How taxes and welfare distort work incentives: static, lifecycle and dynamic perspectives

Mike Brewer, Monica Costa Dias and Jonathan Shaw[1]

Abstract: Personal taxes and benefits affect the incentive to work over the lifecycle by altering income-age profiles, insuring against adverse shocks, and changing the returns to human capital. Previous work investigating the impact of taxes and benefits on work incentives has tended to ignore these dynamic considerations. In this paper, we use a dynamic model to show how a lifecycle perspective alters our impression of the effect of the tax and benefit system on female work incentives. We describe how work incentives change over the life and show how they depend on lifecycle circumstances. We also devise a forward-looking measure of work incentives that incorporates all the dynamic considerations likely to affect work decisions at any given age. We find that individuals experience considerable variability in work incentives across life that outweighs the variability across individuals. Changes pattern of family types across life is key to explaining these patterns: work incentives vary dramatically depending on family composition, and most women experience a number of different family types during the course of their lives. We also find that differences in family type are an important explanation for why static and forward-looking PTRs diverge, though this is more to do with differences in how women in families with different compositions behave.

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[1] Brewer is at Institute for Economic and Social Research, University of Essex and Institute for Fiscal Studies. Costa Dias and Shaw are at Institute for Fiscal Studies. We are very grateful to Alex Beer, Jennifer Bradley, Juliet Clarke, Christoph Erben, Saranna Fordyce, Jonathan Gillham, Ivan Mathers, Kate Mieske, Stefania Porcu, Matthew Whittaker and Edward Zamboni for discussing our research and its policy implications. We greatly benefited from discussions with Richard Blundell, Costas Meghir, Cormac O'Dea and participants in seminars at the University of Copenhagen, IZA, IFS and ISER. Financial support from the ESRC/HMRC grant number RES-194-23-0016 is gratefully acknowledged. The usual disclaimer applies. Data from the British Household Panel Survey (BHPS) were supplied by the UK Data Archive. Neither the original collectors of the data nor the Archive bear any responsibility for the analysis or interpretations presented here.

1. Introduction

A crucial input to any assessment of a personal tax and benefit system is an analysis of how taxes and benefits affect individuals' financial incentives to work and earn more. Personal taxes and benefits affect incentives to work and earn more over the lifecycle by altering income-age profiles, insuring against adverse shocks, and changing the returns to human capital. Most previous work investigating the impact of taxes and benefits on financial work incentives has tended to exclude any dynamic considerations: as we discuss below, few papers break results down by age group let alone think about how work incentives change over time for an individual, and the measure of financial work incentives used is always a static one (in the sense of ignoring future returns from working today).

This paper takes a first step towards filling this gap in the literature by using simulated data produced by a dynamic structural model of female labour supply and human capital to show how a lifecycle perspective alters our impression of the effect of the UK tax and benefit system on the financial work incentives facing women. We describe how women's work incentives (measured in the conventional, static, way) change over the lifecycle, and how they depend on lifecycle circumstances. We also devise a forward-looking measure of the financial incentive to work that incorporates dynamic considerations likely to affect work decisions at any given age; we call this the *forward-looking participation tax rate* (defined below, and explained fully in Appendix B).

As an example, we study the UK personal tax and benefit system. As we explain further in section 3, this combines a relatively simple, individually-based, income tax system with a relatively complicated, family-based set of welfare benefits and tax credits, where maximum entitlements are strongly influenced by family circumstances, and there is a heavy reliance on means-testing. The way that this affects financial work incentives – albeit measured in the usual, static, sense – has been analysed before: see, for example, Adam and Browne (2010), Brewer, Saez and Shephard (2010), and Mirrlees et al (2011). Examples of papers that consider how proposed or hypothetical reforms to the tax and benefit system affect financial work incentives (again, using a static measure of work incentives) include Brewer et al (2012). Similarly, Immervoll (2004) and Immervoll and O'Donoghue (2002) are examples of work which describes the distribution of financial work incentives in various European countries, and OECD (2012) does the same for specimen families across the OECD. All of these papers have analysed work incentives in a static sense. Few papers break down their results by age group (which would show, for example, whether work incentives tend to be stronger or weaker for older workers than younger workers), and none takes a longitudinal approach to analysing work incentives (which would show whether an individual's incentive to work gets stronger or weaker as she ages). The two examples we know of that take a longitudinal approach to measuring financial work incentives are Evans and Williams (2009) and Evans and Eyre (2004). These papers take the "specimen families" approach to measuring work incentives, giving hypothetical families a hypothetical lifecycle (by specifying the time profile of family formation and fertility, and of how earnings and employment change as individuals age). Evans and his co-authors are thereby able to analyse how financial work incentives change for some specific families as they age. But there are clear weaknesses to the approach: the analysis is done only for a small handful of families, the measures of work incentives used are still static ones, and the lifecycle profiles are generated by the researcher with little link to individuals' actual behaviour.

This static view of work incentives is, at best, a partial analysis (as it omits the rich impression we get by studying how work incentives change over an individual's life), and, at worst, is analysing an incorrectly-measured variable (because it focuses only on the current period, ignoring future returns to today's choices). Personal taxes and benefits clearly affect the incentive to work over the lifecycle by altering income-age profiles, insuring against adverse shocks, and changing the returns to human capital or on-the-job experience. In contrast to the literature on characterising work incentives, which takes a predominantly static viewpoint, the literature that seeks to understand individuals' labour supply behaviour has clearly recognised that labour supply has an important dynamic dimension (for example, see Eckstein and Wolpin (1989) and Keane and Wolpin, 1997). Ultimately, a dynamic perspective is necessary because part of the return to working today is realised in future periods, and that future return may turn out to be treated very differently by the tax and benefit system to the way the current return is treated.

An understanding of work incentives that goes beyond the standard static analysis requires some sort of longitudinal data. This paper makes use of simulated lifecycle data produced by a structural, dynamic model of female labour supply and human capital accumulation that embeds a detailed characterisation of UK taxes and benefits, and whose parameters have been estimated so as to create lifecycle profiles that match UK household panel data. The model is a standard lifecycle consumption and labour supply model, in the style of Eckstein and

Wolpin (1989) and (1999), Keane and Wolpin (1997) and Adda et al (2008), but with additional features that make it suitable to assess the impact of taxes and benefits on work incentives and decisions over time. The most important of these are: evolving family composition; a rich characterisation of the tax and benefit system; an education choice; and experience accumulation. To our knowledge, this is the first tool capable of supporting the study of dynamic features of tax and benefit design taking into account labour supply responses, saving and skill formation.

Using simulated data has a number of advantages relative to using observed panel data. The first is practical: it enables us to analyse complete lifecycles. Using panel data, we would be limited to half a full working life at most: the UK's longest-running UK panel dataset (the British Household Panel Survey and its successor) has only existed since 1991, and only a small fraction of the sample has been interviewed in every wave. Second, we can model cleanly the effect of a single tax and benefit system throughout life, allowing individuals to behave as they would under that constant system, and can do so having stripped out cohort effects; by contrast, patterns observed in panel data will be confounded by changes in taxes and benefits over time, as well as cohort effects. Third, we can use our model to calculate our new forward looking measure of work incentives, in which we model explicitly and structurally the way in which part of the return to working today accrues in future periods. Finally, we can use our model as an experimental tool to produce ex ante evaluations of hypothetical policy reforms that allow for behavioural responses. The model we used is described more in Section 2.1, which in turn summarises Blundell et al (2011). Appendix C discusses the ability of the model to replicate the patterns of work incentive patterns in the data.

With such tools, we make two advances on the existing literature. First, we analyse the work incentives inherent in the UK tax and benefit system with an explicit longitudinal focus. We describe how women's work incentives (measured in the conventional, static, way) change over the lifecycle, and how they depend on lifecycle circumstances. We show that, although there is a high degree of persistence in work incentives, there is marked variation across the lifecycle. Much of this variation is associated with changes in family composition, and so few individuals with, for example, high participation tax rates (PTRs, defined below) in one period will face similarly high PTRs throughout their lives. Second, we devise a forward-looking measure of the financial incentive to work that incorporates dynamic considerations likely to affect work decisions of forward-looking individuals at any given age; we call this the *forward-looking participation tax rate* (defined below, and explained fully in Appendix B). We show that for particular groups (e.g. lone mothers) at the beginning of working life, there are substantial divergences between the conventional static PTR and our forward-looking measure. In a companion paper (Brewer et al, 2012), we take a lifecycle approach to examining by how much the UK tax and benefit system redistributes income from rich to poor.

The rest of the paper is arranged as follows. In Section 2, we give a brief account of the model we use to simulate women's lifetimes, and then discuss how we use the model to create various measures of financial work incentives. Section 3 gives an overview of the UK tax and benefit system for working-age adults, with a focus on how it affects financial work incentives. Section 4 analyses the usual static measures of financial work incentives produced by the current UK tax and benefit system. We first analyse these across the population, but then take lifecycle and longitudinal perspectives. We show that work incentives vary considerably across the population, and that a considerable amount of the variation relates to lifecycle circumstances, principally family composition. Given that family composition changes as women age, we then show how working incentives change at the aggregate level as women age, and how they change longitudinally. In Section 5, we introduce our forward-looking measure of financial work incentives. We show how this compares to the usual static measure of financial work incentives, and identify those groups for whom the static PTRs are a poor guide to the (arguably more relevant) forward-looking PTR. Section 6 concludes. In appendices, we provide further details on the UK tax and benefit system, derivation of the relationship between the forward-looking participation tax rate and the usual static measures of work incentives, further details of the structural model used to simulate the individuals' lifetimes, and some supplementary results.

2. Measuring work incentives using a structural, dynamic model of female labour supply

This section provides a brief account of the model we use to simulate women's lifetimes, and then discusses how we use the model to create various measures of financial work incentives (there is more detail on the model in Appendix C and Blundell et al (2011)).

2.1 Overview of the structural model

A dynamic analysis of work incentives requires some sort of longitudinal data, and in this paper we use simulated data produced by a structural, dynamic model of female labour supply and human capital accumulation combined with an accurate UK tax and benefit calculator called FORTAX (see Shephard (2009), Shaw (2011)). We use a standard lifecycle consumption and labour supply model, in the style of Eckstein and Wolpin (1989) and (1999), Keane and Wolpin (1997) and Adda et al (2008), but with additional features that make it suitable to assess the impact of taxes and benefits on work incentives and decisions over time. The most important of these are: evolving family composition; a rich characterisation of the tax and benefit system; an education choice; and experience accumulation. To our knowledge, this is the first tool capable of supporting the study of dynamic features of tax and benefit design taking into account labour supply responses, saving and skill formation.

The focus of the model is women, as previous work has shown them to be more responsive to work incentives than males (see Meghir and Phillips, 2010, or Keane, 2011, for recent surveys). A woman's life is split into education, working life and retirement. At age 17, women choose between three levels of education: basic, intermediate and higher, corresponding to GCSEs, A-levels and university. The level of education determines the type of human capital a woman has to offer in the labour market, and the age at which she enters the labour market. After education, women enter the labour market and, in each year, they choose how much to work (zero, part time (20 hours per week) or full time (40 hours per week)) and save. Family composition changes according to stochastic but exogenous processes of partnering and childbearing. At age 60, individuals compulsorily retire, and choose how much to consume each period until the end of life at age 69. Individuals are risk averse, and face uncertainty over future productivity and family composition but not over future tax and benefit systems. Insurance markets are incomplete, and partial self-insurance is possible through saving and the accumulation of human capital (education and experience). Individuals are unable to borrow except to fund education. This set-up means that the tax and benefit system may be of value to individuals both by providing insurance and by alleviating credit constraints.

Women's work incentives in our model are fully determined by the following factors:

- Female characteristics: age, hours of work and wage (which depends on her education, experience and productivity)
- Partner characteristics: presence of partner, hours of work and wage (which depends on the partner's education, the age of the woman, and the productivity of the partner)
- Child characteristics: presence and age of children
- Family characteristics: the level of rent paid, and whether the family has to pay for childcare

The model is estimated on an unbalanced panel of around 4,200 women and their families taken from the British Household Panel Survey (BHPS) over 16 waves, 1991-2006. Estimation is performed using the method of simulated moments (MSM). Having estimated the model, we simulate full lifecycles for 22,000 women and their families. These are constructed by randomly drawing initial conditions (age 17) from the BHPS data, and then, for each woman, randomly drawing lifecycle profiles for the exogenous components of the model (productivity and family composition) and solving the decision problem at each age. The result is a lifecycle profile for each simulated individual for each of the exogenous and endogenous variables in the model (e.g. labour supply, consumption, assets, experience and education, plus the work incentive measures). The population we simulate is, effectively, all families containing an adult female (single men are the only excluded family type).

When performing these simulations, we assume individuals face a single tax and benefit system throughout life; typically we use the UK April 2012 system. This allows us to focus on the effects of a particular tax and benefit system, rather than worry about individuals being exposed to different tax and benefit systems at different stages of life. The model also effectively strips out cohort effects.

Using simulated data rather has a number of advantages relative to using observed panel data. The first is practical: it enables us to analyse complete lifecycles. Using panel data, we would be limited to half a full working life at most: the UK's longest-running UK panel dataset (the BHPS and its successor) has existed only since 1991, and only a small fraction of the sample has been interviewed in every wave. Second, we can model cleanly the effect of a single tax and benefit system throughout life, allowing individuals to behave as they would under that constant system, and can do so having stripped out cohort effects. In contrast, patterns observed in panel data will be confounded by changes in taxes and benefits over time, as well as cohort effects. Third, we can use our model to calculate our new forward looking measure of work incentives, in which we model explicitly and structurally the way in which part of the return to working today accrues in future periods. Finally, we can use our model as an experimental tool to produce ex ante evaluations of hypothetical policy reforms that allow for behavioural responses.

2.2 Measures of financial work incentives

We use three different measures of work incentives: the marginal effective tax rate (METR), the participation tax rate (PTR) and the forward-looking PTR. This section describes how they are defined.

Marginal effective tax rate

The marginal effective tax rate (METR) describes what fraction of an incremental change to gross family earnings is lost by the family through increased tax liabilities and reduced benefit entitlements. We calculate the METR as:

$$
\begin{aligned}
METR &\equiv \frac{(T_{h+1} - B_{h+1}) - (T_h - B_h)}{E_{h+1} - E_h} \\
&= 1 - \frac{Y_{h+1} - Y_h}{E_{h+1} - E_h}
\end{aligned}
$$

where $Y = E - (T - B)$ and

$E =$ gross family earnings

$Y =$ net family earnings (less childcare costs)

$T =$ tax liabilities (plus childcare costs)

$B =$ benefit entitlements

Gross family earnings is total pre-tax weekly earnings of all adults in the family, and net family earnings subtracts taxes and adds on benefits. Note that we treat childcare costs like a tax liability: in other words, we treat spending on childcare as a cost of working that would not otherwise be incurred and that does not in itself affect the family's utility. This means the METR reflects the marginal (financial) disincentive to working, rather than only that disincentive that arises through by the tax and benefit system.

In our empirical analysis, we calculate the METR by incrementing hours worked, and so the subscript h refers to hours of work. [2] We use a one-hour-per-week increment (and require extra childcare to be bought, if relevant, for this hour). [3] The METR has little practical relevance for those not working (because we observe essentially no one in the data working just one hour a week. Consequently, we condition on being employed when calculating the METR at observed hours, and treat the participation tax rate as the relevant measure of work incentives for this group.[4]

Participation tax rate

The participation tax rate (PTR) describes what fraction of the change in gross family earnings caused by one individual moving into work is lost by the family in terms of increased tax liability and reduced benefit entitlements:

$$PTR \equiv 1 - \frac{Y_h - Y_0}{E_h - E_0}$$

where E and Y are defined as above. The 0 and h subscripts mean that the female works zero and h hours respectively. Note that this is identical to the METR, except that here we consider a large, discrete change in hours rather than an incremental change. In most of our empirical analysis, we calculate the PTR for workers at their *observed* hours, but we also calculate the PTR for non-working women. To do this, we set h equal to the number of hours they would have worked had they been employed – something we know because the model gives us a complete ranking for the different hours choices. [5]

Note that the PTR for someone contemplating, say, 20 hours a week work is simply the average of the METRs on each of the 20 additional hours. In general:

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[2] An alternative is to calculate the METR by altering the hourly wage holding hours worked constant. Both have been done in the literature; we do the former since hours of work are probably more under individuals' control, and because it is consistent with the definition of the PTR (see below) and with earlier work (e.g. Adam et al, 2006). Calculating the METR by incrementing hours or wages will be equivalent for families (i) not needing to buy extra childcare as a result of the hours increment, and (ii) where the hours increment does not take the female across an hours threshold in the tax and benefit system (e.g. 16, 24 or 30 hours per week for Working Tax Credit). Given the structure of the model, condition (i) fails to hold only for families with a child aged 10 or under, where all adults in the family are working. Condition (ii) is always satisfied.

[3] Results are not sensitive to the size of this increment (within reason), but some are affected by the treatment of childcare. Note that we set the fraction of families paying for childcare in the model to match that in data.

[4] In principle, there could also be calculated starting from a position where all individuals work part-time or full-time.

[5] In principle, there could also be calculated comparing not working to part-time work for everyone, or to full-time work for everyone, or starting from a position where all individuals work part-time and are moved to full-time work.

$$
\begin{aligned}
PTR &= 1-\frac{Y_h-Y_0}{E_h-E_0} \\
&= 1-\frac{\sum_{k=0}^{h-1}(Y_{h-k}-Y_{h-k-1})}{\sum_{k=0}^{h-1}(E_{h-k}-E_{h-k-1})} \\
&= \frac{\sum_{k=0}^{h-1}[(E_{h-k}-E_{h-k-1})-(Y_{h-k}-Y_{h-k-1})]}{\sum_{k=0}^{h-1}(E_{h-k}-E_{h-k-1})} \\
&= \sum_{k=0}^{h-1}\frac{(E_{h-k}-E_{h-k-1})}{\sum_{j=0}^{h-1}(E_{h-j}-E_{h-j-1})}\left[1-\left(\frac{Y_{h-k}-Y_{h-k-1}}{E_{h-k}-E_{h-k-1}}\right)\right] \\
&= \frac{1}{h}\sum_{k=0}^{h-1}METR_k
\end{aligned}
$$

A forward-looking participation tax rate

The METR and PTR are both static measures of work incentives that consider only the current period. But part of the return to working today is realised in future periods. In our model, there are two channels through which employment decisions have dynamic effects: experience accumulation (e.g. working today increases a woman's experience and so raises the wage available to her tomorrow) and savings (e.g. working today allows a woman to save more, thereby reducing her need to work tomorrow). These considerations mean that the return to working today will depend on future work decisions and family circumstances, and so a complete measure of the extent to which the tax and benefit system distorts work incentives could diverge from a static measure such as the PTR. If individuals are forward-looking, then the former is what will be relevant for individuals' labour supply choices.

We define a *forward-looking participation tax rate* that takes into account these dynamic considerations. In essence, the forward-looking participation tax rate simply measures what fraction of current and future earnings is offset by current and future increases in tax liabilities and reductions in benefit entitlements. The appeal of this measure of work incentives is that it is consistent with the way in which forward-looking individuals make decisions, and therefore with our model. For example, consider an individual who chooses not to work at time a. For such a person, our model can calculate the future stream of labour supply choices, and thereby gross earnings and net incomes from age a onwards, conditional on the individual not working in period a. We can also use the model to simulate labour supply choices, and thereby gross earnings and net incomes, in periods subsequent to a, conditional on the individual working in period a. We define the forward-looking PTR for this individual at time a as:

$$\text{Forward-looking } PTR_a \equiv 1 - \frac{\sum_{s=0}^{A-a} \beta^s (Y_{a+s|h_a=h} - Y_{a+s|h_a=0})}{\sum_{s=0}^{A-a} \beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})}$$

where β is the discount rate, E and Y are the (optimal choice of) gross and net family earnings as before, the $a + s$ subscript is the age of the individual (equivalently, the time period) up to some terminal age A, and the conditioning is on the value of labour supply at time a. When calculating the forward-looking PTR, none of the measures of earnings or income is equivalised.[6]

The forward-looking PTR can also be expressed in terms of static PTRs and METRs. Following similar steps to those for the PTR-METR relationship, we can write (see Appendix B for the missing steps of algebra):

$$\begin{aligned} \text{Forward-looking } PTR_a &= 1 - \frac{\sum_{s=0}^{A-a} \beta^s (Y_{a+s|h_a=h} - Y_{a+s|h_a=0})}{\sum_{s=0}^{A-a} \beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})} \\ &= \alpha_a PTR_a + \sum_{s=1}^{A-a} \alpha_{a+s} TR_{a+s} \end{aligned}$$

where:

$$\begin{aligned} \alpha_{a+s} &= \frac{\beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})}{\sum_{t=0}^{A-a} \beta^t (E_{a+t|h_a=h} - E_{a+t|h_a=0})} \text{ with} \sum_{s=0}^{A-a} \alpha_{a+s} = 1 \\ TR_{a+s} &= 1 - \left(\frac{Y_{a+s|h_a=h} - Y_{a+s|h_a=0}}{E_{a+s|h_a=h} - E_{a+s|h_a=0}} \right) \end{aligned}$$

and where terms involving $E_{a+s|h_a=h} - E_{a+s|h_a=0}$ as the denominator are omitted if it is equal to zero.

This formulation expresses shows the forward-looking PTR as a weighted average of today's PTR and future tax rates ("TR"), which are either PTRs or METRs. As we show in Appendix B, the precise measure of the TR , and weight α in period $a + s$ in the formula depends on how future labour supply behaviour is affected by the change in employment today. It is helpful to think of three cases.

[6] Equivalisation makes no difference to the METR and PTR because it cancels from the numerator and denominator. But this isn't true for the forward-looking PTR because family composition varies across life so different terms in the discounted sum will be scaled differently. In practice, this seems to make little difference.

1. if an individual will not work in a period $a+s$ regardless of whether she works in the current period (a “never worker” in the future period), then, as today’s labour supply decision has no impact on the level of pre-tax earnings or tax paid in a future period, the term in the summation relating to the period $a+s$ is zero.
2. if an individual will always work in period $a+s$ regardless of whether she works in the current period (an “always worker” in period $a+s$), then the relevant tax rate term for period $a+s$ is the METR that applies to any additional earnings in the future period (working now may affect hourly wages in period $a+s$ through an experience effect), and the weight is related to the size of the experience effect on hourly wages multiplied by hours worked in period $a+s$.
3. if an individual’s labour supply choice in period $a+s$ does depend upon whether she works in the current period, then the relevant tax rate is the PTR in period $a+s$ is (defined appropriately over the change in labour supply; note this could be from not working to working part- or full-time, or from part-time to full-time, or even a reduction in labour supply from full-time to part-time or to not working), and the weight is related to the size of the change in weekly earnings in period $a+s$.

The simple case is where future labour supply decisions are not affected by today’s labour supply choice, which restricts attention to cases 1 and 2. In this situation, the forward-looking PTR is a weighted average of today’s PTR and of METRs for all future periods in which the individual works, with the weights reflecting the age-profile of the experience effects and the hours worked in each period. In such cases, whether a forward-looking PTR exceeds the static PTR will depend upon the time profile of METRs, and their relationship to the static PTR: for example, a forward-looking PTR is more likely to exceed a static PTR for women whose static METR exceeds the static PTR, or whose METR rises with age.

But the intuition is less clear in cases where a woman’s future labour supply is affected by today’s labour supply choice. In general, the forward-looking PTR for such women is a weighted average of future METRs and PTRs, with much larger weights placed on the PTRs in periods in which future labour supply decisions are affected by today’s labour supply choice than on the METRs in those periods where she is an always- or never-worker (furthermore, the weight on the PTRs might be negative if increasing labour supply now reduced labour supply in a future period). For such women, a forward-looking PTR is more likely to lie below a static PTR for women whose static METR is less than the static PTR, or whose METR falls with age, or whose PTR falls with age.

It is also important to notice that, unlike the static METR and PTR, the forward-looking PTR at age a is unknown at age a. This is because uncertainty about future circumstances (e.g. family composition) means that the individual cannot perfectly predict future employment decisions and earnings, and therefore dynamic incentives are unknown when each employment decision is made. Consequently, we focus on the expected forward-looking PTR, calculated by simulating a number of different replications for future outcomes. Note that we can calculate the forward-looking PTR at any age of the individual, just like the static METR and PTR. In the final period, at age $a = A$, the forward-looking PTR is identical to the static PTR since there are no remaining dynamic considerations. As a tends towards A, the forward-looking PTR will generally tend towards the static PTR.[7]

Note that each of the three measures of work incentives described above can easily be decomposed into those for component taxes and benefits. Taking the METR as an example, and supposing there are J taxes and K benefits, we show in Appendix B that we can write:

$$\mathrm{METR} \quad = \quad \left(\sum_{\mathrm{j}=1}^{\mathrm{J}} \mathrm{METR}_{\mathrm{T_j}}\right) - \left(\sum_{\mathrm{k}=1}^{\mathrm{K}} \mathrm{METR}_{\mathrm{B_k}}\right)$$

[7] This is generally true, but need not hold in any particular case, precisely because of the sort of optimal future adjustments in response to being moved into or out of work described in the previous paragraph.

3. An overview of the UK tax and benefit system

This section gives an overview of the tax and benefit system in the UK (as of April 2012) with a focus on the features of the system that are relevant given our concern over how the system affects work incentives. This consideration means we examine only the working-age population, and ignore issues relating to income from self-employment and unearned income. More detail is in Appendix A; see also Adam and Browne (2011) and Jin et al (2010). We also indicate which aspects of the tax and benefit system are not reflected in our model.

Overall, the UK combines a relatively simple, individual-based, income tax system with a relatively complicated, family-based set of benefits and tax credits in which maximum entitlements are strongly influenced by family circumstances and there is a heavy reliance on means-testing. 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 that together produce a progressive rate schedule with a combined marginal effective tax rate that rises from 0% on earnings below £146 a week (£7,592 a year) to 52% on earnings above £150,000 a year. The most common combined METR, which applies to those whose earnings lie between £8,105 and £42,475 (approximately the 5th and 85th quantiles in the distribution of earnings[8] is 32%.

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. (Child benefit, the only non-means-tested benefit we model, will become means-tested from January 2013). Entitlements to benefits depend upon family or household circumstances in very particular ways, and this means that the impact they have on a given individual's work incentives will depend upon the earnings of any partner, and on other family or household characteristics (such as the presence and age of children, and housing tenure). The benefits can be thought 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) income-based Jobseeker's Allowance (hereafter JSA; our model ignores the small contributory-based form of Jobseeker's Allowance), Employment and Support

[8] http://www.hmrc.gov.uk/stats/income_distribution/3-1table-feb2012.pdf)

Allowance (ESA) which we abstract from in our model and Working Tax Credit (WTC). The eligibility conditions have been designed so that families are entitled to at most one: IS, JSA and ESA are intended as income top-ups for families where no one is in paid work[9], 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. IS is, in general, available only to families where all adults work less than 16 hours a week (including not working at all). 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. As explained in Appendix A, 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).

The way that the personal taxes affect work incentives is fairly standard, but the benefits and tax credits affect work incentives in much more complicated ways. The fact that the income-replacement benefits have a 100 per cent withdrawal rate results in extremely weak incentives to work for low-wage individuals unless such individuals would be entitled to WTC if they did work. As we explained above, women in our model choose between working 0, 20 and 40 hours a week: 40 hours a week is enough to give WTC entitlement to all (before the means-test is applied), but 20 hours a week paid work is not sufficient to gain entitlement to WTC for single adults without children, or for those in couples whose partner is not in work. This means that mothers, and particularly lone mothers, are entitled to generous subsidies if out of work, but these are compensated by work-contingent benefits,

[9] Entitlements to IS and income-based JSA are calculated in the same way; the key distinction is that that IS does not have a job-search requirement, but is only open to specific groups (mainly lone parents with young children), and income-based JSA can be claimed by anyone but includes a job-search requirement (which we do not model). The benefits top income up to a prescribed level, and then impose a 100% withdrawal rate. ESA is designed similarly but is intended for families where the claimant is unable to work through disability or ill-health.

resulting in reasonable PTRs for most. The other group of benefits (CTC, HB, CTB) that are unrelated to hours of work but means-tested can only weaken work incentives (however measured). They do so the most for those entitled to the largest amounts, which, in general, will be those with children, and those paying high rents for their housing.

Unsurprisingly, workers facing the highest METRs are not those on very high earnings, but those facing multiple withdrawal of means-tested benefits. The modal METR is 32%, and the METR on earnings faced by those on the highest levels of earnings is 52%. Those subject to a withdrawal of child or working tax credit face an additional 41% (making 73% for those paying the basic rate of Income Tax), and those also facing a withdrawal of HB or CTB will face a METR in excess of 90%. The very highest METRs arise for those in work and who receive an income-replacement benefit (IS, JSA or ESA): such workers face a 100% METR. However, the least amount of positive labour supply that women in our model can provide is 20 hours a week, and this is sufficient to remove entitlement to these benefits.

Figures 3.1 and 3.2 show budget constraints, METRs and PTRs for a number of example families. The 100 per cent withdrawal rate for income replacement benefits is evident between around 0-10 hours work in Figure 3.1. The discontinuous jumps in net family income at 16 and 30 hours correspond to entitlement (or increased entitlement) to WTC. PTRs can be very low for lone parents, particularly above 16 hours of work. The high METRs caused by withdrawal of housing benefit and childcare costs are a feature of the right-hand panel in Figure 3.1. From Figure 3.2, low wage couples with children experience high METRs and PTRs (middle panel). Individuals in childless couples (left panel) and hich wage couples with children tend to have lower METRs and PTRs.

4. A static analysis of how the UK tax and benefit system affects work incentives

This section analyses the usual static measures of financial work incentives (hereafter "work incentives"), but with a lifecycle perspective. We first show how static work incentives vary across the population, then how they change in aggregate over the lifecycle (and how these changes relate to lifecycle circumstances, principally family composition), and finally how they change longitudinally for individual women.

4.1 Cross-sectional analysis

Table 4.1 shows the mean and median METR for working women in our simulated data, and the PTR for all women, if they face the April 2012 UK tax and benefit system throughout life (these are the usual static measures of financial work incentives, as described in Section 2).

Figure 4.1 plots cumulative distributions for the METR (conditional on working) and PTR (we present cumulative distributions rather than probability densities because mass points in the METR distribution mean that probability densities cannot easily be drawn). Tables 4.2 and 4.3 show which taxes and benefits are responsible on average for different ranges of METRs and PTRs. The most striking feature of the figure is the fact that more than 70 per cent of working women have an METR of exactly 0.32, which Table 4.2 shows is made up of basic rate income tax (0.20) and National Insurance (0.12). For individuals with METRs in excess of 0.6 (poor work incentives), childcare, working tax credit, child tax credit and housing benefit are also important components.[10] The distribution of PTRs is much smoother. Individuals with relatively strong incentives to work (low PTRs) typically have a working tax credit award that offsets the loss of income support when moving into work, as Table 4.3 shows. Almost 70 per cent of women have a PTR between 0.2 and 0.6, for whom the key components are income tax, National Insurance and income support and to a lesser extent childcare, child tax credit and council tax benefit. PTRs in excess of 0.8 are largely due to housing benefit and income support.

Not surprisingly, work incentives differ by observable characteristics. Figure 4.2 classifies women into one of four family types: childless singles, childless couples, lone parents and couple parents. Lone parents have the highest METRs, with three quarters facing an METR over 0.4, reflecting the large amount of means-tested support targeted towards them. However, PTRs for this group are relatively low, because of the generous work-contingent

[10] Remember we treat childcare like a tax, and so families who pay for childcare must buy more of it to cover additional hours of work.

Working Tax Credit. Women in childless couples generally enjoy the strongest work incentives: over 90 per cent have METRs of 0.32 or less, and over three quarters have a PTR under 0.30. This is because in-work support (the withdrawal of which contributes to high METRs) is focused towards families with children in the UK, and because women with partners but no children are unlikely to be entitled to out-of-work benefits were they not to work because most of their partners are working. Almost all childless single women have PTRs of at least 0.40, a consequence of the loss of IS on moving into work which is only sometimes offset by entitlement to WTC in work, and the effect of income tax and National Insurance.

There are also differences by education, but these are less dramatic. Figure 4.3 shows that the basic education group is more likely to have METRs above 0.4, but also more likely to have very low PTRs. Both reflect that women in the low education group tend to be less well paid, and more likely to be lone mothers, and lone parents tend to face reasonably strong incentives to do some work (low PTRs), but relatively weak incentives to work more (high METRs amongst workers).

4.1.1 What causes weak and strong incentives to work?

To provide some insights into the underlying causes of high or low PTRs and METRs, we offer three complementary pieces of analysis: a decomposition of the variation (using the simple linear regression based approach due to Fields (2003)); an analysis of which sorts of women are more likely to have strong or weak incentives, and an analysis of which components of the tax and benefit system contribute to weak or strong incentives.

METRs

A simple technique to help understand what causes the variability in METRs is to use a decomposition based on a linear regression.[11] The METR is a deterministic function of variables that we can measure in the data, and so, in principle, we could explain 100% of the variation if we interact all our categories with each other. But this would not be especially helpful. Instead, in Table 4.4, we show what fraction can be explained by six categories: the level of earnings and pattern of hours worked by the adults, female education, presence of partner and presence and age of children (family composition), expenditure on childcare, and expenditure on rent.[12] Across all working women, we can explain just over 60 per cent of the total variation in the METR using this approach. Of this, the majority is due to family hours

[11] Fields (2003); we use the "ineqrbd" Stata package.

[12] For these decompositions, variability is measured using half the squared coefficient of variation.

and earnings (34 per cent), followed by family composition and childcare expenditure. Conditional on the other factors, female education and whether renting do not seem to matter at all. Family employment decisions matter seem to matter less, and childcare expenditure more, for more highly educated women (this probably reflects that such women are less likely to be entitled to in-work tax credits, which can lead to very high METRs). An alternative approach (but still using the regression-based decomposition) is shown in Table 4.5; this shows what fraction of the variability in the METR can be explained by female hours and earnings alone, and what fraction can be explained by family hours and earnings alone (which includes the former). Amongst all women, female hours and earnings explains only a small fraction (0.140), and family hours and earnings explains considerably more (0.312). But this means that more than two thirds of the variation is explained by factors other than the working patterns and earnings levels of the adults in the family.

Next, we investigate what sort of families are likely to have high METRs (defined as above 73 per cent or more[13]). Full results are shown in Table D.1 in Appendix D, but the main predictors are: the woman having low earnings; being a lone parent; being in a couple family with a non-working or low-paid partner; being aged 25 or more; and paying for childcare. All of these factors will increase the likelihood that the family is entitled to WTC and CTC when the woman works, which will tend to lead to high METRs; the last (paying for childcare) directly increases the METR as we have defined it for women whose children are of an age that require additional childcare. Table 4.6 shows which income components are responsible for high METRs. Amongst all women, individuals in the top decile of METRs have an average METR of 0.765. In decreasing order, this is explained by WTC (0.250), income tax (0.196), NI (0.119), CTC (0.100) and childcare (0.076).[14]. There is relatively little variation by education, the main difference being the relative shares attributed to WTC and CTC, which simply reflects the mechanical way in which the joint means-test for these two benefits works.

PTRs

Table 4.7 decomposes the variation in PTRs (using the linear regression method of Fields (2003)) into the same five categories: the earnings and pattern of hours worked by the adults,

[13] Because of the mass point at 0.73, the top "decile" accounts for slightly more than 10 per cent of individuals. We are unable to analyse the bottom decile group sensibly because of large mass points in the distribution of METRs.

[14] IS doesn't feature in this list is because it can only be claimed by individuals working less than 16 hours a week, below the lowest in-work hours point in our model. Housing benefit does not feature in the table: it can lead to METRs exceeding 73%, but is received by only a minority of working women

female education, presence of partner and presence and age of children (family composition), expenditure on childcare, and expenditure on rent. Family hours and earnings appears to explain nearly all the variation in the PTR, but there are important interactions between the working patterns of the family and family composition, which lead family composition to explain a large *negative* share of the variation in the PTR. In our alternative analysis, Table 4.8 shows that we can explain less than 15 per cent of the variation in PTR by female hours and earnings alone, and 40 per cent by considering the pattern of hours worked and earnings across all adults in the family (and almost 60 per cent for highly educated women). The converse of this is that factors other than pattern of hours worked and earnings are particularly important in explaining variation in PTRs amongst women in the low education group.

Individuals with very high PTRs tend to be low-earners, in couples with a non-working or low-earning partner, paying for childcare and renting (see Table D.5 in Appendix D for the top decile group; results for the top quartile are very similar). These individuals will be entitled to potentially large income support and housing benefit awards when out of work, and their in-work income is barely enough to compensate for the loss of these benefits. Table 4.9 shows that PTRs in the top decile group are mostly caused by income support (the loss of which amounts to an average of 46% of the gross earnings of the woman), more than half of the total on average. Other important components include housing benefit and childcare. For the top quartile, income support still dominates, but is a little less important. By education (see Tables D.2 to D.4 in Appendix D), the mean PTR falls with education, due mainly to falls in the income support and housing benefit components.

As regression results in Table D.5 in Appendix D show, individuals in the bottom decile are disproportionately low-earners who are either lone parents (and therefore entitled to generous WTC awards) or who have employed high-earning partners (so they are not entitled to any form of support if they do not work), particularly if the female works part-time. Table 4.9 shows that individuals in the bottom decile of PTRs typically have a large negative contribution from WTC (-0.179 on average) that more than outweighs the impact of income support (0.170). Most other components are small, resulting in an extremely low average overall PTR (0.033). Results by education are given in Tables D.2 to D.4 in Appendix D. Interestingly, although the mean PTR differs little by education level, the size of the offsetting WTC and income support components falls dramatically with education. For individuals with higher education, it is virtually zero: for these highly-educated women, low PTRs occur because they are not entitled to support if they do not work.

4.2 Aggregate changes over the lifecycle

The previous section showed the considerable variation in incentives by family composition, and this points towards the importance of considering work incentives from a lifecycle perspective, since family composition varies considerably across the lifecycle. In this section, we show how the cross-sectional differences by family type and education translate into patterns by age, something that has not been drawn out by the previous literature.

The left panel in Figure 4.4 plots the mean and various quantiles of the METR for employed women by age.[15] Although the 10th to 50th percentiles remain constant at 0.32 throughout life (basic-rate income tax and National Insurance, there are substantial changes in the right tail as individuals age, with the mean METR rising by almost 0.1 between ages 20 and 40, and the 75th percentile rising by over 0.2. The right panel in Figure 4.4 shows that this coincides with a large rise in the share of families with children; as we saw in Figure 4.2, women with children (particularly lone mothers) generally have higher METRs than those without. Clear lifecycle patterns also emerge for the PTR. The left panel in Figure 4.5 shows that there is a slight downward trend and a narrowing of the distribution over the lifecycle, both of which are consistent with wages increasing with age (due to experience effects: there is no secular real growth in our model). The relationship between PTRs and family types shown in the right panel in Figure 4.5 is less clear, but this also matches the finding from Section 4.1 (and Figure 4.2 in particular) that families with children do not uniformly have higher (or lower) PTRs than those without children.

The experience is not uniform across different education groups.[16] Figure 4.6 shows that the dispersion of the METR for the high education group is less marked than it is for the low education group: the 75th percentile of the METR for the high education group remains below 0.5 throughout working life, but peaks at almost 0.7 for those in the low education group. It is also the case that the high educated group have substantially lower dispersion in their

[15] Because we show METRs for working women only, differential selection into paid employment over time may explain some of the lifecycle variation in these graphs.

[16] Appendix D shows the analysis by age and potential lifetime earnings quartile, which is obviously highly correlated with education and thus reveals similar patterns.

(static) PTRs throughout the lifecycle than the low educated group; but there is somewhat less of a downward trend (see Figure 4.7).

We saw above that family composition has a huge impact on a woman's work incentives. But interpreting how work incentives change with age conditional on family type is complicated because the composition of each family type changes as women age (e.g. a 20-year-old lone mother is likely to be different from a 40-year-old lone mother). We therefore show (in Figures 4.8 and 4.9) the mean and various quantiles of the distribution of work incentives for women in different family types at particular ages. It shows that there is little lifecycle variation in the METR amongst women without children. Among women with children, the general pattern is for METRs to be lower where the mother is older, presumably reflecting that women's and their partners' wages rise with age, reducing entitlement to means-tested tax credits. The distribution also narrows somewhat with age. There is also little lifecycle profile in PTRs amongst women without children. Amongst those with children, older lone mothers tend to have higher PTRs than younger ones, and older mothers in couples tend to have lower PTRs than younger ones. These seem likely to be due to a combination of compositional changes and lifecycle changes in labour supply and hourly wages. The compositional change arises because older mothers tend to be more highly educated than younger mothers (as higher educated women tend to have children later than low educated women). The lifecycle change arises because experience effects mean that older women tend to earn more than younger women (the same is also true for these women's partners, if they exist). For mothers with a partner, both factors reduce the likelihood that they would be entitled to any tax credits if they did not work (hence lowering their out-of-work income, and thus their PTRs). For lone mothers, who are always entitled to substantial out-of-work benefits, both factors described above will reduce their entitlement to benefits when in work, as well as moving them on to higher tax rates. Finally, in Appendix D, we show a variant of this analyses by showing a breakdown by age and a time-invariant classification of family type: this strongly suggest the role that having children has on financial work incentives: the 90:10 range of METRs for never parents stretches from 32% to 42% for almost all of life, with no bulge upwards in METRs during the 30s and 40s, and the distribution of PTRs is more compressed than that of women who do have children, with never-parents seeming not to face the very weak or very strong incentives to work.

4.3 A longitudinal analysis

So far we have considered how the distribution of work incentives varies with age across a population of women, without considering how persistent (or not) they are over time for any given individual. This is an important issue, since the policy implications may be quite different if individuals face widely varying PTRs from period to period than if the same individuals experience high PTRs throughout life.

In Table 4.12, we decompose the variance of the METR and PTR (measured across all the women in our model in all the years of working-life) into "between" (i.e. across individual) and "within" (i.e. across lifecycle) components. Two thirds of the METR and PTR variances are explained by the within (across lifecycle) component, confirming that individuals experience considerable variability in work incentives across their lives. Nevertheless, the difference in work incentives for two randomly drawn women in two randomly selected years is expected to be around 50% higher than the difference for the same woman in two randomly selected years.

To get a feel for how this translates into persistence in work incentives across the lifecycle, Tables 4.13 and 4.14 present transition matrices across the METR and PTR distributions. We take women aged 25-29 in the base year and consider four different horizons: one, five, 10 and 20 years. In both cases, the tables show a high degree of persistence for one-year transitions and a decline in persistence as the horizon lengthens, which is particularly dramatic for high METRs.

Tables 4.15 and 4.16 show how these patterns evolve with age, based on five-year transitions. Looking first at PTRs (Table 4.15), for all but the top quintile, persistence (the proportion on the diagonal) increases with age, reflecting the fact that family transitions become less likely with age, and experience profiles flatten out. For the top band, persistence declines with age. The patterns are a little less clear for METRs (Table 4.16), though again we see a marked decline in persistence for the top band. (To aid interpretation, Table 4.17 shows 5-year transitions between the family types, again measured at different ages. This confirms that family transitions become less likely with age, particularly for some family types).

5. A dynamic measure of work incentives: the forward-looking participation tax rate

So far, we have examined, in common with the rest of the literature, a static measure of how the tax and benefit system affects work incentives. Such a measure ignores that working today can bring returns tomorrow. If individuals are forward-looking, then a dynamic perspective is necessary because today's decisions may partly depend on the tomorrow's return to working, and, as has been shown comprehensively in Section 4.2 and 4.3, the way that the current tax and benefit system treats additional current earnings may well be different from the treatment of future earnings by future tax and benefit systems. There is good reason to suspect, then, that for some women at least, a simple static measure of work incentives is a misleading impression of the true way in which the tax and benefit system affects work incentives.

In this section we present results for a new measure which takes into account these dynamic considerations, the forward-looking PTR, whose construction we described in Section 2. We then assess how it is distributed across the population, paying attention to identifying the sort of women for whom the forward-looking PTR differs from the static PTR.

5.1 The distribution of forward-looking PTRs

Figure 5.1 plots the distribution of the static PTR and the forward-looking PTR, both measured at the start of working life.[17] The overall patterns are similar, but the distribution of the forward-looking PTR is less dispersed and is concentrated at slightly lower values.

Table 5.1 provides the simple regression-based decomposition of the variance in FLPTRs that we undertook in Section 4.1 for the convention static measure.[18] Using the same explanatory factors, we are able to explain a lot less of the variability in FLPTR than we could for the PTR. Much of this is due to a fall in the explanatory power of family employment decisions, though this remains by far the most important factor. The patterns by education remain roughly the same (including the problem of family composition explaining a negative share of the variability for higher educated individuals). Table 5.2 shows that female hours and

[17] As described in Section 2, we calculate the expected value of the forward-looking PTR, as at any age, its actual value is not known with certainty; results look little different if we consider the ex post realised values instead.

[18] To calculate meaningful decompositions, it is necessary to exclude extreme values of the FLPTR (which arise when future employment decisions are affected by changes in employment today). Table 5.1 therefore excludes values outside the range -1 to 2.

earnings alone explain less than 10 per cent of the variation in FLPTRs, and family hours and earnings together around 30 per cent of the variation, both smaller values than for the PTR (shown in Table 4.6).

Table D.6 in Appendix D shows that strong predictors of being in the bottom decile of forward-looking PTRs are being a low-earner, and being either a lone parent or in a couple with an employed, high-earning partner (the latter particularly if the female works part time). These factors are similar to the ones that predicted having low PTRs (see Table D.5), and they occur here for similar reasons.

5.2 Differences between static and forward-looking PTRs

If women do behave in the manner implicit in our model, then the FLPTR is a more relevant measure of the extent to which the tax and benefit system weakens the gain to working than the conventional PTR. But rather than analyse in detail the FLPTR, we instead analyse in detail the difference between the forward-looking PTR and the static PTR, as large (in magnitude) values of this variable indicate women for whom the commonplace static measure of work incentives may be giving a misleading impression of the true way in which the tax and benefit system affects work incentives.

Figure 5.2 plots, by age, the mean and various quantiles of the distribution of the difference between the forward-looking PTR and the static PTR (positive numbers mean the forward-looking PTR is greater than the static PTR, indicating that the tax and benefit system is reducing the return to work by more when we take account of future consequences of today's working decisions).[19] In general, differences between the forward-looking PTR and the static PTR decline with age; by the end of working life, the distribution of the forward-looking PTR has converged to that of the static PTR, because there are no future periods of work to create a difference between the two measures. Early in life, the mean difference is negative (but small), meaning that the mean static PTR is (slightly) greater than the mean expected FLPTR, or that the conventional static view of work incentives may be (slightly) over-stating the extent to which the tax and benefit estimate is weakening work incentives. Later in life, the distribution of differences shifts upwards, and become skewed towards large positive

[19] A decomposition of the variance of the difference between the expected forward-looking PTR and the static PTR using the same factors and methods as before shows that much less of the variance in the difference between these measures can be explained: the only factors with any meaningful predictive power are family hours and earnings, accounting for just 0.053 of the overall variation. Similarly, Table 5.4 shows that female hours and earnings on its own explains about five per cent of the variability; adding hours and earnings of the family males little difference.

differences; although the median difference remains negative, the mean difference rises above zero at age 28, implying that, after this age, the mean static PTR may be slightly under-stating the extent to which the tax and benefit estimate is weakening work incentives. But these large positive differences (where the forward-looking PTR suggests weaker incentives to work than the static PTR) become much less likely once women reach age 40.

Two key questions are: for whom are forward-looking and static PTRs different, and why. Figure 5.3 shows the mean and various quantiles of the distribution of the difference between the expected forward-looking PTR and the static PTR, splitting women by education. (As before, positive numbers mean the forward-looking PTR is greater than (weaker incentive to work than) the static PTR). Amongst women in the lowest education group, the differences start slightly negative, but the distribution shifts upwards and becomes skewed towards large positive differences as women age; although the median difference remains negative, the mean difference rises above zero at age 22 where it remains until age 56, implying that the mean static PTR thereafter may be (very slightly) under-stating the extent to which the tax and benefit estimate is weakening work incentives for low education women between these ages. The distribution of differences does not begin to narrow noticeably until women reach age 45. There is a similar pattern in the mean difference for women in the middle education group (the mean difference is negative until age 29 and is positive thereafter), although there are fewer very large positive differences than there are for the lowest education group, and the distribution of differences begins to narrow noticeably earlier in life (from about age 40). Finally, the mean difference between the expected forward-looking PTR and the static PTR for the high education group also starts negative, but it takes until age 35 to turn positive, where it remains until age 57. In general, the distribution of the difference between the expected forward-looking PTR and the static PTR is much less dispersed for the highest education group than for the other groups: at almost all ages, 90% of women in the highest education group have an expected FLPTR that is within 5 percentage points of their static PTR.

Figure 5.4 shows the mean and various centiles of the distribution of the difference between the expected forward-looking PTR and the static PTR, splitting women by family type.[20] Amongst single women with no children, mean and median differences are clearly negative,

[20] This graph, of course, has the potential to mislead, as some of the changes over time will reflect changes in composition of women in each family type. But it is also very clear that the family situation is a good guide to the difference between the expected FLPTR and static PTR.

meaning the conventional static view of work incentives may be over-stating the extent to which the tax and benefit system is weakening work incentives, but the size of any discrepancy tends to be small. On the other hand, mean and median differences are clearly positive amongst lone mothers, meaning the conventional static view of work incentives may be under-stating the extent to which the tax and benefit system is weakening work incentives, and is doing so to a large extent for some: for example, almost 10 per cent of lone mothers aged 45 have an expected FLPTR that is 20 percentage points higher than their conventional static PTR. The differences between the expected FLPTR and PTR are, in general, smaller for women in couples than single women; they tend to be positive at the mean for those without children (implying that the conventional static view of work incentives may be under-stating the extent to which the tax and benefit system is weakening work incentives) and negative at the mean for those with children (implying that the conventional static view of work incentives may be over-stating the extent to which the tax and benefit system is weakening work incentives).

Regression results in Appendix D Table D.7 show that individuals in the bottom decile of the distribution of expected forward-looking PTR less the static PTR (ie women for whom the forward-looking PTR is smaller than the PTR, or for whom the static PTR may be over-stating the extent to which the tax and benefit system is weakening the incentive to work) tend to be low-earners, working full-time, in couples, paying for childcare, and renting. These are women for whom either the static METR is lower than the static PTR, or whose METR or PTR falls with age. Conversely, being in the top decile of the distribution (ie women for whom the forward-looking PTR is above the PTR, or for whom the static PTR may be under-stating the extent to which the tax and benefit system is weakening the incentive to work) is associated with being a low-earner, a lone parent, or having a high-earning partner (particularly if the female prefers to work part time), and not paying for childcare. These are women for whom either the static METR is higher than the static PTR, or whose METR or PTR rises with age. Interestingly, these are all factors that also help predict whether a woman has a low PTR measured in the static sense (as discussed in Section 4.2), and this indicates that mean-reversion is part of the explanation here: certain groups of women do have relatively strong incentives to work if considered in the static sense, but these strong incentives do not always persist throughout the rest of their lifetime. Finally, Table D.8 in Appendix D shows that individuals whose forward-looking PTR is very similar to their static PTR (an absolute difference of no more than 0.01) tend to be single women without children, those with high earnings, non-renters, those with basic education and older individuals. Having a forward-looking PTR that is very similar to a static PTR can arise for two distinct reasons. First. it could reflect that women have a strong preference for not working in the future, such that working now has no impact on future decisions, and this might explain the correlations with low education, and being relatively old. Second, it could reflect that these women face a series of future METRs (or PTRs) which are similar to the current static PTR; this might explain the correlation with being a single woman without children, who face a relatively flat budget constraint compared to those with children, and it might explain the correlation with being low educated, for whom the returns to additional experience are very low, which would also explain a relatively flat profile of METRs with age.

What is causing individuals to have expected forward-looking PTRs that differ from the static PTRs? Section 2 explained is helpful to think of two cases.

Case 1. Future labour supply decisions not affected by current labour supply choice. In this case, the forward-looking PTR is a weighted average of today's PTR and of METRs for all future periods in which the individual works (with the weights reflecting the age-profile of the experience effects and the hours worked in each period). Whether a forward-looking PTR for such a woman exceeds the static PTR will depend upon the time profile of METRs, and their relationship to the static PTR: for example, a forward-looking PTR is more likely to lie below a static PTR for women whose static METR is lower than the static PTR, or whose METR will fall in the future.

Case 2. Future labour supply decisions are affected by current labour supply choice. The forward-looking PTR for such women is a weighted average of future METRs (for all future periods in which the individual works regardless of current labour supply) and appropriately-defined PTRs (for all future periods in which labour supply choice is affected by current labour supply), with much larger absolute weights placed on the PTRs than on the METRs (however, the weight on the PTRs might be negative if increasing labour supply now reduced labour supply in a future period). For such women, a forward-looking PTR is more likely to lie below a static PTR for women whose static METR is less than the static PTR, or whose METR or PTR will fall in the future.

An obvious candidate for the pattern of changes described above is that of changing family formation, and the differences in the way that women in different family circumstances are treated by the tax and benefit system. For example, single women with no children, especially when young, are highly unlikely to remain in that family state. More importantly, lone mothers, who tend to have low PTRs in a static sense, are likely to be come either mothers in couples, or single women without dependent children in future and, in both cases, the change in tax credit entitlements will likely lead to a considerably higher PTR. Conversely, mothers in couples are likely to become either lone mothers, or women in couples without dependent children in future, and both are likely to lead to a strengthening of work incentives as measured by the PTR. On the other hand, high-earning women are much less likely to have their incentives to work affected by means-tested tax credits as they are unlikely to be entitled to them whatever their family situation: this is likely to be the explanation why the distribution of differences between the forward-looking PTR and the static PTR is much more compressed for the highly educated groups than the others.

5.3 Uncertainty over the forward-looking PTR

So far we have only been considering the expected value of forward-looking PTRs. But the degree of uncertainty is an important dimension that should be taken into consideration. Here we discuss who has much greater uncertainty over their lifecycle PTRs, and why. We measure uncertainty using the standard deviation of the forward-looking PTR across different replications, where each replication based on a new series of shocks in future periods, allowing decisions to respond optimally to those new shocks.

Figure 5.5 plots cumulative distributions for the standard deviation of the forward-looking PTR at three different ages: the start of working life, age 35 and age 55. A number of interesting patterns emerge. First, for the majority of individuals, the standard deviation of the forward-looking PTR is small. For example, at the start of working life, almost half of individuals have a standard deviation under 0.05. Second, there is a long tail of individuals with very high standard deviations: roughly 25 per cent of individuals have standard deviations in excess of 0.1 at the start of working life. Third, the variance of lifecycle PTRs shows an inverted U-shape with respect to age: uncertainty rises with age and then falls. The size of this effect is quite substantial, as can be seen for the age 35 group on the graph: for this group, more than 10 per cent have a standard deviation in excess of 1, which is enormous).

As stated above, each replication of the forward-looking PTR is based on a new series of shocks and individuals are allowed to respond optimally to those new shocks. This means that a high dispersion in the forward-looking PTR could be the result of different productivity shocks or family composition shocks causing substantial changes in future METRs, or different productivity shocks or family composition shocks changing decisions about labour supply. As we set out above, the latter receives a much larger weight in the calculation of the forward-looking PTR than the former, and so this seems the more likely explanation of the high dispersion. This suggests that individuals with a high standard deviation of the forward looking PTR are likely to be those who, in future period, would almost indifferent between different labour supply choices, such that a small change to hourly wages (through an experience effect) will alter a future hours-of-work choice. Figure 5.6 is supportive of this hypothesis: it shows that childless singles and childless couples, who we would expect to have a strong attachment to working full-time, to have low standard deviations, with couple parents and lone mothers having higher variances.

Table 5.5 repeats the simple regression-based decomposition used above, but this time on variation in the standard deviation of the FLPTRs.[21] Using the same explanatory factors, we are able to explain around 15-20 per cent of the variability in the standard deviation of the FLPTR. By far the most important component across all education grousp is family employment decisions. Table 5.6 shows that female hours and earnings alone are able to account for around 10 per cent of the variation, a little over half what family hours and earnings can. Table D.9 in Appendix D shows that strong predictors of having a low FLPTR standard deviation are being a high-earner, having basic education, being aged at least 25, having no children and not renting. Predictors of having the largest standard deviations (top decile) include having moderately low earnings, children, high-paid working partner, female is part time in work and no childcare.

[21] To calculate meaningful decompositions, it is necessary to exclude extreme values of the standard deviation of the FLPTR (which arise when future employment decisions are affected by changes in employment today). Tables 5.5 and 5.6 therefore exclude values greater than 2.

6. Conclusion

Personal taxes and benefits affect incentives to work and earn more over the lifecycle by altering income-age profiles, insuring against adverse shocks, and changing the returns to human capital. Most previous work investigating the impact of taxes and benefits on financial work incentives has tended to exclude any dynamic considerations: as we discuss below, few papers break results down by age group let alone think about how work incentives change over time for an individual, and the measure of financial work incentives used is always a static one (in the sense of ignoring future returns from working today).

This paper takes a first step towards filling this gap in the literature by using simulated data produced by a dynamic structural model of female labour supply and human capital to show how a lifecycle perspective alters our impression of the effect of the UK tax and benefit system on the financial work incentives facing women. In doing so, we bring the analysis of how taxes and benefits affect decisions to work, earn more, and invest in human capital in line with the literature on how individuals make those same decisions to work, earn more, and invest in human capital, which has long recognised the need for a dynamic perspective. Our companion paper analyses how well does a modern tax-benefit system, based on annual information, target lifetime inequality, and which elements of the tax-benefit system are most progressive from a lifetime perspective.

As an example, we analyse in detail the 2012 UK tax and benefit system, which is characterised by individual-level income taxes, and generous child-contingent subsidies that are means-tested against the income of a couple. We described how work incentives change over the life, and show how they depend on lifecycle circumstances. Our analysis of the usual static measures of work incentives under the 2012 UK tax and benefit system confirmed the findings of others that there is considerable variation by family circumstances. For example, lone mothers have the highest METRs, but have PTRs that are relatively low, and both reflect the large amount of in-work support targeted towards them, which lowers PTRs but which is means-tested, thus increasing METRs. Women in childless couples generally enjoy the strongest work incentives; both reflect that in-work support (the withdrawal of which contributes to high METRs) is focused towards families with children in the UK, and because such women are unlikely to be entitled to out-of-work benefits were they not to work (because most of their partners are working), giving them low PTRs.

However, family circumstances do not stay constant throughout a woman's lifetime, and this emphasises the importance of analysing work incentives by age. In fact, there are particularly large changes in the number of women in work facing very high METRs, which the 75th centile of METRs rising by over 0.2 between ages 20 and 40, before falling back again. Overall incentives to work, measured by the PTR, fall slightly with age and become less dispersed. These patterns are not common to women of all education levels: lifecycle changes in work incentives are the most pronounced for the low education group, and the least pronounced for the high education group.

Of course, the fact that the usual static measure of work incentives varies considerably over an individual's life suggests that a dynamic perspective will lead to different conclusions about the way in which the tax and benefit system affects women's work incentives. If women do behave in the manner implicit in our model, then the FLPTR is a more relevant measure of the extent to which the tax and benefit system weakens the gain to working than the conventional PTR. We analysed in detail the differences between the forward-looking PTR and the static PTR, as large (in magnitude) values of this variable indicate women for whom the commonplace static measure of work incentives may be giving a misleading impression of the true way in which the tax and benefit system affects work incentives. We showed that, early in life, the conventional static view of work incentives may be over-stating (at the mean) the extent to which the tax and benefit system is weakening work incentives. But as women age, the distribution of differences first shifts upwards and become skewed towards large positive differences (where the forward-looking PTR suggests weaker incentives to work than the static PTR), and then narrows and converges to zero, with large positive differences becoming much less likely once women reach age 40. If we look across education groups, we find in general that the pattern for low education women is an exaggerated version of the average, and that for high education women, a somewhat attenuated version.

The model we used is necessarily limited in the characterisation of individual circumstances and decisions. One important caveat is that the analysis excluded state benefits and pensions for those over State Pension Age. The fact that some part of pensions is earnings-related, and the fact that there are means-tested benefits for pensioners, mean that benefits provided for pensioners will also affect a forward-looking measure of work incentives, although the direction of bias is unclear.

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Tables

Table 4.1. Mean and median METR if working and PTR

	METR if working	PTR
Mean	0.378	0.368
Median	0.32	0.382

Notes: Authors' calculations based on simulated data.

Table 4.2. Mean composition of METR by METR band

	≤0.2	(0.2,0.4]	(0.4,0.6]	(0.6,0.8]	>0.8
Childcare	0.000	0.002	0.107	0.067	0.296
Income tax	0.002	0.199	0.236	0.186	0.187
National insurance	0.016	0.119	0.059	0.116	0.114
Working tax credit	0.000	-0.001	0.039	0.247	0.127
Child tax credit	0.000	0.000	0.020	0.096	0.051
Income support	0.000	0.000	0.000	0.000	0.000
Housing benefit	0.000	0.000	0.000	0.001	0.052
Council tax benefit	0.018	0.001	0.014	0.012	0.023
Other	0.000	0.000	0.000	0.000	0.005
Total	0.036	0.320	0.474	0.725	0.854
Share of individuals	0.042	0.722	0.113	0.102	0.022

Notes: The notation $(x, y]$ in the column headings means greater than x and less than or equal to y. Authors' calculations based on simulated data.

Table 4.3. Mean composition of PTR by PTR band

	≤0.2	(0.2,0.4]	(0.4,0.6]	(0.6,0.8]	>0.8
Childcare	0.020	0.024	0.041	0.097	0.040
Income tax	0.042	0.117	0.087	0.063	0.002
National insurance	0.028	0.071	0.055	0.041	0.002
Working tax credit	-0.166	-0.049	0.014	0.006	0.010
Child tax credit	0.004	0.020	0.050	0.019	0.000
Income support	0.149	0.092	0.157	0.266	0.819
Housing benefit	0.001	0.005	0.018	0.134	0.111
Council tax benefit	0.014	0.019	0.045	0.049	0.035
Other	0.007	0.003	0.003	0.003	0.000
Total	0.099	0.304	0.470	0.679	1.020
Share of individuals	0.202	0.358	0.334	0.072	0.033

Notes: The notation $(x, y]$ in the column headings means greater than x and less than or equal to y. Authors' calculations based on simulated data.

Table 4.4. Fields decomposition for METR

	Overall	Basic education	Intermediate education	Higher education
Family hours and earnings	0.344	0.435	0.329	0.262
Female education	0.001	0.000	0.000	0.000
Family composition	0.115	0.082	0.135	0.123
Childcare expenditure	0.150	0.119	0.159	0.282
Rent	0.000	0.000	0.000	0.000
Unexplained	0.389	0.363	0.377	0.332

Notes: conditional on working. Authors' calculations based on simulated data.

Table 4.5. Fields decomposition for METR to understand the role of hours and earnings

	Overall	Basic education	Intermediate education	Higher education
Female hours and earnings	0.140	0.138	0.138	0.148
Family hours and earnings	0.312	0.351	0.305	0.305

Notes: conditional on working. Authors' calculations based on simulated data.

Table 4.6. Mean METR by income component for those with the highest METRS (the top decile)

	Overall	Basic education	Intermediate education	Higher education
Childcare	0.076	0.075	0.076	0.083
Income tax	0.196	0.194	0.198	0.199
National insurance	0.119	0.118	0.119	0.12
Working tax credit	0.250	0.272	0.239	0.17
Child tax credit	0.1	0.078	0.111	0.178
Income support	0	0	0	0
Housing benefit	0.012	0.016	0.008	0.003
Council tax benefit	0.012	0.013	0.011	0.01
Other	0.001	0	0.001	0.002
Total	0.765	0.767	0.764	0.765

Notes: conditional on working. Decile groups calculated across all families. Authors' calculations based on simulated data.

Table 4.7. Fields decomposition for PTR

	Overall	Basic education	Intermediate education	Higher education
Family hours and earnings	0.578	0.465	0.653	0.935
Female education	-0.001	0.000	0.000	0.000
Family composition	-0.026	0.120	-0.069	-0.247
Childcare expenditure	0.036	0.022	0.048	0.077
Rent	0.058	0.063	0.046	0.027
Unexplained	0.355	0.330	0.322	0.208

Notes: Authors' calculations based on simulated data.

Table 4.8. Fields decomposition for PTR to understand the role of hours and earnings

	Overall	Basic education	Intermediate education	Higher education
Female hours and earnings	0.131	0.126	0.142	0.101
Family hours and earnings	0.400	0.336	0.461	0.588

Notes: Authors' calculations based on simulated data.

Table 4.9. Mean PTR by income component at extremes of distribution

	Bottom decile	Bottom quartile	Top quartile	Top decile
Childcare	0.000	0.020	0.075	0.076
Income tax	0.010	0.055	0.067	0.042
National insurance	0.008	0.036	0.042	0.028
Working tax credit	-0.179	-0.145	0.023	0.006
Child tax credit	0.002	0.004	0.038	0.011
Income support	0.170	0.130	0.269	0.457
Housing benefit	0.000	0.001	0.072	0.130
Council tax benefit	0.012	0.013	0.044	0.045
Other	0.009	0.006	0.004	0.002
Total	0.033	0.120	0.633	0.797

Notes: Authors' calculations based on simulated data.

Table 4.10. Distribution of METRs: by age and family types

	Childless single women						Women in childless couple			
Age	25	35	45	55		**Age**	**25**	**35**	**45**	**55**
Mean	0.369	0.358	0.366	0.381		**Mean**	0.304	0.306	0.309	0.325
p10	0.320	0.320	0.320	0.320		**p10**	0.135	0.270	0.320	0.320
p25	0.320	0.320	0.320	0.320		**p25**	0.320	0.320	0.320	0.320
p50	0.320	0.320	0.320	0.320		**p50**	0.320	0.320	0.320	0.320
p75	0.320	0.320	0.320	0.320		**p75**	0.320	0.320	0.320	0.320
p90	0.730	0.420	0.487	0.730		**p90**	0.320	0.320	0.320	0.320
	Lone mother						**Women in childless couple parent**			
Age	**25**	**35**	**45**	**55**		**Age**	**25**	**35**	**45**	**55**
Mean	0.639	0.635	0.607	0.570		**Mean**	0.439	0.422	0.386	0.336
p10	0.319	0.320	0.320	0.320		**p10**	0.320	0.320	0.320	0.320
p25	0.528	0.472	0.343	0.320		**p25**	0.320	0.320	0.320	0.320
p50	0.730	0.730	0.730	0.730		**p50**	0.320	0.320	0.320	0.320
p75	0.786	0.784	0.730	0.730		**p75**	0.552	0.529	0.456	0.320
p90	0.852	0.824	0.809	0.730		**p90**	0.730	0.709	0.635	0.420

Notes: Authors' calculations based on simulated data.

Table 4.11. Distribution of PTRs: by age and family types

	Childless single women						Women in childless couple			
Age	**25**	**35**	**45**	**55**		**Age**	**25**	**35**	**45**	**55**
Mean	0.477	0.468	0.474	0.466		**Mean**	0.264	0.254	0.249	0.248
p10	0.383	0.377	0.375	0.376		**p10**	0.013	0.013	0.005	0.082
p25	0.402	0.392	0.391	0.392		**p25**	0.182	0.183	0.161	0.171
p50	0.430	0.420	0.419	0.423		**p50**	0.231	0.234	0.228	0.226
p75	0.465	0.461	0.464	0.469		**p75**	0.320	0.297	0.301	0.288
p90	0.670	0.665	0.703	0.681		**p90**	0.507	0.485	0.482	0.462
	Lone mother						**Women in childless couple parent**			
Age	**25**	**35**	**45**	**55**		**Age**	**25**	**35**	**45**	**55**
Mean	0.261	0.317	0.375	0.400		**Mean**	0.490	0.411	0.342	0.306
p10	0.056	0.076	0.101	0.117		**p10**	0.154	0.065	0.038	0.023
p25	0.136	0.159	0.217	0.280		**p25**	0.346	0.251	0.208	0.200
p50	0.224	0.319	0.436	0.455		**p50**	0.485	0.410	0.327	0.271
p75	0.389	0.473	0.511	0.513		**p75**	0.600	0.544	0.464	0.426
p90	0.506	0.538	0.575	0.569		**p90**	0.747	0.663	0.602	0.559

Notes: Authors' calculations based on simulated data.

Table 4.12. Decomposition of variance into between and within components

	METR (conditional on working)	PTR
Overall	0.026	0.047
Between	0.011	0.015
Within	0.018	0.031

Notes: components do not sum due to small sample correction, differing group sizes (because high education individuals enter the labour market later) and rounding. Authors' calculations based on simulated data.

Table 4.13. Transition matrix for PTR bands for different horizons (individuals aged 25-29 in base year)

	1 year forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.78	0.14	0.06	0.02	0.01	0.179
0.2-0.4	0.07	0.78	0.13	0.01	0.00	0.317
0.4-0.6	0.04	0.12	0.81	0.04	0.01	0.387
0.6-0.8	0.04	0.04	0.18	0.69	0.05	0.073
>0.8	0.07	0.03	0.05	0.09	0.75	0.044

	5 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.52	0.22	0.18	0.05	0.03	0.179
0.2-0.4	0.12	0.55	0.27	0.05	0.01	0.317
0.4-0.6	0.10	0.26	0.55	0.06	0.02	0.387
0.6-0.8	0.09	0.14	0.33	0.38	0.07	0.073
>0.8	0.19	0.10	0.15	0.14	0.42	0.044

	10 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.44	0.25	0.23	0.05	0.03	0.179
0.2-0.4	0.14	0.48	0.31	0.06	0.01	0.317
0.4-0.6	0.14	0.31	0.46	0.07	0.02	0.387
0.6-0.8	0.14	0.20	0.34	0.27	0.06	0.073
>0.8	0.22	0.13	0.22	0.14	0.29	0.044

	20 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.38	0.31	0.25	0.04	0.02	0.179
0.2-0.4	0.17	0.48	0.29	0.05	0.01	0.317
0.4-0.6	0.20	0.39	0.34	0.05	0.01	0.387
0.6-0.8	0.20	0.31	0.28	0.18	0.04	0.073
>0.8	0.28	0.19	0.22	0.13	0.17	0.044

Notes: Authors' calculations based on simulated data.

Table 4.14. Transition matrix for METR bands for different horizons (individuals aged 25-29 in base year and employed in both years)

	1 year forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.785	0.167	0.024	0.023	0.000	0.037
0.2-0.4	0.011	0.930	0.032	0.023	0.004	0.735
0.4-0.6	0.012	0.135	0.721	0.101	0.032	0.097
0.6-0.8	0.015	0.188	0.093	0.656	0.048	0.101
>0.8	0.001	0.032	0.085	0.192	0.690	0.030

	5 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.456	0.383	0.035	0.125	0.000	0.026
0.2-0.4	0.021	0.801	0.108	0.056	0.014	0.738
0.4-0.6	0.013	0.244	0.539	0.151	0.054	0.101
0.6-0.8	0.046	0.400	0.127	0.370	0.057	0.104
>0.8	0.004	0.149	0.235	0.338	0.275	0.032

	10 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.278	0.461	0.087	0.171	0.004	0.025
0.2-0.4	0.022	0.700	0.168	0.088	0.022	0.733
0.4-0.6	0.012	0.348	0.427	0.164	0.049	0.104
0.6-0.8	0.043	0.478	0.133	0.289	0.056	0.106
>0.8	0.006	0.292	0.222	0.306	0.174	0.033

	20 years forward					
	≤0.2	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.155	0.644	0.072	0.123	0.006	0.035
0.2-0.4	0.025	0.729	0.128	0.102	0.016	0.725
0.4-0.6	0.015	0.668	0.183	0.116	0.019	0.102
0.6-0.8	0.037	0.684	0.069	0.184	0.026	0.106
>0.8	0.011	0.632	0.105	0.207	0.045	0.033

Notes: Conditional on working in both years under sconsideration. Authors' calculations based on simulated data.

Table 4.15. 5-year transition matrix for PTR bands at different ages

Age 25-29	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.52	0.22	0.18	0.05	0.03	0.179
0.2-0.4	0.12	0.55	0.27	0.05	0.01	0.317
0.4-0.6	0.10	0.26	0.55	0.06	0.02	0.387
0.6-0.8	0.09	0.14	0.33	0.38	0.07	0.073
>0.8	0.19	0.10	0.15	0.14	0.42	0.044

Age 35-39	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.61	0.22	0.11	0.03	0.03	0.198
0.2-0.4	0.14	0.61	0.20	0.04	0.01	0.336
0.4-0.6	0.08	0.27	0.57	0.07	0.01	0.350
0.6-0.8	0.09	0.17	0.36	0.33	0.05	0.083
>0.8	0.21	0.11	0.20	0.13	0.35	0.034

Age 45-49	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.65	0.21	0.10	0.02	0.02	0.226
0.2-0.4	0.13	0.68	0.16	0.02	0.01	0.392
0.4-0.6	0.06	0.30	0.60	0.04	0.01	0.299
0.6-0.8	0.09	0.18	0.30	0.40	0.03	0.060
>0.8	0.18	0.10	0.12	0.24	0.35	0.024

Notes: Authors' calculations based on simulated data.

Table 4.16. 5-year transition matrix for METR bands at different ages (for individuals employed in both years)

Age 25-29	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.456	0.383	0.035	0.125	0.000	0.026
0.2-0.4	0.021	0.801	0.108	0.056	0.014	0.738
0.4-0.6	0.013	0.244	0.539	0.151	0.054	0.101
0.6-0.8	0.046	0.400	0.127	0.370	0.057	0.104
>0.8	0.004	0.149	0.235	0.338	0.275	0.032

Age 35-39	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.426	0.495	0.016	0.063	0.000	0.033
0.2-0.4	0.024	0.848	0.072	0.049	0.008	0.602
0.4-0.6	0.016	0.328	0.503	0.120	0.034	0.188
0.6-0.8	0.021	0.462	0.104	0.380	0.034	0.140
>0.8	0.007	0.278	0.177	0.355	0.184	0.037

Age 45-49	**≤0.2**	**0.2-0.4**	**0.4-0.6**	**0.6-0.8**	**>0.8**	**Share**
≤0.2	0.366	0.547	0.024	0.060	0.002	0.041
0.2-0.4	0.016	0.895	0.047	0.041	0.002	0.707
0.4-0.6	0.022	0.584	0.313	0.074	0.007	0.114
0.6-0.8	0.013	0.568	0.048	0.361	0.010	0.120
>0.8	0.017	0.362	0.052	0.447	0.122	0.019

Notes: Conditional on working in both years under sconsideration. Authors' calculations based on simulated data.

Table 4.17. Five-year transition matrices for family types at different ages

Start of working life	Si0Kd	Co0Kd	Si1Kd	Co1Kd
Si0Kd	0.54	0.26	0.09	0.11
Co0Kd	0.15	0.50	0.07	0.29
Si1Kd	0.00	0.00	0.64	0.36
Co1Kd	0.00	0.00	0.31	0.69

Age 25	Si0Kd	Co0Kd	Si1Kd	Co1Kd
Si0Kd	0.59	0.24	0.05	0.11
Co0Kd	0.10	0.40	0.05	0.45
Si1Kd	0.00	0.00	0.64	0.36
Co1Kd	0.00	0.00	0.19	0.82

Age 35	1	2	3	4
Si0Kd	0.71	0.20	0.04	0.05
Co0Kd	0.06	0.52	0.02	0.40
Si1Kd	0.07	0.03	0.66	0.24
Co1Kd	0.00	0.03	0.07	0.90

Age 45	Si0Kd	Co0Kd	Si1Kd	Co1Kd
Si0Kd	0.92	0.08	0.00	0.00
Co0Kd	0.07	0.93	0.00	0.00
Si1Kd	0.33	0.02	0.60	0.05
Co1Kd	0.02	0.26	0.04	0.67

Notes: The family types are as follows: Si0Kd = childless singles, Co0Kd = childless couples, Si1Kd = lone parents and Cou1Kd = couple parents. Authors' calculations based on simulated data.

Table 5.1. Fields decomposition for forward-looking PTR

	Overall	Basic education	Intermediate education	Higher education
Family employment decisions	0.435	0.382	0.466	0.559
Female education	-0.001	0.000	0.000	0.000
Family composition	-0.043	0.055	-0.067	-0.130
Childcare expenditure	0.026	0.018	0.034	0.045
Rent	0.036	0.041	0.027	0.013
Unexplained	0.546	0.505	0.540	0.512

Notes: Authors' calculations based on simulated data.

Table 5.2. Fields decomposition for forward-looking PTR to understand the role of hours and earnings

	Overall	Basic education	Intermediate education	Higher education
Female hours and earnings	0.077	0.078	0.074	0.026
Family hours and earnings	0.294	0.264	0.323	0.362

Notes: Authors' calculations based on simulated data.

Table 5.3. Fields decomposition for difference between forward-looking PTR and PTR

	Overall	Basic education	Intermediate education	Higher education
Family hours and earnings	0.053	0.031	0.066	0.109
Female education	0.000	0.000	0.000	0.000
Family composition	0.019	0.028	0.020	-0.016
Childcare expenditure	0.001	0.000	0.001	0.004
Rent	0.007	0.008	0.008	0.004
Unexplained	0.920	0.933	0.904	0.899

Notes: Authors' calculations based on simulated data.

Table 5.4. Fields decomposition for difference between forward-looking PTR and PTR to understand the role of hours and earnings

	Overall	Basic education	Intermediate education	Higher education
Female hours and earnings	0.045	0.036	0.053	0.062
Family hours and earnings	0.054	0.041	0.064	0.081

Notes: Authors' calculations based on simulated data.

Table 5.5. Fields decomposition for standard deviation of forward-looking PTR

	Overall	Basic education	Intermediate education	Higher education
Family hours and earnings	0.139	0.114	0.152	0.183
Female education	0.001	0.000	0.000	0.000
Family composition	0.028	0.021	0.032	0.040
Childcare expenditure	-0.004	-0.001	-0.005	-0.010
Rent	0.000	0.001	0.000	0.001
Unexplained	0.836	0.866	0.822	0.785

Notes: Excludes standard deviations greater than 2. Authors' calculations based on simulated data.

Table 5.6. Fields decomposition for standard deviation of forward-looking PTR to understand the role of hours and earnings

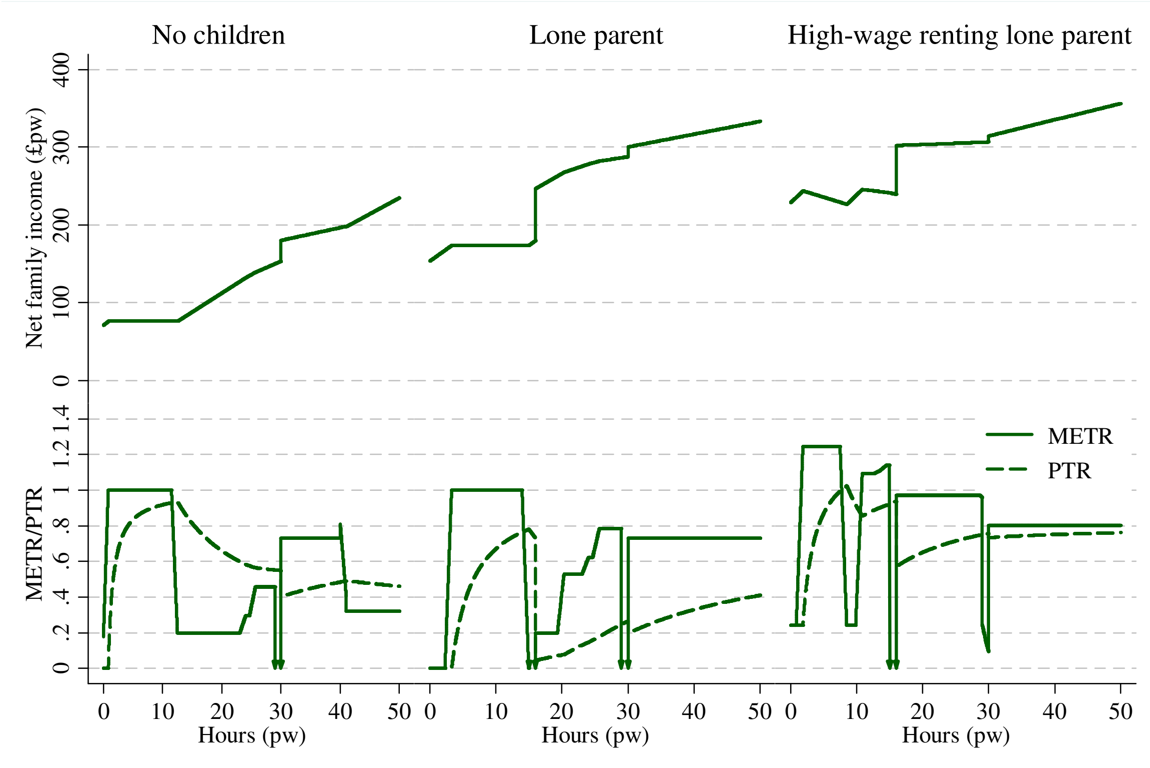
	Overall	Basic	Intermediate	Higher

		education	education	education
Female hours and earnings	0.108	0.064	0.092	0.110
Family hours and earnings	0.168	0.147	0.178	0.205

Notes: Excludes standard deviations greater than 2. Authors' calculations based on simulated data.

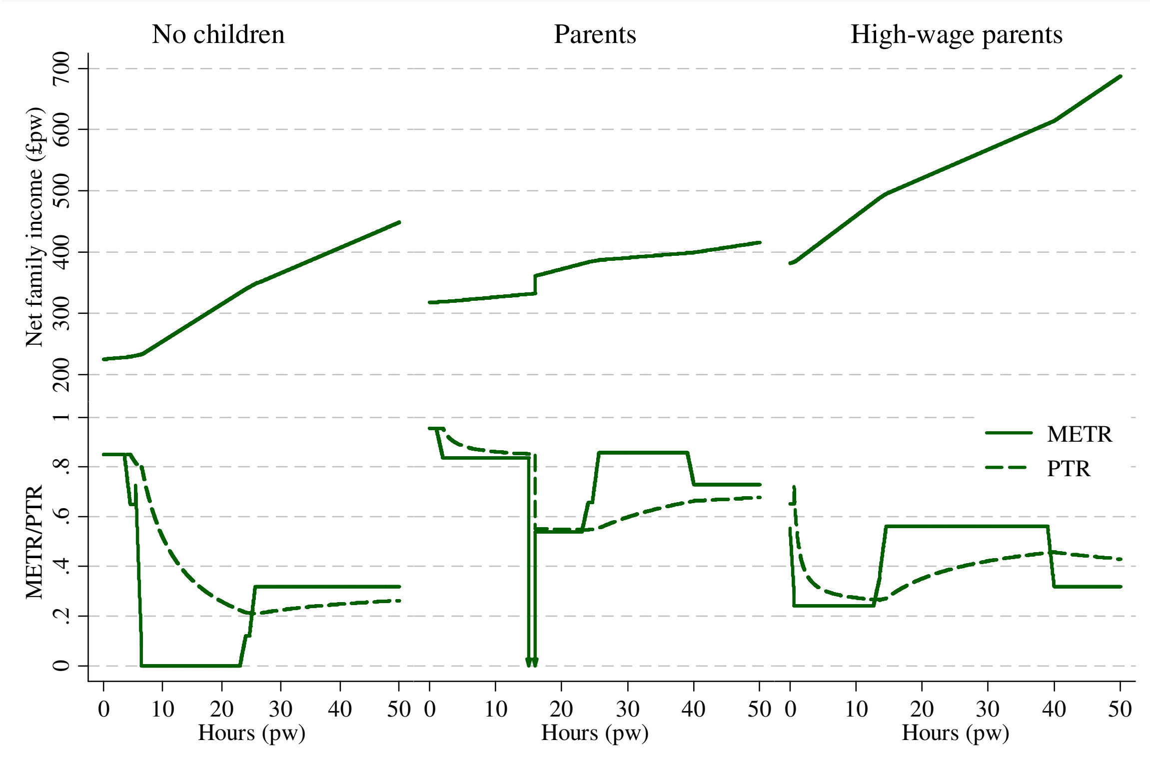
Figures

Figure 3.1. Example budget constraints and work incentive measures for single individuals



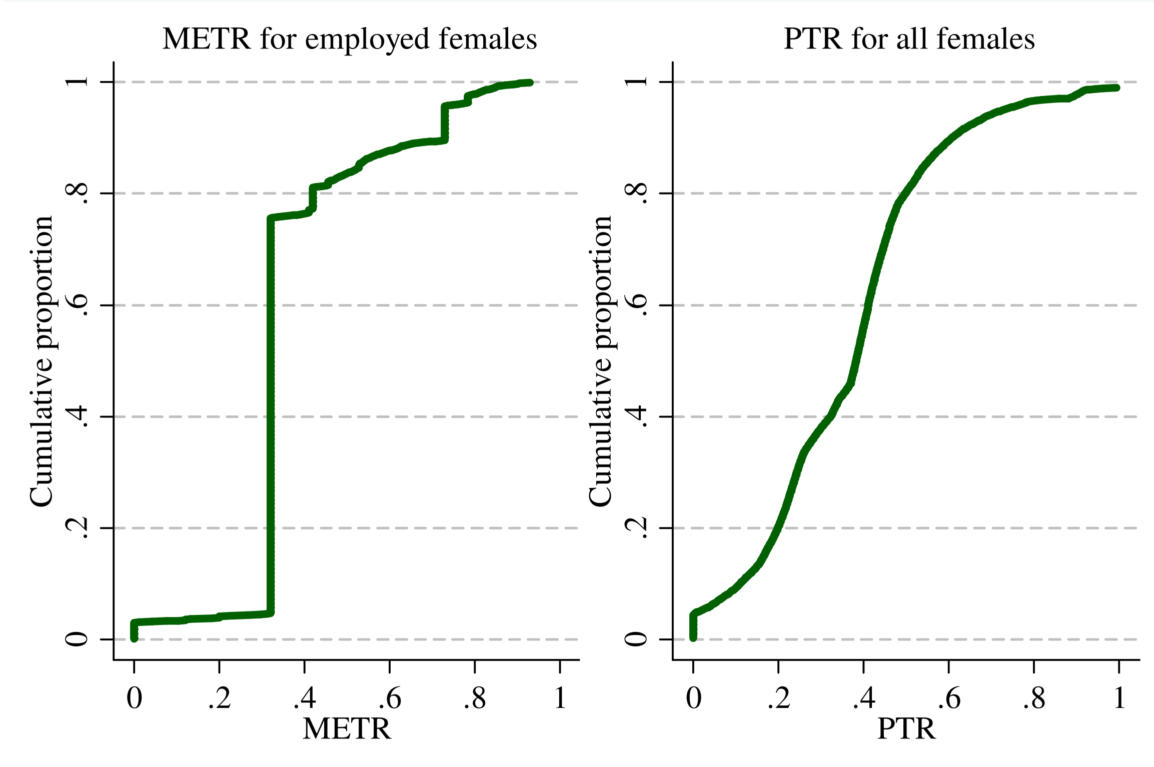
Notes: The "No children" panel assumes the April 2012 minimum wage (£6.08ph) and no rent. The "Lone parent" panel adds a child aged four and assumes nothing is spent on childcare. The "High-wage renting lone parent" panel assumes a wage at the 75th percentile of female wages (£10.70ph), rent of £75pw, and positive childcare costs (£2.60ph for every hour worked). Arrows at zero on the METR series indicate that the METR goes negative at this point. Authors' calculations.

Figure 3.2. Example budget constraints and work incentive measures for couple individuals



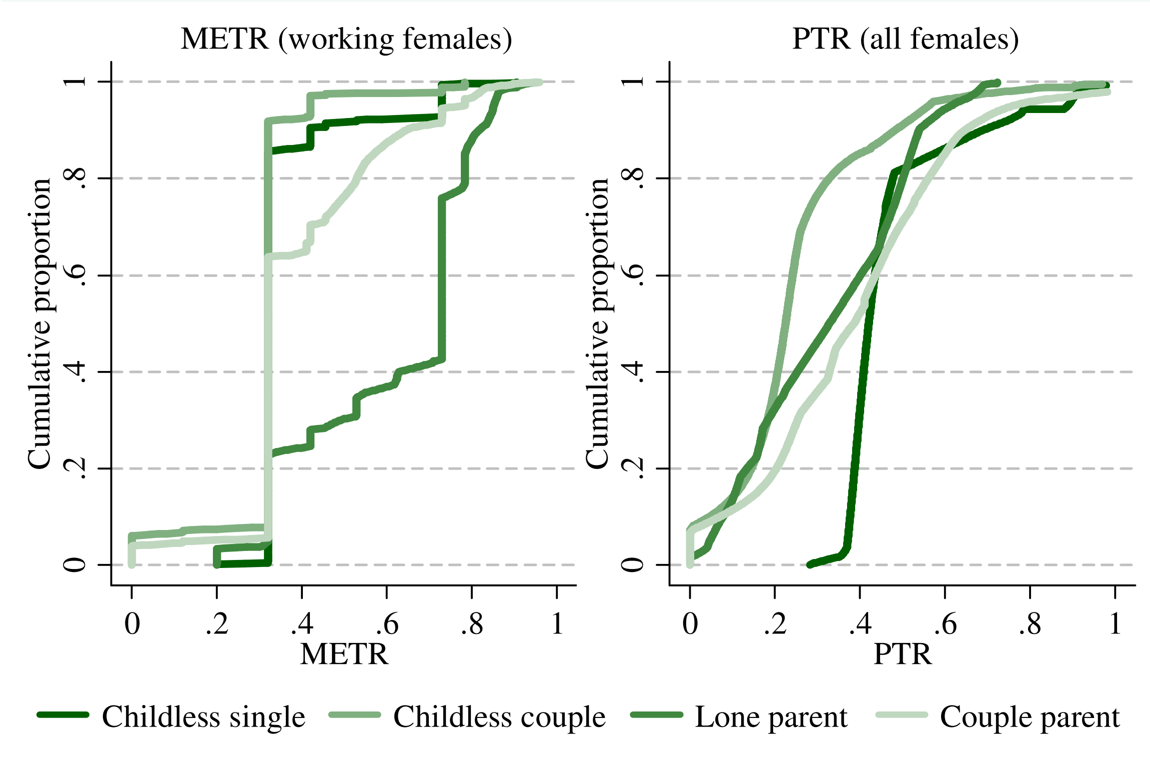
Notes: The "No children" panel assumes both individuals earn the April 2012 minimum wage (£6.08ph). The partner works 40 hours per week and the family pays rent of £75pw. The "Parents" panel adds a child aged four and positive childcare costs (£2.60ph for every hour worked), but assumes no rent. The "High-wage parents" panel both members of the couple earn a wage equal to the 75th percentile of the appropriate gender-specific age wage distribution (£10.70ph and £12.14ph for females and males respectively). The family faces childcare costs (£2.60ph for every hour worked) but no rent. Arrows at zero on the METR series indicate that the METR goes negative at this point. Authors' calculations.

Figure 4.1. Cross-sectional distributions of static the METR and PTR



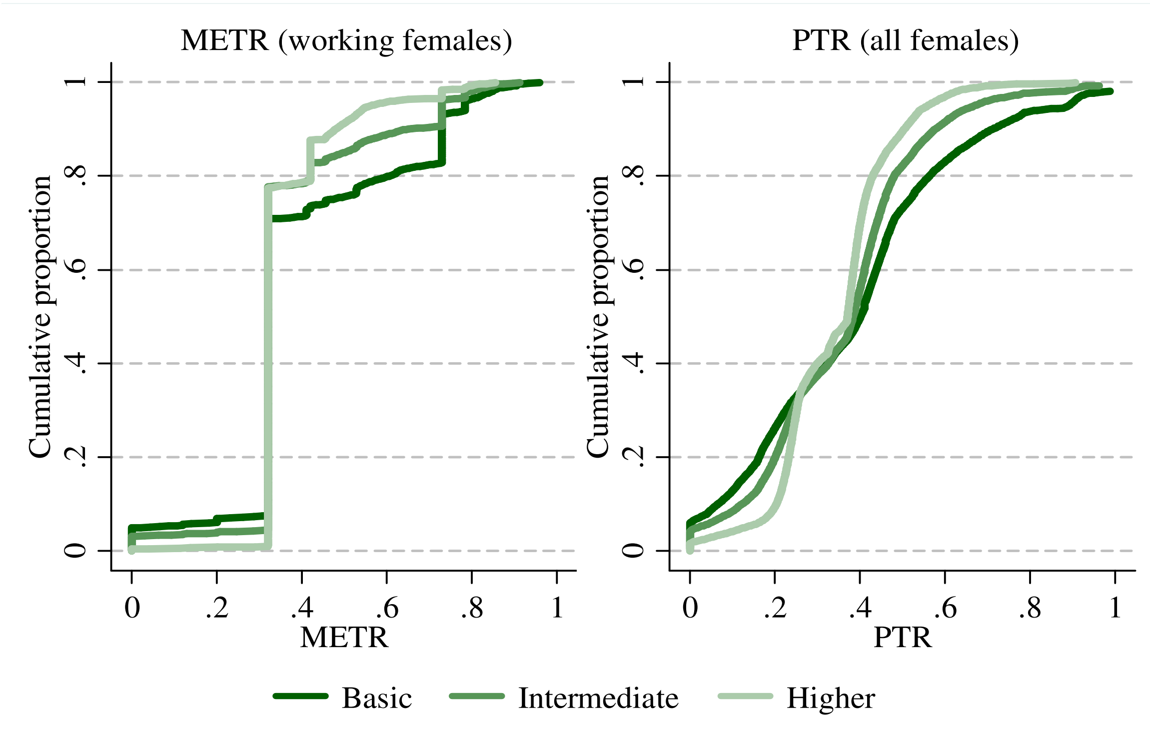
Notes: Authors' calculations based on simulated data.

Figure 4.2. Cross-sectional distributions of static the METR and PTR: by family type



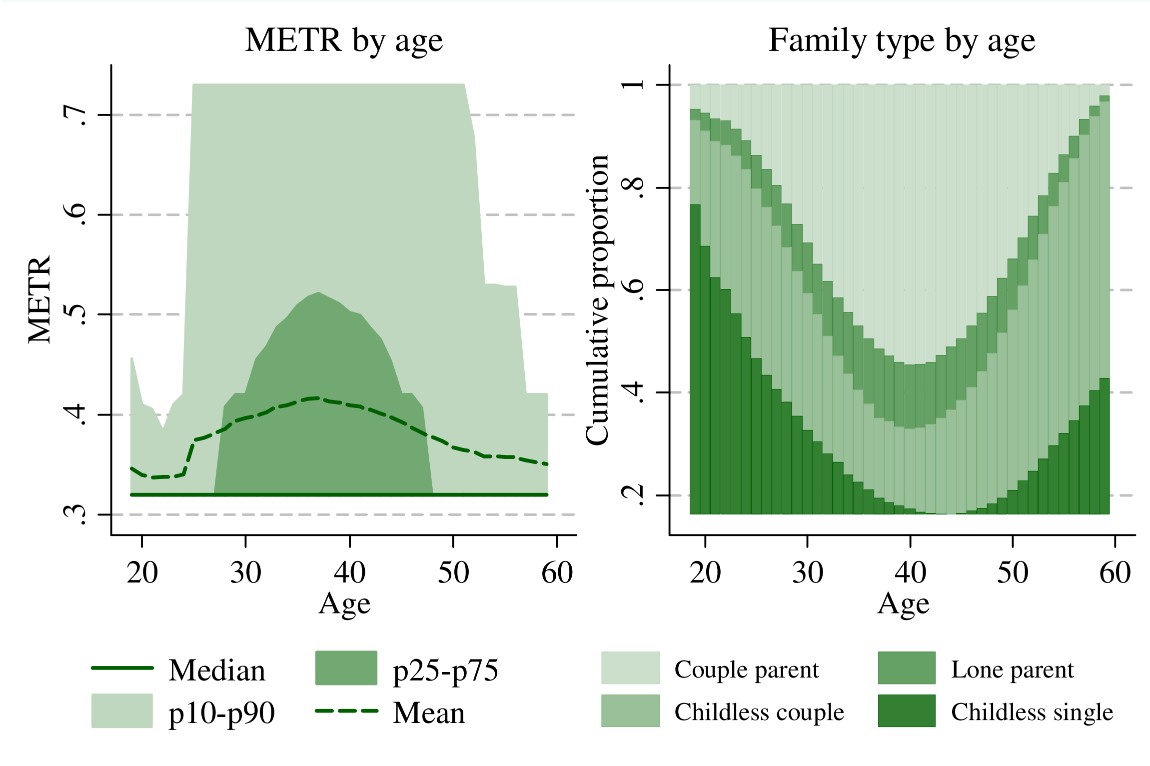
Notes: Authors' calculations based on simulated data.

Figure 4.3. Cross-sectional distributions of static the METR and PTR: by education



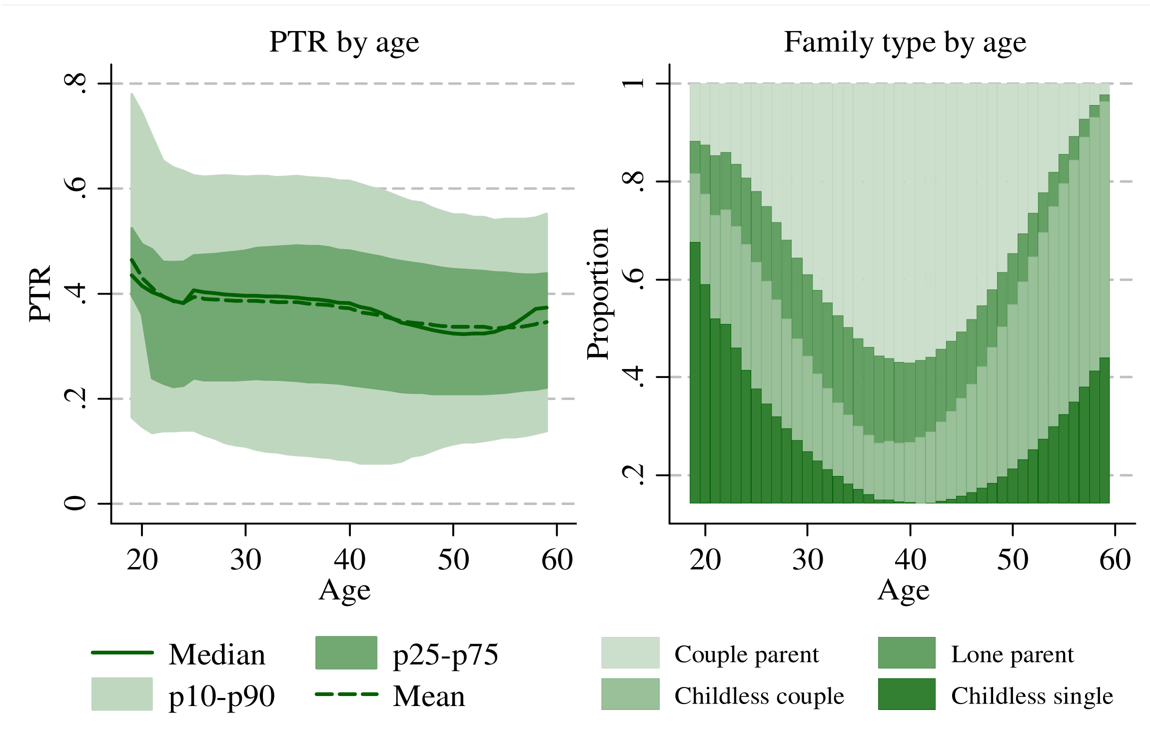
Notes: Authors' calculations based on simulated data.

Figure 4.4. Distribution of METRs and family types for working women across the lifecycle



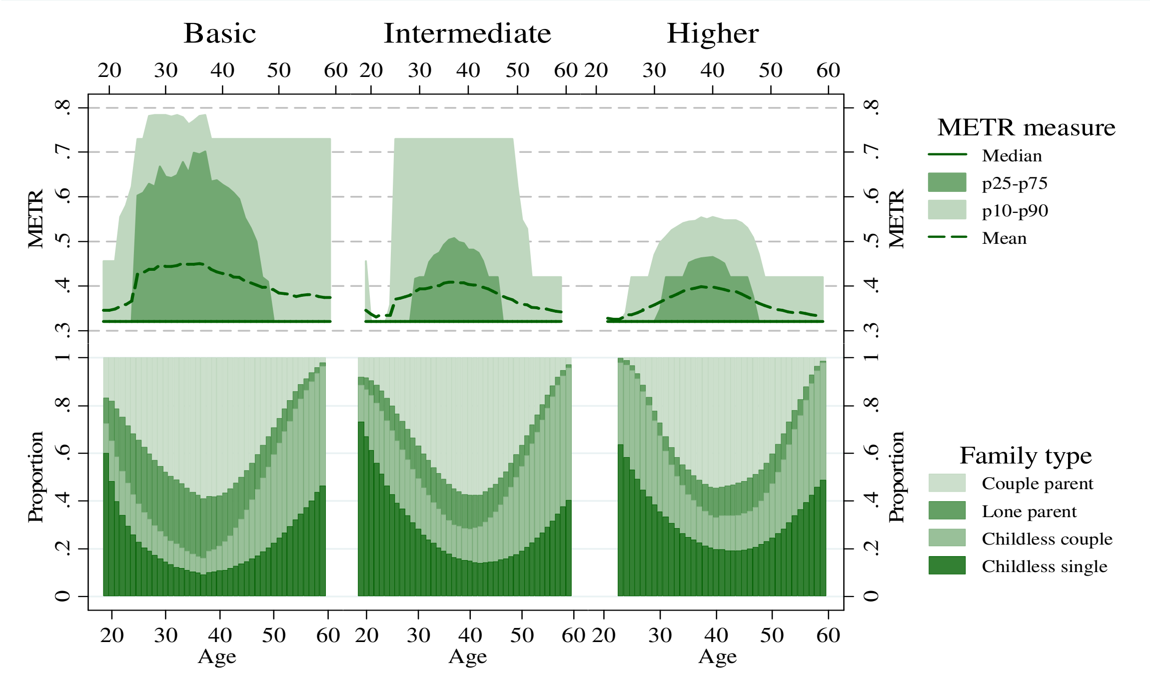
Notes: Authors' calculations based on simulated data.

Figure 4.5. Distribution of PTRs and family types for all women across the lifecycle



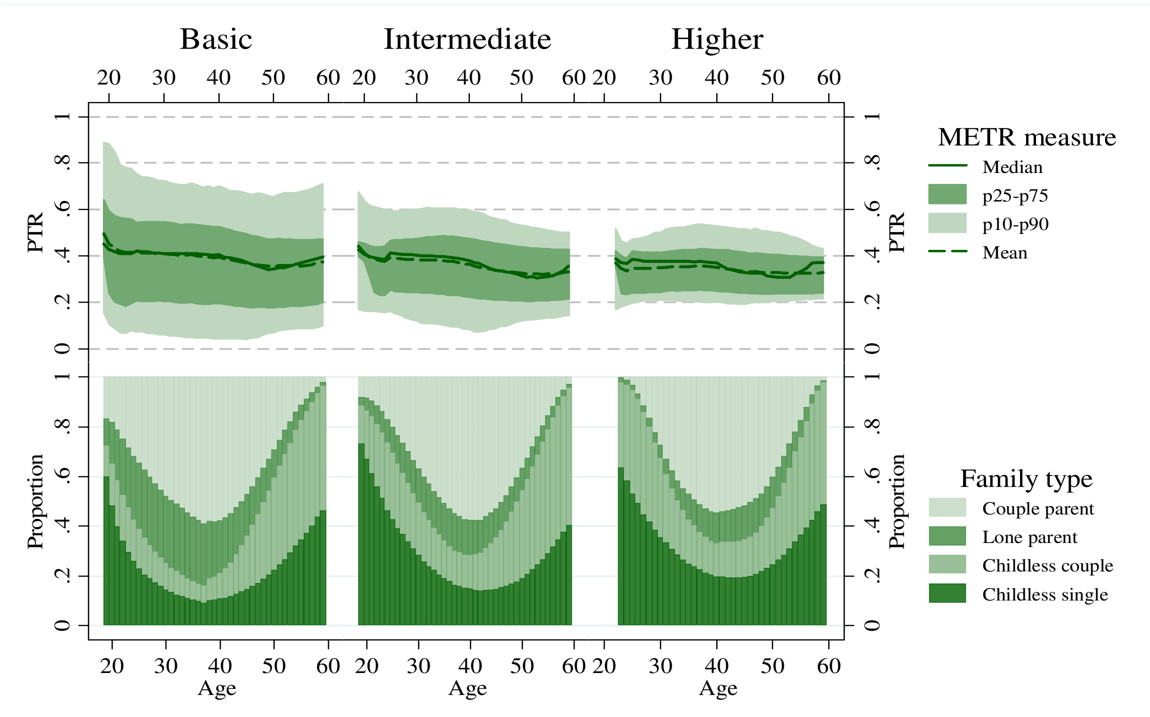
Notes: Authors' calculations based on simulated data.

Figure 4.6. Distribution of METRs and family types for working women across the lifecycle: by education



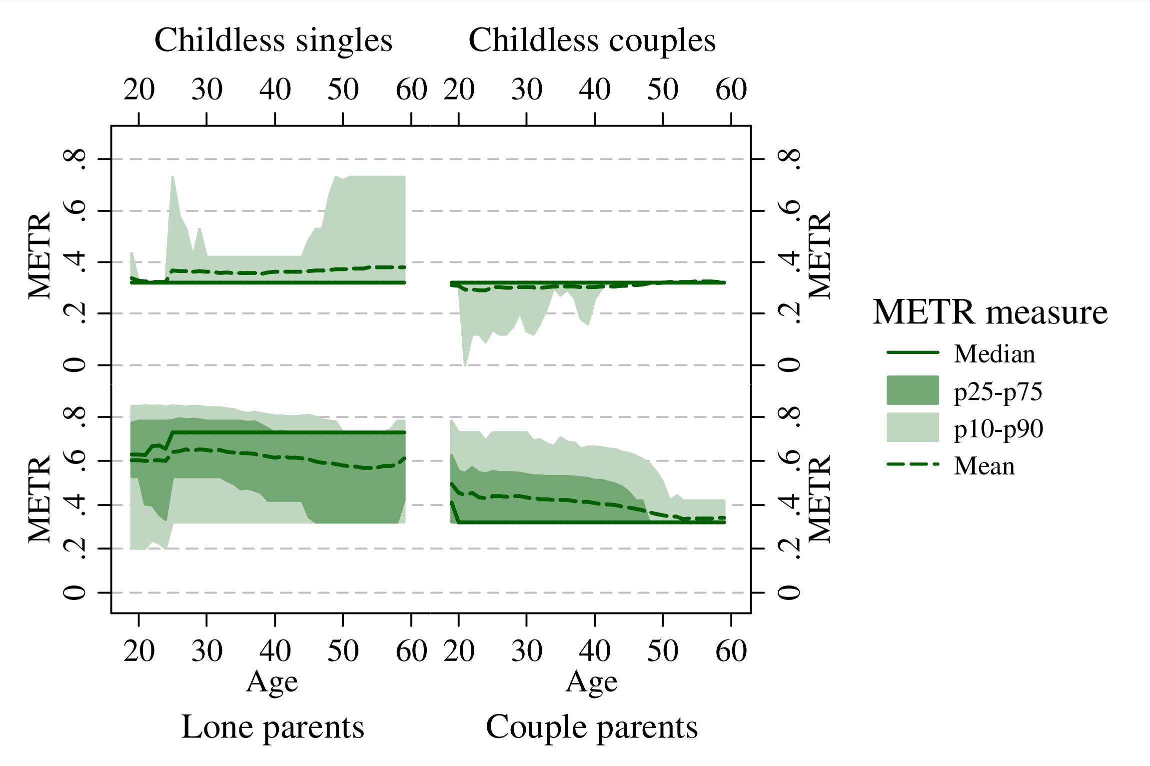
Notes: Authors' calculations based on simulated data.

Figure 4.7. Distribution of PTRs and family types for all women across the lifecycle: by education



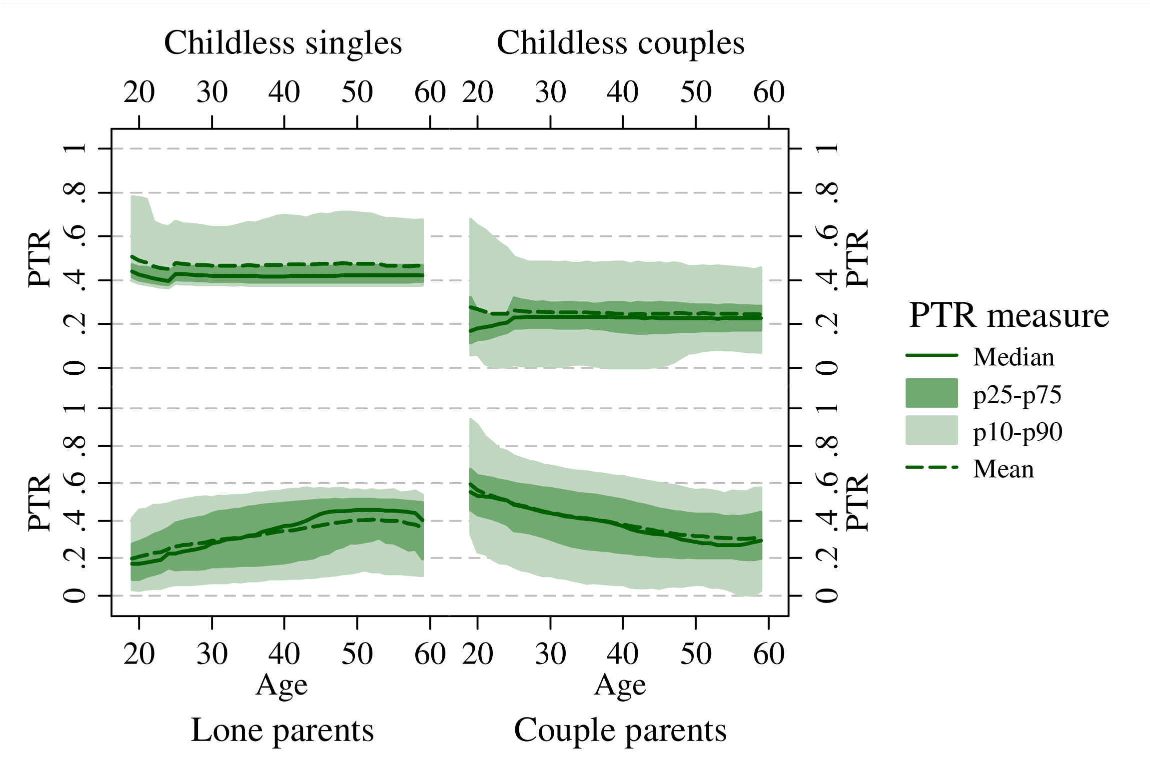
Notes: Authors' calculations based on simulated data.

Figure 4.8. Distribution of METRs for working women across the lifecycle: by family type



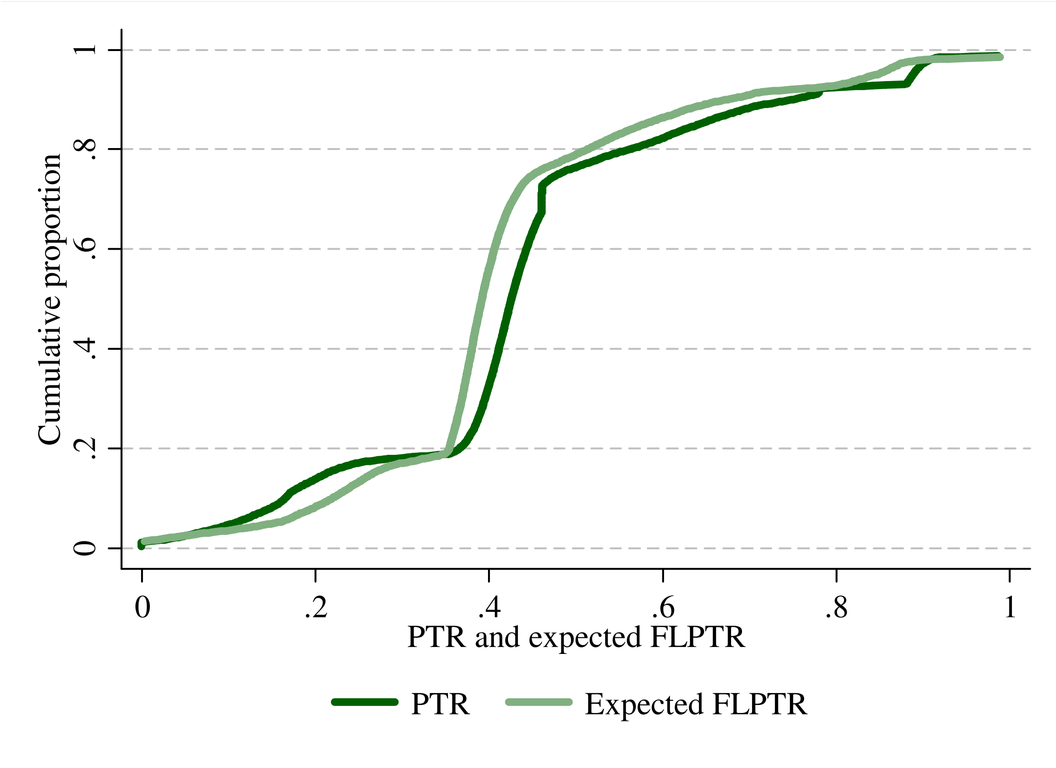
Notes: Size and composition of each group changes with age. Authors' calculations based on simulated data.

Figure 4.9. Distribution of PTRs for all women across the lifecycle: by family type



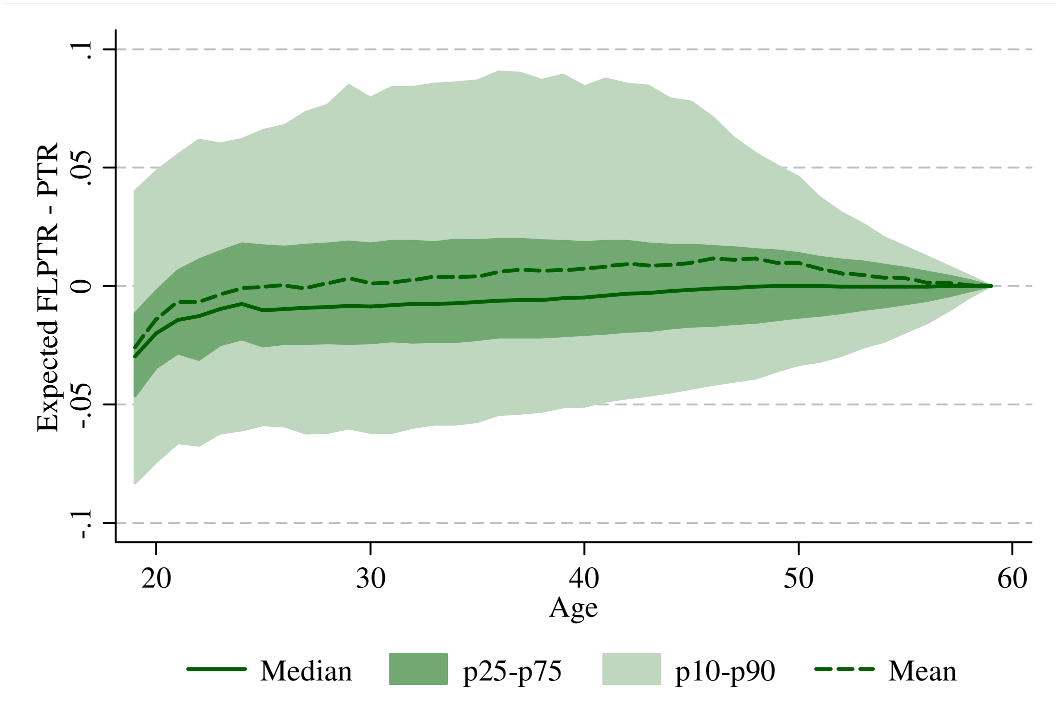
Notes: Size and composition of each group changes with age. Authors' calculations based on simulated data.

Figure 5.1. PTR and forward-looking PTR at start of working life



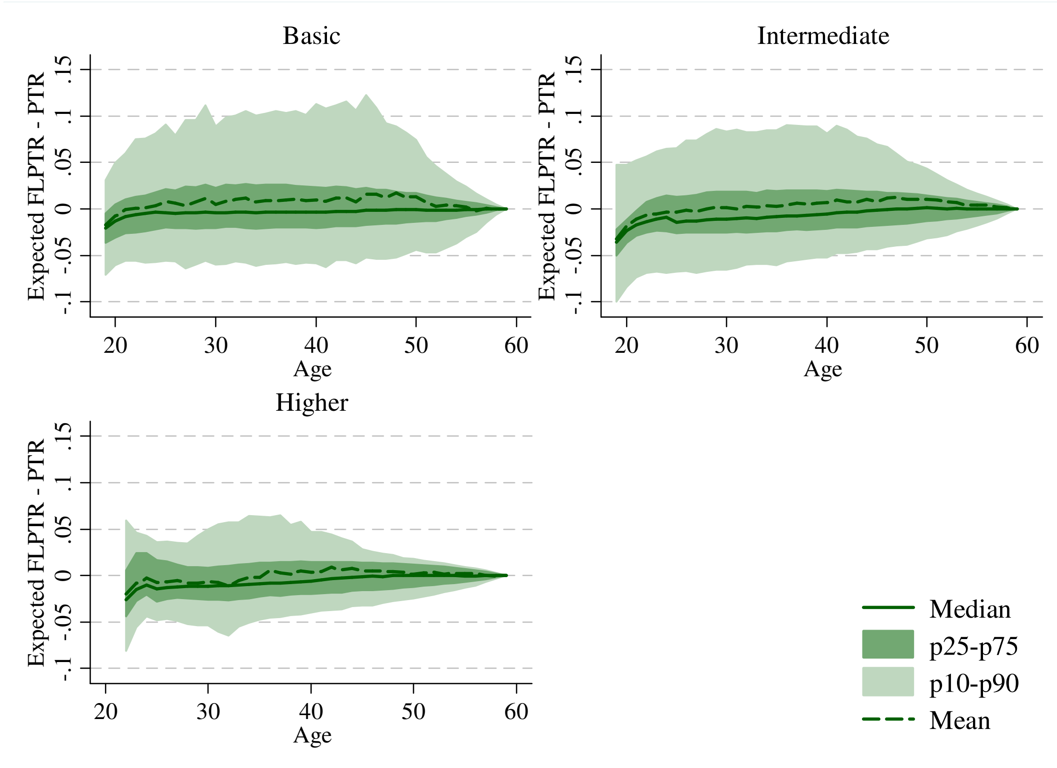
Notes: Authors' calculations based on simulated data.

Figure 5.2. Distribution of difference between expected FLPTR and PTR, by age



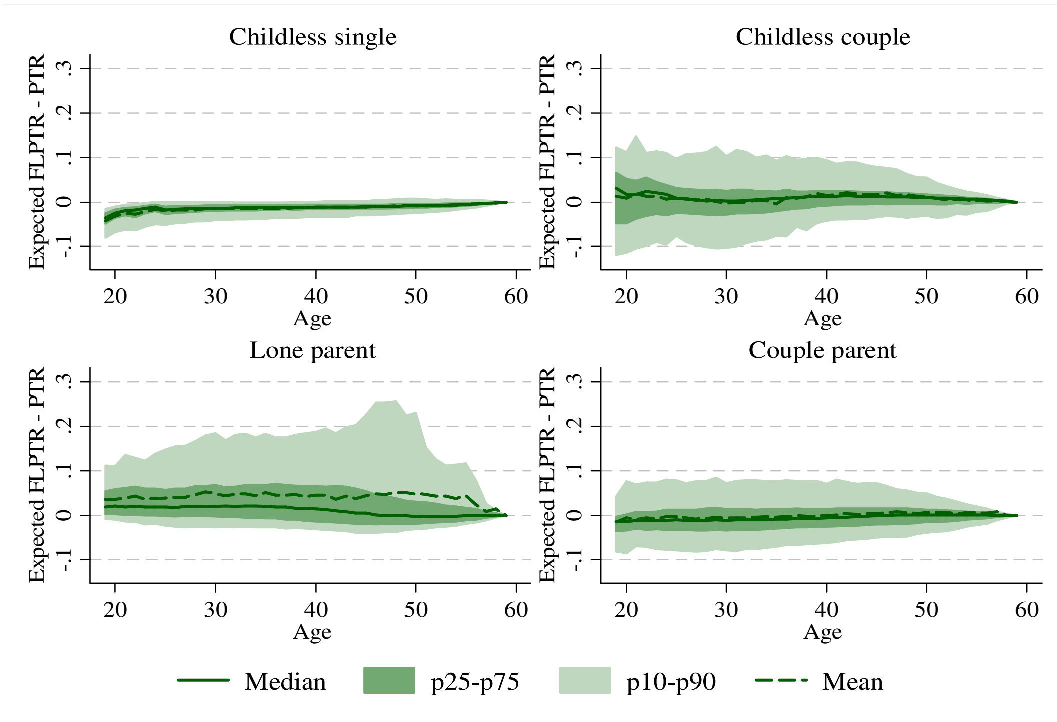
Notes: Mean excludes values outside [-2,2]. Authors' calculations based on simulated data.

Figure 5.3. Distribution of difference between expected FLPTR and PTR, by age and education



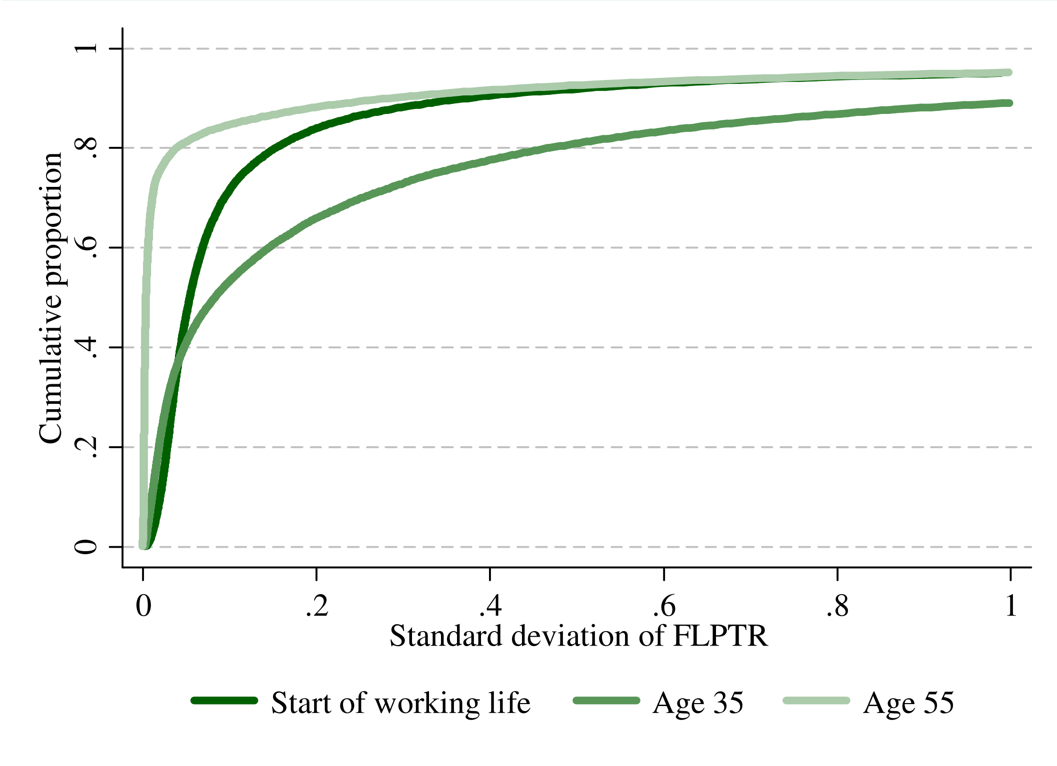
Notes: Mean excludes values outside [-2,2]. Authors' calculations based on simulated data.

Figure 5.4. Distribution of difference between expected FLPTR and PTR, by age and family type



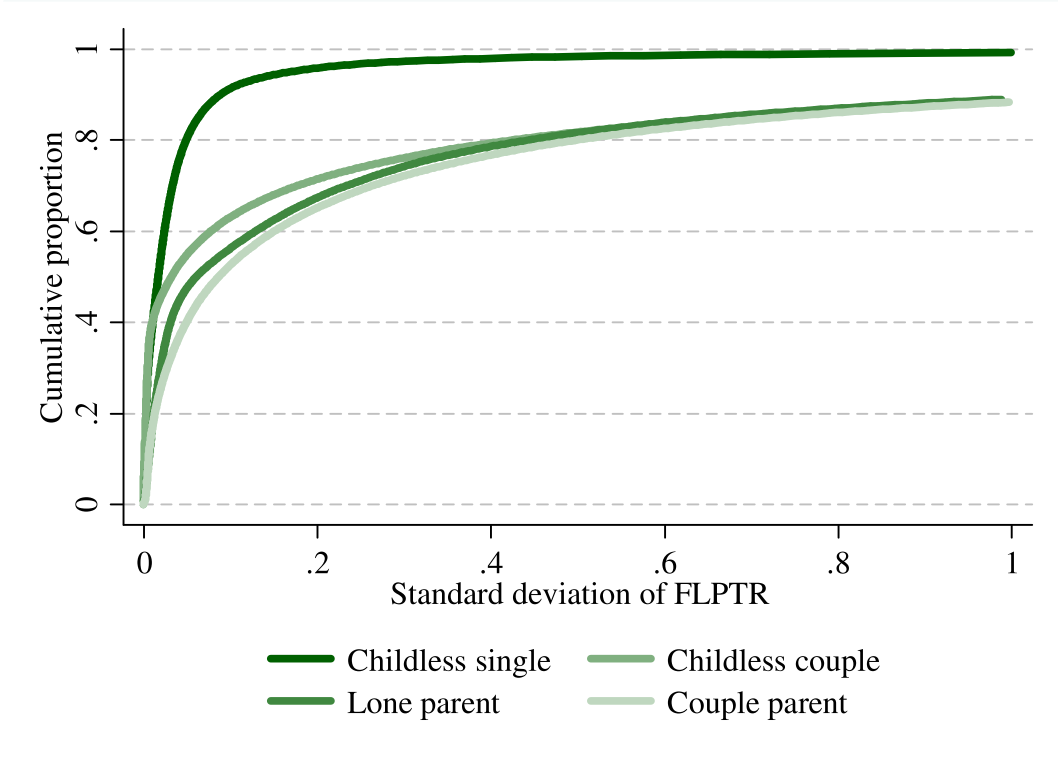
Notes: Mean excludes values outside [-2,2]. Authors' calculations based on simulated data.

Figure 5.5. Distribution of standard deviation of FLPTR for different age groups



Notes: Authors' calculations based on simulated data.

Figure 5.6. Distribution of standard deviation of FLPTR by family type



Notes: Authors’ calculations based on simulated data.

Appendix A: more details of the UK tax and welfare benefit system

Personal taxation

There are two main personal taxes on earnings: income tax and National Insurance. Income tax operates through a system of tax-free allowances and income bands that are subject to different rates of tax. In 2012-13, the standard tax-free allowance is £8,105 per year and there are there are three main bands: a basic rate of 20% on taxable earnings (i.e. earnings less the tax-free allowance) up to £34,370, a higher rate of 40% on taxable earnings up to £150,000 and an additional rate of 50% on taxable earnings above £150,000.[22] National Insurance (NI) is a payroll tax that works in a similar way to income tax except that there are both employee and employer contributions (we ignore the latter).[23] Nominally, payment of NI contributions entitles individuals to certain "contributory" benefits (none of which we model here), although in practice the link between contributions and benefits is very weak as all benefits are flat-rate. Allowances and bands in NI are broadly similar, except that there is no equivalent of the additional rate band. The tax-free allowance is £146 per week; the next £671 per week is subject to a 12% tax rate, and any earnings above that attract a 2% rate.

Since most employed individuals earn enough to put their final pound in the basic rate band for income tax, the most common combined METR due to taxes will be 32% (20% + 12%). Higher rate taxpayers typically face an METR due to taxes of 42% (40% + 2%).

Aside from income tax and National Insurance, the other main personal tax is council tax, a tax on residential dwellings that is set by local government. The amount due for a given house depends on the valuation band, A-H, into which it falls. In 2012-13, the average band D rate in England is £1,444 for the year.[24] Other bands are fixed multiples of the band D rate. A 25 per cent reduction exists for single-adult households. Unlike income tax and National Insurance , council tax liability does not depend on earnings, and so by itself does not affect the METR or PTR. However, the welfare benefit which exists to rebate CT liabilities (and currently known as Council Tax Benefit) is income-related, and so does affect work incentives.

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[22] Individuals with taxable earnings above £100,000 have their personal allowance gradually withdrawn, creating a range of taxable earnings (£100,000 to £116,210) where the marginal tax rate is effectively 60%.

[23] Other differences to income tax are that National Insurance is weekly rather than annual and is only levied on employment earnings and self-employment profits and not on income in the form of interest, dividends and pensions. None of these affect our modelling setup.

[24] Source: www.communities.gov.uk/documents/statistics/pdf/2110513.pdf.

Most of the key benefits in the UK are means-tested, meaning they are tapered away from better-off families. Of the ones that are not, the only one that we model is child benefit (and that will become means-tested from January 2013);

The main welfare benefits are: income support/jobseeker's allowance, housing benefit, council tax benefit, child tax credit, working tax credit, maternity grant, free school meals and child benefit. These can be thought of as forming two groups: first, income support/jobseeker's allowance and working tax credit, which are mutually-exclusive means-tested benefits designed to support (respectively) low-income families who are not in work and who are in work; second, all of the others, which are designed to compensate families for particular needs, and are (mostly) means-tested against income in some way. These means-tested benefits (but not the means-tested tax credits) also have maximum limits on the financial savings that recipients can have, and rules which impute an income from savings that is included in the means-test, but we do not reflect this in our simulations.

There are many additional welfare benefits that we do not model. Most of these are not means-tested, and are conditional on being sick or disabled, or being a full-time carer for a disabled person.

Income support (IS) and **income-based jobseeker's allowance** (JSA) are means-tested benefits that top net family income up to a specified level based on family needs. They are designed to support families who are not in paid employment and so neither benefit can be claimed by those in full-time work (16 or more hours for the claimant, 24 or more for their partner). IS and income-based JSA are basically the same benefit; the key distinction is that that IS does not have a job search requirement but is only open to specific groups (mainly lone mothers with young children), while income-based JSA can be claimed by anyone but includes a job search requirement (which we do not model). From now on, we will use IS to refer to both IS and income-based JSA.[25] The level that IS tops net family income up to depends on family circumstances: the number and age of adults in the family and whether it is a lone parent family. In 2012-13, this level is £71 per week for most single individuals and £111.45 per week for most couples.

[25] There is another type of JSA: contribution-based JSA. This is claimed by individuals rather than families and is available to those who meet certain National Insurance contribution conditions. It is a bit more generous than income-based JSA but can only be claimed for a maximum of six months, hence our reason for not modelling it (our model is annual).

Working tax credit (WTC) provides means-tested support for low-income working families with and without children. To be eligible, an hours-of-work condition must be satisfied. In families with children, at least one adult must work 16 hours or more a week and couples with children must also together work a total of 24 hours or more a week. In families without children, at least one adult must work 30 or more hours a week and be aged 25 or over. Maximum WTC comprises up to four elements: a basic element (£1,920 per year), an element for lone parents and couples (£1,950), a 30-hour element (£790). In addition, families with children can claim a childcare element, which is potentially very generous (covering 70% of formal childcare costs up to a limit of £175 per week for one child, £300 for two or more children). To be eligible for the childcare element, all adults in the family must work at least 16 hours. Income Support and Working Tax Credit can be thought of as complimentary programmes. They are mutually exclusive (in that individuals in families where someone works 16 or more hours cannot receive IS, and individuals in families where no one works 16 or more hours cannot receive WTC), but they are not exhaustive: individuals in families without children where no one is aged 25 or over and someone works 16 or more hours, individuals in families without children where someone works 16 or more hours but no one 30 or more hours, and individuals in couples with children where someone works 16 or more hours but no one 24 or more hours all can receive neither IS nor WTC. It is also the case that the relative generosity of WTC and IS varies between family types, WTC being higher than IS for lone parents, and lower than IS for all other family types.

Housing benefit (HB) is a means-tested benefit that helps low-income families meet rent payments. HB potentially covers a family's entire rent bill, although there are caps on maximum rent that vary dramatically by region. As of April 2012, childless single individuals aged under 35 (the group treated least generously) could expect to get a maximum of between £45 and £123.50 per week depending on the region, while lone parent or couple families with one child could get a maximum of between £75 and £290. Families on IS automatically get full HB. Other families are subject to a means test much like the one for IS, with the HB award being tapered away once net family income exceeds a specified level that varies by family type. The taper rate is 65%. This high taper rate combined with potentially very large awards mean that HB can be very detrimental to work incentives. **Council tax benefit** (CTB) is almost identical to HB, except that it helps meet council tax rather than rent payments. Maximum CTB is equal to the family's council tax liability, which for most families will work out as less than £30 per week. Families on IS automatically get full CTB; others are subject to a means test. The taper rate is 20%.

Child tax credit (CTC) is the main source of means-tested support for families with children. No employment conditions have to be met. Maximum CTC is equal to a family element (£545 per year) plus a child element (£2,690) for each child. CTC is withdrawn against income in a joint means-test with WTC that operates at the family level: once gross earnings exceed a given threshold, tax credit awards are tapered away at a rate of 41%.

The generosity of tax credit awards and the substantial taper rate mean they are a significant contributor to high METRs. But WTC hours rules mean that WTC actually acts to reduce PTRs for families without a working partner.

The **maternity grant** is a one-off £500 payment for each newborn child, but only if there are no other children aged under 16 in the family (i.e. it is basically only available for first births). Families receive the maternity grant if they get IS or more Child Tax Credit than just the family element. We assume that the maternity grant relates to the first year of a child's life, so allocate 1/52 to each week of that first year. **Free school meals** (FSM) are a benefit in kind available to school-age children in families getting IS or full CTC and no WTC. They are worth the equivalent of around £30 per week per child. **Child benefit** is (at the time of writing) the only non-means-tested benefit we consider. It is available to families with children aged under 16 or aged 16-19 and in full-time education. In April 2012, it was worth £13.40 a week per child plus an extra £6.90 for the first child.

Appendix B. Algebra of work incentive measures

As stated in Section 2, the forward-looking participation tax rate can be expressed in terms of static participation tax rates and marginal effective tax rates. This can be shown as follows:

$$
\begin{aligned}
\text{Forward-looking } PTR_a \quad &\equiv \quad 1 - \frac{\sum_{s=0}^{A-a} \beta^s (Y_{a+s|h_a=h} - Y_{a+s|h_a=0})}{\sum_{s=0}^{A-a} \beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})} \\
&= \frac{\sum_{s=0}^{A-a} \beta^s \left[(E_{a+s|h_a=h} - E_{a+s|h_a=0}) - (Y_{a+s|h_a=h} - Y_{a+s|h_a=0})\right]}{\sum_{s=0}^{A-a} \beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})} \\
&= \sum_{s=0}^{A-a} \frac{\beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})}{\sum_{t=0}^{A-a} \beta^t (E_{a+t|h_a=h} - E_{a+t|h_a=0})} \left[1 - \left(\frac{Y_{a+s|h_a=h} - Y_{a+s|h_a=0}}{E_{a+s|h_a=h} - E_{a+s|h_a=0}}\right)\right] \\
&= \alpha_a PTR_a + \sum_{s=1}^{A-a} \alpha_{a+s} TR_{a+s}
\end{aligned}
$$

where:

$$
\begin{aligned}
\alpha_{a+s} &= \frac{\beta^s (E_{a+s|h_a=h} - E_{a+s|h_a=0})}{\sum_{t=0}^{A-a} \beta^t (E_{a+t|h_a=h} - E_{a+t|h_a=0})} \text{ with } \sum_{s=0}^{A-a} \alpha_{a+s} = 1 \\
TR_{a+s} &= 1 - \left(\frac{Y_{a+s|h_a=h} - Y_{a+s|h_a=0}}{E_{a+s|h_a=h} - E_{a+s|h_a=0}}\right)
\end{aligned}
$$

and where terms involving $E_{a+s|h_a=h} - E_{a+s|h_a=0}$ as the denominator are omitted if it is equal to zero. This result shows that the forward-looking PTR is a weighted average of today's PTR and future values of a tax rate term, *TR*. The interpretation of *TR* depends on how future behaviour is affected by the change in employment today. Let $H_{a+s|h_a=h}$ be the number of hours worked at age $a + s$ if h hours are worked at age a (or where h is second preference for hours if the individual is unemployed). Then:

Case 1 ($\boldsymbol{H_{a+s|h_a=h} = H_{a+s|h_a=0} = 0}$): TR_{a+s} term drops out

Case 2 ($\boldsymbol{H_{a+s|h_a=h} = H_{a+s|h_a=0}} > 0$): TR_{a+s} is the same as $METR_{a+s}$ except that it is calculated on an increment to wages rather than hours

Case 3 ($\boldsymbol{H_{a+s|h_a=h} \neq H_{a+s|h_a=0}}$): TR_{a+s} is approximately equal to PTR_{a+s} for the given discrete change in hours (it is not exactly equal to the PTR because experience accumulation will mean that wages are higher in period $a + s$ will be higher if the individual does work in period a than if she does not, but the size of this effect is likely to be greatly outweighed by the move into or out of work at $a + s$.)

The simplest case is where future labour supply decisions are not affected by moving into or out of work today, and then we can restrict attention to cases 1 and 2. In this situation, the forward-looking PTR is a weighted average of today's PTR and future METRs for those periods in which the individual is employed. However, the weights, α_{a+s}, are no longer a simple average as they were for the PTR-METR relationship: they now depend on future employment choices, $H_{a+s|h_a=h}$ and $H_{a+s|h_a=0}$. Much greater weight is given to periods in which the employment decision changes, because then the difference $E_{a+s|h_a=h} - E_{a+s|h_a=0}$ in the numerator of the weight will be much bigger. This means that the PTRs corresponding to any future change in employment will feature much more heavily in the forward-looking PTR than they would do under a straight average. Complicating matters further, if $H_{a+s|h_a=h} < H_{a+s|h_a=0}$ then α_{a+s} becomes negative (assuming that the sum in the denominator of the weight is positive).

The three work incentive measures that we use in this paper can each be decomposed into sums of work incentive measures for component taxes and benefits. Taking the METR as an example, and supposing there are J taxes and K benefits, we show in Appendix B that we can write:

$$\begin{aligned}
\mathrm{METR} &= \frac{(\mathrm{T_{h+1}} - \mathrm{B_{h+1}}) - (\mathrm{T_h} - \mathrm{B_h})}{\mathrm{E_{h+1}} - \mathrm{E_h}} \\
&= \frac{\left(\sum_{j=1}^{J} \mathrm{T_{j,h+1}} - \sum_{k=1}^{K} \mathrm{B_{k,h+1}}\right) - \left(\sum_{j=1}^{J} \mathrm{T_{j,h}} - \sum_{k=1}^{K} \mathrm{B_{k,h}}\right)}{\mathrm{E_{h+1}} - \mathrm{E_h}} \\
&= \left(\sum_{j=1}^{J} \frac{\mathrm{T_{j,h+1}} - \mathrm{T_{j,h}}}{\mathrm{E_{h+1}} - \mathrm{E_h}}\right) - \left(\sum_{k=1}^{K} \frac{\mathrm{B_{k,h+1}} - \mathrm{B_{k,h}}}{\mathrm{E_{h+1}} - \mathrm{E_h}}\right) \\
&= \left(\sum_{j=1}^{J} \mathrm{METR_{T_j}}\right) - \left(\sum_{k=1}^{K} \mathrm{METR_{B_k}}\right)
\end{aligned}$$

Appendix C. Further detail on the labour supply model

This section provides a brief account of the model we use to simulate women's lifetimes. A comprehensive description can be found in Blundell et al (2011).

The model is a standard lifecycle consumption and labour supply model, in the style of Eckstein and Wolpin (1989) and (1999), Keane and Wolpin (1997) and Adda et al (2008), but with additional features that make it suitable to assess the impact of taxes and benefits on work incentives and decisions over time. The most important of these are: evolving family composition; a rich characterisation of the tax and benefit system; an education choice; and experience accumulation. To our knowledge, this is the first tool capable of supporting the study of dynamic features of tax and benefit design taking into account labour supply responses, saving and skill formation.

We model women between the ages of 17 and 69 on an annual basis. We split life into three stages , and choices at each age depend on the circumstances (or "state") the individual begins that age with and the options open to her:

Stage 1 (education): At age 17, individuals choose between three levels of education: secondary, sixth form and university. The level of education determines the type of human capital the individual has to offer in the labour market. The age at which individuals complete education depends on their education choice

Stage 2 (working life): After education, individuals enter the labour market and in each period choose how much to work – zero, part time (20 hours per week) or full time (40 hours per week) – and save. Hours of work determines how much experience is accumulated. Family composition changes according to processes of partnering and childbearing.

Stage 3 (retirement): At age 60, individuals retire. The treatment of retirement is fairly simple: individuals choose how much to consume each period, and exogenous changes in family composition continue. End of life is at age 69

All decisions are all made by comparing the value of alternatives, taking into account their implications for future opportunities. Individuals are risk averse and face uncertainty over future productivity and family composition (both described below), but have perfect foresight over future tax systems. Insurance markets are incomplete, meaning that individuals cannot completely insure against these sources of uncertainty; partial self-insurance is possible through saving and the accumulation of human capital (education and experience). Individuals are unable to borrow except to fund education.

Four features of the model are especially important for the determination of work incentives: the female wage process, the dynamics family composition (through its effect on benefit entitlement), the treatment of housing and the treatment of childcare. We discuss these in turn.

The female wage process is central to work incentives: it determines what individuals can earn in the labour market in the current period, and it governs how wages evolve over time in response to previous employment decisions (central to the forward-looking PTR). Our setup is fairly standard in the literature: female wages depend on education, experience and a stochastic productivity process intended to capture other factors that affect wages (e.g. health shocks). Individuals accumulate one unit of experience for each period of full-time work, and a fraction of a unit for each period of part-time work (this fraction is estimated from data). Experience depreciates during life. The wage return to experience is estimated to be increasing strongly in the level of education achieved.

Family composition matters for work incentives both because partners contribute income to the family and because the tax and benefit system treats different family types differently. We model changes to family composition during working life and retirement as exogenous (i.e. not chosen by individuals inside the model) but stochastic, with the arrival and departure probabilities set to replicate patterns observed in the data. Children arrive with a probability that depends on female age, education, presence of partner and presence of older children. Children depart with certainty when they reach age 18. To reduce the state space, we record only whether or not a family has children (and not how many), giving benefits and tax credits to families with children as if they had one child. However, we allow women with children to experience childbirth again, but this acts solely to reset the age of youngest child to zero. Partners of a given education level arrive with a probability that depends on female age and education, and depart with a probability that depends on female age, presence of child and the partner's education. Partners are characterised by their education, employment status and wage. Partners stochastically work either zero hours or full time (40 hours), and the partner wage process is the same as that for women except that it depends on age rather than experience. Implicitly, therefore, female decisions are made conditional on those of her partner. Given gross earnings of all adults in the family, and family circumstances, we calculate net family income using FORTAX, a detailed UK tax and benefit calculator; see Shephard (2009) and Shaw (2011) for details.

Whether a family rents or owns their home is important for work incentives because of potential eligibility to housing benefit (which covers rent payments). A complete treatment of this issue would require housing tenure and quality to be an endogenous choice in the model, something that would entail a considerably more complex model. Instead, we assign a fraction of women (taken from the data and conditional on the women's education level) as being renters throughout their lives. Since median rent does not vary much by family type in BHPS data, we assume that all renters in the model pay the same in rent that is set equal to the median in the data. As a first approximation, this is reasonable but it cannot capture the declining fraction of renters with age and – because particular family types are more common at particular ages (e.g. childless singles are typically young) – it does not perfectly match the fraction of renters by family type. These are limitations of the model that should be borne in mind.

Childcare is important for work incentives both because it may be required to enable parents to work, and because it is subsidised by various parts of the tax and benefit system. In survey data, typically only a minority of families with children are observed paying for childcare even when none of the parents in the family are observed staying at home to look after children (presumably this is because these families have access to free informal childcare, such as grandparents or friends). Consequently, we assign a fraction of women (taken from the data) as needing to pay for childcare if no one in the family stays at home to look after children, and the remainder are assumed to have access to free childcare. Children aged five or under are assumed to need childcare for every hour where all adults in the family are working (i.e. 20 hours of childcare per week would be required by a couple where the mother works 20 hours and the father 40 hours). Children aged 6-10 are assumed to be at school for the equivalent of 20 hours, so will need 20 hours of childcare if all adults in the family work full time and no childcare otherwise. Children aged 11+ are assumed not to need childcare, roughly in accordance with what we find in the data. The hourly price for childcare for those who pay is also based on what we observe in the data. When calculating consumption choices and work incentives, we treat spending on childcare as if it were a tax. We also assume that childcare requirements adjust to changes in hours of work (e.g. when calculating measures of work incentives).

Estimation

The model is estimated on an unbalanced panel of around 4,200 women and their families taken from the British Household Panel Survey (BHPS) over 16 waves, 1991-2006. Estimation follows a three-stage procedure:

1. Set three parameters – the interest rate, the discount rate and an intertemporal preference parameter – using values from the literature. We do this because they are hard to estimate satisfactorily using the available data.
2. Estimate some parameters outside the model. These include the male employment and wage processes, family dynamics and childcare costs.
3. Estimate all remaining parameters inside the model. These include parameters relating to the: female wage equation, experience accumulation, taste for employment, distribution of unobserved heterogeneity and cost of education.

The third stage uses the method of simulated moments: this compares the moments calculated on simulated data produced by the model with comparable moments calculated on panel data, and choosing the set of parameters to minimise the distance between the two sets of moments. The moments we use describe the dynamics of employment, earnings and family composition in some detail. This procedure ensures that the parameters are such that the model is able to replicate the dynamics of employment, earnings and family formation observed in real data.

Validation

One reason we are using simulations to investigate lifecycle work incentives is that no UK panel data contains information about complete lifecycles. But for us to have confidence in our simulations, it is important that we are able to replicate results that can be calculated using existing panel data. Of course, given how stylised the model is, we would not expect a perfect fit. In this section, we show how well our simulated results compare with those derived from BHPS data. We focus on being able to match the distributions of static METRs and PTRs by family type; comparisons split by other characteristics are typically at least as good as those presented here.

BHPS work incentives are calculated by running FORTAX directly on the BHPS data. The comparison is based on the April 2006 tax and benefit system, which corresponds to the last year of BHPS data we use. All the comparisons are for working women because it is only in this situation that the BHPS provides female hours of work and childcare expenditure. We assume the hourly price of childcare in the BHPS is the same as that in the model (this makes little difference to the results) and exclude rent from the comparison. Finally we reweight the BHPS and simulated data so that composition by age, education and family type matches. This is necessary because the BHPS data reflects the experiences of multiple cohorts while the simulations are for a single cohort.

Figures C.1 and C.2 compare the simulated and observed distributions of the METR and PTR respectively. Generally the fit is good. It is a bit better for METRs than PTRs, and not quite so good for couple parent families (which isn't surprising given how simple our model of partners is). One feature of the PTR graphs we do not manage to replicate is the long tail of high PTRs found in the BHPS. On closer inspection, however, this tail may in fact largely be measurement error. All individuals in this group are in low paying jobs. Some are working very few hours, but the majority seem to be working for less than the adult minimum wage. It is therefore not clear that we actually want to be able to replicate this group.

Figure C.1. BHPS vs simulations: distribution of METRs for working women by family type

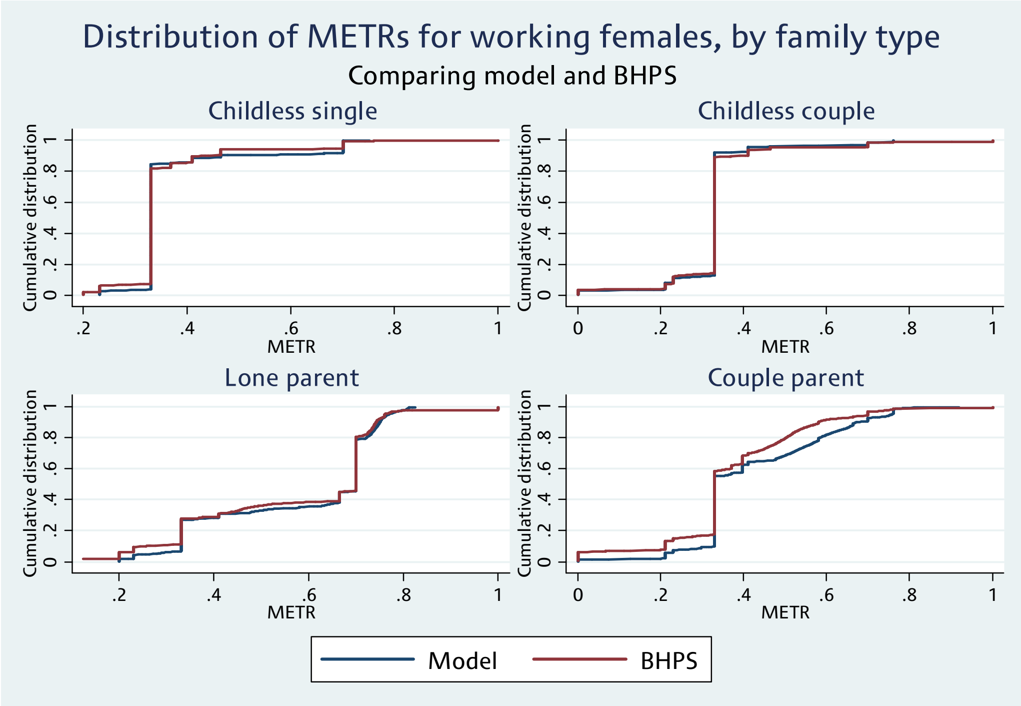
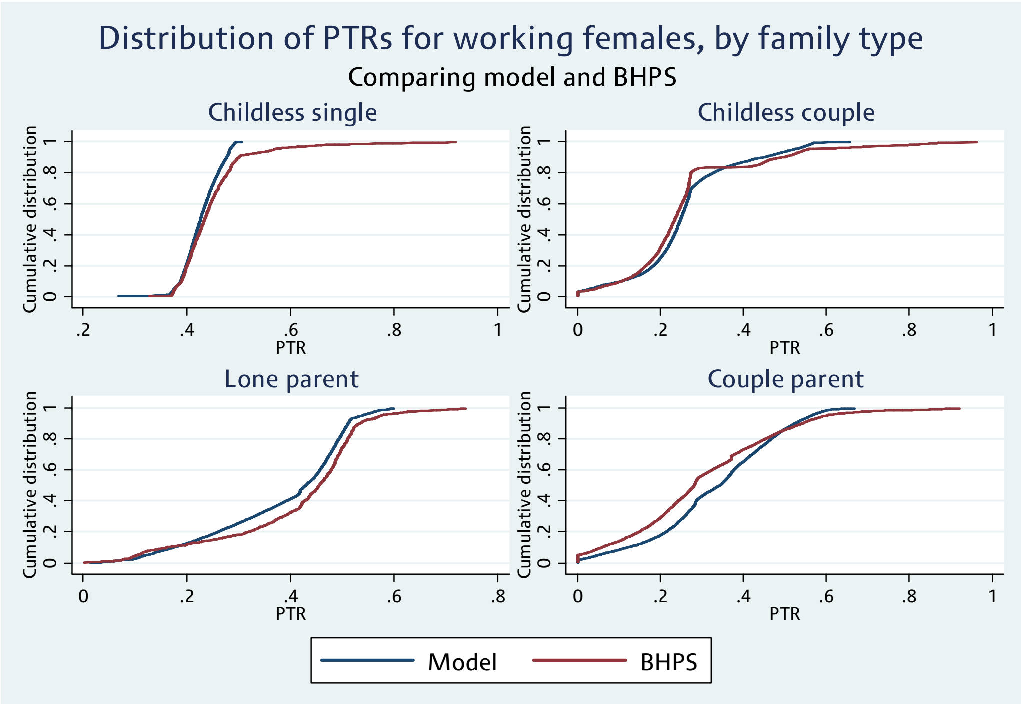


Figure C.2. BHPS vs simulations: distribution of PTRs for working women by family type



Appendix D. Supplementary Tables and Figures

Table D.1. Predictors of being in top decile of METRs among workers (regression on explanatory characteristics)

Variable	Coefficient	Standard error
Female earnings vingtile:		
3	0.064071	0.001771***
4	0.341249	0.001887***
5	0.320616	0.001998***
6	0.109312	0.002058***
7	0.066282	0.002091***
8	0.051217	0.002110***
9	0.018937	0.002124***
10	0.016491	0.002136***
11	0.013336	0.002145***
12	0.010688	0.002156***
13	-0.05174	0.002168***
14	-0.06191	0.002180***
15	-0.07273	0.002193***
16	-0.0799	0.002204***
17	-0.08649	0.002210***
Intermediate education	-0.00407	0.000659***
Higher education	-0.00566	0.000890***
Aged 25+	0.127401	0.000857***
Childless couple	0.238801	0.001383***
Lone parent	0.455928	0.002245***
Couple parent	0.261567	0.002288***
Partner employed	0.020662	0.002976***
Partner earnings quartile x female hours in work:		
Bottom quartile, full-time	-0.31169	0.002869***
Second quartile, part-time	-0.24184	0.002941***
Second quartile, full-time	-0.36364	0.002856***
Third quartile, part-time	-0.34322	0.002609***
Third quartile, full-time	-0.35806	0.002855***
Fourth quartile, part-time	-0.36515	0.002524***
Fourth quartile, full-time	-0.33889	0.002869***
Female part-time in work	-0.12589	0.002011***
Age of child:		
1-4	-0.02602	0.001966***
5	-0.05377	0.002619***
6-10	0.04072	0.001990***
11-18	0.019761	0.001975***
Pays for 20 hours childcare	0.138743	0.001315***
Pays for 40 hours childcare	0.090192	0.002173***
Is a renter	-0.0051	0.000766***
Constant	-0.05812	0.001948***

R-squared	0.4628	
Number of observations	716,839	

Notes: Dependent variable is dummy for top METR decile. Authors' calculations based on simulated data.

Table D.2. Mean PTR by income component at extremes of distribution: basic education

	Bottom decile	Bottom quartile	Top quartile	Top decile
Childcare	0.000	0.032	0.082	0.081
Income tax	0.009	0.039	0.046	0.034
National insurance	0.007	0.026	0.030	0.022
Working tax credit	-0.258	-0.238	0.023	0.002
Child tax credit	0.002	0.005	0.029	0.007
Income support	0.246	0.211	0.316	0.483
Housing benefit	0.001	0.002	0.094	0.145
Council tax benefit	0.016	0.019	0.049	0.047
Other	0.012	0.009	0.003	0.001
Total	0.034	0.106	0.673	0.822

Notes: Deciles defined with respect to all females (not just those with basic education). Authors' calculations based on simulated data.

Table D.3. Mean PTR by income component at extremes of distribution: intermediate education

	Bottom decile	Bottom quartile	Top quartile	Top decile
Childcare	0.000	0.012	0.074	0.073
Income tax	0.011	0.063	0.076	0.050
National insurance	0.009	0.041	0.048	0.033
Working tax credit	-0.116	-0.092	0.027	0.012
Child tax credit	0.002	0.004	0.042	0.016
Income support	0.111	0.083	0.242	0.432
Housing benefit	0.000	0.000	0.055	0.112
Council tax benefit	0.009	0.010	0.042	0.042
Other	0.006	0.004	0.004	0.002
Total	0.032	0.126	0.609	0.770

Notes: Deciles defined with respect to all females (not just those with intermediate education). Authors' calculations based on simulated data.

Table D.4. Mean PTR by income component at extremes of distribution: intermediate education

	Bottom decile	Bottom quartile	Top quartile	Top decile
Childcare	0.000	0.002	0.046	0.045
Income tax	0.017	0.085	0.119	0.080
National insurance	0.014	0.054	0.073	0.051
Working tax credit	-0.020	-0.021	0.007	0.008
Child tax credit	0.001	0.002	0.059	0.032
Income support	0.019	0.020	0.168	0.338
Housing benefit	0.000	0.000	0.041	0.094
Council tax benefit	0.002	0.003	0.034	0.040
Other	0.001	0.001	0.005	0.004
Total	0.035	0.148	0.554	0.691

Notes: Deciles defined with respect to all females (not just those with higher education). Authors' calculations based on simulated data.

Table D.5. Predictors of very low or very high PTRs (regression on explanatory characteristics)

	Bottom decile		Top decile	
Variable	Coefficient	Standard error	Coefficient	Standard error
Female earnings vingtile:				
2	0.234592	0.001426***	-0.08377	0.001564***
3	0.089106	0.001114***	-0.12097	0.001221***
4	0.046033	0.001165***	-0.12148	0.001277***
5	-0.03327	0.001235***	-0.11284	0.001354***
6	-0.19233	0.001278***	-0.10979	0.001402***
7	-0.18361	0.001302***	-0.11343	0.001428***
8	-0.17878	0.001316***	-0.1151	0.001443***
9	-0.17755	0.001326***	-0.12325	0.001454***
10	-0.17591	0.001334***	-0.12405	0.001463***
11	-0.17606	0.001342***	-0.14894	0.001472***
12	-0.17622	0.001351***	-0.14669	0.001481***
13	-0.17528	0.001360***	-0.14608	0.001492***
14	-0.17493	0.001370***	-0.15158	0.001503***
15	-0.1736	0.001380***	-0.15656	0.001514***
16	-0.17247	0.001389***	-0.1643	0.001524***
17	-0.17221	0.001394***	-0.17038	0.001528***
Intermediate education	-0.01119	0.000514***	0.007385	0.000563***
Higher education	-0.02336	0.000740***	0.012683	0.000812***
Aged 25+	-0.01195	0.000674***	-0.00189	0.000739***
Childless couple	-0.01955	0.001011***	0.201775	0.001109***
Lone parent	0.099493	0.001463***	-0.32719	0.001605***
Couple parent	-0.10832	0.001468***	0.208138	0.001610***
Partner employed	0.010006	0.001435***	-0.43737	0.001573***
Partner earnings quartile x female hours in work:				
Bottom quartile, full-time	0.068267	0.001561***	0.155683	0.001712***
Second quartile, part-time	0.107801	0.001507***	-0.21143	0.001652***
Second quartile, full-time	0.130979	0.001544***	0.105739	0.001693***
Third quartile, part-time	0.507284	0.001520***	-0.18281	0.001666***
Third quartile, full-time	0.151402	0.001545***	0.104248	0.001694***
Fourth quartile, part-time	0.689895	0.001444***	-0.18398	0.001584***
Fourth quartile, full-time	0.141376	0.001568***	0.111951	0.001720***
Female part-time in work	-0.00289	0.001158**	0.227645	0.001270***
Age of child:				
1-4	-0.0005	0.001196	-0.00521	0.001312***
5	-0.02223	0.001684***	0.009884	0.001847***
6-10	0.055311	0.001269***	0.027793	0.001391***
11-18	0.014399	0.001277***	0.058015	0.001401***
Pays for 20 hours childcare	-0.24672	0.000880***	0.104955	0.000965***
Pays for 40 hours childcare	0.012348	0.001922***	0.179174	0.002107***
Is a renter	-0.03573	0.000572***	0.23752	0.000627***
Constant	0.160329	0.001076***	0.189909	0.001180***
R-squared	0.5290		0.4336	

Number of observations	921,248		921,248	

Notes: Dependent variable is dummy for bottom PTR decile (first two columns) and top PTR decile (last two columns). Authors' calculations based on simulated data.

Table D.6. Predictors of very low or very high forward-looking PTRs (regression on explanatory characteristics)

	Bottom decile		Top decile	
Variable	Coefficient	Standard error	Coefficient	Standard error
Female earnings vingtile:				
2	0.151961	0.001734***	-0.05097	0.001688***
3	0.016907	0.001354***	-0.05536	0.001318***
4	-0.01729	0.001416***	-0.0586	0.001378***
5	-0.04739	0.001501***	-0.06693	0.001461***
6	-0.09756	0.001554***	-0.07496	0.001513***
7	-0.11101	0.001584***	-0.07305	0.001541***
8	-0.11885	0.001601***	-0.08131	0.001557***
9	-0.12746	0.001612***	-0.09252	0.001569***
10	-0.1344	0.001623***	-0.10777	0.001579***
11	-0.14268	0.001632***	-0.11131	0.001588***
12	-0.1485	0.001643***	-0.11043	0.001598***
13	-0.15111	0.001654***	-0.11247	0.001610***
14	-0.15562	0.001666***	-0.11545	0.001621***
15	-0.15699	0.001678***	-0.11769	0.001633***
16	-0.15733	0.001690***	-0.11951	0.001644***
17	-0.16344	0.001695***	-0.12269	0.001649***
Intermediate education	-0.02812	0.000625***	-0.01174	0.000608***
Higher education	-0.04275	0.000900***	-0.00849	0.000876***
Aged 25+	-0.00894	0.000820***	0.014628	0.000798***
Childless couple	-0.00295	0.001229**	0.136902	0.001196***
Lone parent	0.109208	0.001779***	-0.30352	0.001731***
Couple parent	-0.06792	0.001785***	0.136146	0.001737***
Partner employed	0.032394	0.001745***	-0.37177	0.001698***
Partner earnings quartile x female hours in work:				
Bottom quartile, full-time	0.044253	0.001899***	0.172782	0.001848***
Second quartile, part-time	0.083972	0.001832***	-0.20842	0.001783***
Second quartile, full-time	0.135281	0.001877***	0.149703	0.001827***
Third quartile, part-time	0.369147	0.001848***	-0.18947	0.001798***
Third quartile, full-time	0.178909	0.001878***	0.152681	0.001828***
Fourth quartile, part-time	0.546213	0.001756***	-0.19567	0.001709***
Fourth quartile, full-time	0.162252	0.001907***	0.154452	0.001856***
Female part-time in work	-0.0219	0.001408***	0.304246	0.001370***
Age of child:				

1-4	0.001163	0.001455	-0.00838	0.001416***
5	-0.0199	0.002048***	0.002958	0.001993
6-10	0.012702	0.001543***	0.018788	0.001501***
11-18	-0.02204	0.001553***	0.047479	0.001511***
Pays for 20 hours childcare	-0.1916	0.001070***	0.080693	0.001041***
Pays for 40 hours childcare	-0.04294	0.002337***	0.101526	0.002274***
Is a renter	-0.01222	0.000695***	0.187707	0.000676***
Constant	0.141961	0.001309***	0.141881	0.001274***
R-squared	0.3035		0.3405	
Number of observations	921,248		921,248	

Notes: Dependent variable is dummy for bottom forward-looking PTR decile (first two columns) and top forward-looking PTR decile (last two columns). Authors' calculations based on simulated data.

Table D.7. Predictors of very low or very high PTR difference (regression on explanatory characteristics)

	Bottom decile		Top decile	
Variable	Coefficient	Standard error	Coefficient	Standard error
Female earnings vingtile:				
2	-0.03665	0.002005***	0.187631	0.001874***
3	-0.01299	0.001566***	0.223208	0.001463***
4	-0.01701	0.001638***	0.135832	0.001530***
5	-0.03115	0.001736***	0.065187	0.001622***
6	-0.03444	0.001797***	0.037038	0.001679***
7	-0.03683	0.001831***	0.025791	0.001711***
8	-0.04319	0.001850***	0.010467	0.001729***
9	-0.04939	0.001864***	-0.00225	0.001742
10	-0.05815	0.001876***	-0.01291	0.001753***
11	-0.06916	0.001887***	-0.01791	0.001763***
12	-0.07886	0.001899***	-0.02609	0.001775***
13	-0.08693	0.001913***	-0.03051	0.001787***
14	-0.09883	0.001926***	-0.03518	0.001800***
15	-0.10529	0.001940***	-0.03807	0.001813***
16	-0.11366	0.001953***	-0.04201	0.001825***
17	-0.134	0.001960***	-0.05047	0.001831***
Intermediate education	0.035754	0.000722***	0.014577	0.000675***
Higher education	0.040739	0.001041***	0.023024	0.000973***
Aged 25+	-0.06468	0.000948***	-0.00826	0.000886***
Childless couple	0.086806	0.001421***	-0.01346	0.001328***
Lone parent	-0.07814	0.002057***	0.140276	0.001923***
Couple parent	0.105798	0.002064***	-0.03433	0.001929***
Partner employed	-0.19989	0.002017***	-0.04458	0.001885***
Partner earnings quartile x female hours in work:				
Bottom quartile, full-time	0.130172	0.002195***	0.117288	0.002052***
Second quartile, part-time	0.023205	0.002119***	0.039749	0.001980***
Second quartile, full-time	0.154448	0.002170***	0.153287	0.002028***

Third quartile, part-time	0.079832	0.002136***	0.211308	0.001997***
Third quartile, full-time	0.165651	0.002172***	0.16962	0.002030***
Fourth quartile, part-time	0.03662	0.002030***	0.164605	0.001898***
Fourth quartile, full-time	0.15432	0.002205***	0.15292	0.002061***
Female part-time in work	0.053595	0.001628***	0.143824	0.001521***
Age of child:				
1-4	0.009311	0.001682***	0.005355	0.001572***
5	0.022246	0.002368***	-0.01151	0.002213***
6-10	0.015472	0.001784***	0.026522	0.001667***
11-18	-0.0063	0.001796***	-0.00746	0.001678***
Pays for 20 hours childcare	0.000158	0.001237	-0.09177	0.001156***
Pays for 40 hours childcare	0.10675	0.002702***	-0.02513	0.002525***
Is a renter	0.10641	0.000804***	-0.04968	0.000751***
Constant	0.136651	0.001513***	0.002841	0.001414**
R-squared	0.0691		0.1869	
Number of observations	921,248		921,248	

Notes: “PTR difference” = forward-looking PTR – PTR. Dependent variable is dummy for bottom PTR difference decile (first two columns) and top PTR difference decile (last two columns). Authors’ calculations based on simulated data.

Table D.8. Predictors of PTR difference close to zero (regression on explanatory characteristics)

Variable	Coefficient	Standard error
Female earnings vingtile:		
2	-0.10909	0.003027***
3	-0.12485	0.002363***
4	-0.10299	0.002472***
5	0.015133	0.002620***
6	0.028862	0.002713***
7	0.008573	0.002764***
8	0.011181	0.002793***
9	0.029268	0.002814***
10	0.059317	0.002832***
11	0.090421	0.002848***
12	0.116447	0.002867***
13	0.150133	0.002887***
14	0.20627	0.002908***
15	0.292526	0.002929***
16	0.362959	0.002949***
17	0.440711	0.002958***
Intermediate education	-0.16043	0.001090***
Higher education	-0.24382	0.001571***
Aged 25+	0.171323	0.001431***
Childless couple	-0.17222	0.002145***

Lone parent	-0.17488	0.003105***
Couple parent	-0.24518	0.003115***
Partner employed	0.207685	0.003045***
Partner earnings quartile x female hours in work:		
Bottom quartile, full-time	-0.02257	0.003314***
Second quartile, part-time	-0.07562	0.003198***
Second quartile, full-time	-0.05931	0.003276***
Third quartile, part-time	-0.17541	0.003225***
Third quartile, full-time	-0.14794	0.003278***
Fourth quartile, part-time	-0.05787	0.003065***
Fourth quartile, full-time	-0.11948	0.003328***
Female part-time in work	0.024128	0.002457***
Age of child:		
1-4	-0.02966	0.002539***
5	-0.03879	0.003574***
6-10	-0.05452	0.002693***
11-18	-0.00389	0.002711***
Pays for 20 hours childcare	0.05857	0.001867***
Pays for 40 hours childcare	-0.28945	0.004079***
Is a renter	-0.08992	0.001213***
Constant	0.331851	0.002284***
R-squared	0.1384	
Number of observations	921,248	

Notes: "PTR difference" = forward-looking PTR – PTR. Dependent variable is dummy for PTR difference no greater than 0.01 in absolute value. Authors' calculations based on simulated data.

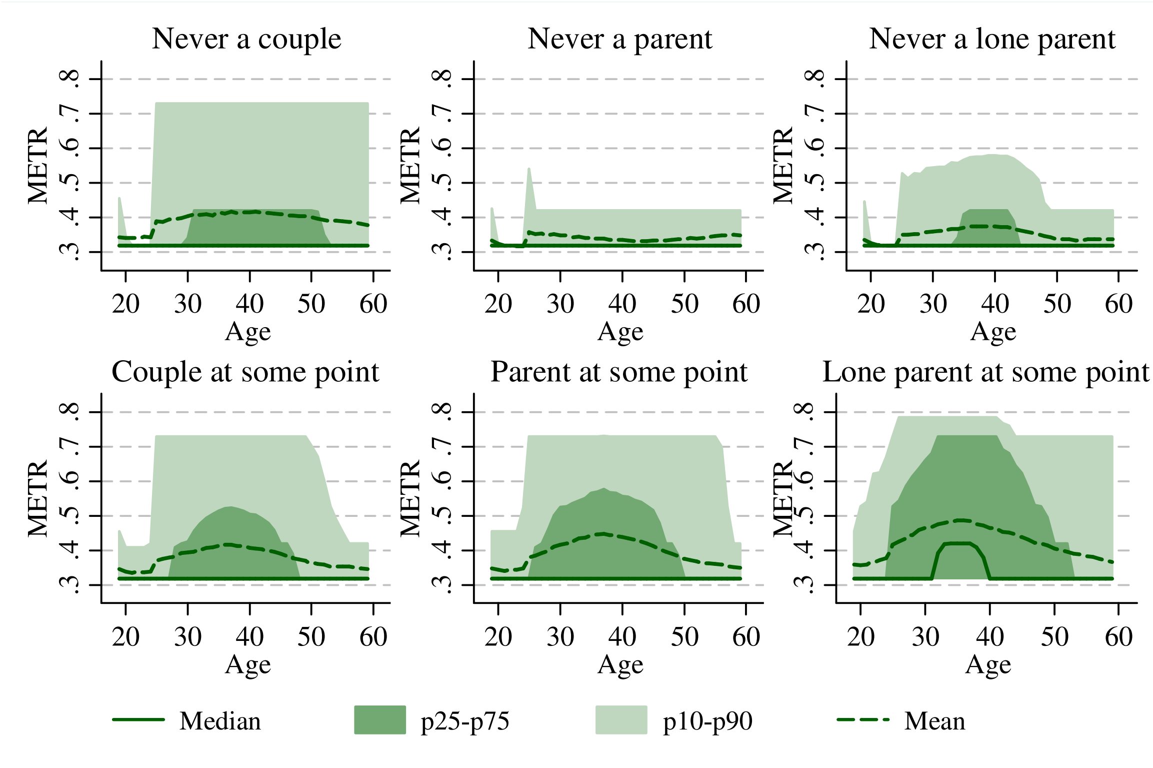
Table D.9. Predictors of low or high FLPTR standard deviation (regression on explanatory characteristics)

	Less than 0.01		Top decile	
Variable	Coefficient	Standard error	Coefficient	Standard error
Female earnings vingtile:				
2	-0.012883	0.002666***	0.061376	0.001961***
3	-0.016718	0.002081***	0.172742	0.001531***
4	0.024156	0.002177***	0.154780	0.001602***
5	0.048633	0.002308***	0.123716	0.001698***
6	0.061769	0.002389***	0.110342	0.001758***
7	0.096103	0.002434***	0.105426	0.001791***
8	0.144086	0.002460***	0.093104	0.001810***
9	0.174544	0.002478***	0.078973	0.001823***
10	0.202638	0.002494***	0.067299	0.001835***
11	0.231537	0.002508***	0.059378	0.001845***
12	0.265711	0.002525***	0.047589	0.001857***
13	0.301422	0.002543***	0.042677	0.001871***

14	0.346103	0.002561***	0.035806	0.001884***
15	0.407994	0.002580***	0.033431	0.001898***
16	0.470077	0.002597***	0.029535	0.001910***
17	0.564115	0.002605***	0.014001	0.001917***
Intermediate education	-0.070297	0.000960***	-0.019516	0.000706***
Higher education	-0.068902	0.001384***	-0.021094	0.001018***
Aged 25+	0.286489	0.001260***	-0.009118	0.000927***
Childless couple	-0.043773	0.001889***	0.025043	0.001390***
Lone parent	-0.218235	0.002735***	0.093234	0.002012***
Couple parent	-0.266487	0.002744***	0.050491	0.002018***
Partner employed	0.025039	0.002682***	-0.015584	0.001973***
Partner earnings quartile x female hours in work:				
Bottom quartile, full-time	0.009326	0.002918***	0.061418	0.002147***
Second quartile, part-time	-0.036046	0.002816***	0.026014	0.002072***
Second quartile, full-time	-0.015437	0.002885***	0.129117	0.002123***
Third quartile, part-time	-0.067966	0.002840***	0.178141	0.002089***
Third quartile, full-time	-0.030817	0.002887***	0.154758	0.002124***
Fourth quartile, part-time	0.002693	0.002699***	0.100079	0.001986***
Fourth quartile, full-time	-0.047366	0.002931***	0.127591	0.002156***
Female part-time in work	0.026000	0.002164***	0.132362	0.001592***
Age of child:				
1-4	-0.024846	0.002236***	-0.002769	0.001645***
5	0.002577	0.003147***	-0.010527	0.002316***
6-10	-0.053652	0.002371***	-0.009999	0.001744***
11-18	0.158186	0.002387***	-0.058305	0.001756***
Pays for 20 hours childcare	0.044665	0.001644***	-0.082256	0.001210***
Pays for 40 hours childcare	-0.229501	0.003592***	-0.066313	0.002642***
Is a renter	-0.080353	0.001068***	-0.006309	0.000786***
Constant	0.045149	0.002012***	-0.040707	0.001480***
R-squared	0.2845		0.1096	
Number of observations	921,248		921,248	

Notes: Dependent variable is dummy for standard deviation of FLPTR less than 0.01 (first two columns) and top decile of FLPTR (last two columns). Authors' calculations based on simulated data.

Figure D.1 Distribution of METRs and PTRs for working women across the lifecycle, by family type defined over the lifecycle



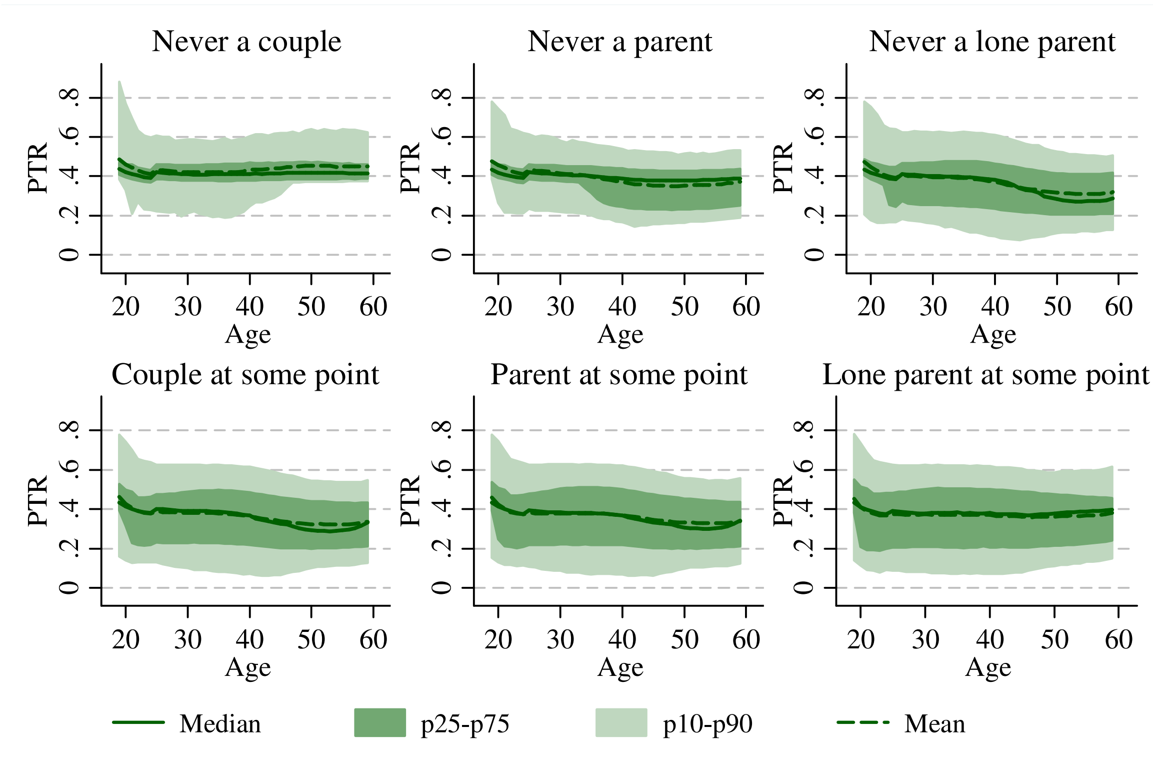


Figure D.2 Distribution of METRs and PTRs for working women across the lifecycle, by whether ever a parent

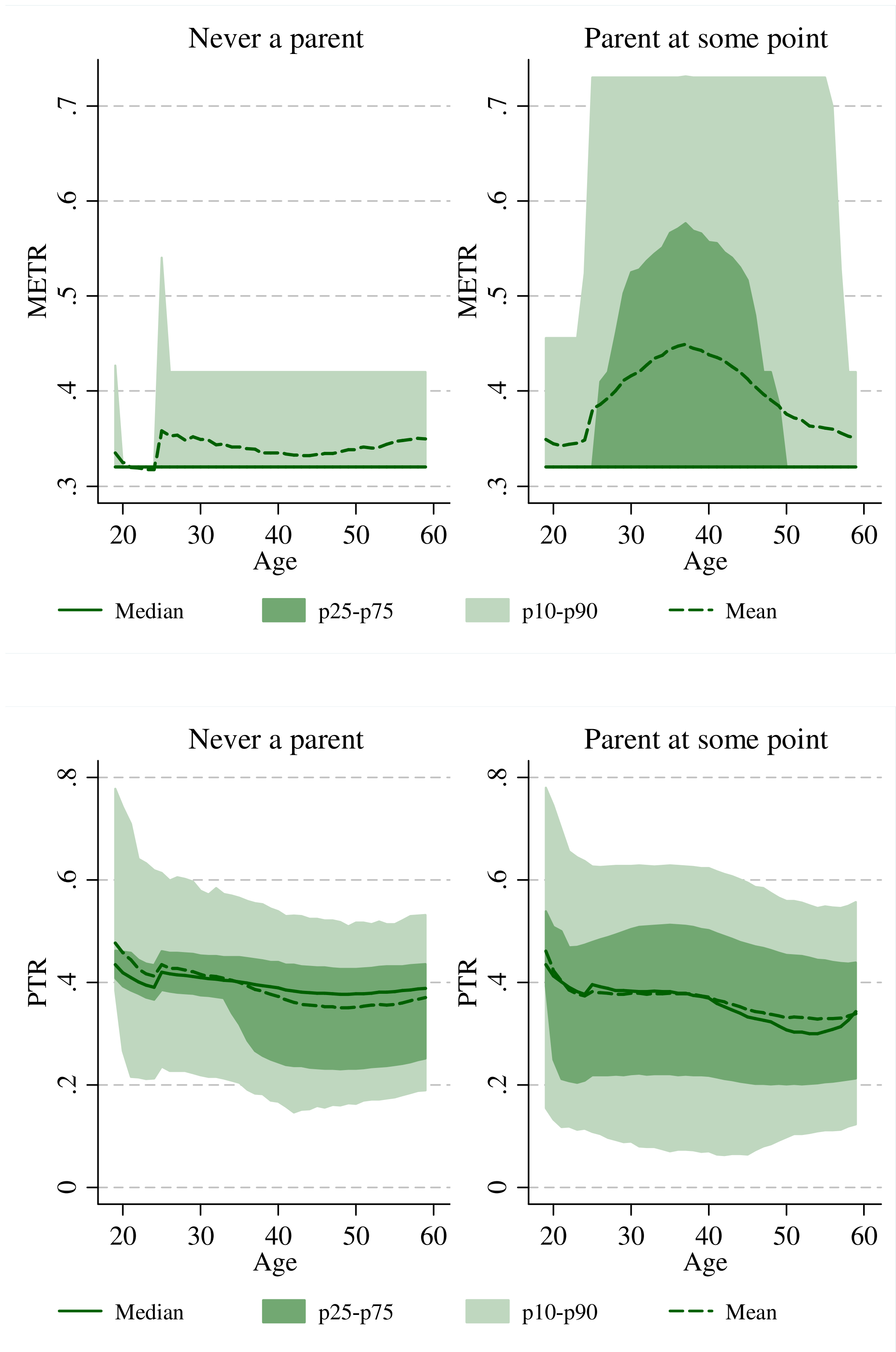


Figure D.3 Distribution of METRs and PTRs for working women across the lifecycle, by lifetime earnings quartile

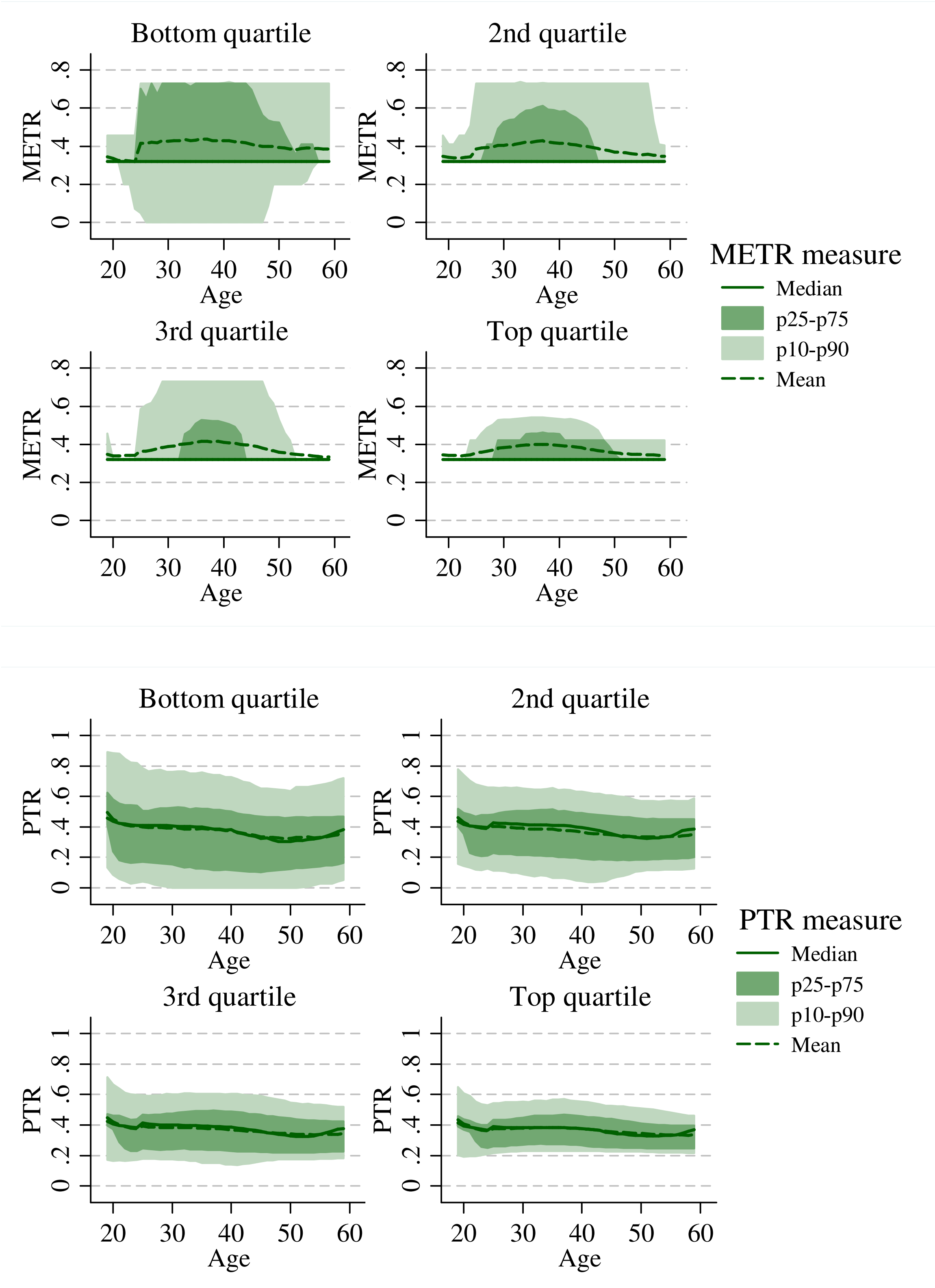


Figure D.4 Distribution of PTRs for women across the lifecycle, conditional on unemployment and employment, by education