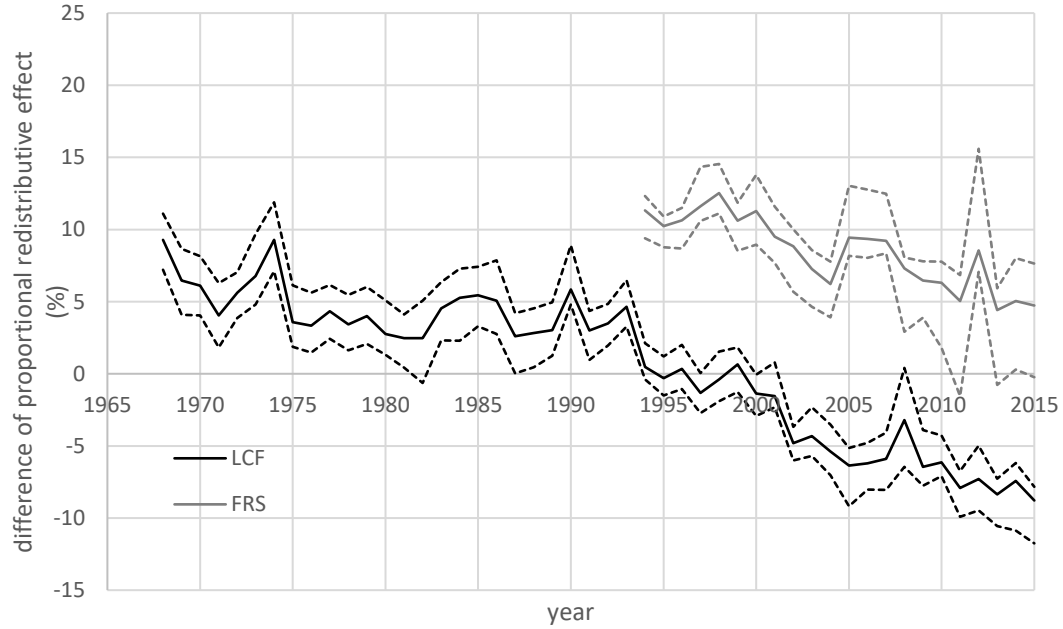
Figure E.10: Redistribution of household equivalised income by year and data source; low inequality aversion variant (v = 1.5)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.9.

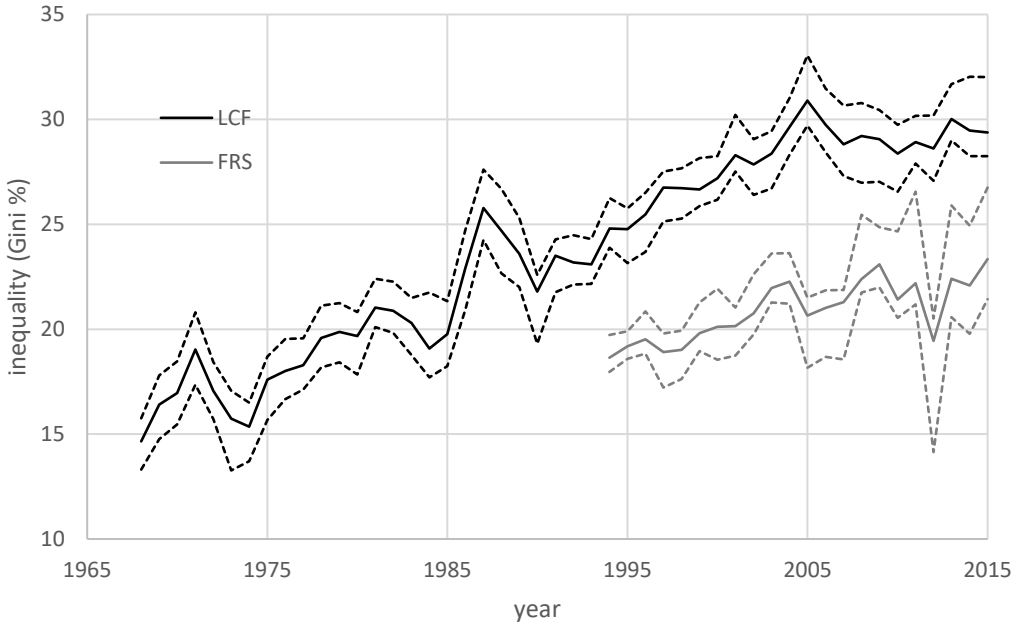
Figure E.11: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year and data source; low inequality aversion variant (v = 1.5)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.9.

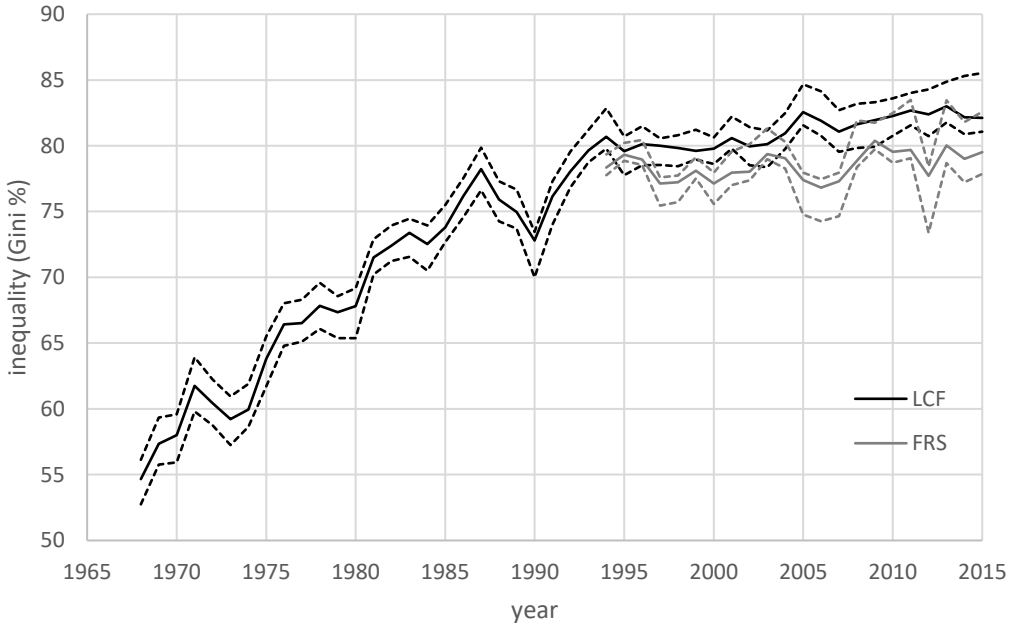
Figure E.12: Inequality of equivalised disposable income by year and data source; low inequality aversion variant (v = 1.5)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: As for Figure E.9.

Extended Gini, high inequality aversion variant (v = 4.0)

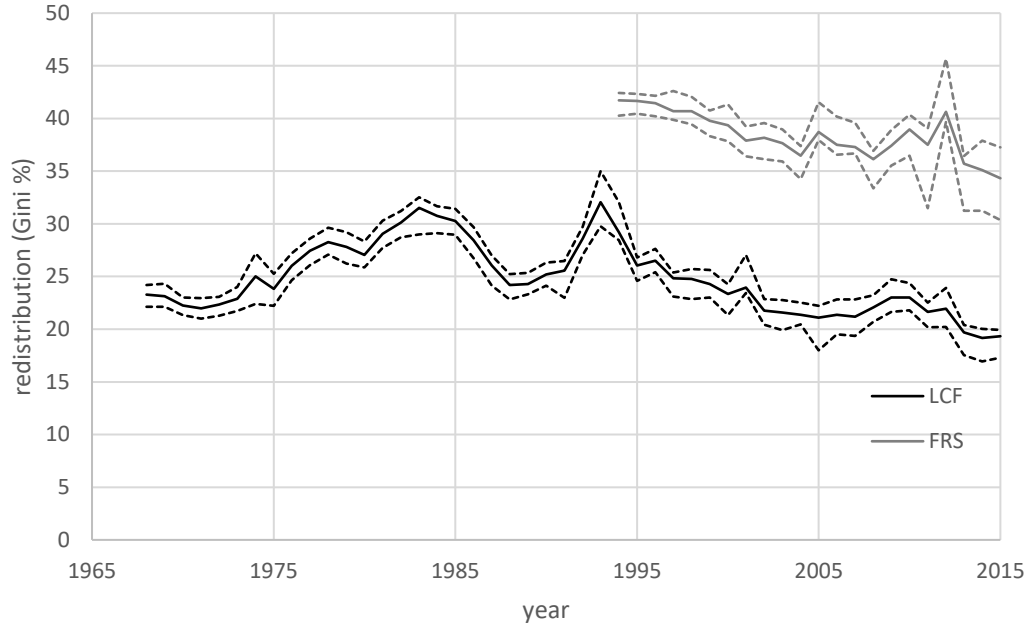
Figure E.13: Inequality of equivalised private income by year, data source, and equivalence scale; high inequality aversion variant (v = 4.0)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

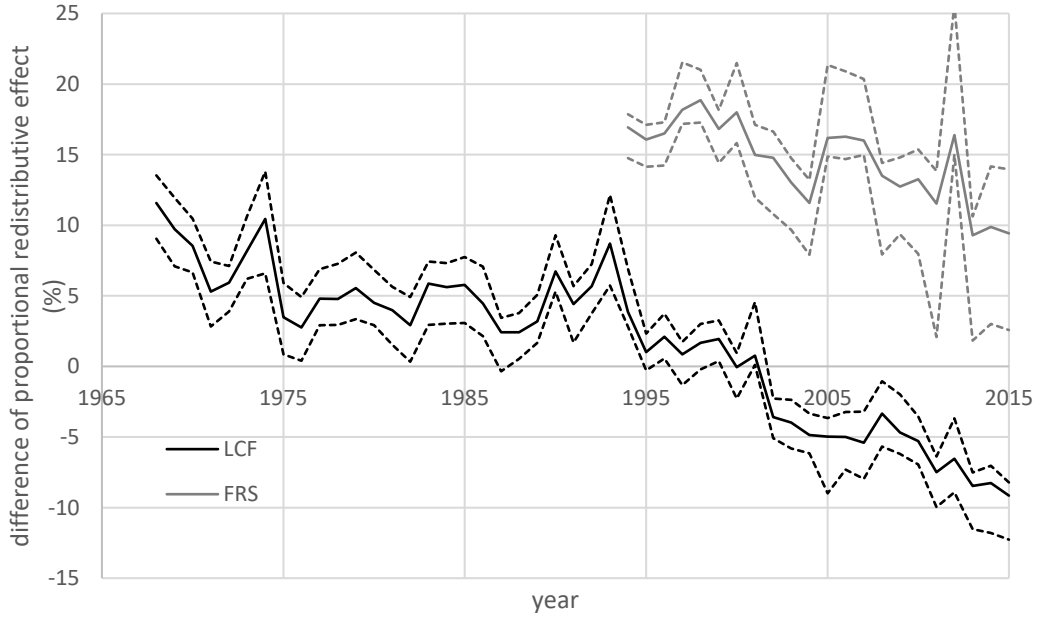
Notes: All inequality statistics report extended Gini coefficients as percentages, with inequality aversion parameter *v* = 4.0. Household equivalised incomes weighted by survey weights and the number of household members. Equivalisation calculated using individual specific tax implicit scales, evaluated as described in Section 3.2, and measured relative to single adult households, comprised of one adult, aged 25-59, with disposable income worth at least £60 per week, not in receipt of disability or own-business income, and without children. Dotted lines indicate 90% confidence intervals of bootstrap point estimates.

Figure E.14: Redistribution of household equivalised income by year and data source; high inequality aversion variant (v = 4.0)



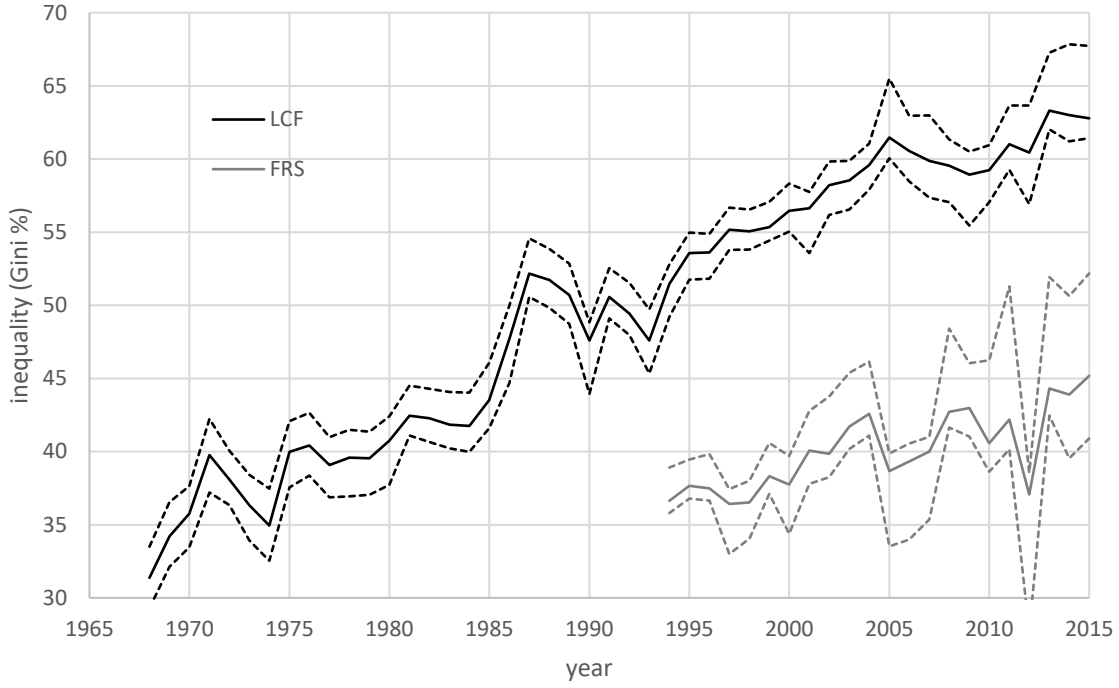
Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.13.

Figure E.15: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year and data source; high inequality aversion variant (v = 4.0)



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.13.

Figure E.16: Inequality of equivalised disposable income by year and data source; high inequality aversion variant (v = 4.0)

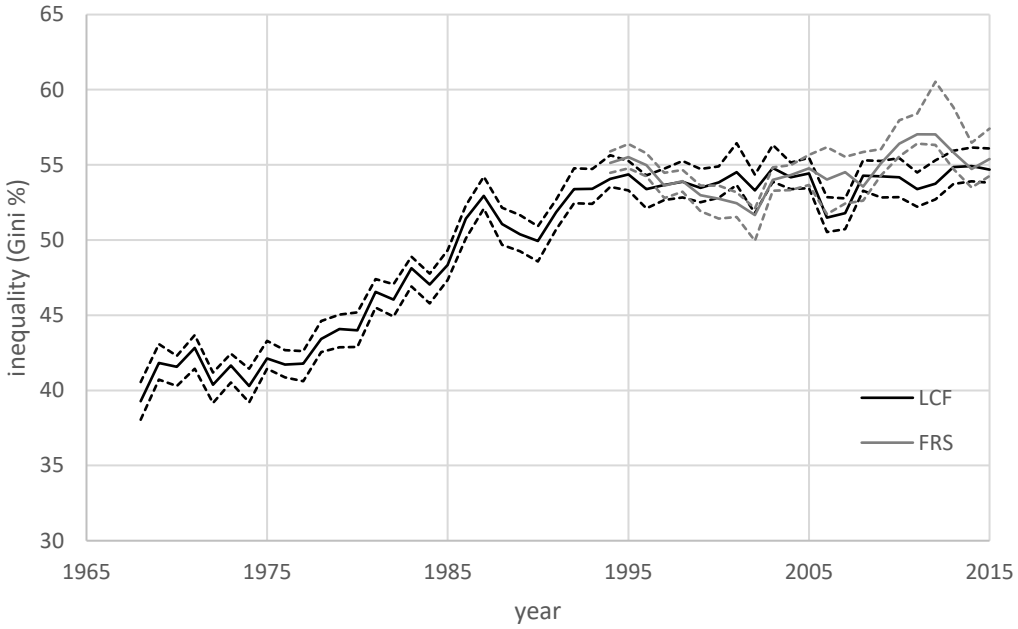


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: As for Figure E.13.

Appendix E.4: Sensitivity to reference unit characteristics

This appendix reports distributional statistics calculated for income equivalised using tax implicit scales with working-age couple as reference units, in place of single adults. Results are broadly similar to those reported elsewhere in this paper, with the notable exception that inequality of equivalised private income is approximately unchanged between 1995 and 2015 when adult couples are assumed as the reference unit, in contrast to the upward trend observed when single adults are the reference unit (Figure E.5 compared with Figure E.17).

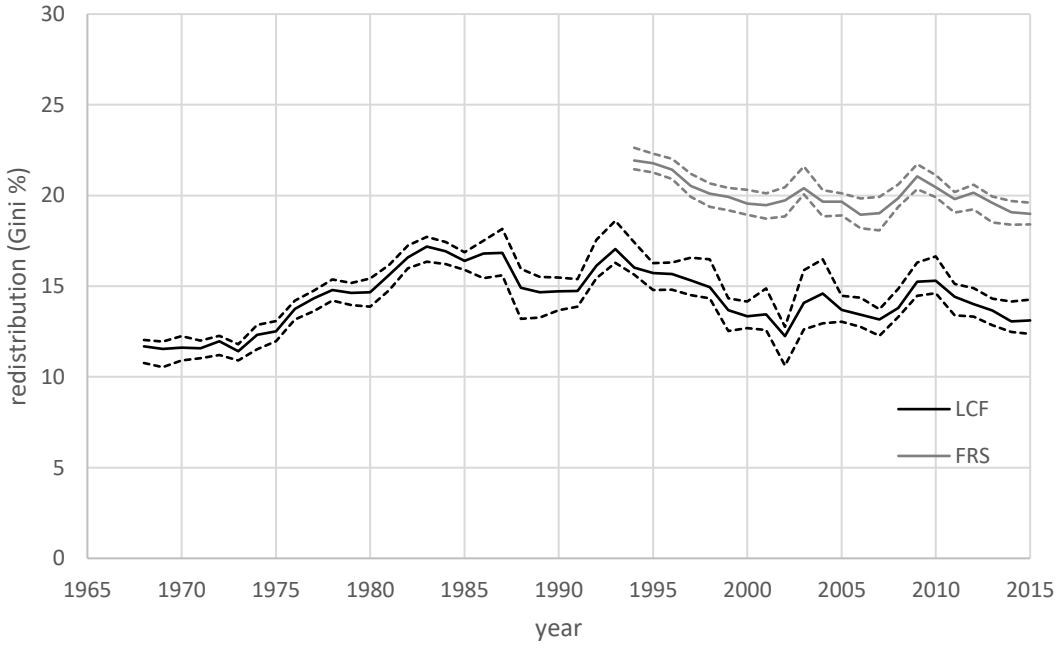
Figure E.17: Inequality of private income equivalised using tax implicit scales with working age couples as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: All inequality statistics report Gini coefficients as percentages. Household equivalised incomes weighted by survey weights and the number of household members. Equivalisation calculated using individual tax implicit scales evaluated as described in Section 3.2, and measured relative to households comprised of two adults, aged 25-59, with disposable income worth at least £100 per week, not in receipt of disability or own-business income, and without children. Dotted lines indicate 90% confidence intervals of bootstrap point estimates.

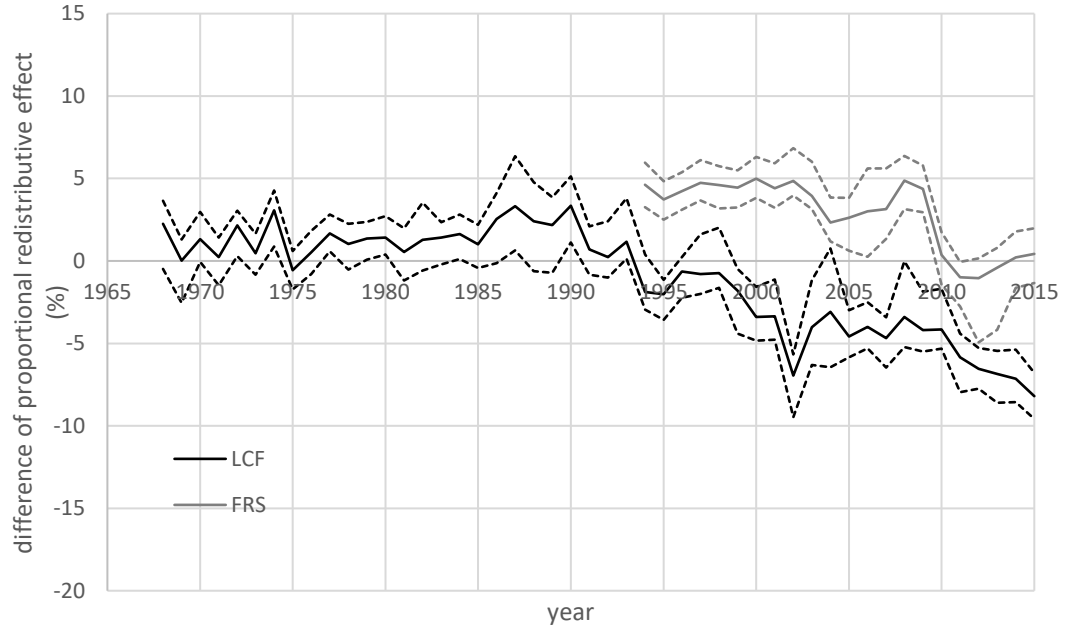
Figure E.18: Redistribution of household income equivalised using tax implicit scales with working age couples as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.17.

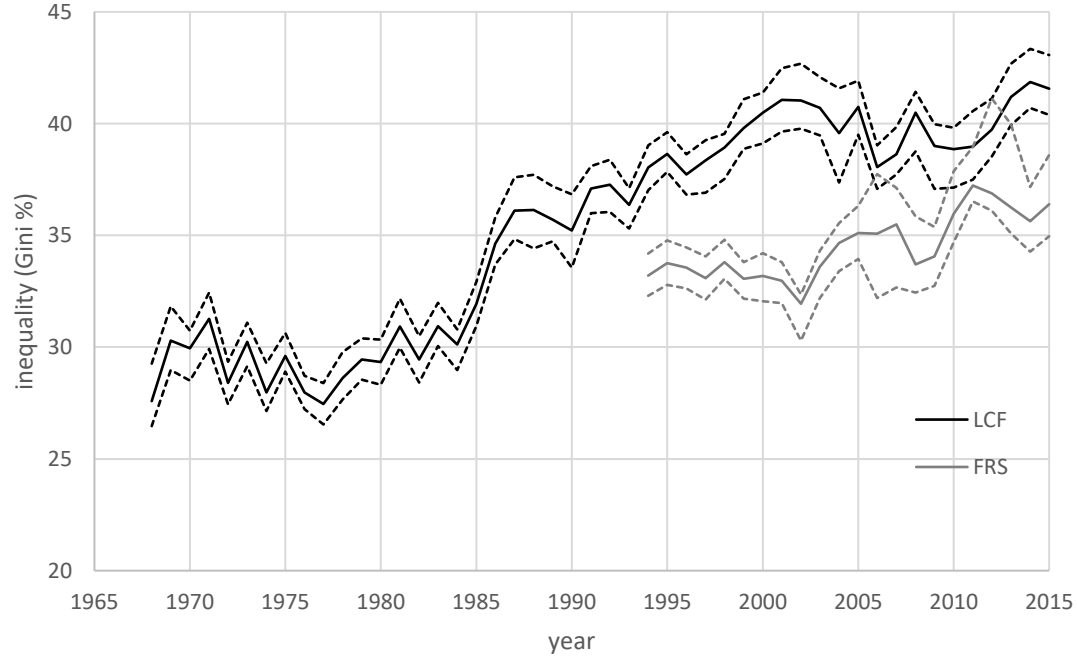
Figure E.19: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year and data source



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.17.

Figure E.20: Inequality of disposable income equivalised using tax implicit scales with working age couples as reference unit



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

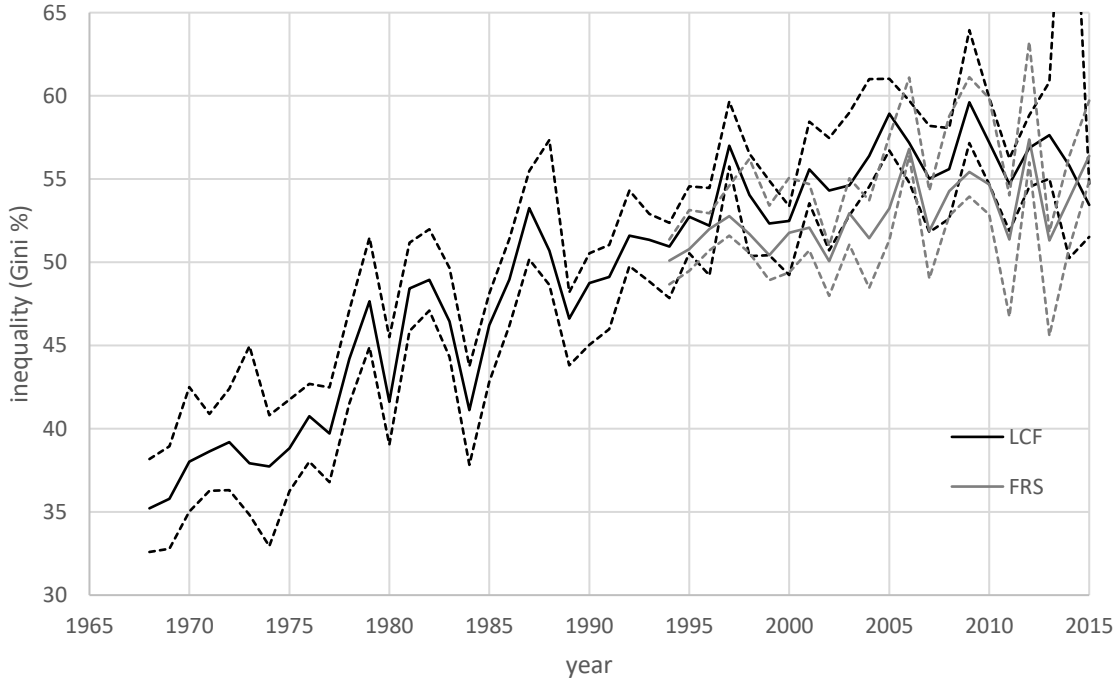
Notes: As for Figure E.17.

Appendix E.5: Sensitivity to data used to estimate reference unit tax function

Sensitivity to pooling across sample years

This appendix reports distributional statistics similar to those reported in Appendix E.2, but with the relationship between private and disposable income for reference households estimated on data for a single survey year, rather than the three-year pooled data considered in Appendix E.2 and Section 4.2. Comparing the statistics reported here with those reported in Appendix E.2 reveals that using un-pooled data to estimate tax functions for reference households increases the volatility and confidence intervals associated with inequality estimates, without otherwise altering the conclusions discussed elsewhere in this paper.

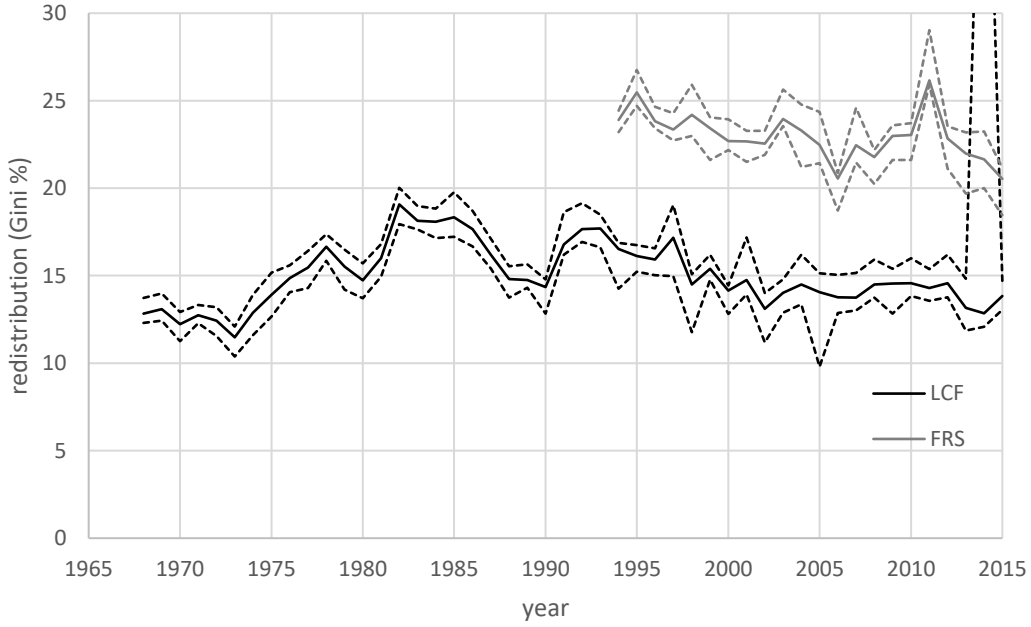
Figure E.21: Inequality of equivalised private income by year and data source; un-pooled estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: As for Figure E.5. Income equivalised using individual tax implicit scales evaluated as described in Section 3.2. Relationships between private and disposable income estimated for reference units on (un-pooled) data for individual survey years.

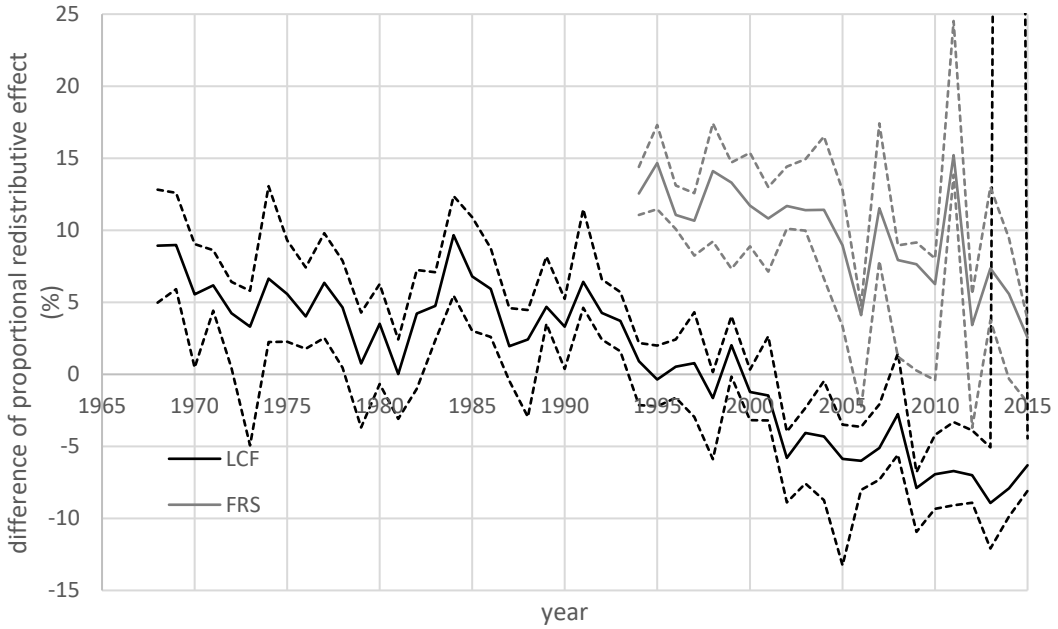
Figure E.22: Redistribution of household equivalised income by year and data source; un-pooled estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.21.

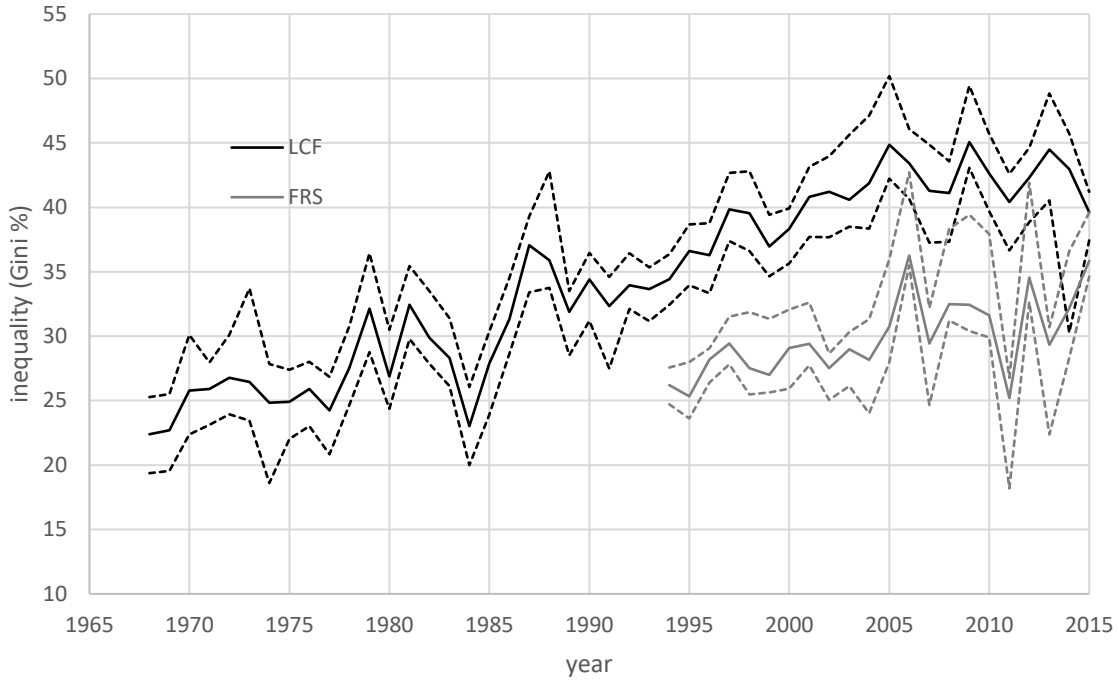
Figure E.23: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year and data source; un-pooled estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.21.

Figure E.24: Inequality of equivalised disposable income by year and data source; un-pooled estimates

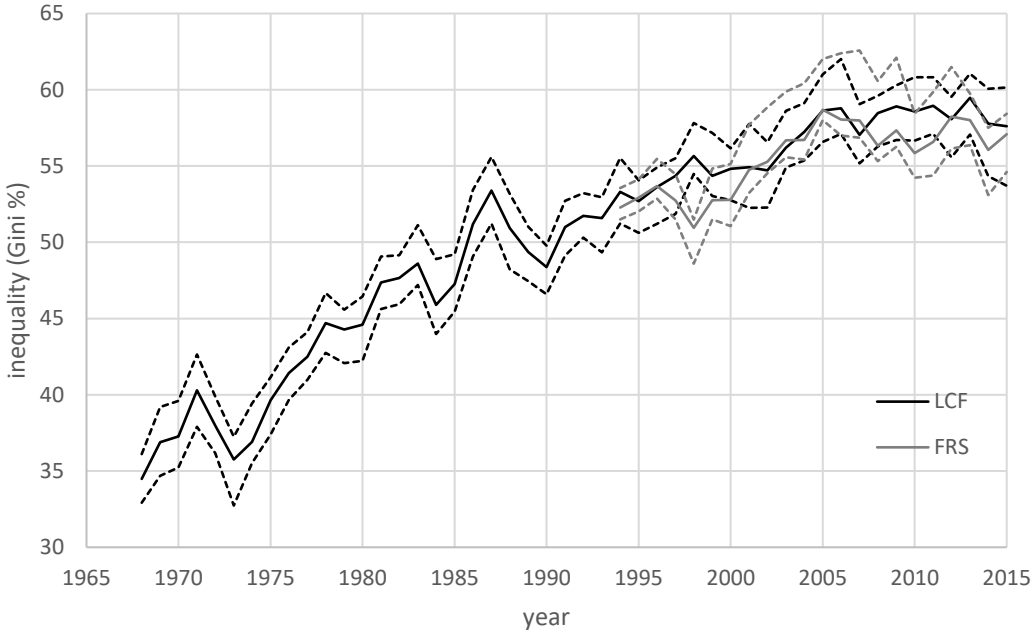


Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).
Notes: As for Figure E.21.

Sensitivity to truncation of sample population

This appendix reports distributional statistics similar to those reported in Appendix E.2, but with the relationship between private and disposable income for reference households estimated on data not truncated to omit households reporting very low disposable incomes. These results indicate that the findings reported in the paper are insensitive to truncation of survey data.

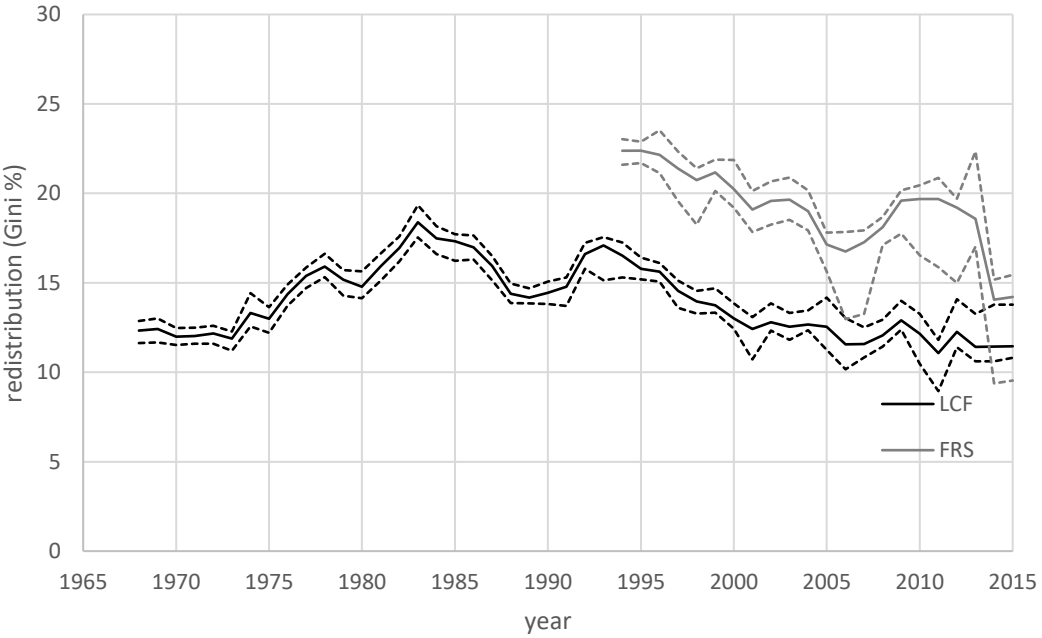
Figure E.25: Inequality of equivalised private income by year, data source, and equivalence scale; un-truncated estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: As for Figure E.5. Income equivalised using individual tax implicit scales evaluated as described in Section 3.2. Relationships between private and disposable income estimated for reference units on three-year pooled data, including households reporting disposable income under £60 per week.

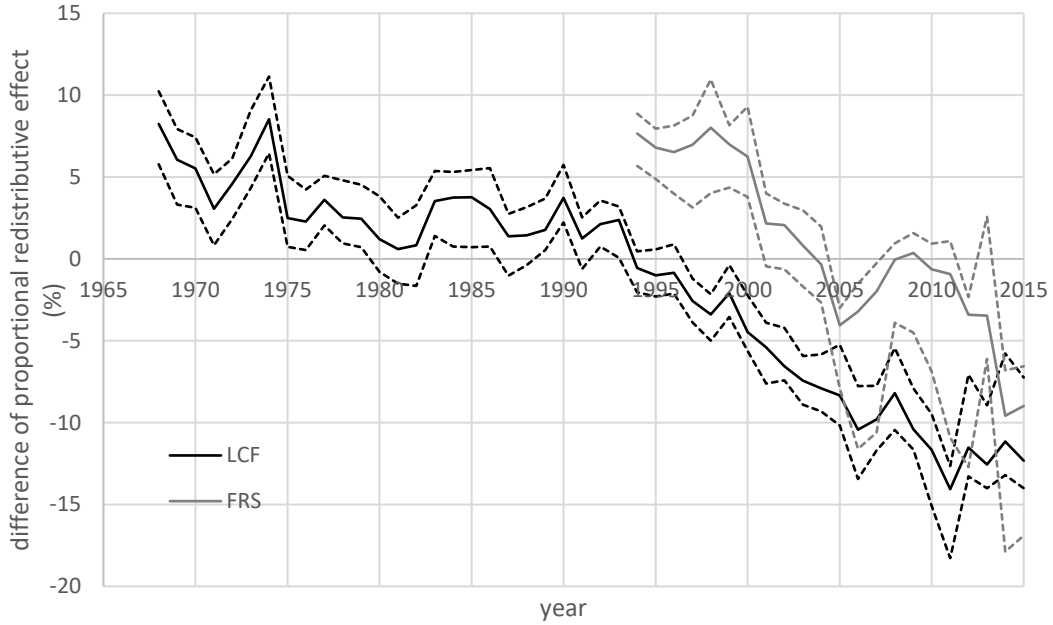
Figure E.26: Redistribution of household equivalised income by year and data source; un-truncated estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.25.

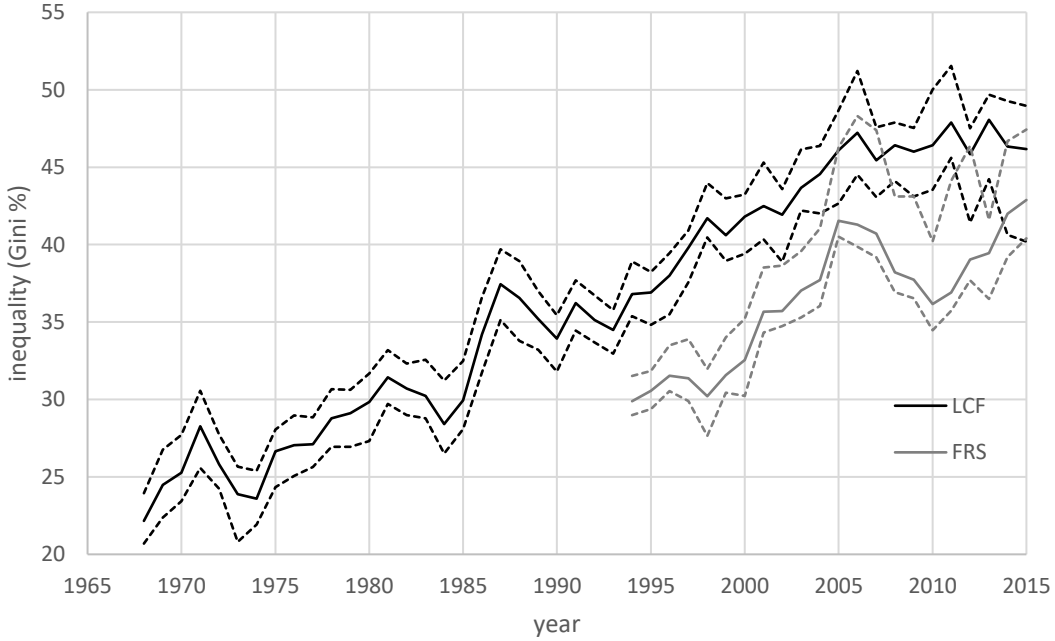
Figure E.27: Proportional redistributive effect of income equivalised using tax implicit scales less the same effect equivalised using the OECD scale, by year and data source; un-truncated estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: Proportional redistributive effect calculated as the inequality of private income less the inequality of disposable income, all divided by the inequality of private income. Redistribution measured as inequality of private income less inequality of disposable income. See notes to Figure E.25.

Figure E.28: Inequality of equivalised disposable income by year and data source; un-truncated estimates



Source: Authors' calculations using data from the Living Cost and Food Survey (LCF, EFS, and FES) and the Family Resources Survey (HBAI series, FRS).

Notes: As for Figure E.25.