Lifetime inequality and redistribution

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Abstract

In this paper we look at lifetime inequality to address two main questions: How well does a modern tax system, based on annual information, target lifetime inequality? What aspects of the transfer system are most progressive from a lifetime perspective? To answer to these questions it is crucial to relate lifetime and annual inequality and determine the main building blocks of lifetime disparities. We look at lifetime inequality and the redistribution properties of taxes and benefits using a dynamic life-cycle model of women's education, labour supply and savings with family dynamics and rich individual heterogeneity in preferences and productivity. The model is coupled with a detailed description of the UK personal tax and benefit system and is estimated on UK longitudinal data covering the 1990s and early 2000s. We show that the tax-benefit system is more redistributive from an annual than from a lifetime perspective, and it is most progressive at the bottom of the income distribution in both cases. We then establish that heterogeneity in family experiences throughout adult life is the main vehicle through which the tax-benefit system moderates lifetime inequality. Although transitory, family conditions under which working is especially costly, such as lone-motherhood, are especially prevalent among the lifetime poor. By targeting this group, particularly using polices specifically designed to improve the work incentives of those with the lowest earnings capacity, the tax-benefit system does achieve life-cycle redistribution. Other policies like universal benefits towards family with children are less well targeted towards the lifetime poor but are more progressive and improve the work incentives in the middle 60% of the distribution of lifetime income.

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1 Introduction

At a time of ever scarcer public resources, understanding how to reduce income inequality at minimum efficiency cost is of utmost importance. But inequality is a complex concept, with various measures and accounting periods that emphasise different features of it possibly leading to different policy conclusions. For example, most inequality studies base their analysis on income measured over short periods, often annual due to data limitations. Since individual positions in the distribution of annual income change over time because of the dynamics of the income process, the intertemporal nature of decisions and the effects of transitory income shocks, taking too such short an accounting period may produce an incomplete and misleading picture of the disparities between individuals.[1] Instead, true economic differences are more accurately revealed by the distribution of income measured over long periods, and especially the entire life-cycle, as this implicitly accounts for the moderating impact of income mobility. Lifetime income is also a more relevant variable for welfare analysis as transitory variability in income can typically be smoothed by saving and borrowing.[2]

The need to consider longer accounting periods is particularly strong for informing the design and assessing the redistributive effects of the tax-benefit system. For example, a snapshot assessment of a benefit like unemployment insurance would suggest it is a powerful mitigator of inequality. But from a lifetime perspective, its impact may be more modest if unemployment is a transitory state. That is, annual redistribution overstates longer-term redistribution as it partly represents intra-personal transfers across life-cycle periods (Layard, 1977; Sandmo, 1999; Liebman, 2002). Several empirical studies have found this to be the case, with intra-personal transfers accounting for a large proportion of public spending on transfers to families.[3] Yet, the lifetime redistributive properties of the tax-benefit system are still largely unknown. We lack the understanding of which policies best target permanent economic differences, and the economic mechanisms that justify their performance.

[1] Empirical studies to date did find that dispersion in income decreases with the the length of the accounting period (some early references are Lillard, 1978, Shorrocks, 1978, and more recently Creedy, 1993, Bjorklund, 1993), and that income mobility is non-negligible (Jarvis and Jenkins, 1998, Kopczuk, Saez and Song, 2010).

[2] This is not to say that publicly provided insurance mechanisms designed to smooth income instability are not justified (Browning and Crossley, 2001). They are, for example under the assumptions that people dislike income risk and have limited access to the credit and insurance markets.

[3] Piketty and Saez (2007), or Bengtsson et al. (2012), find that the tax-benefit system is less progressive from a lifetime perspective than it is annually. Bovenberg et al. (2008) estimates that intra-personal redistribution accounts for three fourths of the taxes levied to fund public transfers in Denmark; other studies have found comparable proportions, smaller when pensions are excluded (van de Ven, 2005) and larger when the value of major publicly provided services like education and health are included (Pettersson and Pettersson, 2003).

This paper addresses precisely these points. We answer two main questions: (*i*) How well does a modern tax-benefit system, based on annual information, target lifetime inequality? and (*ii*) What elements of the tax-benefit system are most progressive from a lifetime perspective and why? To answer these questions it is crucial to relate lifetime and annual inequality, and to determine the main building blocks of lifetime disparities. We do this for the UKs tax-benefit system, which has a tax system that operates at the individual level, with a benefit system that has a heavily reliance on income-testing at the family level, and that is much more generous to those with children than those without.

The study of the lifetime redistributive properties of the tax-benefit system cannot be easily performed on observational data alone, even if complete individual life histories can be observed. This is because data does not contain the sort of variation required to identify lifetime effects given the universality of taxes and benefits. Even on the rare occasions when one has data from an experiment, the experiment is a short lived one, and cannot possibly be used to identify life-long effects. Moreover, tax-benefit systems are typically constantly changing, often in response to changes in the economic environment, implying that individuals live through a myriad of institutional settings each implemented over a short period of time, and different generations experience different sequences of policies and different economic conditions. Such time and cohort effects confound the identification of the impact of specific taxes or benefits, even if we were ready to extrapolate from lifetime effects of short-lived policies to the effects had the policy been permanently alive. Thus, the existing empirical literature has not attempted to understand what aspect of the tax-benefit system helps achieve lifetime progressivity; instead, the focus has been on assessing how much redistribution is achieved by specific policies, conditional on individual choices under the specific institutional environments in place during his/her life. This literature is not vast but is growing with the increasing availability of long longitudinal data (e.g. Bjorklund, 1993; Bjorklund et al., 1995; Kopczuk et al, 2010; Bartels, 2011; Bengtsson et al., 2012).

Rather than use observational data, we therefore study these questions using simulated data from an estimated life-cycle model of education, labour supply and savings (the model was originally developed in Blundell et al., 2012). Simulated data brings important advantages to the type of analysis we undertake, as we can observe individuals over their entire adult lives, and we can have complete control over the institutional setting. Unsurprisingly, therefore, simulation models have been used in the past to describe the redistributive features of parts of the tax-benefit system, particularly the social security system and pensions.[4] But previous studies have not modelled employment or

[4]Some examples are Layard (1977); Lillard (1977); Pettersson and Pettersson (1993); Nelisses (1998); Liebman

education choices, which may respond to tax reform and strongly influence lifetime inequality. For our purpose of assessing the long-term impact of aspects of the tax-benefit system on lifetime inequality, it is important that these are accounted for.[5]

In this paper we study the way that the UK tax-benefit system affects women. Relative to men, women are found to be especially vulnerable to poverty and career breaks, particularly during childbearing years and conceivably explaining part of the gender wage differentials (Adda et al., 2011b, and references therein). Perhaps in response to the accumulating evidence pointing to a strong economic divide by gender, some of the most meaningful welfare reforms of the last 20 years in developed countries were especially designed to alleviate poverty and encourage women into work. An example of this are the various versions of generous work-contingent benefits for families with children that have been implemented in the UK, US and other English-speaking countries, but also in some continental European countries. And since women have been found to be especially responsive to work incentives (Phillips and Meghir, 2010; Keane, 2010), it may well be the case that such policies have strong consequences for lifetime inequality. We therefore look specifically at the impact of different life experiences, from education to motherhood, on lifetime outcomes and inequality, and we investigate how well do tax-benefit systems that tag particular transitory circumstances achieve redistribution from a lifetime perspective.

Our desire to separate the main sources of lifetime inequality and to understand the impact that targetting specific (transitory) conditions has on long-term redistribution among women imposes some strong demands on the underlying model. Ever since the seminal paper by Eckstein and Wolpin (1989), the literature on female life-cycle behaviour has acknowledged the importance of two main forces explaining labour-force participation and earnings: family circumstances and experience.[6] The main drive in this literature has been to endogeneise family-related choices like marriage and fertility, in recognition of their importance for career intermittency, experience losses and the potential simultaneity of labour supply and family decisions.[7] We take a simpler route and consider marriage, separation and fertility to be stochastic, education-specific, processes, but ones which are exogenous. Instead, our focus is on producing a compelling and realistic description of women's earnings and

(2002); or van de Ven (2005).

[5]One exception is Bowlus and Robin (2011), who propose a dynamic statistical model of income and employment. However, employment is exogenous, so the model cannot predict labour supply responses to policy reform. There is also no attempt to model the institutional background.

[6]This is in sharp contrast with the literature on the life-cycle labour supply and earnings of men, which has focused on hours of work and savings. See Keane (2010) for an overview.

[7]Marriage is first considered by van der Klaauw (1996); fertility is considered by Francesconi (2002); later papers by Keane and Wolpin (2007 and 2010) have endogenised both decisions.

family income processes that can support an informative discussion of the role of taxes and benefits in the short- and long-term. In contrast to what has been done before, women's wages are assumed to be driven by a dynamic process of human capital formation that separates state dependence through experience effects and heterogeneity through persistent productivity shocks. We consider a flexible specification of the role of experience, allowing data to dictate the relative cost of working fewer or no hours by including depreciation and hours-specific learning.[8] Moreover, we allow for heterogeneity in wage profiles through a persistent productivity process that is correlated with preferences for work at the start of working life. We find evidence of strong persistency in wages, which implies that ignoring it would bias estimates of the experience effects, limit our ability to accurately reproduce wages and earnings mobility, and in the end affect the policy conclusions to be drawn.[9]

We consider two other sources of family income. The first, as usual in this literature, is men's earnings. The typical approach has been to assume that men always work and earn an income that depends on age and, in some cases, on other female socio-demographic characteristics (Francesconi, 2002). Instead, we consider a reduced-form selection model of male employment, with male earnings related to the female partner's wage through education and persistent innovations. The second is what amounts to net transfers from the state. In each period, total earned income together with family characteristics determine the tax liability and subsidy entitlement of each family. These are assessed by a detailed micro-simulation model of the UK tax system, FORTAX.[10]

Two other features differentiate our model from most of the other on female life-cycle labour supply. First, we incorporate education choices at the start of adult life (Keane and Wolpin, 1997, is the first paper to consider endogenous education decisions in a life-cycle model for men). Education is a strong determinant of economic wellbeing and has been shown to respond to incentives in the labour market.[11] Yet, there is to date no study of the impact of major components of a tax-benefit system which can have profound effects on labour market incentives, on education investments. Second, we follow Attanasio et al. (2008) and account for savings decisions, thus reducing the role of labour supply in smoothing consumption across life-cycle periods.

Using simulated data from such a model, we are able to address the questions posed above. In doing so, we make three major contributions to the literature on lifetime inequality. *First*, we decom-

[8] The single paper that considers a similar specification is Adda et al. (2011b).

[9] Huggett et al. (2011) impose permanent differences in wage profiles in a model for men. The data we use in this study does does not support such permanent differences.

[10] See Shepherd, 2009, and Shaw, 2011.

[11] See Willis and Rosen (1979), Keane and Wolpin (1997) or Belzil and Hansen (2002).

pose lifetime inequality into its major building blocks, separating the roles of innate characteristics, initial wealth, education and family arrangements experienced through life.[12] Since these are closely intertwined factors - because, for example, initial conditions affect education investments with consequences for family dynamics - the measurement of their significance for lifetime inequality can only be assessed by jointly accounting for all of them. *Second*, the addition of a micro-simulation model of the tax-benefit system supports the study of how taxes and benefits may alter the relative importance of different sources of lifetime inequality. This information is key to identifying the sources of inequality that may deserve a closer scrutiny from a government trying to reduce long-term economic disparities, either for their significance in explaining differences or for because they are especially responsive to particular interventions. And *third*, we use the model to isolate the impact of different taxes and benefits on lifetime inequality and investigate the economic mechanisms that justify the impacts. This can be done by selectively shutting down elements of the tax-benefit system and studying the consequences on behaviour and outcomes. Using a similar procedure, it is also possible to perform an ex-ante evaluation of hypothetical tax designs that have not been seen in the data.

We show that the long-term inequality and mobility patterns found in the data are well reproduced, suggesting the model is a good instrument for the study of lifetime inequality. Using the 2006 tax-benefit system as if it applied throughout individuals adult lives, we find that lifetime inequality is substantially lower than annual inequality. But the tax-benefit system is much more redistributive from an annual perspective and, for both measures of income, is especially progressive at the bottom of the income distribution. [13] Despite the limited contribution that transitory family conditions have on lifetime inequality, we show that the tax-benefit systems characteristic of the UK during the 2000s are particularly well target towards lifetime inequality explained by heterogeneous family experiences. We identify the generous benefits targeted at families with children, particularly work-contingent benefits, to be the most progressive component of the UK transfer system from a lifetime perspective. To a large extent, their impact is driven by labour supply responses to the improved working incentives for low income families. If substantially reduced, as they were in the tax-benefit systems characteristic of the 1990s, the resulting system is only very mildly progressive. By contrast, universal benefits towards families with children have no substantial impact at the bottom of lifetime income distribution but increase progressivity higher up the distribution, particularly at its middle, by improving the position of mothers in couples.

[12] Some other studies, particularly in the macro-economic literature, have assessed the importance of conditions established at the beginning of working life to explain lifetime inequality (Storesletten et al., 2004, Huggett et al., 2011). This literature has focused on men and has not attempted to provide a more detailed decomposition of the role of crucial factors like education and family experienced through life as the underlying models do not support such analysis.

[13] Redistribution and progressivity are define in section 3.3.

The rest of this paper is organised as follows. Section 2 overviews the main features of the model and describes the timing of choices and events during a female adult life. Section **??** describes the observational and simulated data used to study lifetime inequality and redistribution and defines the concepts of income, redistribution and progressivity adopted throughout the paper. Section 4 provides an overview of the UK 2006 tax-benefit system, which is used as the baseline institutional setup. Section 5 discusses some of the model empirical properties that are more relevant for the study of lifetime inequality and redistribution. Section 6 discusses some of the main results, starting by comparing annual and lifetime inequality and redistribution, showing how these change over the course of life, identifying the sources of lifetime inequality and how the tax-benefit system affects their relative importance and finally showing how progressive the tax-benefit is from a lifetime perspective. Section 7 isolates the effects of specific reforms on lifetime inequality and the progressivity of the transfer system. Finally, section 8 concludes.

2 Overview of the model

The model used in this paper was explicitly designed to inform the study of taxes and benefits. It is a structural dynamic life-cycle model of female labour supply and savings in the tradition of Eckstein and Wolpin (1989) that embeds a detailed microsimulation model of the UK personal tax-benefit system called FORTAX.[14] We summarise its key features here, emphasising the timing of choices and events during the adult life of women, but refer the interested reader to the paper that first set out the model for full details (Blundell et al., 2012) and to Appendix A which contains a brief overview of the model specification, estimation data and process.

We model women's lives from late adolescence until retirement age. Life starts with the choice of education.[15] Education is a major determinant of lifetime economic conditions, and the odds of experiencing periods of hardship, with periods of poverty, unemployment and lone motherhood all being more prevalent among the least educated. It has also been shown to respond to future expected payoffs, both in the labour market and in the form of family outcomes.[16] Up to now, the study of taxes and benefits has abstracted from potential impacts in education decisions despite the

[14] See Shepherd, 2009, Shaw, 2011, for details.

[15] Some recent studies have added education decisions to the standard structural life-cycle model. Most have focused on men, e.g. Keane and Wolpin (1997), Lee (2005) and Adda et al. (2011a). The only study (apart from ours) to consider female decisions is Adda et al. (2011b).

[16] See Willis and Rosen (1979), Keane and Wolpin (1997), Belzil and Hansen (2002), Foster and Rosenzweig (1996, 2001) and Behrman et al. (1999).

sometimes high taxes on its returns (Collins and Davies, 2004). However, responses in education induced by policy reforms are likely to drive the strongest changes in individual lifetime outcomes. In our model, education is the first step in defining women's careers, driving different skills, and offers the prospect of marrying better and avoiding early and single motherhood.[17] Women choose between three alternatives: basic (compulsory education, finished at the age of 16); intermediate (corresponding to high school); and higher (university education). The decision depends on the balance of expected benefits and realised costs, including foregone earnings, direct financial costs representing fees, and idiosyncratic (dis)taste for education related to preferences for work and (stochastic) initial productivity.

Upon leaving education, women enter the labour market. We model annual choices during adult life over consumption and labour supply, with a discrete menu of unemployment, part- and full-time employment. In parallel, family arrangements change according to processes of partnering and childbearing. Working life ends deterministically at the age of 60, after which it is women are assumed to live for another 10 years during which they consume from their accumulated savings. This is necessary to ensure a realistic accumulation of assets throughout life, and to avoid relying excessively on labour supply as a way of smoothing consumption.

Five particular features of the model are especially important for our analysis. *First*, this is essentially a model of continuous human capital formation and destruction.[18] The female rate of human capital accumulation depends on education choices made earlier in life, persistent heterogeneity that is related with preferences for working and the level of human capital accumulated so far. Furthermore, working part-time may affect the accumulation of experience more than proportionally, and taking time out of the labour market leads to human capital depreciating. Women's earnings are then determined by a combination of hours worked, market skill-specific wage rate, and their idiosyncratic level of human capital.

Taking such a flexible account of the lifetime earnings process is crucial to replicate the distribution of earnings over the life-cycle, particularly among individuals for whom career breaks and short working hours are frequent.[19] It is also essential in establishing the dynamic links in the earnings

[17] This is consistent with literature showing that the marriage market is responsible for substantial returns to education (van der Klaauw, 1996, Francesconi, 2002, Keane and Wolpin, 2010, Larsen et al., 2011).

[18] Human capital accumulation in life-cycle models was first considered by Shaw (1989). Later papers are by Heckman et al. (1998) and Imai and Keane (2004).

[19] Blundell et al. (2012) show that the model can explain the flat wage profile observed for women from age 30 onwards as a combination of career intermittency with its consequences on wage rates and the changing composition of working women with age.

process, thus supporting the study of how the tax-benefit system may alter individual choices and outcomes in the short and long term.[20]

Second, family circumstances are a major determinant of female labour supply and human capital investment decisions. This has long been acknowledged in the literature on structural female life-cycle models of labour supply, which has sought to endogeneize marriage and fertiliy decisions.[21] However, this is not the route we follow in this paper. We consider that these demographic processes are certainly important but that responses along family formation dimensions are not of first-order importance for the study of the tax-benefit system.[22] So we assume instead that partnering, separation and fertility are stochastic but exogenous, depending on female characteristics such as age, education and family composition. The model allows for family circumstances to affect female labour supply through various channels, including preferences, fixed costs of working (childcare costs for young children), income pooling in couples and non-proportional consumption needs (implicitly assuming some consumption is public). In the end, we can closely reproduce the labour supply profiles of women over the course of life and by child's age (see Blundell et al., 2012, for details).

Third, family income in couples also depends on the husband's earnings. Just like women, men supply different skills depending on education attainment. Men's earnings follow a dynamic process which depends on their education, but we simplify the human capital component by assuming experience is well approximated by age for them. Contrary to what as been universally assumed in the rest of the literature, we do not impose that men always work. Instead, we use a reduced form, education-specific selection model of male labour supply and earnings. Since in our model more educated women are more likely to draw a more educated husband and less likely to divorce, the implication of this specification is that the marital gains from education are realised both in the employment and earnings of the partner.[23]

Fourth, public transfers constitute the other source of household income, offering minimum

[20] Until now, the literature has abstracted from some of these issues. Two are particularly relevant for us. First, the fact that the process of human capital accumulation depends on life-long characteristics like education and persistent heterogeneity; disregarding those leads to an overestimation of the uncertainty in earnings. And second, the detrimental impact of short working hours may be more than proportional to the number of hours worked (and indeed we find it is). Two late additions extend the literature in these directions. Adda et al. (201b) has introduced hours-specific accumulation rates but abstracts from heterogeneity in wage profiles while Huggett et al. (2011) does the reverse.

[21] See van der Klaauw (1996), Francesconi (2002), Keane and Wolpin (2007, 2010) and Adda et al. (2012).

[22] The existing empirical evidence on the size and direction of the demographic effects of work-contingent subsidies is still largely inconclusive. See Ellwood (2000), Grogger et al. (2009), Francesconi et al. (2009).

[23] Marital sorting by education is a well established empirical fact that can also be observed in our data. See, e.g., Schwartz and Mare, 2005, or Mare, 2008.

income floors during periods of unemployment but potentially affecting employment and education choices. FORTAX - the micro-simulation tax and benefit tool used in the project - draws accurate budget constraints by family circumstances, thereby describing womens financial incentives to undertake work and invest in education. This is obviously crucial for our aim of assessing the redistributive features of taxes and benefits but has not been considered in the life-cycle literature (with the exception of Haan and Prowse, 2010).[24]

And finally, the consumption/savings decision makes our model different from most in the literature (the one exception in the literature on female labour supply being Attanasio et al., 2008). Ignoring savings would overstate the role that labour supply plays in achieving consumption-smoothing, particularly in periods when women are single, and this would compromise the model's ability to reproduce labour supply profiles over the life-cycle. However, we do assume that households are credit constrained as human capital is not accepted for collateral (the exception is for university students, who we allow to benefit from institutional loans to cover their educational and maintenance expenses).

3 Data and definitions

3.1 Observed and simulated data

As described in Appendix A, the data on which the model is estimated comes from the first 16 waves (1991 to 2006) of the British Household Panel Survey (BHPS). Except for data attrition, all families in the original 1991 sample and subsequent booster samples remain in the panel from then onwards. Other individuals have been added to the sample along the way — sometimes temporarily — as they formed families with original interviewees or were born to them. All members of the household aged 16 and above are interviewed, with a great deal of information being collected on demographic characteristics, educational achievement, employment and hours worked, income and benefits, and some expenditures, particularly those with childcare. Information on assets is collected only every 5 years. We follow women over the observation period, so the sample represents all British families with 1 or 2 working-age adults, other than single men. Our full dataset is an unbalanced panel of around 4,400 women aged between 19 and 50 and observed over at least two consecutive periods during the years 1991 to 2006. 10% of these women are observed over the whole period, 60% in no more than 6

[24]However, the literature on labour supply and taxes is extensive, most being static and some taking dynamic considerations into account. Some of the most relevant contributions are Keane and Moffitt (1998) and Blundell, Duncan and Meghir (1998); see Keane (2010) for a extensive survey.

consecutive waves, 24% are observed entering the working life from education. It is used to estimate the model parameters and as a comparison to establish the empirical properties of the model.

Our main empirical work is based on different simulated datasets, which vary with the underlying assumptions about the tax-benefit system and the time window to be considered. The main data, supporting the study of life-cycle inequality and redistribution, comprises simulated information on the education, working and family lives of women aged between 17 and 60 for over 22,000 women. Initial conditions for assets at the beginning of adult life are drawn randomly from BHPS data on savings for young women aged 16 to 18. The additional initial conditions on idiosyncratic preferences for work and education are drawn randomly from their estimated distribution, as are the productivity shocks over the course of life and the unpredictable determinants of family dynamics. We then produce different datasets, one for each of the considered policy regimes, imposing that individuals face, and expect to face, a constant policy environment over the whole course of adult life. These datasets are used to assess the long-term impact of alternative transfer systems and to understand their ability to target persistent inequality while accounting for behavioural responses on education and working decisions.

We can also vary the tax-benefit system annually, to reproduce the sequence of policy reforms implemented in the UK during the observation period and match the conditions faced by individuals in the BHPS.[25] We use simulated data under changing tax-benefit systems to study the empirical properties of the model in section 5, comparing its predictions with the empirical patterns estimated from the BHPS.

3.2 Measures of income

Income is measured at the family level, dictated by the typical family-based benefit entitlement of the tax-benefit system we study below. It is equivalised for family composition using a modified OECD equivalence scale.[26] We focus on employment earnings as this is by far the main income source for families persistently outside the top 2% of the earnings distribution. *Gross income* stands for equivalised pre-tax employment earnings of the (1 or 2) adults in the family. *Net income* is gross income less taxes net of benefits. Income is measured on an annual basis, assuming that individuals work 52 weeks a year at their chosen value of hours per week. Income measures for periods longer

[25] In this case, it is assumed that individuals are myopic in that they cannot predict future changes in taxes and benefits.

[26] The weights are 1, 0.6 and 0.4 for first and second adults and children, respectively.

than a year (including *lifetime income*) are the value of equivalised annual income over the time period being considered, discounted using the risk-free real interest rate.

3.3 Redistribution and progressivity

Throughout, we use the term *redistribution* applied to tax-benefit systems to signify inequality reducing policies, which is achieved when the relative position of individuals at the bottom of the gross income distribution is improved by the tax-benefit system. Thus, for example, a pure flat tax rate would not be redistributive; instead, it is the *progressivity* of the tax system that makes it redistributive. A progressive tax system is one where the *average tax rate* (ATR) is increasing in gross equivalised income, where the ATR is the ratio of total family tax liability (net of benefits) to gross earned income.

4 Overview of the UK tax-benefit system

We study the inequality-moderating features of modern personal tax-benefits systems using the UK 2006 institutional background as a typical example. We then experiment by changing some of its key features to isolate their importance for lifetime inequality. Here we provide a brief description of the main elements relevant for our analysis, thus focusing on the working-age population and abstracting from from issues relating to income from self-employment and unearned income.[27]

Overall, the UK combines a relatively simple, individual-based, income tax system with a relatively complicated, family-based, set of benefits and tax credits relying heavily on means-testing and in which maximum entitlements are strongly influenced by family circumstances. The two main personal taxes on earnings are income tax and National Insurance, both of which are assessed at the individual level. In practice, these two can be thought of as being the same tax, together producing a progressive rate schedule.

Most of the key benefits in the UK are means-tested and assessed against family income, where a family is defined as an adult plus any spouse or cohabiting partner.[28] Entitlements to benefits depend upon family or household circumstances in very particular ways. The benefits can be thought

[27] For a more comprehensive discussion of UK taxes and benefits, see Adam and Browne (2010).

[28] Child benefit is the only exception among the benefits we model. It will become means-tested from January 2013.

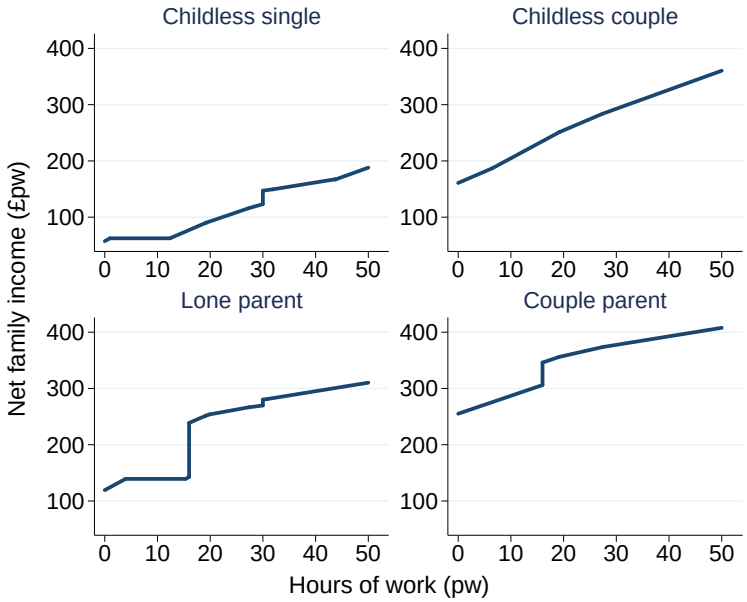
of as forming two groups: those designed to replace, or top-up, earnings, and those designed to compensate for different needs.

The group designed to replace, or top-up, earnings consists of Income Support,(IS) Jobseeker's Allowance (JSA) and Working Tax Credit (WTC). The eligibility conditions have been designed so that families are entitled to at most one: IS and JSA are intended as income top-ups for families where no one is in paid work or is working less than 16 hours per week, and WTC is designed to provide an income top-up for families where someone is in paid work. One way the system distinguishes between them is by examining the number of hours worked a week: to receive WTC, a family with dependent children must have one parent working 16 hours or more a week, couples with children must also together work a total of 24 hours or more a week, and, in families without children, at least one adult must work 30 or more hours a week and be aged 25 or over. Maximum entitlements to all these benefits depend upon family circumstances, being (mostly) higher for couples than single adults.

The group designed to compensate families for particular needs include Child Tax Credit, Housing Benefit and Council Tax Benefit. All are means-tested against income, but do not depend directly on whether the family is engaged in paid work. The maximum entitlement to these benefits depends on the number and presence of children, and whether the household is renting or not (and, if so, the amount of rent paid).

Figure 1 illustrates the budget constraints faced by different types of families by female working hours. All adults are assumed to earn minimum wage, men work full time if present and families with children pay 50 per week in childcare. The most striking feature in the picture is the big jump in income at 16 hours of work per week for women with children, especially pronounced in the case of lone mothers. This is fully explained by the WTC. From the comparison of top and bottom graphs it is also obvious that families with children with one non-working adult are also entitled to generous benefits, with CTC topping up IS. On the other hand, women with children face higher tax rates then those without due to the withdrawal of benefits. Since benefits are tapered away at a reasonably high rate, it effectively promotes bunching at the discontinuity points of 0, 16 and 30 hours per week (where another, much smaller discrete jump in net income of single mothers can be observed, driven by the WTC full-time award). The net earned income of childless women is a much smoother function of working hours. By comparison, the WTC award for childless individuals working 30 or more hours per week is small and only visible for singles as families with a full-time adult are past the entitlement region.

Figure 1: Budget constraints by family type and female working hours: UK 2006 tax-benefit system



Notes: The plotted lines represent family income by female working hours under the 2006 tax-benefit system. All adults are assumed to earn the 2006 minimum wage (5.05 per hour), and males in couples are assumed to be working full time (40 hours per week). Families with children are assumed to have one child aged 4 and spend 50 on childcare. All families assumed to pay no rents for housing.

5 Transitory and persistent inequality in gross income: data versus simulations

This section discusses transitory and persistent differences in gross family income, the main purpose being to assess the models ability to reproduce features of the data that are relevant for the study of life-cycle inequality and redistribution. In doing so, we also document the prevalence of income inequality and mobility in the UK since the 1990s, building a bridge to the existing empirical literature (Jarvis and Jenkins, 1998; Dickens and McKnight, 2008) and laying the ground for the life-cycle results based on simulated data that are discussed later.

We compute two sets of comparable statistics, one based on observed BHPS data, and the other on the simulated data that exactly reproduces the age and time structure of BHPS. This is done by replicating the sequence of tax-benefit systems implemented in the UK over the observable period and

selecting, for each simulated woman, the age window that matches that observed for the corresponding woman in the dataset. The chosen statistics are among the most commonly encountered measures of inequality and mobility, aiding comparability with other studies, and none of them has been used during the estimation procedure, making this a akin to a validation exercise.

As the BHPS data follows individuals for at most 16 years, this exercise can only inform us about inequality assessed over relatively short period of time. But we then examine measures of *income mobility* to make the crucial link between transitory and persistent notions of inequality. Income mobility measures how easy it is to move up or down the income distribution: given the same annual inequality, more income mobility leads to less long-term inequality. And being able to reproduce the observed patterns of income mobility gives us confidence that the model is also reproducing well the (unknown) patterns of life-cycle inequality.

Inequality Table compares the inequality (Gini coefficient) in gross family income in the BHPS data and in the comparable simulated data, where incomes are measured over different time spans, from 1-year to 9-year periods.[29] Inequality in the BHPS data decreases with the lengthening of the accounting period, a symptom of short-lived income variation that bears no consequences for long-term inequality. We find the same pattern for simulated data, but the Gini coefficients for short accounting periods are significantly below the corresponding ones for BHPS data. The inability of the model to closely reproduce inequality for short accounting periods is not surprising, as purely transitory variation in wage rates has been treated as measurement error in the estimation procedure. Such high-frequency volatility, whether resulting from measurement error or not, adds to measured short term inequality in income, but has minimal impact on the dispersion of income over longer periods. In particular, it is inconsequential for the assessment of lifetime inequality. What is more important for our purpose of ensuring that the model produces reliable predictions of life-cycle economic disparity is that the gap between data and simulated Gini coefficients gradually closes as the accounting period lengthens, being zero for 9-year intervals.[30]

Figure 2 provides more detail on the ability of the model to reproduce the income distribution by contrasting data and simulated quantiles in the distribution of income over the life-cycle. It shows

[29]Small sample size due to attrition limits the length of the period we can consider. Estimates for total family income display similar patterns except that total family income is slightly more unequally distributed than equivalised income.

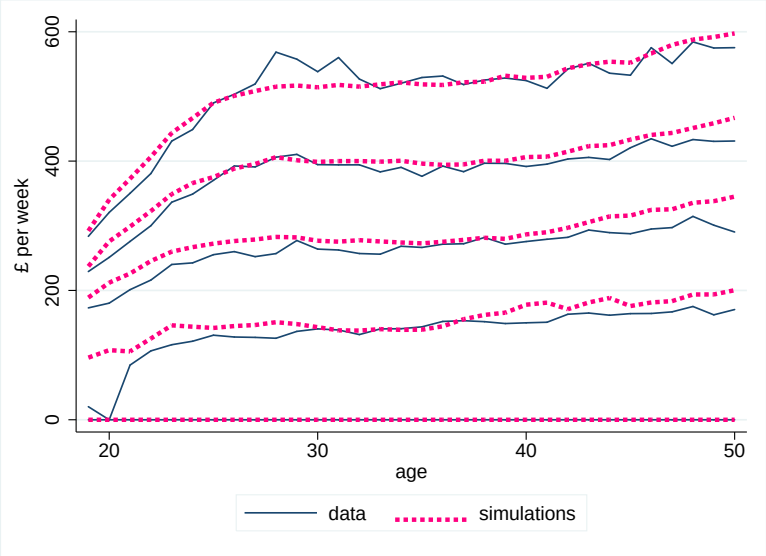
[30]For the first wave of BHPS, Jarvis and Jenkins (1998) report a Gini coefficient for disposable income of 0.309. Dickens and McKnight (2008), using data from the Lifetime Labour Markets Database, an administrative dataset that follows 1% of the entire population, estimated that the Gini coefficient for annual gross earnings has increased over the period since 1979 to 2005, from under 0.3 to over 0.4 for males, and from about 0.35 to 0.43 for females.

Table 1: Gini coefficient for gross equivalised family income; data versus simulations

	data	simulations	difference
1 year	0.406	0.356	0.053
3 years average	0.372	0.343	0.030
5 years average	0.354	0.335	0.021
9 years average	0.319	0.322	-0.001

that, over the life-cycle, the empirical distribution of family income is well reproduced by the model.

Figure 2: Distribution of gross equivalised family income over the life-cycle of women; data versus simulations



Notes: Lines in the graph correspond to the 10th, 25th, 50th, 75th and 90th percentiles of the distribution of equivalised gross familiy income in the real (solid blue) and simulated (dotted pink) datasets.

Mobility Table 2 shows the rank correlations between income in adjacent periods for the BHPS and comparable simulated data, and estimated for different sizes of period. The rank correlations are always high, around 0.8 for data and simulations alike, showing a strong persistence in the position in income distribution.[31] Again, simulations over-predict the rank correlation for short accounting

[31] Comparable numbers on taxable earnings of adults for the US are in the order of 0.9; see Kopczuk et al (2010).

periods due to the exclusion of high-frequency variation from the simulated data, but correlations over longer periods are accurately reproduced at different stages in life.

Table 2: Rank correlation between equivalised gross income at different ages; data versus simulations

	1-year income 1 year interval	3-year income 3-year interval	5-year income 5-year interval
All women			
BHPS data	0.836	0.828	0.805
simulated data	0.870	0.843	0.794
Women 35 or younger			
BHPS data	0.838	0.816	0.788
simulated data	0.848	0.827	0.776

Transition matrices are an alternative and more detailed measure of mobility. Table 3 presents transition rates between quintiles of the income distribution, for different accounting periods and corresponding time intervals between the measurements. Similarly to what was established by Jarvis and Jenkins (1998) on BHPS data, most movement between income quintiles registered both annually and for longer accounting periods is short-range: around 90% of all transitions are either within quintiles or to a neighbouring one. As for other measures discussed above, the figures for data and simulations are very close for long-enough accounting periods.[32]

Table 3: Transition probabilities in equivalised gross family income; data versus simulations

	Same quintile		Same or neighbouring quintile	
	data	simulations	data	simulations
year-to-year, annual income	66.3%	73.2%	91.8%	95.6%
3-year transitions, 3-year mean income	57.3%	59.0%	90.6%	92.2%
5-year transitions, 5-year mean income	52.6%	52.0%	89.5%	89.3%

[32]The full transition matrices underlying these moments can be found in Appendix B.

6 Lifetime inequality and redistribution

We now turn to study the life-cycle redistributive properties of the UK tax-benefit system using our main sample of simulated data covering womens adult lives. The main analysis is based on the UK 2006 tax-benefit system.[33] We first investigate the ability of the tax-benefit system to reduce persistent disparities, as opposed to transitory ones. Since tax liabilities and benefit entitlements are assessed on annual information alone for the policy instruments being considered, we supplement the analysis by studying the features of annual inequality that facilitate redistribution from a lifetime perspective. We then assess the effects of alternative policy environments. We start by investigating how the taxes and benefits changed over the 1990s and 2000s in the UK to isolate major changes and their consequences for lifetime disparities. The main conclusion from this analysis is that policies targetting families with children can moderate lifetime inequalities, despite the transitory nature of family conditions. We also experiment extending entitlement to child subsidies to all the population of parents with dependent children. We show that the redistribution induced by such policy is benefits mostly women in the middle of the income distribution.

State benefits for those over the retirement age, including state pensions and means-tested top-ups, have been omitted from our analysis. When considered with the taxes levied to fund them, these programmes are, without doubt, a major form of inter-temporal redistribution. By excluding them, it means that our use of 'lifetime' strictly means effectively 'adult education and working life', and that our results are biased towards finding relatively more inter-personal redistribution than we would have done had we taken a 'whole adult life' perspective. This is important to keep in mind when comparing annual and lifetime redistribution, as in the first section below, and when assessing our results against those in the literature. But it is less of a concern for the study of the redistributive properties of the set of taxes and benefits being considered.

6.1 Annual versus lifetime inequality

Table 4 compares annual and life-cycle inequality. [34] We consider three alternative inequality measures, all commonly encountered in the literature, and all allowing for zeros in the variable of interest

[33] 2006 is the last year of observation data, and a year that is broadly representative of the institutions that prevailed in the UK and elsewhere during the 2000s.

[34] In this and all that follows, annual statistics rely on annual earned income from the pooled sample of life-cycle periods and life-cycle statistics use the discounted value of life-cycle income.

(as they are frequent in our measure of annual income): the Gini coefficient, the inter-quartile ratio, and half the coefficient of variation.[35]. Since all show similar patterns, we omit discussion of the latter two, and relegate results to Appendix C.

Table 4: Annual and lifetime inequality by education under the 2006 tax system: aggregate Gini coefficients

	Gross income		Net income	
	annual	lifetime	annual	lifetime
Gini coefficient				
all	0.37	0.24	0.28	0.18
education: basic	0.42	0.27	0.24	0.15
education: intermediate	0.32	0.21	0.25	0.16
education: higher	0.28	0.15	0.26	0.13

Row 1 summarises the overall inequality in gross and net income from annual and lifetime perspectives. To ground the results, we draw from empirical estimates of the Gini coefficient in Jenkins (2000). Using a measure of equivalised disposable income (including labour and non-labour income), Jenkins estimates the cross-section Gini coefficient during the early 1990s to be just above 0.3; the Gini coefficient for equivalised net income (including earned income and net public transfers) in the pooled sample from our simulated data is slightly lower, at 0.28 (column 3), and it rises slightly to 0.29 if we assume that women face a tax-benefit system typical of the early 1990s. We would expect empirical results of the sort presented by Jenkins to be above our simulated coefficients for two reasons. First, his measure of income includes sources other than employment earnings, and some of these may be more unequally distributed than earnings; second, as discussed before, we are not accounting for purely transitory variation in wage rates and/or measurement error.

Row 1 reveals a pattern that has been previously established: irrespective of the income measure, inequality is more pronounced on an annual basis. This is the natural result of compensating variation across life-cycle periods, generating mobility and attenuating inequality from a life-cycle perspective.[36] Table 4 also shows that the tax-benefit system reduces inequality substantially, and more so for annual income. For example, the tax-benefit system reduces the Gini coefficient by 9pp

[35]For an overview of inequality measures and their mathematical properties see Cowell, 1995 or 2000

[36]E.g., Blomquist (1981), Bjrklund (1993) and, more recently, Bengtsson et al. (2011) describe a similar pattern in Swedish data, Slemrod (1992) does so using US data, and Bartels (2011) for Germany.

and 6pp, respectively, for annual and lifetime income. That the redistributive effect of the tax-benefit system is larger from an annual than from a lifetime perspective is not surprising: part of the taxes levied simply finance benefits to compensate individuals for transitory variation in income, thus effectively representing transfers across life-cycle periods.[37] What is more surprising is that the tax-benefit system is still very significantly redistributive from a lifetime perspective. [38]

The table also presents results by education, a major determinant of family income and inequality through its impact on labour earnings and marital sorting.[39] Values for the Gini coefficient in rows 2 to 4 show that inequality in pre-tax income is especially pronounced among families with low educated women, both on an annual and a lifetime basis. This is largely a consequence of the high incidence of unemployment among this group.[40] Yet the tax-benefit system seems particularly well targeted to reduce inequality among the least educated, bringing it to levels similar to those for the two higher education groups. Below we investigate why this might be so.

Further information on the nature of family inequality and the redistributive properties of the tax-benefit system is displayed in table 5. Columns 1 to 3 (5 to 7) contain the gross and net income and tax shares by gross annual (lifetime) income quintile. The first two columns show that most of the redistribution in annual income occurs at the bottom and top quintiles, with the tax-benefit system barely affecting the middle of the distribution. Column 3 confirms that the share of contributions to the public budget by the 3 middle quintiles is similar to their gross income shares. Consistent with the previous findings, inequality is less severe on a lifetime basis but there is also less redistribution (columns 5 to 7). Still, most redistribution occurs at the extreme quintiles, just as for annual inequality. Overall, these figures suggest that the tax-benefit system has a non-negligible impact on both inter- and intra- personal income smoothing. The aggregate tax rates on annual and lifetime income (columns 4 and 8, respectively), confirm this pattern.[41] They show a very progressive

[37] See Bovenberg et al. (2007) for a discussion of intertemporal mechanisms in tax design.

[38] As discussed earlier, this result will partly reflect our exclusion of purely transitory income variation, and of retirement pensions and other state benefits of the elderly. These exclusions will reduce annual variation and remove the intertemporal link between social security contributions and pensions, thereby both serving to make annual and lifetime effects more similar than they really are.

[39] There is a growing literature on the importance of education across a range of life dimensions. See Card (1999), Cunha, Heckman and Schennach (2010), Meghir, Palme and Schnabel (2012), and Chiappori, Salanie and Weiss (2011) for examples.

[40] For example, the difference between the Gini coefficients for annual income of the least and medium educated is reduced to 3pp when the analysis is restricted to periods of positive labour earnings (results not shown).

[41] The aggregate tax rat is the ratio of the tax levied to the gross income raised by the group. It is different from the tax shares in columns 3 and 7 as these measure the proportion of the overall tax levied contributed for by each group. So if the aggregate tax rate is constant across groups, tax shares will exactly reproduce the income shares.

taxation at the bottom of the income distribution, particularly for annual income, that then flattens out quickly to exhibit just mild progression.

Table 5: Income shares, tax shares and aggregate tax rate by income quintile under the 2006 tax system

	Pooled annual				Life-cycle			
	Gross income (1)	Net income (2)	Tax liability (3)	Aggregate tax rate (4)	Gross income (5)	Net income (6)	Tax liability (7)	Aggregate tax rate (8)
Poorest	4.3%	8.5%	-10.7%	-55.3%	9.8%	12.5%	-0.2%	-0.6%
2nd	14.5%	14.9%	13.3%	20.2%	15.6%	16.5%	13.2%	18.1%
3rd	20.3%	19.5%	22.8%	24.8%	19.8%	19.5%	20.6%	22.5%
4th	24.7%	23.7%	28.5%	25.4%	23.5%	22.6%	26.9%	24.8%
Richest	36.2%	33.4%	46.1%	28.1%	31.2%	28.8%	39.6%	27.5%

Notes: The Aggregate ATR in columns 4 and 8 is the income quintile tax liability as a proportion of total pre-tax income.

The importance of intra-personal variation in income is shown in table 6.[42] Within group (intra-personal) variation in income represents almost two-thirds of total variation in log gross income when periods of zero labour earnings are included. This proportion is reduced to about half of the total variation after taxes and benefits have been deducted, confirming the disproportionate impact of the tax-benefit system in reducing variation in income between life-cycle periods due to earnings dynamics, unemployment spells or changes in family composition. The exclusion of periods of zero earnings moderates within-group variation and the impact of the tax-benefit system on its relative importance (row 2). In this case, the proportion of the variance explained by within group variation is kept unchanged at about 50% for pre- and post-taxes income.

In the 3rd column, the table shows a massive percentage reduction in total log income variance due to the equalising impact of the tax-benefit system when zeros are included. As expected, a much more modest reduction is displayed when the sample is restricted to periods of positive earned income. Disregarding the particular absolute values of these variations, the overall message from this table is that periods of zero income both account for a substantial proportion of variation in income over the

[42]To include periods of no earned income, we have used the variance of the log income plus 1 unit. This makes no difference to the variance decomposition excluding zeros. Other decomposable inequality measures, such as the coefficient of variation, produce qualitatively similar results.

Table 6: Within group (intra-personal) share of log income variation

	Gross income (1)	Net income (2)	Change in total variance (3)
(1) Including zeros	63%	53%	-90%
(2) Excluding zeros	50%	53%	-17%

Notes: To include periods of no earned income, we have used the variance of log(income+1). This makes no difference to the variance decomposition excluding zeros in row (2).

life-cycle, and are strongly targeted by the UKs tax-benefit system.

We now move to investigate how inequality builds up over the course of life and the properties of the tax-benefit system that best tackle lifetime dispersion in income.

6.2 Inequality and redistribution over the course of life

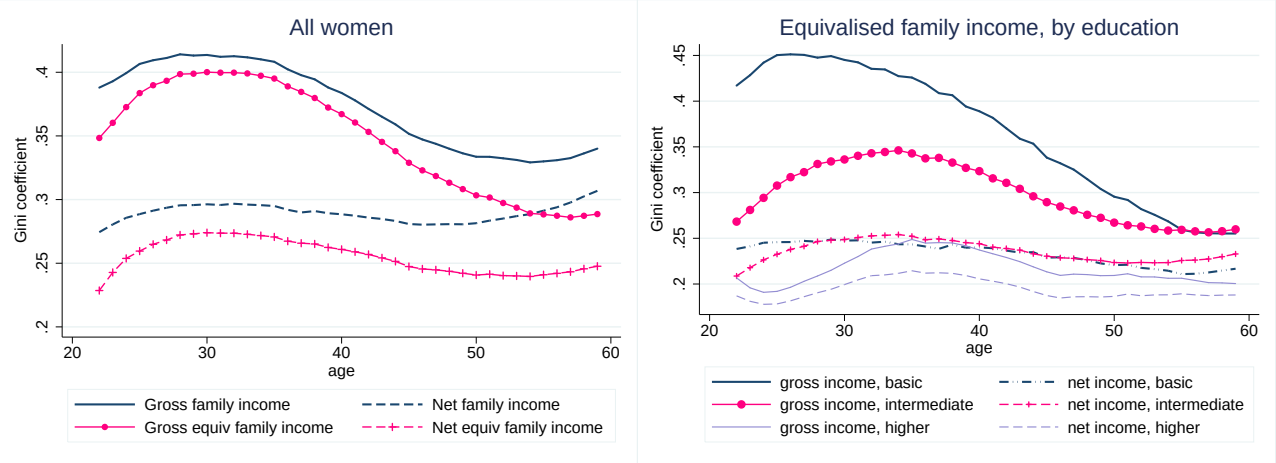
Figure shows how inequality evolves over the life-cycle for all women and by education level. The graph on the left shows some marked variation in inequality by age, with a pattern that resembles an inverted U peaking early in life, when women are in their 30s. (This profile is not mechanically caused by changes in family dimension, as the general shape is independent of whether or not gross income is equivalised). The tax-benefit system seems to be particularly efficient at smoothing the discrepancies at ages when they are most acute, so that inequality in the net income is nearly constant with age. So we conjecture that transitory changes early in life, most likely related to the dynamics of family formation and how they affect behaviour leading to periods of low or no working hours, are at the root of this pattern.

The hump-shape curve for gross income is more evident for women with basic and intermediate education, who also experience systematically higher levels of gross income inequality than more educated individuals (see right-hand graph in figure 3). The highest inequality levels for the least educated are contemporaneous to periods of high fertility and high risk of becoming a lone-mother (see figure 4). Such family circumstances, with their associated monetary and utility costs of working, may lead to unemployment and part-time work together with a disproportionate prevalence of very low

levels of earned income - as seems to be suggested by Figures 5 and 6.[43] We expect the combination of changing family circumstances and labour supply to be at the root of the strong variation in age-specific inequality over the course of life.[44]

The right-hand graph in figure 3 also shows how the tax-benefit system affects inequality within education group over the course of life. Its inequality-reducing effects during childbearing years among individuals in the two lowest education groups are not reproduced among the higher educated. Yet, and despite the strong compression of the income distribution, the incidence of low income remains disproportionately high during childbearing years among the least education women after taxes and benefits have been accounted for (see figure 6). And the tax-benefit system seems to have little impact on the relative positions of individuals in the income distribution, at least for the bottom quintile.

Figure 3: Gini coefficients over the life-cycle: all and by women's education; gross and net



Notes: The plotted Gini coefficients are women's age- and group-specific. Based on simulated data under the 2006 UK tax-benefit system.

6.3 Sources of lifetime inequality

Although these results show the existence of strong variation in income, particularly during childbearing years, we have not yet established what consequences this has on lifetime inequality. It is

[43] Brewer et al., 2012, studies in detail how monetary work incentives change over the life-cycle.

[44] Based in the same model, it has been found that the dispersion of wage rates decreases with education, with differences becoming more pronounced with age partly due to the stronger increase in the dispersion of work experience, and thus of human capital, among the least educated (Blundell et al, 2012).

Figure 4: Family composition over the life-cycle: all and by women's education

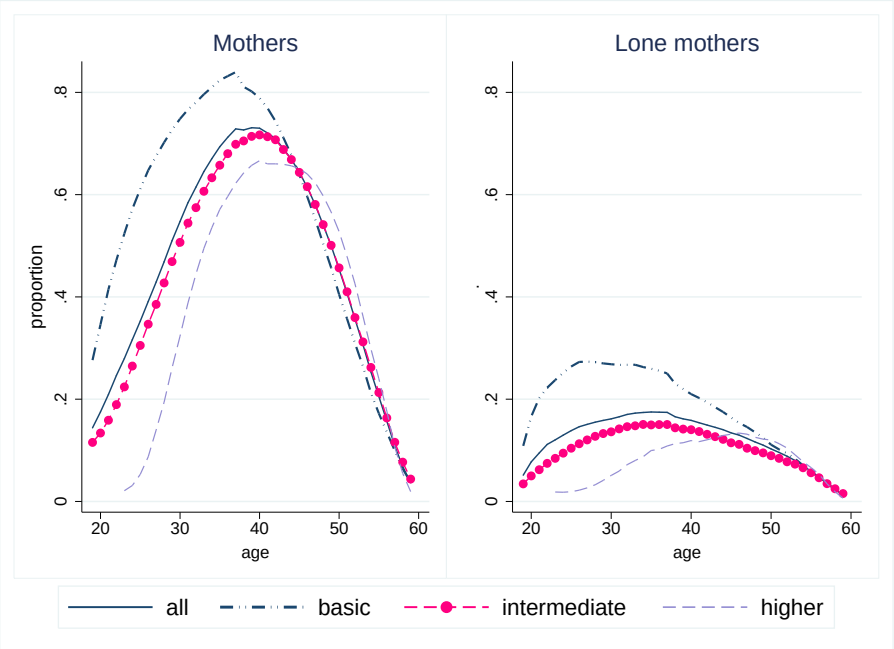
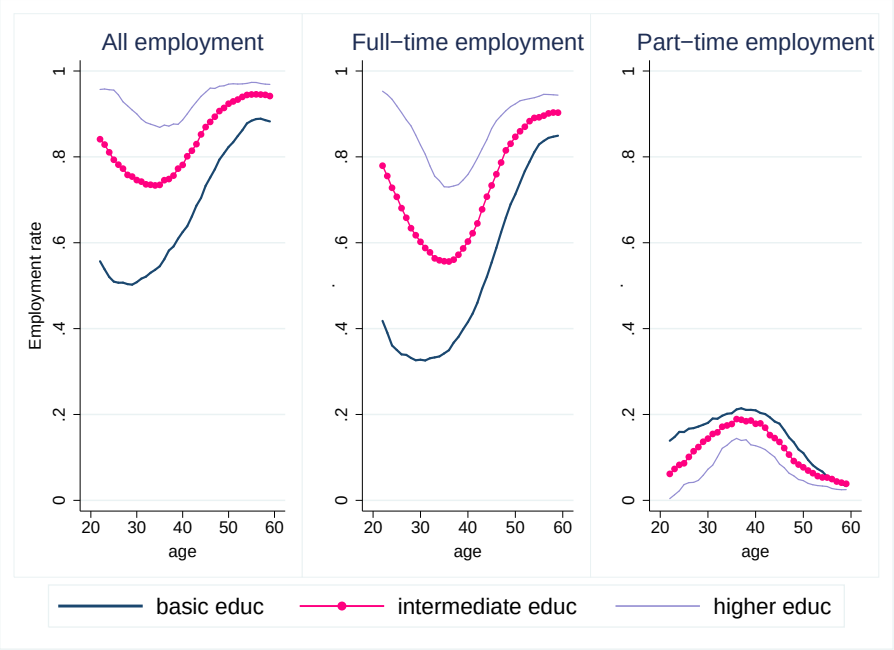
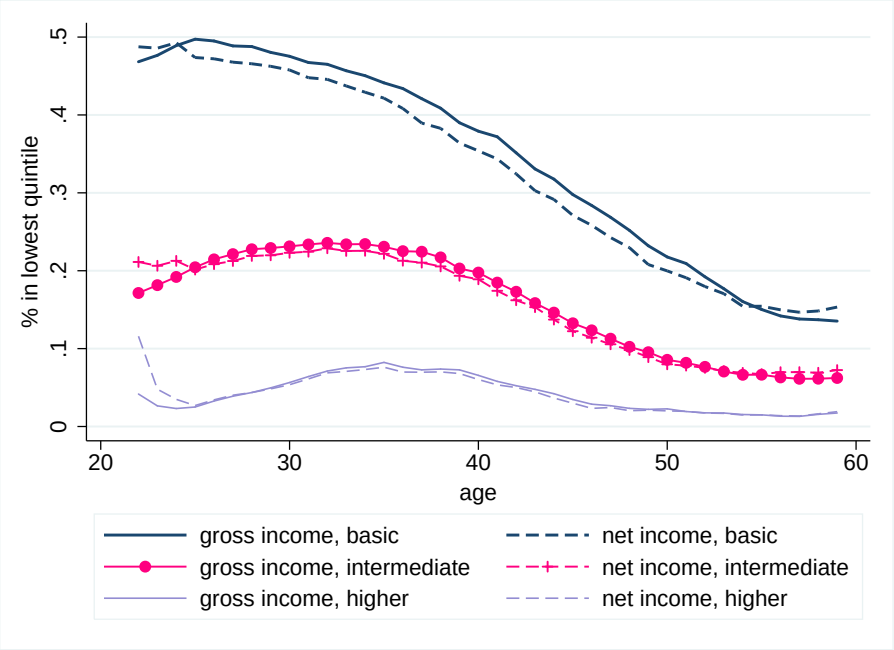


Figure 5: Women's employment rates over the life-cycle by education



conceivable that most of this variation is sufficiently short-lived or originating from inter-temporal decision making; if so, it would have only a weak relation with persistent differences between indi-

Figure 6: Proportion of families in bottom quintile of annual income over the life-cycle: by women's education



viduals. Figure 7 therefore shows how individual rankings in the distributions of annual and lifetime income relate. It clearly shows there to be a particularly strong relationship between income positions during the main childbearing years and the whole life-cycle; this suggests that family circumstances, even if transitory, do affect living standards in the long-term. Moreover, the rank correlation is always strong, above 0.55, indicating that some persistent differences do play a role in explaining inequality both on an annual and lifecycle basis.

To establish the sources of lifetime inequality and understand the role of life-course events in determining differences between individuals, we decompose lifetime inequality into some of its determinants, including initial conditions, education attainment and family circumstances experienced over the course of life. We adopt the simple regression-based decomposition methodology suggested by Fields (2003, following Shorrocks, 1982, decomposition of inequality by factor components). Table 7 details the results and underlying regression estimates can be found in Appendix D.[45]

We consider three determinants of variance in lifetime income: initial conditions, education, and

[45]Other specifications have been tried, including different functional forms and a sequential decomposition accounting for the chronology of life events. This made no significant difference to the results we report.

Figure 7: Rank correlation between annual and lifetime income

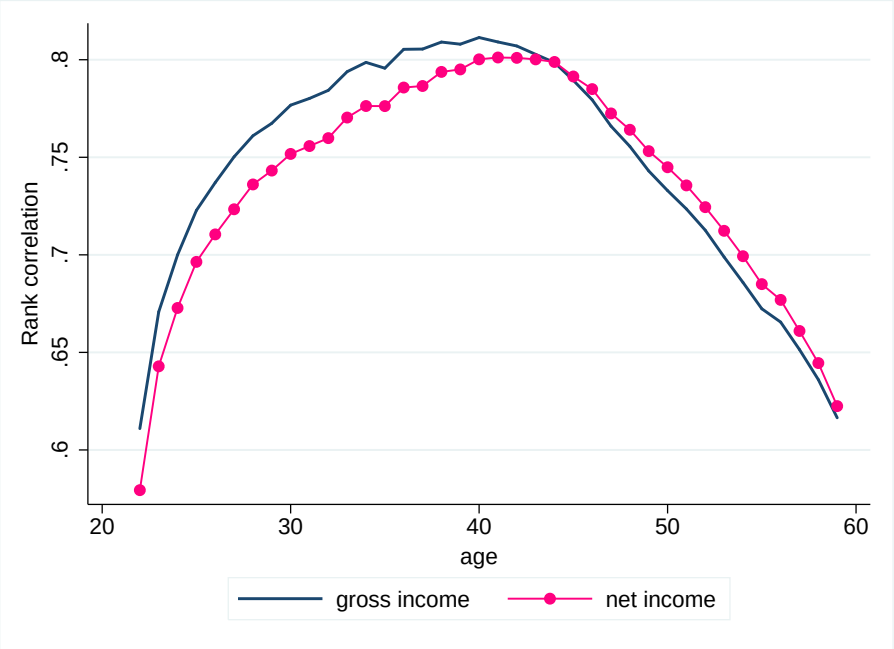


Table 7: Factor decomposition of lifetime inequality: proportion of variance explained by various lifetime dimensions

	Initial conditions	Education	Family history: partner	Family history: children	Family history: lone mother	total
Gross income	13.2%	20.9%	3.4%	6.0%	8.7%	18.1%
Net income	15.3%	24.2%	3.1%	7.2%	1.1%	11.4%

family history.[46] Taken together, the former two account for persistent characteristics determined at the start of working life. The latter describes changing family conditions experienced over the course of life. Among all factors, education makes the largest contribution to the variance in lifetime income. Together with other initial conditions, we find that it accounts for about 35% of the variation in lifetime earnings. This is just above half of what has been found by Huggett et al. (2011) for male earnings in the US.[47] But men are less vulnerable to periods of unemployment and part-time work that may inflate variation in experience and human capital, and their model does not account for

[46] Under the title "initial conditions" is included the value of initial assets, individual permanent preferences for work, which are correlated with initial productivity, and whether faces positive childcare costs.

[47] And is generally below other predictions for men in the US (Storesletten et al., 2004, Keane and Wolpin, 1997).

the dynamics of family composition. Moreover, their decomposition just splits the variation between initial conditions and all the rest. In our case, that would mean that part of the variation assigned to family conditions would be accounted for by initial conditions as these are not unrelated.

By and large, the tax-benefit system does not alter the importance that each component has in explaining the variance. But there is one exception: the contribution of periods as a lone mother. Our results suggest that only 1.1% of the total variation in net lifetime income is due to episodes of single parenthood, but that it explains 8.7% of the total variation in gross income. This is consistent with our previous findings that most redistribution occurs at the bottom of the (annual) income distribution during childbearing years, particularly among the least educated who are at high risk of becoming lone mothers, and that income at this stage in life is strongly correlated with lifetime income. We now find that, by targeting lone parents, the UK tax-benefit system is able to reduce lifetime inequality. Furthermore, since we are controlling for the role of education, and preferences for work and marital status, this effect can be attributed to the impact that lone motherhood itself has on employment and earnings over the course of life, rather than to its selective prevalence among women with the lowest earnings capacity.

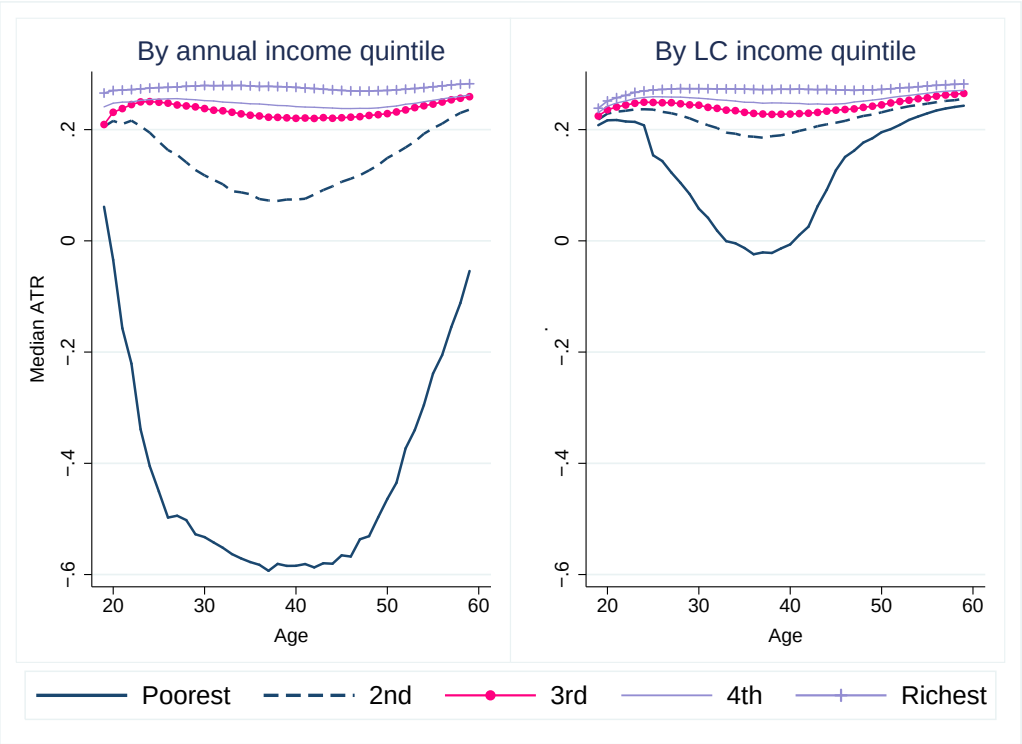
6.4 Lifetime progressivity

Figure 8 shows the progressivity of the tax-benefit system over the lifecycle from both an annual and lifetime perspective. The left-hand graph splits the population by quintile in gross annual income and the right-hand graph splits the population by quintile in lifetime income (the composition of each quintile group therefore remains constant with age for the right-hand graph, but not for the left-hand graph).[48]

Figure 8 further supports the finding that the changes in womens lives during the childbearing years, and the way that these are targeted by the UK tax-benefit system, together help bring about a considerable amount of lifetime redistribution. In line with our previous findings, it shows that

[48]Before proceeding, it should be mentioned that there are a fair number of cells with zero gross annual income (about 13% across all ages), where the annual average tax rate is undefined. These cases are all concentrated in the bottom quintile of annual income, thus affecting the bottom line in the left-hand graph. Our solution here was to consider the median ATR among families with non-zero gross income within the bottom quintile group. As compared to the alternative of presenting the aggregate average tax rate (the ratio of total transfers on total income raised by the group), this approach reduces the difference between the bottom line and the others on the left-hand graph but does not alter the overall picture.

Figure 8: Median Average Tax Rate over the life-cycle by quintile o the distributions of gross annual and lifetime income



the tax-benefit system is especially progressive at the bottom of the annual income distribution, and, indeed, that the progressivity is extended to the second income quintile during the main childbearing years. The left-hand graph now adds information on lifetime progressivity. It shows a much more compressed distribution of tax rates over the life-cycle, but strong progressivity is still evident at the bottom of the distribution during childbearing years. Indeed, if it was not for this period of life, the UK tax-benefit system would be almost neutral from a lifetime perspective.[49]

7 What policies are important in achieving lifetime redistribution?

This section attempts to isolate the impact of specific reforms on the design of taxes and benefits on lifetime inequality. It starts by exploring the reforms implemented in the UK during the 1990s and 2000s and will later assess the redistributive effects of making child-related benefits universal.

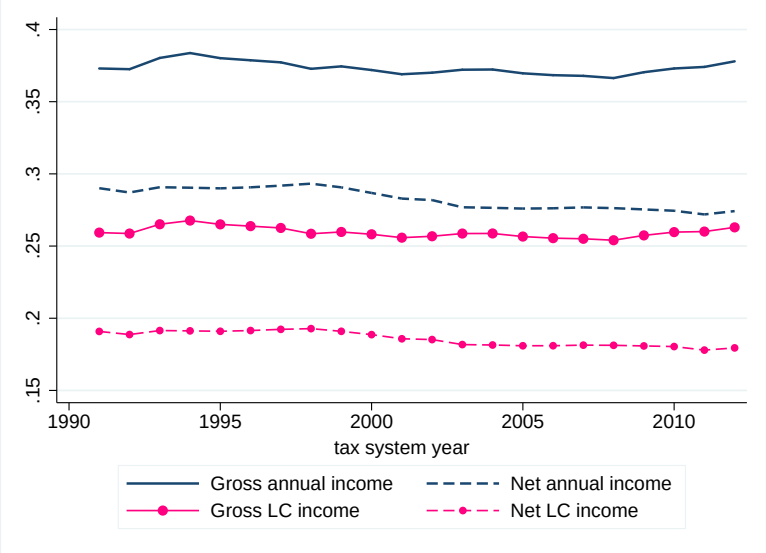
[49]We re-iterate the caveat that this analysis ignores a major source of transfers across the life-cycle in the form of retirement pensions.

7.1 Identifying changes induced by policy reforms implemented during the 1990s and 2000s

By exploring specific policy reforms we can gain further insights into what components of the tax-benefit system are most successful in targeting lifetime inequality.

We start by comparing the 2006 tax-benefit system to the systems in force over the previous fifteen and the following six years.[50] Figure 9 shows annual and lifetime inequality (as measured by the Gini coefficient for gross and net family income) for all tax-benefit systems in force between 1991 and 2006. Different tax-benefit systems have only small impacts on the Gini, reflecting that these are measures of overall inequality, which is difficult to change. Still, a turning point can be observed in 1999 for net measures of income. Tax-benefit systems subsequent to 1999 have lead to successively lower levels of inequality, particularly for net annual income, but also for net lifetime income.

Figure 9: Gini coefficients for annual and lifetime income by tax-benefit system

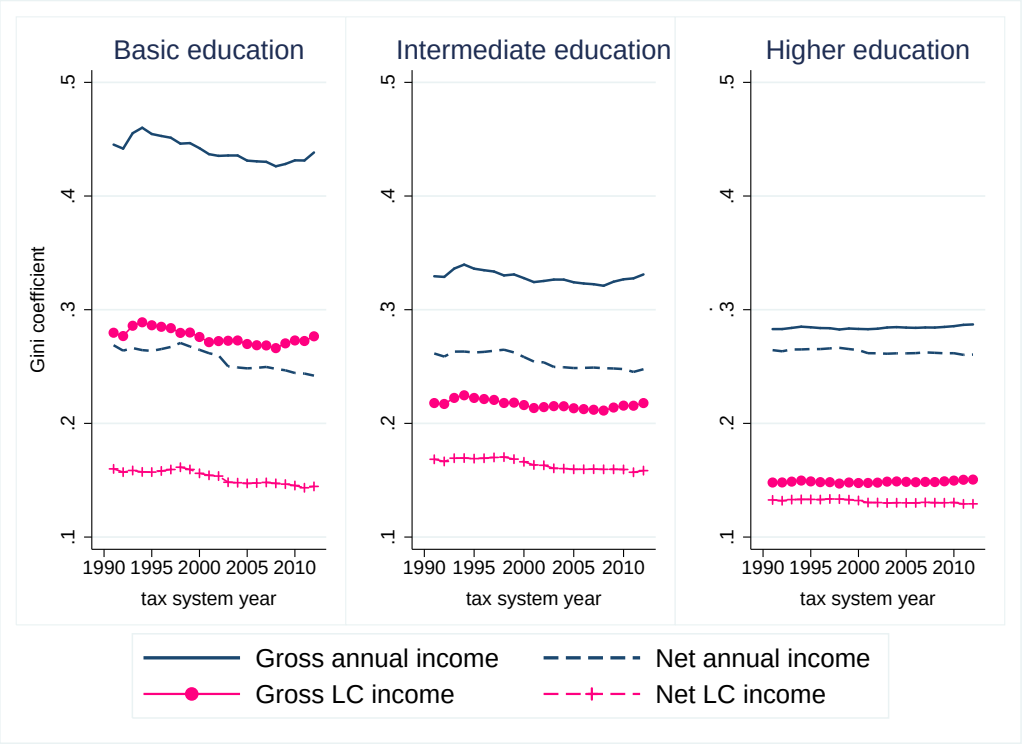


The differences between the tax-benefit systems before and after 1999 are more obvious if plotted by education group (see figure 10). The fall in inequality in net income is particularly large among the least educated, but is also present among women with secondary education. Interestingly, inequality of gross family income among the least educated is also lower under the post-1999 tax-

[50] As described earlier, we do this by re-simulating the data on the assumption that women faced, for example, the 2002 or 1993 tax-benefit system throughout their adult life. For comparability, earnings and the tax-transfers systems are deflated using the time trends for gross earnings over the whole population.

benefit systems, suggesting that behavioural responses induced by the tax reforms partly explain the trend in inequality in net income. For example, the Gini coefficient for lifetime income among women with basic education under the 2006 tax-benefit system was lower than that under the 1999 tax-benefit system by 1.1pp and 1.5pp in gross and net terms respectively (the corresponding values for annual income are 2.0pp and 2.5pp, respectively).

Figure 10: Gini coefficients for annual and lifetime income by tax-benefit system and education



The major tax reforms of the early 2000s were family oriented. Work-contingent subsidies for families with children were substantially increased with the Working Families Tax Credit (WFTC) reform (late 1999), which was then expanded further between 2000 and 2002. This unambiguously strengthened the work incentives of lone parents, but may have weakened those of second earners in couples, as well as changing (in heterogeneous ways) the relative value of working full-time and part-time (Brewer et al., 2006). Support for non-working families also increased from 1999, with Income Support (IS) becoming more generous for families with children; note that this would have partly offset the strengthening of work incentives brought about through WFTC, particularly for lone mothers. In 2003, work-contingent benefits (WTC) were extended to families with no children, but at modest levels and designed in a way that only those with the lowest hourly wages would benefit. And 2003 to 2006 saw continual real-terms increases in the generosity of Child Tax Credit, a means-tested

programme for, broadly speaking, the poorest half of families with children.

Given their likely redistributive potential from a lifetime perspective, we now focus on specific aspects of the UK tax-benefit system that were intended to support families with children. Our hypothesis is that the greater inequality-reducing power of the 2006 tax-benefit system compared to its predecessors in the 1990s was most caused by increases to work-contingent, means-tested, support for families with children. [51]

To investigate the role of these family policies in tackling lifetime inequality, we start by plotting in Figure 11 the life-cycle profiles of inequality under the tax-benefit systems of 1999, 2002 and 2006, and separately for the three education groups.[52] As the actual tax-benefit systems raise different amounts of revenue, we make these reforms revenue neutral by adjusting the basic rate of tax in the 2002 and 2006 tax systems.

The way that the 1999-2006 reforms lowered inequality over the life-cycle are especially evident for the young and the least-educated women, a group at high risk of unemployment and lone motherhood. The reforms reduce inequality in gross family income only for this group, suggesting that the behavioural responses partly responsible for the fall in inequality are concentrated among the least-educated women. And the differences in the age-specific Gini coefficients for both gross and net income have widened over time, in parallel with the generosity of the benefits. For women with intermediate education, the 2002 tax-benefit system reduce disparities in net income compared with the 1999 tax-benefit system, but the 2006 tax-benefit has almost no additional impact. And the 1999-2006 reforms have only a negligible impact on the income distribution of higher educated women.

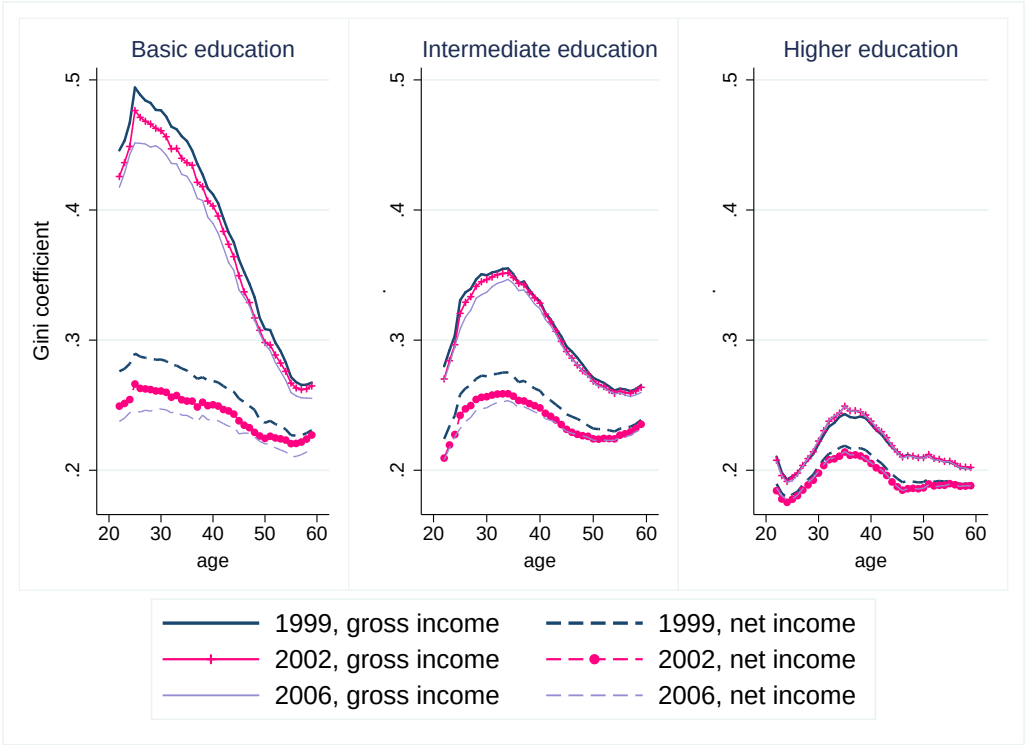
The most significant reforms during this period occurred between 1999 and 2002, with parallel increases in work-contingent support for families with children (WFTC), and in welfare benefits for families with children (IS). Figure 12 separates the impact of these two reforms by comparing four alternative tax-benefit systems: that of 1999, that of 1999 but with the 2002 version of WFTC (1999+2002WFTC), that of 1999 with the 2002 version of WFTC and IS (1999+2002WFTC/IS), and that of 2002.[53] It shows that most of the additional redistribution for the two least educated

[51] There were, of course, other changes. For example, the gradual fall in the main tax rate from 25% to 20% may have induced some women back into the labour market, thus contributing to the drop in inequality. But this fall has been balanced with changes in the tax bands, that also fell over time, and rises in the NI contribution rate.

[52] 1999 is the pre-reform year of 1999; 2002 is when WFTC was at its most generous level; 2006 is after the WTC/CTC reform.

[53] This exercise is more difficult to implement for the WTC/CTC reform, as that involved major changes and relabeling

Figure 11: Gini coefficients over the life-cycle: annual gross and net income by tax-benefit system and education



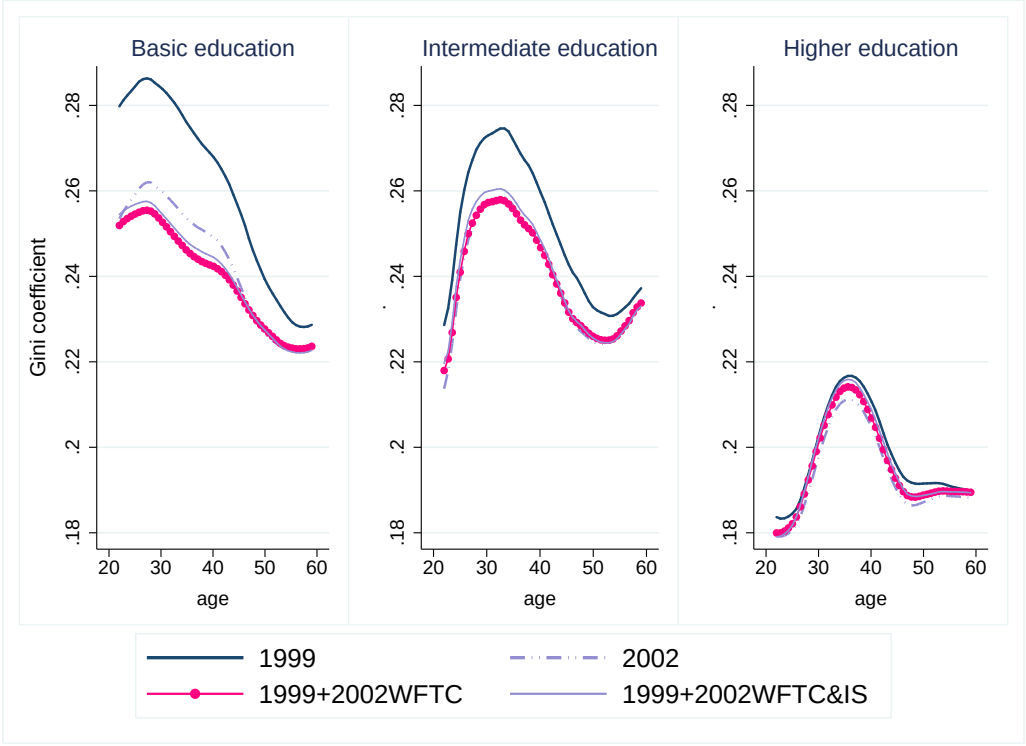
Notes: Age-specific Gini coefficients. All reforms revenue neutral by adjusting the basic tax rate in the post 1999 tax systems.

groups was achieved by the WFTC reform. For women with basic education, the inequality-reducing impact of introducing the 2002-style WFTC into the 1999 tax-benefit system is considerably larger than that of implementing the full 2002 tax-benefit system. This happens largely because the increase to IS partly offsets the strengthening of work incentives caused by WFTC: WFTC alone reduces the unemployment rate of the least educated lone mothers by 12pp, but this effect shrinks to less than 5pp when the IS reforms between 1999 and 2002 are added.

Figure 13 supports this hypothesis. It assesses the impact of adding WFTC as of 2002, and of adding WFTC and IS as of 2002, to the 1999 tax system, and then isolates the role played by the behavioural responses in labour supply. The left-hand graph shows that, for the least educated group, most of the redistribution induced by WFTC arises from the changes in labour supply decisions. But adding IS as of 2002 alters this result, as behaviour responses cease to make much difference to

of other benefits, complicating the task of separating the exact changes in work-related benefits.

Figure 12: Gini coefficients over the life-cycle: annual net income by tax-benefit system and education



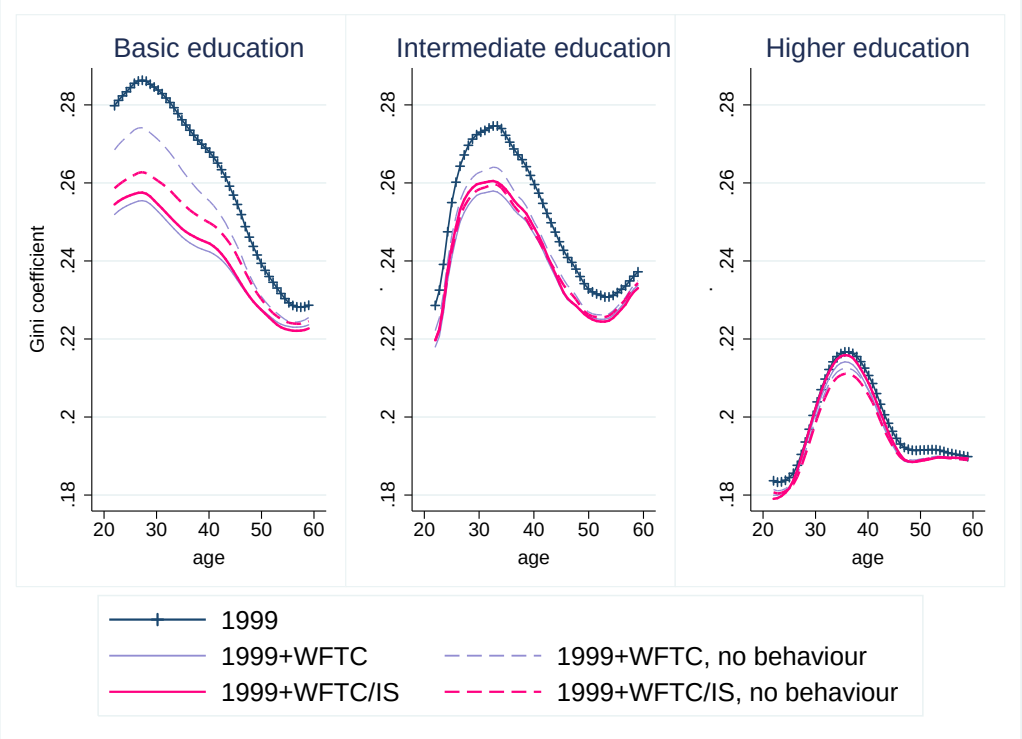
Notes: Age-specific Gini coefficients. All reforms revenue neutral by adjusting the basic tax rate in the post 1999 tax systems.

inequality. We conclude that most of the inequality achieved by the joint reforms in WFTC and IS arises from the more generous subsidies that are being targeted on those with low (annual) incomes.

Earlier, we showed that the 2006 tax-benefit system is strongly progressive from a lifetime perspective at the bottom of the income distribution. This too is a consequence of the family-related policy reforms implemented during the 2000s. Figure 14 shows the measure of progressivity (ATRs) for the bottom quintile of the annual (left-hand graph) and lifetime (right-hand graph) income distribution. On an annual basis, the variation in progressivity with age becomes more marked for later tax-benefit systems, but can be observed in all cases. But from a lifetime perspective, the clear progressivity that we had observed during child-bearing years under the 2006 tax-benefit system is hardly visible in the 1999 system, before the various reforms to child-contingent programmes.

We have investigated the redistributive features of other reforms in the tax-transfer system implemented during the 1999-2002 interval. None had any visible impact on lifetime redistribution

Figure 13: Gini coefficients for annual net income by tax-benefit system and education:



Notes: Age-specific Gini coefficients. All reforms revenue neutral by adjusting the basic tax rate to reproduce the 1999 public budget position.

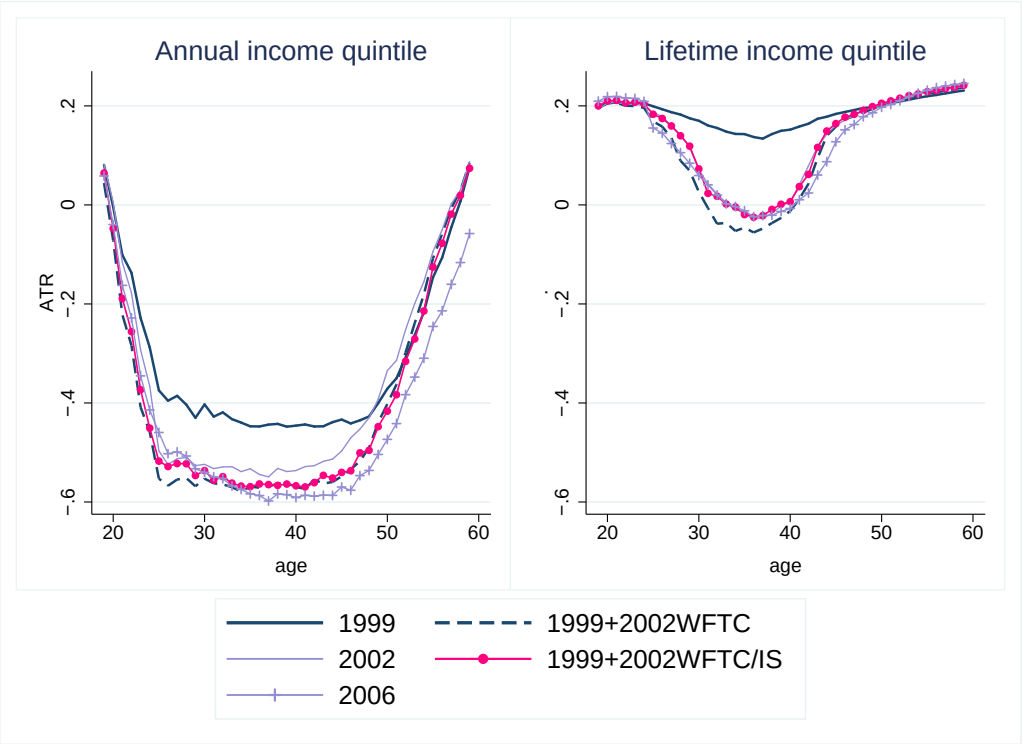
(evidence in Appendix E).

7.2 The impact of universal benefits for children

Having studied the impact of changing work-contingent subsidies and unemployment compensation for families, we now investigate the potential impact of relaxing eligibility to subsidies for families with children, making them universal. Our experiment amounts to changing the baseline tax-benefit system of 2006 by allowing universal entitlement to the child element of the 2006 CTC.

Universal CTC may affect behaviour in two opposite directions. On the one hand, reducing the benefits exposed to withdrawal at some part of the earnings distribution raises the incentives to work and to work longer hours among individuals whose potential family earned income lies on the affected region. On the other hand, an income effect may reduce labour supply among women whose family

Figure 14: Median Average Tax Rate over the life-cycle at the bottom quintile of the distribution of annual and lifetime gross income by tax-benefit system



Notes: All reforms revenue neutral by adjusting the basic tax rate to reproduce the 1999 public budget position.

income is too high to grant entitlement to the child element of CTC. These effects are expected to negligible at the bottom of the income distribution, where entitlement to CTC is mostly independent of whether the policy is universal or not since CTC is phased out only after exhaustion of entitlement to CTC. However, this is an expensive policy, costing the equivalent of a raise in the basic tax rate of 3.3%, and may, through this channel, affect labour supply and the ATRs of women in the lowest quintile of the lifetime income distribution.

Unsurprisingly, figure 15 shows that making the child element of CTC universal has little effect on the ATRs for the bottom quintile of lifetime income. There is a slight increase in the tax rates faced by women during their main childbearing years, mostly due to a combination of higher basic tax rate and its negative impact of the employment and working hours of lone mothers, who face the lowest ATRs and represent a disproportionate share of women in the bottom quintile of lifetime income (employment among lone mothers drops by 0.5pp and part-time work increases by 0.9pp).

However, the figure also shows that other quintiles are also affected. Universal benefits for children reduce the ATRs during the main childbearing years at other parts of the distribution of lifetime income, more pronouncedly so for quintiles two to four resulting in more progressivity at the top 80% of the distribution. This is mainly explained by the effects that making CTC universal has on the work incentives of mothers in couples, who are most exposed to the withdrawal of non-universal CTC if their partners work. Extending eligibility to all the population of parents means such disincentive is removed, thus reducing the ATR for working women whose family earnings lie within and above the withdrawal region and raising employment among mothers in couples by +2.5pp.

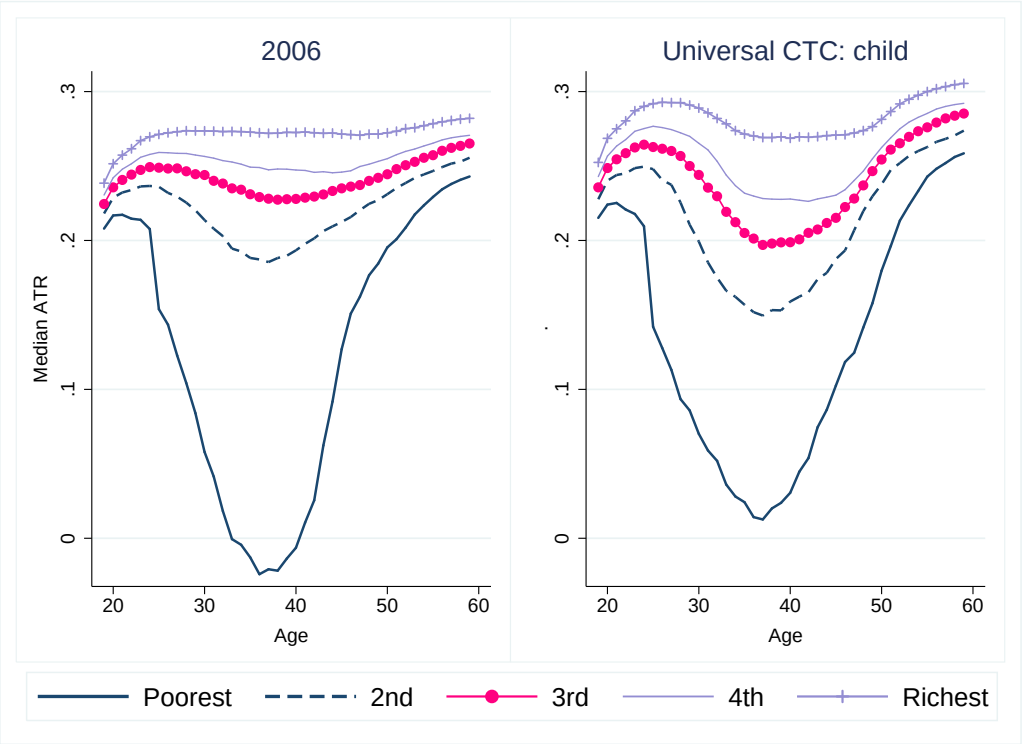
The consequences of these responses for inequality are captured by the changes in the Gini coefficients. Universal CTC induces a drop in lifetime inequality, amounting to 0.5pp of the Gini coefficient for all the population of women, and a similar 0.5pp and 0.4pp for the intermediate and higher educated. However, and consistently with our previous finding of negligible effects for whom entitlement to CTC is mostly likely to be unaffected by the reform, the drop in lifetime inequality is more modest among the least educated, at 0.1pp.

8 Conclusions

This paper investigates the role of personal taxes and benefits for reducing lifetime inequality among women. The analysis is based on simulated life-cycle data for women generated by a dynamic model of education, labour supply and savings with family dynamics combined with a micro-simulation of the UK tax-benefit system. The model captures well the dynamics of female (and family) earned income, driven by the process of human capital formation and by labour supply responses to changing productivity and family circumstances. This feature makes it particularly well suited to assess the lifelong effects of reforms in taxes and benefits.

We show that the UK tax-benefit system of the mid-2000s is particularly successful in reducing disparities during the main childbearing years, when age-specific inequality reaches its maximum and the incidence of low income families is disproportionately high. Changing family circumstances are key to the strong life-cycle variation in the levels of inequality and redistribution we find. But their transitory nature could imply they are of little consequence in the longer-term, for lifetime economic conditions. Indeed we predict that the contribution of family dynamics over the life-cycle towards lifetime inequality is small when compared to permanent differences determining labour market productivity like, for example, education.

Figure 15: Median Average Tax Rate over the life-cycle by quintile of the distribution of lifetime gross income - universal benefits for children



Notes: All reforms revenue neutral by adjusting the basic tax rate to reproduce the 2006 public budget position.

However, family income during the main child-bearing years is a especially good predictor of lifetime income as the consequences of permanent differences in productivity and marriage prospects can be more visible at a time when working is particularly costly. Conceivably, therefore, a strong focus on redistribution towards this period of life may successfully reach the lifetime poor. This is what we find, our results suggesting that the strongest relative contribution of the 2006 tax-benefit system towards reducing lifetime inequality arises from its impact on that part of inequality that is caused by family circumstances, particularly lone-motherhood.

By exploring the models ability to predict labour supply and education responses to policy reforms, we assess how specific elements of the tax-benefit system contribute to lifetime redistribution. We show that, among the reforms of the past two decades in the UK, the huge increase in means-tested subsidies that were conditional on work and having children led to a significant amount of lifetime redistribution. By targeting the poor work incentives of low income mothers, particularly

lone-mothers, the reforms initiated in 1999 by the introduction of WFTC and gradually intensified during the 2000s turn out to be especially progressive from a lifetime perspective, raising labour supply and the income of families at the bottom of the lifetime income distribution. By contrast, making the child element of CTC universal has no substantial impact at the bottom of lifetime income distribution. But it does increase progressivity higher up the distribution, particularly at the middle, reducing inequality and improving the position of mothers in couples.

The use of simulated data is not without drawbacks as the underlying model is necessarily limited in the characterisation of individual circumstances and decisions. We exclude pensions and model the retirement years only loosely, and this surely affects our measures of lifetime inequality relative to annual inequality. However, it is unlikely that the inclusion of retirement pensions would dramatically alter change our main conclusions on the importance of targeting particular life circumstances for lifetime redistribution. Quite on the contrary, improving the working incentives of individuals with the lowest earnings capacity may lead to further gains at the bottom of lifetime income distribution through higher pensions. Other sources of income and the top of the income distribution are also excluded from our analysis, which could result in our results being less visible if they were to be considered. And certainly, other responses to tax reforms could influence the results. Our main omissions are family related decisions in terms of marriage and fertility. These are open areas for future research.

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Appendix A: Model specification, data and estimation

Brief overview of the model specification

In each period of her adult life, which we take to be a year, a woman maximises expected lifetime utility taking as given her current characteristics - age, education, acumulated assets, working experience, idiosyncratic productivity and the utility cost of working full (FT) or less (PT) hours, rep-

resented by $(a, s, w, e, \upsilon, \theta_{FT}, \theta_{PT})$ - and her family arrangements - presence of partner, his education, labour supply and productivity, presence of children and the age of the youngest child, represented by $(m, \tilde{s}, \tilde{l}, \tilde{\upsilon}, k, a^k)$. We call X_a the state space in period a. In all that follows, lowercase represents individual observed characteristics, the tilda denotes men's variables, parameters and prices, uppercase is for market prices and functions and Greek letters are reserved for constant parameters and unobserved shocks. With this notation, her inter-temporal problem as viewed from age a is:

$$\max_{\{c_\alpha, l_\alpha\}_{\alpha=a,\dots A}} \mathrm{E}_a \left\{ \sum_{\alpha=a}^{A} \beta^{\alpha-a} U\left(c_{i\alpha}, l_{i\alpha}; s, m_\alpha, l_\alpha^m, k_\alpha, a_\alpha^k, \theta_{FT}, \theta_{PT}\right) \middle| X_a \right\} \tag{1}$$

where E_a is the expectation operator conditional on the available information at age a, β is the discount rate and U is the instantaneous utility function. Maximisation is subject to the budget constraint,

$$w_{a+1} = (1+R)w_a + l_a y_a + m_a \tilde{l}_a \tilde{y}_a - T\left(X_a, l_a, \tilde{l}_a\right) - CC\left(a^k, l_a, \tilde{l}_a\right) - c_a \tag{2}$$

$$w_{a+1} \geqslant \underline{w}_s \tag{3}$$

where R is the risk-free interest rate, $(y, \tilde{y})$ are the wage rates of wife and husband, T is the net transfer to the public sector and CC are childcare costs for the youngest child if all adults in the household work. We assume only some women face positive childcare, others may have informal arrangements in place, and the costs are estimated as a function of the youngest child age for working parents. The borrowing limit is zero for all except university graduates, who we allow to benefit from institutional loans to cover their educational and maintenance expenses. The dynamic processes for the wage rates are:

$$\begin{aligned} \text{Woman:} \quad \ln y_a &= \ln W_s + \gamma_s \ln(e_a + 1) + \upsilon_a \\ \upsilon_a &= \rho_s \upsilon_{a-1} + \mu_a \\ e_a &= e_{a-1}(1-\delta_s) + g_s(l_a) \end{aligned} \tag{4}$$

$$\begin{aligned} \text{Man:} \quad \ln \tilde{y}_a &= \ln \tilde{W}_{\tilde{s}} + \tilde{\gamma}_{\tilde{s}} \ln(a-18) + \tilde{\upsilon}_a \\ \tilde{\upsilon}_a &= \tilde{\rho}_{\tilde{s}} \tilde{\upsilon}_{a-1} + \tilde{\mu}_a \end{aligned}$$

A few of remarks on the set of equations (4): (i) They allow for state dependence through experience effects and heterogeneity in wage profiles through the persistent productivity shock, which is correlated with preferences for work at the point women enter the labour market; (ii) the concave profile of experience effects is consistent with observed evolution of wages; (iii) the function $g(l)$ represents the accumulation of human capital depending on working hours: it is equal to 1 for full-time workers, and estimated for part-time work; (iv) human capital depreciates during unemployment at rate δ_s; it may also depreciate while in part time work depending on the level of human capital and the estimated

value of $g(l)$; (v) conditional on education, the spouses' productivity processes are independent; and (vi) all parameters are education-specific.

Optimal choices also depend on the stochastic processes describing the evolution of family circumstances, which can be represented by the transition probabilities

$$\text{Child:} \quad p\left(a_k \left| a, s, k_{a-1}, a^k_{a-1}, m_{a-1}\right.\right) \tag{5}$$

$$\text{Partner:} \quad p\left(m_a, \tilde{s}_a, \tilde{l}_a \left| a, s, k_{a-1}, m_{a-1}, \tilde{s}_{a-1}, \tilde{l}_{a-1}, \tilde{y}_a\right.\right) \tag{6}$$

At the start of life, aged 17, a woman decides how much to invest in education based on expected returns and realised costs. She takes as given: initial wealth, preferences for work, preferences for basic, intermediate and higher education ($s = 1, 2, 3$, respectively), and liability to pay childcare costs if working, represented by $(w_{17}, \theta_{FT}, \theta_{PT}, \varpi_1, \varpi_2, \varpi_3, d_{CC})$. We call V_s the discounted value of lifetime utility conditional on education choice s. It is defined as (1) but excluding labour supply and public transfers during education years (which last up to 18 for basic and intermediate levels, and 21 for the high level). The optimal choice of education can now be defined,

$$s \quad = \quad \underset{s\in\{1,2,3\}}{\text{argmax}} \left\{V_s\left(w_{17}, \theta_{FT}, \theta_{PT}, d_{CC}\right) + \varpi_s\right\}. \tag{7}$$

Estimation sample

The model is based on data from the first 16 waves of the British Household Panel Survey (BHPS), 1991 to 2006. Except for data attrition, all families in the original 1991 sample and subsequent booster samples remain in the panel from then onwards. Other individuals have been added to the sample along the way — sometimes temporarily — as they formed families with original interviewees or were born to them. All members of the household aged 16 and above are interviewed, with a great deal of information being collected on demographic characteristics, educational achievement, employment and hours worked, income and benefits, and some expenditures, particularly those with childcare. Information on assets is collected only every 5 years.

We follow women over the observation period, and consider their changing family circumstances including childbearing, partnering and partner characteristics, employment status and earnings. So the sample represents all British families with 1 or 2 working-age adults other than single men. Our full dataset is an unbalanced panel of around 4,400 women aged between 19 and 50 and observed over

at least two consecutive periods during the years 1991 to 2006. 10% of these women are observed over the whole period, 60% in no more than 6 consecutive waves, 24% are observed entering the working life from education.

Data needed some preparation prior to estimation. *First*, all monetary variables in the model were set in real terms, 2006 prices. *Second*, this period saw secular growth in real wages; since the focus here is not on the changing macro-economic conditions, we have removed this trend. We also adjust the monetary parameters of the tax-benefit system. *Third*, there is also wide evidence of changing women's behaviour over time, with younger cohorts likely to work more and be better paid than their older counterparts. Given that we follow women over a limited number of working years, such cohort effects would confound the identification of life-cycle profiles. We therefore remove them, again at the aggregate level. *Fourth*, our model is not intended to explain the high end of the earnings distribution. Moreover, one would expect the incidence of measurement error in hours worked to be especially high at both the bottom and top of the wage distribution. We drop the whole histories of individuals ever observed at the 2% ends of the distribution and claim our analysis excludes the top end of the earnings distribution (the censoring at the bottom of the distribution is essentially measurement error in earnings or, most likely, hours of work; we drop observations of wage rates below 1.8 pounds per hour in 2006 prices, well below the minimum wage). *Fifth*, we attribute purely transitory variation in wage rates to measurement error, thus excluding it from the model. And *finally*, families with self-employed individuals have been excluded since explaining their more unpredictable earnings is outside the scope of this paper.

Estimation

A total of 55 parameters are estimated using longitudinal data from 16 waves of the British Household Panel Survey and combining two methods. The exogenous elements of the model, including the stochastic processes of family dynamics and the male selection model of wages, are estimated outside the structural model. The parameters associated with preferences, female earnings and the distribution of shocks are estimated using the Method of Simulated Moments.[54] We simulate individuals under different tax regimes and compute a total of 207 overall moments to match with those in the data.[55] A remainder of three parameters are set: the real interest-free interest rate R, at 0.015

[54] Original references are Lerman and Manski (1981), McFadden (1989) and Pakes and Pollard (1989).

[55] A total of 207 moments include employment rates by family type, transition rates, means, variances and percentiles of earnings distribution, earnings at entrance in working life, change in earnings by past hours, education achievement, whether pay for childcare, all by level of education.

per year; the discount rate, at 0.98, slightly higher than the interest rate implying that agents have some degree of impatience; and the parameter governing risk aversion and intertemporal substitution in our CRRA specification of the instantaneous utility of consumption, set at 1.56 (consistent with evidence in Blundell, Browning and Meghir, 1993, and Attanasio and Weber, 1995).

Appendix B: Transition matrices - data versus simulations

Table 8 displays the annual, 3-year and 5-year transition matrices underlying the numbers in table 3 in the main text, showing the model quite accurately predicts medium term transitions.

Appendix C: Measures of inequality

Table 9 contains values of alternative aggregate measures of inequality, alternative to the Gini coefficient used in the main text. Qualitatively, the inter-quartile ratio and the coefficient of variation show a pattern similar to the Gini coefficients in table 4.

Appendix D: Regressions for the decomposition of lifetime inequality

Table 10 contains estimates of the regressions underlying the inequality decomposition of table 7. We have tried different specifications, with flexible functional forms, as well as implementing the decomposition in steps following the timing of life events. This does not change the composition results.

Appendix E: Isolating the impact of reforms implemented during the 1999-2002 period

We investigated how reforms during the 1999-2002 time window might have affected the progressivity of the tax-benefit system. Figure 16 illustrates results for dimensions of the transfer system: IS for

Table 8: Transition probabilities in gross equivalised family income by quintile: data versus simulations

	BHPS data					Simulated data				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Year-to-year transitions, annual income										
1st	79	13	4	2	2	82	13	3	2	1
2nd	12	62	19	5	3	11	71	16	2	1
3rd	4	16	57	19	4	4	14	64	16	2
4th	3	6	17	58	16	2	2	16	66	14
5th	2	3	4	15	76	1	1	1	14	83
3-year transitions, 3-year average income										
1st	76	17	6	1	0	73	19	6	2	0
2nd	18	48	24	8	2	21	50	23	5	1
3rd	4	22	45	23	6	7	27	45	24	4
4th	2	7	19	48	24	2	6	20	51	21
5th	2	3	6	20	69	1	1	3	19	76
5-year transitions, 5-year average income										
1st	71	19	7	2	1	68	21	8	2	1
2nd	18	44	23	12	3	23	44	22	8	3
3rd	3	18	44	29	6	7	20	42	25	6
4th	3	8	21	36	32	3	7	22	40	28
5th	2	2	6	24	66	1	2	6	22	69

Notes: The notation "1st" to "5th" in the titles for rows and columns refers to quintiles in the distribution of the respective measure of gross equivalised family income.

families with children (which became more generous over the period), IS as a whole (which became less generous for families without children), council tax (which increased during the period) and the joint reforms to income tax and NI (which amounted to reductions in the tax bands). Overall we cannot detect that any of these changes, per se, have changed the median ATR at the bottom quintile of the lifetime income distribution.

Table 9: Annual and lifetime inequality by education under the 2006 tax-benefit system: other summary measures

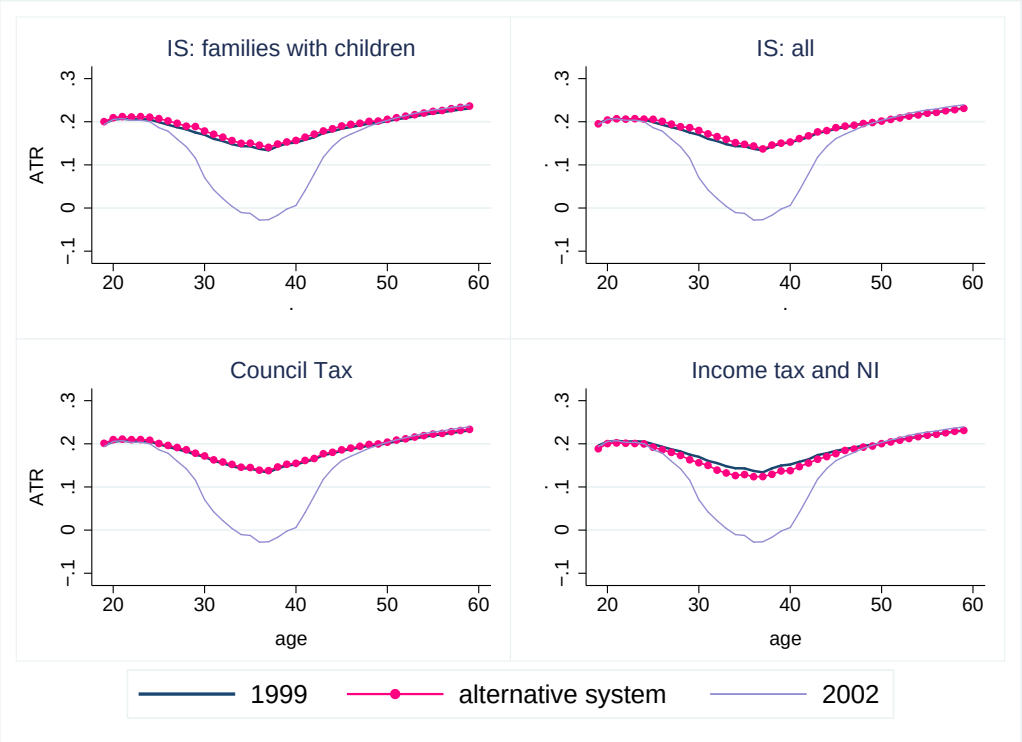
	Gross income		Net income	
	annual	lifetime	annual	lifetime
Inter-quartile ratio (Q25/Q75)				
all	0.43	0.55	0.55	0.64
education: GCSEs	0.37	0.56	0.56	0.70
education: A-levels	0.50	0.62	0.54	0.69
education: university	0.57	0.72	0.59	0.74
Half the coefficient of variation				
all	0.20	0.09	0.12	0.05
education: GCSEs	0.23	0.09	0.10	0.04
education: A-levels	0.16	0.07	0.10	0.04
education: university	0.13	0.04	0.11	0.03

Table 10: Sources of lifetime inequality - underlying regressions

	Gross income		Net income	
	coefficient	st. error	coefficient	st. error
Intermediate education	.292*	.006	.189*	.003
Higher education	.521*	.008	.373*	.004
Time as mother	-.418*	.015	-.304*	.008
Time in couple	.360*	.013	.241*	.008
Time as lone mother	-.477*	.023	-.051*	.013
Initial assets	-.008*	.004	-.004	.002
Initial assets squared	.001	.001	.000	.000
Childcare costs	-.021*	.005	-.030*	.002
Rented accommodation	-.338*	.007	-.055*	.004
Preferences for work	-.373*	.005	-.223*	.003
	9.003*	.010	8.785*	.005
R-squared	0.54		0.52	

Notes: * Statistically significant at 5% level.

Figure 16: Median Average Tax Rate over the life-cycle at the bottom quintile of the distribution of annual and lifetime gross income by tax-benefit system



Notes: All reforms revenue neutral by adjusting the basic tax rate in the post 1999 tax systems.