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The Incidence of an Earned Income Tax Credit: Evaluating the Impact on Wages in the UK

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Abstract
Tax credits have been a popular way to alleviate in-work poverty. The assumption is typically that the incidence is on the claimant workers. However, economic theory suggests no particular reason to believe that this should be the case. This paper investigates the incidence of the Working Families Tax Credit in the UK introduced in 1999, which unlike similar tax credit policies was paid through the wage packet, increasing the connection between the employer and worker with regard to the tax credit. Using two stage parametric and non-parametric censored regression methods we find compelling evidence to suggest that (1) the firm discriminates by cutting the wage of claimant workers relative to similarly skilled non-claimant workers when looking at men and (2) there is a spill-over effect onto the wage of both groups for both men and women.

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1 Introduction

Over the last two decades there has been a huge expansion across many OECD countries in welfare to work programmes. Different approaches have been carried out to enhance the labour market attachment and earnings of the low skilled. The three (often conflicting) goals are to raise the standard of living, encourage work and self sufficiency and to keep government costs low.

A popular policy has been to use tax credits, for example, the Earned Income Tax Credit in the USA, the Self-Sufficiency Program in Canada and the Working Families' Tax Credit (WFTC) in the UK. In general, these "tax subsidy" policies are motivated by the desire to encourage participation and hours of work of certain groups in the economy, for example, lone parents and low income couples. These so-called "in-work benefits" aim to alleviate poverty at the lower end of the wage distribution, reduce income inequality and redistribute income by reducing the dispersion of earnings.

Given the prior aims and motivations of such policies, most of the literature to date focuses on estimating the labour supply response to changes in and/or introductions of tax credit policies (Eissa & Leibman (1996), Meyer and Rosenbaum (1999), Blundell et al (2005), Brewer et al (2005)). In particular, with regard to the WFTC, once the income and substitution effect are accounted for, the policy was said to have had a "more than average" impact on lone parents and women with unemployed partners[1]. It is however, typically assumed that the incidence of the tax credit is solely on the claimant worker (and therefore the claimant household).

This paper will investigate whether there is evidence to suggest that tax credits are not fully incident on the employee who is eligible[2] and claiming the tax credit. This can be with or without a boost to the economy's overall labour supply. We use a simple general equilibrium model with perfect competition to

[1] See Blundell &Walker (2001).

[2] Eligibility usually being contingent on having children, working a certain number of hours and having a household income below a certain threshold level.

show that under the assumption that the employer has formal knowledge, or at least awareness, of which of her employees are claiming a tax credit, she can share in the incidence of the tax credit by cutting the gross equilibrium wage of the claimant worker. This can be done without reducing the worker's net equilibrium wage such that the worker is no worse off and, more likely, still better off from receiving the tax credit. Moreover, given the degree of substitution between the claimant and other workers, the model predicts that there will be a spillover effect which reduces the wage of both eligible and similarly skilled ineligible workers. The information assumption is still important in the spillover case because by knowing the fraction of eligible workers and the average amount claimed in the work-place, the employer can extract some of the tax credit by "averaging" out the effect.

In this paper we highlight two very important factors, which may be specific to the country where the change in policy occurs. These factors will determine the strength of the effect in question. Firstly, the method by which the tax credit is paid will play a vital role, as it can alter the amount of information that the employer has about her employees' eligibility circumstances. For example, the Working Families' Tax Credit in the UK differed from its predecessor, Family Credit, in that WFTC was paid via the wage packet. The motivation for this change was to reduce the stigma attached to receiving tax credits in the form of a welfare benefit. However, using this method gave employers complete information on *which* employees were claiming and also *how much* WFTC they were receiving. Secondly, institutional factors such as minimum wages impose a lower bound below which the employer cannot cut the wage. This was the case in the UK with the introduction of the National Minimum Wage (NMW) in April 1999. This is also important because it implies that those at the lower end of the wage distribution are more likely to be protected by the national minimum from a cut in gross wage. Additionally (and perhaps more obviously), those at the top end of the wage distribution are unlikely to be affected because tax credits are less relevant to their household income, as they probably receive too little or they earn too much to be eligible. It is therefore those in the middle of the wage distribution who are most likely to be affected.

The empirical investigation is carried out using the change in the UK in October 1999 when the government replaced the Family Credit (a minimum working hours based credit for families with children) with the Working Families' Tax Credit. The change in policy altered the eligibility criteria and it became more generous [3]. Although focusing on this policy change is important in its own right because of this increase in generosity, it is made even more interesting by the fact that we incorporate and exploit two crucial changes in the UK: firstly, the National Minimum Wage (NMW) was introduced six months prior to the WFTC and secondly, the WFTC was paid via the wage packet. The introduction of the NMW plays a fundamental role in this analysis as it offers an interesting identification strategy by acting as an exogenous barrier below which the employer cannot cut the gross wage. In the analysis it is also used as a point of censoring when comparing the change in wages before 1999 to after the introduction of the tax credit.

The payment of the tax credit though the wage packet also plays a central role in the analysis. In the UK employers became responsible in April 2000 for paying the WFTC through the employees' wage or salary. The eligible claimant would claim the approximate tax credit from the Inland Revenue, who would work out the amount of tax credit payable. The Inland Revenue would then notify the relevant employer of the amount of tax credit to be paid and when the tax credit is to start and finish[4]. Employers would pay the tax credit out of the tax and National Insurance contribution that they would otherwise have forwarded to the Inland Revenue[5]. Recent work in the USA by Leigh (2004) and Rothstein (2005) investigates the impact of increased labour supply resulting from changes in the Earned Income Tax Credit (EITC), on the equilibrium wage. In the US however, the employer is not responsible for income tax filing on behalf of employees and so the EITC is not visible in the wage packet. In the UK, payment of WFTC through the wage packet made

[3] A more in-depth description will be given in a later section

[4] It is important to note that this notification would not break down the various components of the credit or distinguish between the WFTC and disabled person's tax.

[5] The employer will lose the benefit of the time lag between marking these deductions and forwarding on the account office.

the employer responsible for the payment of the tax credit and so increased the connection between the wage paying firm and the claimant employee. This paper exploits these differences to get a good measure of the effect of tax credits on wages.

We use two measures of WFTC: the first is the reported number of claimants and the second is the amount of WFTC, which is calculated using the eligibility criteria. This second measure is particularly useful as it allows us to distinguish between the effect of the change in generosity from Family Credit and the change in visibility (i.e. payment through the wage packet) on the wage. Using both a parametric and non-parametric two-stage censored regression based technique, this paper finds strong evidence to suggest that, firstly, the firm discriminates by cutting the wage of the claimant worker relative to a similarly skilled non-claimant for men, such that the employer extracts 35%[6]. Secondly, there is a "spillover" effect for both men and women such that as the average amount of WFTC and the fraction of employees claiming WFTC increases by industry (or by education group), the wages of similarly skilled claimants and non-claimants fall. We find that the "spillover" effect by industry for men is approximately -0.2% and -0.3% for women and when looking by education group, the spillover effect for men is -0.1% and -0.7% for women[7]. Finally, as a robustness check we identify the workers for who the NMW binds and find that the tax credit does not have the same effect on their wages, indicating that the NMW protects them from a wage cut.

The analysis is extended to show that the size of the firm plays an important role in the size of the incidence transfer and as the size of the firm increases, the spillover effect is the principle effect. This is not particularly unusual when one considers that as the size of the firm increases, there is a higher chance that there are workers doing identical jobs, such that the employer would find it difficult to cut the gross wage of one worker and not the other on grounds of eligibility. She therefore shares the burden across all workers. Finally, we address the concern of selectivity in the "take-up" rates and the problem of previously ineligible

[6] These figures are calculated using the change in weekly wages over the average weekly WFTC claim.

[7] These figures are evaluated at the average WFTC rate and average fraction of eligible in the sample.

workers altering their behaviour to become eligible. We tests the exogeneity of the WFTC variables using the Smith-Blundell (1986) procedure and find no evidence of endogeneity .

These results have important academic and policy implications. In particular, they imply that there is a significant shift in the burden of tax credits, in line with the theory presented. This is of critical policy importance as we can no longer assume that it is the case that the person eligible for such tax credits is the sole beneficiary. These results are critical to our understanding of the consequences of the expansion, application and generosity of tax credits. Moreover, the way in which they are distributed may have unexpected consequences.

The rest of the paper is structured as follows: Section 2 gives a brief overview of the past literature on tax credits. Section 3 introduces a general equilibrium model which explains how a tax credit can reduce the gross equilibrium wage. In Section 4 a short history and the main descriptive statistics are given for tax credit policy changes in the UK. Section 5 describes the empirical framework used to test the hypothesis proposed in Section 3. Section 6 describes the data and explains the main results. Section 7 extends the analysis from Section 6 and highlights and deals with potential problems. Section 8 discusses the implications of these results and suggests policy implications. Finally, Section 9 concludes.

2 Related Literature

As mentioned in the introduction, much of the literature to date focuses on evaluating the participation effect of tax credit changes/introduction. One of the most well known papers is that of Eissa & Leibman (1996) where the authors examine the impact of the Tax Reform Act of 1986 in the USA, which included the expansion of the Earned Income Tax Credit (EITC). They focus on the labour market participation and hours of work of single women with children and identify the change by comparing the change in the labour supply of single women with children and single women without children. They find that labour supply increases by 2.8%. Another prominent paper which focuses on the changes in labour supply of single women in the USA is that of Meyer and Rosenbaum (1999). They however, take a more general approach to looking at various policy changes in the US in the 1980s and 1990s that affect this group of women. They found that although benefit cuts, welfare time limit alterations, changes in training programs and childcare expansions had some impact on making women with children work, the largest share of the increase could be attributed to reforms in EITC. Blundell & Hoynes (2001) examine the labour market impact of in-work benefit reform in the UK and then compare it with the USA policy reform (i.e. EITC). They look at why the impact of similar reforms in the UK seem to be small relative to the USA (in terms of increasing employment rates). They conclude that it is attributed to the interactions with other means tested benefits in the UK, the importance of workless couples with kids, the level of income support given to non-working parents and the strength of the USA upturn in the 1990s.

In the UK work has been done to look at the labour supply impact of the Working Families' Tax Credit (WFTC) which was introduced in October 1999 and then replaced by a new tax credit in April 2003 (Child Tax Credit and Working Tax Credit). Using a structural model of labour supply, Brewer et al (2005) find that although labour supply increased for lone mothers, the effect on other groups in the economy was minimal. Blundell et al (2005) and Leigh (2005) also look at the labour supply impact but instead using the difference-in-difference methodology and find similar results. These papers find a 3-5% increase in participation of lone mothers, no significant effect on married mothers and -0.5 to 0.75% change in father's employment.

There are however, a growing number of papers that go beyond looking purely at participation effects from tax subsidies. In particular, an interesting aspect is that of the effect on skill formation resulting from increased participation (Card, Michalopoulos & Robins (2001), Heckman, Lochner & Cossa (2002)). The main question posed in these papers is whether tax credits create an incentive to invest in skills that are useful for the work place, and/or if skills are acquired as a by-product of being in the workplace. The effects on human capital are rather ambiguous and depend on the view taken as to whether learning is rivalrous to work or not. Heckman et al find that the entry effect of EITC is small, but the reduction in the average earnings amongst uneducated women can be as large as 18%. In the UK, Lydon & Walker (2004) also question whether the introduction of the WFTC promoted incentives to increase investment in on-the-job search and training in general skills. They look to see if factors such as these promoted wage growth and found that for people who were previously claiming Family Credit, WFTC's predecessor, incentives are unchanged, but for those who became eligible for the tax credit and had not been previously eligible, there was a 2.7% wage progression.

More recently, literature in the US has emerged which looks at the incidence of tax credits. In particular, Leigh (2004) and Rothstein (2005) use different approaches to investigate the impact of changes in the EITC in the mid-1990s, to see if changes in labour supply had any impact on the equilibrium wage within the same skill group. Using variation across states in EITC supplements, Leigh (2003) generates cross-sectional variation in the average tax rate faced by women with children and finds that an increase of 10% in the generosity of EITC is associated with a 4% fall in wages of the high school drop-outs and a 2% fall in the wage of college graduates. In addition to the state variation, Leigh also uses variation across the wage distribution and still finds that increasing EITC is associated with a fall in hourly wage. The prime explanation for these results is that the increase in EITC generosity boosts labour supply as individuals respond to average falls in tax rates and not marginal tax rates. Rothstein uses variation across the wage distribution using the DiNardo, Fortin and Lemieux (1996) approach in the implementations of the mid-1990s federal EITC expansion (in which maximum total credits, associated marginal total credits and associated marginal tax rates approximately doubled over a three year period) to identify the EITC's effect on women's aggregate labour supply and on the female wage schedule. He found that wage changes were insignificant given the rise in labour supply, but the wage of EITC eligible women grew at a slower rate than that of non-eligible women.

3 Tax Credit Incidence: Theoretical Approach

The aim of this section is to show how, in a theoretical setting, it is possible for a tax credit to influence the equilibrium wage in a general equilibrium framework. The Proposition adapts the Harberger (1962) model of tax incidence[8] to show that a change in the tax credit can lead to a shift in the burden of the tax credit from employee to employer. Moreover, the model shows that when allowing for heterogeneity between workers, there is an indirect effect which affects both eligible and non-eligible. The impact of this effect will depend on the elasticity of substitution between the eligible worker and ineligible worker and the fraction of eligible workers in the work place.

Before introducing the main proposition, let us consider a very simple economy in which workers are perfect substitutes and the law of one wage applies. We can show that it is only in "special" circumstances that the imposition of the tax credit does not alter the wage of the claimant. Moreover, it implies that it is not only the claimant (or claimant's household) who is affected by the policy, but also other groups in the economy are affected.

Let workers comprise of either being eligible for a tax credit (group 1), N_1^s, or ineligible for a tax credit (group 2), N_2^s, and s is the subsidy rate. In equilibrium, at wage w, labour demand, N^d, will equal labour supply:

$$N^d(w(s)) = N_1^s(w(s)(1+s) + N_2^s(w(s))$$

The effect of the subsidy on the gross wage is characterised by:

[8] See Fullerton & Metcalf (2002) for a full review on tax incidence.

$$\frac{\partial \ln w}{\partial \ln(1+s)} = -\frac{\theta \eta_1^s}{\theta \eta_1^s + (1-\theta)\frac{\eta_2^s}{1+s} - \frac{\eta^d}{1+s}}$$

Where η_1^s and η_2^s are the labour supply elasticities for the eligible and ineligible group, respectively, and η^d is the labour demand elasticity. The fraction of each group is represented by θ. See Appendix for the proof.

We can interpret this simple calculation, given that the expression lies between 0 and 1, as the fraction of the subsidy that shifts from worker to employer. The larger the supply elasticity of group 1, the more elastic the labour demand and/or the larger the fraction, then the bigger the shift. Only in special circumstances will the tax credit have no effect on the gross wage, for example, if labour demand elasticity is infinite or if labour supply was perfectly elastic.

The path breaking general equilibrium analysis of Harberger (1962) derives the burden of a tax on capital in one sector. Here, the procedure is adapted to show the general equilibrium effect of a tax credit on input compensation in a one sector model which uses two different types of labour (N_1, N_2) to produce one good (X). The heterogeneity of workers comes from the difference in being able to satisfy the eligibility criteria[9]. In the simple economy example, the incidence effect is the same for all workers, but here by differentiating workers, we can look to see how the effect differs for the eligible and ineligible groups.

Proposition 1 *A change or an introduction of a tax credit under a general equilibrium setting, given that workers are not perfect substitutes, will result in a direct change in the gross wage of the eligible claimant group and an indirect effect on both groups.*

Let it be the case that workers who are eligible for the tax credit, N_1, are paid the gross wage w_1 and workers who are not eligible for the tax credit, N_2, are paid the gross wage w_2. The subsidy rate is given

[9] We do not specify a particular functional form since by assuming the production function $X = F[N_1, N_2]$ we avoid the limitations of computational general equilibrium models. This can be any production function with constant returns to scale. However, as noted by Fullerton & Metcalf (2002), using a log-linearisation method is only valid for small changes.

by s and θ is the fraction of eligible group. Another important feature here is the elasticity of substitution between the two groups, σ_x. The effect of the subsidy on the gross wage is given by:

$$\frac{\partial \ln w_1}{\partial \ln(1+s)} = -\frac{(1-\theta)\eta_1^s}{(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X} \quad \textit{if eligible claimant (group 1)}$$
$$\frac{\partial \ln w_2}{\partial \ln(1+s)} = \frac{\theta\eta_1^s}{(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X} \quad \textit{if ineligible (group 2)}$$

The proof is given in the Appendix.

This proposition suggests that when one accounts for heterogeneity amongst workers, based on the eligibility criteria, it causes the wage of claimant workers to be different from the ineligible workers and the subsidy affects the gross wage of both groups of workers. The strength of this impact will depend on: (1) The fraction of each group, θ and (2) the level of substitutability between the two groups, σ_x. The substitution effect is captured in the labour demand elasticity and the effect on the non-eligible group becomes smaller as the proportion of claimants falls[10].

Since θ is defined as the cost share, it is endogenous in terms of the population share. It is interesting to look at the cross-derivatives with respect to s and θ. This tells us what happens to wages when the share changes:

$$\frac{\partial^2 \ln w_1}{\partial \ln(1+s)\partial\theta} = \frac{\eta_1^s(\sigma_X + \eta_2^s)}{((1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X)^2}$$
$$\frac{\partial^2 \ln w_2}{\partial \ln(1+s)\partial\theta} = \frac{\eta_1^s(\sigma_X + \eta_1^s)}{((1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X)^2}$$

The visibility of the tax credit may play an important role for the shift in incidence, such that the employer has some knowledge/information about which of her workers are eligible for the tax credit. The most simple and straightforward way in which this would be the case is when the tax credit is paid via the wage packet. Here the employer can see clearly if the worker is a claimant (and how much she is receiving). However, one can still maintain this assumption even in the event that the employer does not have full

[10]The simple economy case will be a special case here when $w_1 = w_2 = w$.

information. For example, if there exists some kind of "internal knowledge" of whether or not the employee is claiming tax credit (e.g. the employer may know if his employee has children), or it may be that there is statistical discrimination.

Finally, we may be interested to know how the results change when we consider a non-competitive framework, for example a monopsony or a wage posting model. In his paper, Harberger (1962) addresses this issue when looking at the corporate sector. He adjusts his analysis to accommodate for potential monopoly power and concludes that the tax bites into monopoly profit as well as into the returns in capital (in the context of our model, this would be the wage). Overall, although it would be interesting to lay out a model and to see how in equilibrium the distributions of the two different types of labour and the relative prices of the labour will change, in the end the tax burden that is not directly borne by monopsony profits will be "determined by a mechanism that differs only in minute details from that which determines the incidence of the [corporation income tax] in the competitive case"[11].

4 The Working Families' Tax Credit

In the UK, since the 1980s, there has been a dramatic shift in the composition of the lowest decile of the income distribution from pensioners, to families of working age and lone parents in particular (Goodman, 2001). The Working Families' Tax Credit (WFTC), introduced in October 1999, was designed to target low income families with an income supplement that was contingent on working. However, systems of support for families with dependent children in the UK have been around since 1971, when Family Income Support (FIS) was introduced. FIS entitled families with children and working more than 24 hours per week, to an income supplement.

[11] See Harberger (1962).

In 1988, FIS was renamed Family Credit (FC) with some structural reform and an increase in generosity. Namely, the hours requirement fell to 16 hours and a childcare disregard was introduced to encourage higher participation especially amongst mothers of young children. In October 1999, FC became WFTC and the government estimated twice as many families to be in receipt of WFTC as received by FC. Figure 1 shows how the number of claimants changed from 1988 to 2002[12]. There were 1.1 million claims for WFTC in August 2000, which increased to 1.3 million claims in August 2001. This is almost 430,000 more than claimed under Family Credit in August 1999 .

Eligibility for WFTC was based on the family income being less then £92.90 per week, the presence of children, a minimum of 16 hours of work in the family per week and low household savings. Although not innovative, it was more generous and extended further up the income distribution. In particular, the marginal deduction rate fell from 70% to 55% and there was a larger childcare subsidy. The maximum weekly rate of WFTC was made up of an adult credit for each child and a bonus if the claimant or their partner worked for 30 hours or more each week. An important aspect of the policy was that income from most other benefits, like housing benefit, child benefit and council tax benefit were not included in the calculation for the entitlement of WFTC. This, as argued in Blundell & Walker (2001), could potentially offset the work incentive effects of WFTC.

In terms of government spending on the program, by 2000 the government had spent £5 billion per year (which accounts for 1.5% of the government budget and 0.6% of the GDP). This was almost £2 billion more than that expected under FC. The huge increase in expenditure came from increased credit per child from £19.85 to £26; the threshold support increase from £80.65 to £92.90, and of course, the reduced taper. In addition, the childcare cost accounted for 70% of actual childcare cost (accounting for weekly childcare costs up to a maximum of £135 for one child and £200 for two or more children). The effect of these changes

[12] In April 2003, WFTC changed again to the Working Tax Credit.

meant that those who were currently receiving the maximum payment would see a small increase in the level of their payment if they had children under the age of 11 years old. Those with net income between £80.65 and £92.90 would move from being on the taper to receiving full support. The others on the taper would see the taper rate fall from 70% to 55% and the largest cash gain would go to those who were previously just at the end of the taper. Figure 2 shows how the average claim changed over time. In addition, an encouraging sign of WFTC effectiveness was that its take-up rate by 2002 was estimated to be 72-76% compared to 66-70% under FC. The take-up rate was highest for those entitled to the biggest awards. Also, the greater generosity of WFTC relative to FC meant that the take-up of WFTC was higher than would have been expected had FC simply continued unchanged.

As mentioned in the introduction, one key difference between FC and WFTC was that the payment was made through the wage packet. This was an attractive move because it became more convenient to distribute and it reduced the stigma attached to the tax credit for being a welfare benefit. In April 2000, the eligible claimant would claim the approximate tax credit from the Inland Revenue, who would work out the amount of tax credit payable. The Inland Revenue would then notify the relevant employer of the amount of tax credit to be paid and the employer would pay the tax credit out of the tax and National Insurance contribution that they would otherwise have forwarded to the Inland Revenue.

5 Empirical Framework

In this section we empirically test the theoretical hypothesis that a change in tax credit can lead to a shift in the incidence from worker to employer. In addition to a direct effect on claimants, we examine whether there exists an indirect (spillover) effect of the tax credit on the wage of both the claimant and similarly skilled ineligible (and/or non claimants), which becomes stronger when the fraction of claimant workers and/or the average tax credit amount increases within an industry (or within an education group)[13]. Finally, we use the empirical model to distinguish between the effect of the change in generosity of the WFTC and the change of its visibility on the wage. We propose both a parametric and non-parametric two stage censored regression model to estimate these effects. In addition, as a robustness check we extend the two stage analysis to identify those workers for who the NMW binds to see how WFTC affects their wages. Before explaining the methodology, let us begin by discussing the identification of some key variables.

We want to identify the effect of WFTC on the wages of "similar" people, where some are eligible for WFTC and some are not eligible. We define "similar" people as those who have the same predicted wage in the absence of WFTC. The idea is that we want to estimate the (log) wage, W_i^*:

$$W_i^* = \beta_0 + \beta_1 W_i^c + \beta_2 WFTC_i + \beta_3 FCGen_i + \beta_4 (W\bar{F}TC * \theta) + u_i$$

Where W_i^c is the counterfactual (log) wage we would have if there was no WFTC; $WFTC_i$ is the tax credit variable[14] and $FCGen_i$ represents the change in the generosity of WFTC from Family Credit (FC). The spillover effect, $(W\bar{F}TC * \theta)$, is captured using the average WFTC in an industry (or education group), weighted by the fraction of claimants in that industry (education group) and u_i is the error term. The main problems for identification are that we do not know the counterfactual wage and secondly, we may be concerned that u_i is correlated with $WFTC_i$. Our task is therefore to construct some sort of *predicted* measure of the counterfactual wage, $\hat{w}_i$, and to find an appropriate WFTC measure, $W\hat{F}TC_i$. In other words, we want to ensure that: $correl(\hat{w}_i, u_i) = correl(W\hat{F}TC_i, u_i) = 0$. This section is devoted to explaining how this is done.

One of the key tasks is to construct a measure for WFTC. We identify the WFTC variable in two ways: (1) Using a simple indicator which identifies those who report claiming WFTC, we work out the probability

[13] We use two measures of spillover: Industry and education groups. We discuss these later in this section.
[14] The construction of this variable will be discussed in more detail later in this section.

of claiming WFTC and (2) using the eligibility criteria, we identify those who are eligible for WFTC and the amount for which they are entitled. In addition, this second measure enables us to distinguish between the change in generosity from Family Credit (FC) to WFTC and the change of visibility from payment as a welfare benefit to payment through the wage packet. We do this by calculating the amount of FC a person would be eligible for, given that it was still in operation and then by taking the difference from the amount of WFTC, we work out the increase in generosity. However, since eligibility does not imply take-up, it is good to estimate using both methods.

The receipt of WFTC differs across households for four main reasons: (1) hourly wages, (2) hours worked, (3) household income and (4) presence of children. These four factors not only determine *eligibility*, but will also determine the *amount* received. The outcome variable under investigation is the hourly wage variable and so the variation in the latter three factors (hours worked, household income and presence of children) can be used to evaluate the change in hourly wage that is due to the change in tax credit policy. Typically, the literature on tax credits ignores the different sources of variation and the analysis is conducted by comparing people with children to those without (Eissa & Leibman (1996), Blundell et al (2005)). We use the variation from all three factors to conduct the analysis, but we are assuming that people do not alter their behaviour (significantly enough) in hours of work, for example, to make the criteria endogenous. We discuss this in more detail later in this section[15].

By comparing eligible with non-eligible workers who have the same pre-WFTC wage, we do not have the standard treatment and control group because of the potential spillover effects discussed in Section 3. Instead, as it will become clear later in this section, we use a cross-sectional wage structure before WFTC (as the *predicted* wage variable) and then add in the wage growth and policy change to see what happens to the eligible and non-eligible with the same predicted wage. Essentially, we use a predicted wage measure

[15] We are not concerned by presence of children since, at least in the short run, this will not be altered. In addition we use *predicted* weekly wages to work out household income (this will become clear in the next section).

which is some function of characteristics, a WFTC variable which is also some function of characteristics and then we identify the effect through a particular functional form. For example, suppose that two people have the same predicted wage before WFTC is introduced. They both have children and a low household income, but one person (or one household) works too few hours to be eligible for WFTC. Here we compare their relative before and after wage changes.

Typically the literature on tax credit analysis only focuses on women since, as noted in Eissa (1995), they are usually the largest group of taxpayers eligible for WFTC and they are the group most relevant for studying whether WFTC reduces welfare dependency. However, for the purpose of our analysis, it seems reasonable to look at both women *and* men. The institutional structure of WFTC specifies that either parent can claim the tax credit in their wage packet. Given that in a coupled household it is more likely that the male member of the household will be in work, it is therefore more likely that he will be the tax credit claimant. It therefore not justified to drop men from our analysis.

5.1 The role of the National Minimum Wage:

In the same year as the WFTC was introduced, the UK had another important introduction: National Minimum Wage (NMW). For the first time, the government introduced a national minimum in April 1999 of £3.60 for adults (aged 22 years and above) and £3.00 for those aged 18 - 21 years[16]. Since this policy was introduced only six months before the introduction of the WFTC, we may pose the question: Is this a nuisance or an aid for the following analysis?

We argue that the NMW plays a fundamental role in the evaluation method and is something that should not be ignored in any analysis on WFTC. In the following analysis it is used for both identification and as a censoring point. It offers an unusual source of variation because it is a floor below which the employer *cannot*

[16] Although there were Wage councils abolished in 1993

cut the wage. Although it has the strongest effect on those at the lower end of the wage distribution, as WFTC does, the NMW will protect those with the lowest wages from a wage cut (i.e. the part of the wage distribution where the employer is set to gain the most in incidence). This has a very interesting implication that it is those in the middle of the wage distribution who lose the most, since those at the upper end of the wage distribution will either not be eligible to claim or will receive so little that either they don't claim or it is not in the employer's interest to cut their wage.

5.2 The "WFTC (LFS)" Indicator:

The UK's Quarterly Labour Force Survey (LFS), which is discussed in more detail in the next section, contains information on the types of family related benefits that are claimed. From Spring 2000, information on WFTC claim is reported[17]. This is a useful variable as it helps to identify reported claimants, however take-up of the tax credit is likely to be correlated with the amount of WFTC to be claimed and other individual, household and job characteristics. For this reason we use the probability of claiming WFTC instead of actual claim in a probit model, such that:

$$Pr(ClaimWFTC = 1|X, WFTC\ amount) = \Phi(\theta' X_i + \gamma WFTC\ amount_i)$$

Where $\Phi(.)$ denotes the standard cumulative distribution function of the standard normal, X_i is a 1xK vector of conditioning variables[18] and we use the predicted WFTC amount.

In addition, to make the analysis more rigorous and to account for the individual level of importance of WFTC (relative to household income), a "WFTC Rate" is calculated using the policy eligibility criteria. The nature of this variable allows us to distinguish between the two important changes with regard to the WFTC, namely the change in generosity and change in visibility.

[17] It is important to note that this is *reported* claim and not government reported *actual* claim.

[18] The controls include: Age, Education, Region, Ethnicity, Experience (plus higher orders), Tenure (plus higher orders), Marital Status, Number of Children, Firm Size, Public Ownership, Occupation Type, Industry Type, Full-time Status.

5.3 Calculation of the "WFTC Rate" variable:

WFTC Rate The wage change analysis becomes complicated when measuring the amount of WFTC as WFTC is computed using *household* income rather than the individual wage. One possible way of tackling this is to use the data to match earners in the household and then to estimate the amount of WFTC the household is entitled to claim using the eligibility criteria. This variable is then used in the regression framework. The (per week) WFTC has 3 main parts[19]: (1) A basic credit of £59.00 (one for each family), (2) A 30 hour tax credit bonus of £11.45 (where the worker works at least 30 hours per week) and (3) A tax credit for each child in the eligible household of £26.00. In addition, the criteria also specified that the household should have low savings. The LFS does not report data on savings and so we cannot use it in constructing the WFTC variable. However, here this is not a big problem since only 3.6% of couples and 2.7% of lone parents reports having savings over £5,000 and for those on maximum awards, no one reports having savings over £5,000[20].

The payable WFTC is based on each component added together to make a maximum credit. If net household income ($HHInc$) is above £92.90 per week, the maximum WFTC is reduced. There will be a reduction of £0.55 for each pound over £92.90. If the net income is below £92.90, the maximum WFTC is payable.

In general, the "WFTC" variable is calculated as follows:

∘ *Gross WFTC = £59.00(if hours=>16) + £11.45(if hours=>30) + £26.00 per child (given hours=>16)*

$$\circ\ \textit{Reduced WFTC} = \begin{cases} \textit{(HHInc-£92.90(per week))*55\%} & \textit{if HHinc=>£92.90} \\ 0 & \textit{otherwise} \end{cases}$$

∘ *WFTC = Gross WFTC - Reduced WFTC*

It is important to note that when we calculate household weekly income, we use the *predicted* wage (and

[19] Figures are given for April 2001.
[20] Working Families' Tax Credit Statistics, Inland Revenue Quarterly Enquiry (2002).

not actual wage) of the earner in the sample[21] using wage data from before 1999. The weekly wage of the earner in the sample is calculated by multiplying the predicted hourly wage with hours worked and then the total household weekly income will include the weekly wage of other members of the household. Since WFTC affects the wage through the household income, we cannot put actual weekly wages into calculating the $WFTC$ variable as it would be endogenous and this is why we use the predicted household income.

In addition to this, instead of using this $WFTC$ variable in the wage analysis that follows, we use the *rate* of WFTC ($WFTCRate$). Since wages are used to calculate the $WFTC$ variable, they are endogenous when used as a regressor in any analysis where wage is the dependent variable. It is the case that $WFTC$ will increase as wages (or household income) decreases. The $WFTCRate$, on the other hand, is a non-linear variable which weights household $WFTC$ by *(predicted)* weekly wages.

- $WFTC\ Rate = \left(\frac{WFTC}{weekly\ wage}\right)$

FC Generosity The change in tax credit criteria in 1999 meant that WFTC was more generous compared with FC for three main reason: (1) The threshold increased from £86.65 (per week), (2) Credit for each child increased from £19.85, (3) The taper fell from 70%[22]. By constructing a counterfactual FC variable using this criteria when WFTC was in operation, we can calculate the change in generosity of the policy, such that:

- $FC\ Generosity = \left(\frac{WFTC-FC}{weekly\ wage}\right)$

This will allow us to distinguish between the two effects on wages: change in generosity and change in visibility.

[21] The earner referred to here is the female worker when we restrict the analysis to just women and likewise, it is the male workers when we restrict the analysis to men.

[22] In 1998-99 the last year of Family Credit, the basic rate was £52.30 and the 30 hour bonus was £11.05.

5.4 Spillover Effect

The theory suggests that as the elasticity of substitution increases between eligible and ineligible workers and/or as the fraction of eligible increases, then there is a stronger spillover on to the wages of all "similar" workers. We measure spillover in two ways: (1) by industry and (2) by education group. When we use the WFTC claim variable, this is simply the fraction of claimants by industry (education group) and when using the WFTC rate variable this is the average rate in the industry (education group) weighted by the fraction of eligible in the industry (education group). Tables 1a and 1b shows these figures.

5.5 Two-Stage Empirical Strategy

The two components to the empirical strategy are as follows:

(1) The wage is estimated before the imposition of NMW (i.e. predicted wages are calculated using data before 1999)

(2) The predictions from stage 1 are used to compare the before and after effect of WFTC from 2000 to 2003.

Finally, we extend the analysis to identify the workers with a binding NMW to see how the tax credit affects their wage outcomes.

5.5.1 Stage One: Predicted Wage

Using a linear regression method on the log wage before 1999, W_i^c, we estimate the expected log wage. This is done by controlling for individual, family and job characteristics in the vector X_i, where X_i is a 1xK vector of conditioning variables[23]. The aim of this exercise is to predict the wage as closely as possible to

[23] The controls include: Age, Education, Region, Ethnicity, Experience (plus higher orders), Tenure (plus higher orders), Marital Status, Number of Children, Firm Size, Public Ownership, Occupation Type, Industry Type, Full-time Status.

the earned wage without the NMW and WFTC.

The expected wage, w_i, is calculated such that:

$$E(\log wage|X)_i = \hat{\alpha}X_i = \hat{w}_i$$

Is there a Problem of Sample Selection? The predicted wage variable is key to our analysis. We make the assumption that the *relative* rates of return, $\hat{\alpha}$, on the vector X remain the same in the post-WFTC period (2000-2003). This is not to say that the rates of return are unchanged throughout, but we are assuming that if there are changes in the rates of return, they will be the same for both eligible and non-eligible workers with the same predicted wage. This is a less restrictive assumption, however it relies on the supposition that an increase in labour supply does not change the composition of each group. If, for example, a change in tax credit increases participation by drawing in people from unemployment or inactivity, one may argue that the returns to skill for the eligible group fall relative to the non-eligible and so, in effect the average "predicted" wage falls. Although it is difficult to solve this problem of sample selection, we argue in this section that the analysis is free from these selection issues.

Firstly, we use a dataset[24] with an extremely detailed education variable (which proxies for skill) and so we do not have the issue of selection on observables. It can be seen from the descriptive statistics in Table 1c that the proportion of eligible with no education does not increase for the eligible group relative to the ineligible after 1999. Secondly, the introduction of the NMW imposes a lower bound below which the employer cannot cut the gross wage. In essence, this means that a huge influx of lower skilled workers will not impact the wage as severely as it would have done without a minimum wage. Finally, in the particular case of WFTC, there is evidence to suggest that participation only increased for lone mothers. Recent work by Blundell et al (2005) finds that although there was a 3% increase in participation for lone parents (where

[24] The Quarterly Labour Force Survey.

the sample of lone fathers is very small), there was no effect on married mothers and a -0.5% effect on married fathers. In effect, this suggests that the increase in participation is only an issue for a sub-sample of eligible workers. In the analysis that follows, we look separately at men and women and for each, the effect on the sub-samples of married and single parents.

5.5.2 Stage Two: Estimating the Wage Change

Let us consider the situation in which we have two groups of people: (1) Those eligible for (and/or claiming) WFTC and (2) those not eligible (and/or not claiming). The model predicts that the employer can gain by cutting the gross wage of the eligible (claimant). In addition, the model in Section 3 predicts that as the elasticity of substitution between eligible and ineligible workers increases, the aggregate effect on the wages of all people in the same skill group will become stronger.

In the absence of the NMW, we would therefore want to estimate the following wage equation(s):

(1) $W_i^* = \delta_0 + \delta_1 \hat{w}_i + \delta_2 \Pr(Claim\ WFTC)_i + \delta_3 \theta^{ind} + \delta_4 \theta^{edu} + \varepsilon_i$

(2) $W_i^* = \gamma_0 + \gamma_1 \hat{w}_i + \gamma_2 WFTCrate_i + \gamma_3 FCGen_i + \gamma_4 (WFT\bar{C}rate^{ind} * \theta^{ind}) + \gamma_5 (WFT\bar{C}rate^{edu} * \theta^{edu}) + v_i$

Where $\hat{w}$ captures the predicted wage before the policy changes of 1999 are introduced and equation (1) and (2) use the different measures of WFTC, $\Pr(Claim\ WFTC)_i$ and $WFTCrate_i$, respectively. In equation (2) we also include a measure of the change in generosity from FC to WFTC, $FCGen$. The spillover, θ^{ind} and θ^{edu}, measures the fraction of claimants (eligible) in each industry and education group, respectively. When using the WFTC rate variable, we use these fractions to weight the average WFTC rate in each industry, $WFT\bar{C}rate^{ind}$, and average WFTC rate in each education group, $WFT\bar{C}rate^{edu}$, respectively.

For simplicity, we will use a general expression in the rest of this section:

$$W_i^* = \beta_0 + \beta_1 \hat{w}_i + \beta_2 TC_i + \beta_3 (T\bar{C}^{ind} * \theta^{ind}) + \beta_4 (T\bar{C}^{edu} * \theta^{edu}) + u_i$$

$$\text{st. } TC = \{\Pr(Claim\ WFTC)_i, (WFTCrate_i, FCGen_i)\}$$

Where TC is the tax credit variable, which represents two different measures: $\Pr(Claim\ WFTC)$ and $WFTCrate$ (including the change in generosity variable, $FCGen_i$ and where $(\bar{TC} * \theta)$ is a measure of the "Spillover" effect. This is estimated by taking the average WFTC, $\bar{TC}$, in each industry (education group) and then weighting it by the fraction of WFTC eligible workers, θ, in that industry (education group)[25].

However, the imposition of the NMW in April 1999 distorts the actual wage from the predicted wage for those who the NMW binds. Figure 3 represents this distortion. It highlights that for those with a binding NMW, there exists a "Gap" between actual and predicted wage. For those who are unaffected by the NMW (i.e. those who were previously earning above the national minimum), no "Gap" exists between the actual wage and the predicted wages. This imposition has two main roles. Firstly, it acts as a point of censor and secondly, it can be used as an identification restriction.

This imposition implies that we have a censored regression model where the censoring point in 1999 is £3.60, the NMW[26]. At this point we have a positive probability mass at the NMW. Essentially:

$$W_i = \begin{cases} w_{\min} & \text{if } W_i^* \leq w_{\min} \\ W_i^* & \text{if } W_i^* > w_{\min} \end{cases}$$

In essence if W_i^* denotes the actual (log) wage where $E(\log wage|X)_i = \hat{\alpha} X_i = \hat{w}$, we only observe W_i^* when $W_i^* > w_{\min}$ and so we can define observed (log) wages, W_i , as:

$$W_i = \max(w_{\min}, W_i^*)$$

In the context of our model this implies:

$$W_i = \max(w_{\min}, \beta_0 + \beta_1 \hat{w}_i + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) + u_i)$$

Figure 4 gives a clear representation of the type of effects we would expect.

[25] When using the WFTC (LFS) we only use the fraction of claimants in each industry and education group, respectively.
[26] The NMW changes between 1999 and 2003 and we adjust the censoring point accordingly.

Standard Censored Tobit Model A model that is directly relevant here is the Tobit model (Tobin, 1956). We can re-write the above as :

$$W_i - w_{\min} = \max(0, (\beta_0 + \beta_1 \hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) + u_i) - w_{\min})$$

To estimate $\boldsymbol{\beta}$ we assume W_i^* given the covariates has a homoskedastic normal distribution (i.e. $u|x \sim Normal(0, \sigma^2)$). Since the model is in log transformation, the assumption is more plausible but is still quite strong. We compare these Tobit estimates with a non-parametric alternative in the following section. The advantages of a non-parametric estimator, according to Berg (1998), are that it is robust to non-normality of the error terms and it is robust to heteroskedasticity (which is common in most cross sectional datasets).

Censored Least Absolute Deviation: Powell's Estimator An alternative way to estimate the model, without imposing a structure on the distribution of u is to use Powell's (1984) censored least absolute deviation (LAD) estimator. Powell's estimator is restricted to a linear functional form and he shows that the median function $q_{50}(\boldsymbol{\beta}, \hat{w_i}, TC_i, (\bar{TC} * \theta))$ is equal to the function $\max(w_{\min}, \beta_0 + \beta_1 \hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) + u_i)$, such that:

$$q_{50}(W_i | \hat{w_i}, TC_i, (\bar{TC} * \theta)) = \max(w_{\min}, q_{50}(\beta_0 + \beta_1 \hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) + u_i | \hat{w_i}, TC_i, (\bar{TC} * \theta)) =$$
$$\max(w_{\min}, \beta_0 + \beta_1 \hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta))$$

Where q_{50} denotes the median of the distribution conditional on covariates and the median distribution of u_i is assumed to be zero. The censored LAD objective is to consistently estimate $\boldsymbol{\beta}$ by the parameter vector that minimises:

$$\sum_{i=1}^{N} |W_i - \max(w_{\min}, \beta_0 + \beta_1 \hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta))|$$

The consistency of this estimator does not require knowledge of the distribution of the u, nor is it assumed that the distribution is homoskedastic, only that it has median 0^{27}.

Identification with the NMW The NMW offers an interesting variation which allows us to test the hypothesis that if the employer is restrained by an exogenous barrier to cut the gross wage, she cannot cut the wage below the predicted wage. In the event that a NMW binds, the implication is that for those who have a predicted wage below the NMW, there no negative tax credit effect. Given that we have some workers with a predicted wage above the NMW and some with a predicted wage below the NMW, we test this by identifying each group to see how WFTC affected each separately in an extended Tobit model.

Since we want to estimate:

$$W_i^* = \beta_0 + \beta_1 \hat{w}_i + \beta_2 TC_i + \beta_3 (\bar{TC} * \theta) + u_i$$

Where we assume that the error is normally distributed (i.e. $u|x \sim Normal(0, \sigma^2)$) and, as before, a censored model. The introduction of the NMW in April 1999 imposed the restriction on observed wages to be:

$$W_i = \max(w_{\min}, W_i^*) = w_{\min} + \max(0, W_i^* - w_{\min})$$

The average wage, given the tax credit and predicted wage, is given by:

$$E[W_i|\hat{w}_i, TC_i] = w_{\min} + E[\max(0, W_i^* - w_{\min})|\hat{w}_i, TC_i]$$

$$= 0. \Pr(W_i^* < w_{\min}) + (1 - \Pr(W_i^* < w_{\min}) E[W_i^* - w_{\min}|W_i^* \geq w_{\min}, \hat{w}_i, TC_i]$$

$$= (1 - \Pr(W_i^* < w_{\min})[-w_{\min} + E[W_i^*|W_i^* \geq w_{\min}, \hat{w}_i, TC_i]]$$

Since we assume a standard normal, this can be re-written as:

[27] As pointed out by Deaton (1997), a useful property of quantiles is that they are preserved under monotone transformations. Here, since we have a set of positive observations, and we take the logarithms, the median of the logarithm of the median of the untransformed data.

$$E[W_i|\hat{w_i}, TC_i] = \Phi(\frac{\beta_0 + \beta_1\hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) - w_{\min}}{\sigma})[-w_{\min} + E[W_i^*|W_i^* \geq w_{\min}, \hat{w_i}, TC_i]]$$

To work out the final term, we use the truncated normal distribution [28]. Therefore, if $u|x \sim Normal(0, \sigma^2)$, then:

$$E[u_i|\hat{w_i}, TC_i, u_i > w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC} * \theta)] = \frac{\sigma\phi(\frac{w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC}*\theta)}{\sigma})}{1 - \Phi(\frac{w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC}*\theta)}{\sigma})}$$

Substituting this into the wage equation, W_i, we get[29]:

$$W_i = w_{\min}.\Pr(W_i^* < w_{\min}) + (1 - \Pr(W_i^* < w_{\min}))(\beta_0 + \beta_1\hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC}*\theta) + \frac{\sigma\phi(\frac{w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC}*\theta)}{\sigma})}{1 - \Phi(w\frac{w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC}*\theta)}{\sigma})}$$

And so the equation that we estimate is:

$$W_i = \beta_0 + \beta_1\hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) + \Pr(W_i^* < w_{\min})(w_{\min} - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC} * \theta)) + \phi(\frac{w_{\min} - \beta_0 - \beta_1\hat{w_i} - \beta_2 TC_i - \beta_3(\bar{TC}*\theta)}{\sigma})$$

Essentially this equation uses the data on everyone to estimate the equation in Section 5.3. In addition, by using the probability of the predicted wage being below the minimum wage, we can use this equation to see how the tax credit will affect those for who the NMW binds. Basically this is a robustness check on our estimates as we make the assumption that the NMW acts as a exogenous barrier and so we would expect that the tax credit will have no effect or less of an effect.

5.6 Standard Error Correction of the Predicted Regressor

It is not immediately clear how to deal with the standard errors since we use cross sectional data, $\hat{w_i}$ is constructed using data from a *different* dataset (i.e. different period to that of the Second Stage). It is not

[28] We suppose that $z \sim Normal(0, 1)$, then for any constant c, $E(z|z > c) = \frac{\phi(c)}{1 - \Phi(c)}$ and $\phi(.)$ is the standard normal denisty of z given $z > c$ is $\phi(z)/[1 - \Phi(c)]$, $z > c$, and then intergrating $z\phi(z)$ from c to ∞.

[29] Where $\Pr(W_i^* < w_{\min}) = 1 - \Phi(\frac{\beta_0 + \beta_1\hat{w_i} + \beta_2 TC_i + \beta_3(\bar{TC} * \theta) - w_{\min}}{\sigma})$. We use the general notation for simplicity.

automatically clear how to correct the standard errors since the $\hat{w_i}$ is neither a straightforward generated regressor, nor a regressor generated from a "Split Sample" as described by Angrist and Krueger (1994).

After much deliberation, we find that the simplest way to ensure the robustness of the standard errors is to conduct what we call a Two Stage Bootstrap: The resampling method of bootstrapping is applied first to the data which generates $\hat{w_i}$ and then to the final regression(s) in Stage 2.

6 Data & Results

The empirical investigation is done using the UK's Quarterly Labour Force Survey (LFS). The LFS is a repeated cross-section quarterly survey and it has information on individuals, households and families. This includes, information on employment, earnings and a variety of control variables needed to estimate the (log) wage equation in the first stage. The constructed data set uses data from 15 quarterly LFSs: from 1997 quarter 4 (December-Febuary) to 2003 quarter 1 (March-May), inclusive[30]. The sample includes people who are aged between 21 and 60 years old[31]. People in full-time education, sick/disabled or on a government training programme are removed from the sample. In addition, observations of gross wages below £2 and above £60 are excluded. The resulting sample size, after pooling all 15 quarters, is 366,317.

The LFS does contain information on benefit receipt[32] but it does not indicate how much WFTC the reported claimant receives. In addition to using the dummy variable that indicates receipt in the analysis that follows, data on household income, hours worked, presence of children (i.e. the eligibility criteria) is used to "roughly" estimate the amount of benefit received (or, at least, how much she is eligible for).

Tables 1c presents the descriptive statistics for eligible and for those who are not eligible, before and after 1999. However, it is important to note that these are unmatched and only give the group averages.

[30] Although data is available beyond this period, WFTC is replaced in April 2003 by the Working Tax Credit.
[31] We use data on people over 21 to avoid the problem of having two different minimum wages.
[32] This includes: Family Credit (pre-October 1999), WFTC, Maternity Allowance and Guardian Allowance.

There are a similar proportion of white workers in the sample (around 93-96%) and the number working in the public sector is roughly 27% for both groups. The non-eligible and eligible tend to have the same mean age of 35-38 years and the tenure is fairly similar at around 33 months for the ineligible and 26 months for the eligible. Also, the proportion each group being married is around 60%. There are some noticeable differences between the two groups. In particular, the mean hourly wage for the eligible group is £6.00 and for the non-eligible group it is £8.24 and the proportion with no qualifications in the non-eligible group is 12% versus 18% in the eligible group. The number of hours worked is around 36 hours in the non-eligible group compared with 28 hours in the eligible group and (as expected) the eligible have a higher probability of children.

The summary statistics indicate that the eligible group are not identical to the ineligible. This is not a surprise and although we are not solely comparing people with children to those without (as identification comes from various sources of the eligibility criteria), one would expect differences in characteristics. However, for the purpose of this analysis, the most important thing is that the *composition* of the groups do not change. It can be seen from Table 1c that there is almost no change in the summary statistics for the eligible and ineligible before and after 1999 (the year that both the NMW and WFTC where introduced). As described in the empirical framework, workers are matched on their predicted wages before 1999 and then the change in gross wage is assessed after the introduction of WFTC. As a means of checking that the WFTC variables are representative, Figure 5 uses the WFTC indicator variable to show that as the predicted wage increases, the fraction of claimants fall. In the same way, Figures 6 and 7 show that as the amount of WFTC (rate) falls and as the fraction of eligible people falls, the predicted wage increases, respectively.

Another pressing issue is that when using the "WFTC Rate" variable, not all assumed eligible are actual claimants. To ensure that this sample of eligible workers is representative of the actual group of claimants, Figure 8 and Figure 9 compare the fraction of recipient families by gross weekly earnings with that of those in the sample. It can be seen that the patterns are fairly similar and so it is probable that the wage distribution is well represented.

6.1 Results

In this section we present the OLS, Tobit and Censored LAD results on log wages for men and women, respectively. In addition, we look separately at the results for single men, married men, single women and married women. The regression results in Tables 2a and 2b estimate the equations in Section 5.3 using the probability of claiming WFTC, Pr($Claim\ WFTC$), and the WFTC Rate variable, $WFTCrate$, respectively. We end this section by presenting the results in Tables 3a and 3b for when the NMW is used for identification. This is essentially used as a robustness check for the previous results.

6.1.1 Men

The regressions are first performed for men, with the output displayed in Table 2a. This table and Table 2b, report the marginal effects of WFTC and the spillover effect on the actual (log) wage, W_i^*, between 2000 and 2003. There are three striking results to come out of the analysis on men. The first interesting result is that a WFTC claimant has approximately a 20% fall in his gross wage relative to a similarly skilled non-claimant (non eligible) who has the same predicted wage. From Panel B, when we use the WFTC Rate, the results are confirmed. Here the results tell us that as the rate of WFTC increases for the eligible worker, the gross wage falls 24% relative to a similarly skilled non eligible worker. When we evaluate this at the average weekly wage and average weekly WFTC, this implies that there is a 35% shift in incidence from the eligible worker to the employer. The results become weaker when we look at lone fathers but since the number of lone fathers, claiming WFTC is very small (Blundell et al, 2005), we would expect this effect.

The second salient result is that there is a strong and negative spillover effect when we look by industry and by education group. When using the WFTC rate variable in Panel B, which has the advantage of telling us the amount the worker is eligible for, this result is essentially telling us is that as the fraction of men eligible for WFTC increases in an industry (in an education group), there is a wage fall for all similar workers by about 6% (15%). This is approximately -0.2% (-0.1%) when evaluated at the average WFTC rate, which is weighted by the fraction of total eligible.

Finally, in Panel B where we include a measure which controls for the change in the tax credit generosity from Family Credit to WFTC, there does not seem to be any significant effect. In essence, this implies that the effect on the gross wages is a result of the change in payment method (i.e. the payment through the wage packet).

6.1.2 Women

As noted earlier, it is traditional to focus on women when looking at the participation effects of tax credits. However, when looking at the wage impact the reasoning for this is less obvious since men are at least, if not more, likely to claim the tax credit in their wage packet. In particular in a coupled household, it is more likely that it is the male household member who will be in the labour force and so he is more likely to be the claimant. The results in Table 2b offer interesting insights and confirm this hypothesis. When using the probability of claiming WFTC variable in Panel A, the results indicate that the direct effect of WFTC is negative only for lone mothers and a positive effect on married women[33]. However, these results are not very stable and when we replace the claim variable with the WFTC rate variable in Panel B, the effect on both groups is insignificant. It is not entirely obvious why the downward direct effect should be stronger for men than women. One explanation may be that women have a lower average wage than men and they work, on average, fewer hours and so the potential incidences from WFTC are smaller. Alternatively, it may be that

[33] When using the Censored LAD measure.

women are more likely to be "protected" from a wage (growth) cut because of the NMW barrier.

The result that is fascinating for women is the strong and negative spillover effect, by industry and education groups. This is the case when all women are grouped together, as with men. The result is essentially telling us that as the fraction of claimant women increases in the work place, there is a bigger wage fall for everyone in the same skill group (i.e. those with the same predicted wage). This is coherent with the theory laid out in Section 3 where the proposition implies that, given the elasticity of substitution, the shift in the burden of the tax incidence increases with the fraction of eligible (claimants). When comparing the results from the three different estimation techniques, the story remains coherent but the order of magnitude of the coefficients fall when we use the Censored LAD. The results from the WFTC Rate variable in Panel B confirm this and imply that as the fraction of women eligible for WFTC increases in an industry (in an education group), there is a wage fall for all similar workers by about 9% (4%). This is approximately -0.3% (-0.7%) when evaluated at the average WFTC rate, which is weighted by the fraction of total eligible.

6.1.3 NMW Identification

Tables 3a and 3b run an OLS regression using the probability of claiming WFTC variable and WFTC rate variable, respectively. By using the NMW for identification purposes, we are essentially running a robustness check to ensure that the eligible workers with a predicted wage below the minimum wage are "protected" from any wage cut resulting from the introduction of the NMW. We identify whether a worker has a positive probability of having a predicted wage below the NMW and interact it with the WFTC variable. In addition, we control for the potential selectivity bias associated with this probability (using the truncated normal distribution). Although the results in Table 3b, which uses the WFTC rate variable are insignificant, in Table 3a it is clear that the WFTC claim does not affect the workers for who the NMW binds in the same way as those for who the NMW doesn't bind. Moreover, the results seem to indicate that there is a wage increase for claimant workers (above their predicted wage).

7 Extensions

In this section, we try to broaden the analysis to investigate some interesting questions. First, does the size of the firm have any impact on the share in incidence between workers and firms? Second, is the WFTC variable endogenous?

7.1 Firm Size

There is a large literature relating the size of the firm to wages. Brown & Medoff (1989) conclude that one of the main reasons why wages are higher in larger firms is that they hire higher quality workers. So far we have assumed a competitive model and so we would expect that the hourly wages would be the same in all firms, otherwise we would need a model with rents. We try to investigate this proposition by applying the methodology from Section 5 to compare (1) Small sized firms (employing 1-19 workers), (2) Medium sized firms (20-49 workers) and (3) Large sized firms (more than 50 workers).

Tables 4a and 4b report the OLS, Tobit and Censored LAD estimates for each firm size category using the probability of claiming WFTC, $\Pr(Claim\ WFTC)$, and the WFTC Rate variable, $WFTCrate$, respectively for men and women. The main consistent result coming from this analysis is that as the size of the firm increases, the degree of "spillover" by industry also increases. This seems quite reasonable given that larger firms have more uniformity in wage contracts across workers as there are more people doing identical jobs and receiving the same hourly wage rate. It would be harder for the employer to only cut the gross wage of those claiming WFTC and to leave the wage of the non-claimants unchanged. Instead, the higher industry spillover effect reflects that the burden of the tax credit is shared across all workers and that as the fraction of claimants increases, the size of the cut also increases. The "direct" effect results and the "spillover" effect by education group are, however, inconclusive. We may have expected that the direct effect would be stronger in smaller firms, where contracts are more individualistic and so it becomes "easier" for the employers to discriminate compared to large firms in which there are many workers with the same characteristics and differentiated only by eligibility.

7.2 Endogeneity of the WFTC Variable

The estimation technique used to derive the WFTC rate variable uses the eligibility criteria to estimate the amount of WFTC a worker is eligible for, given his predicted wages. In the analysis we compare the results from using this variable to the WFTC claim variable obtained from the LFS. This LFS indicator variable is the number of reported claimants. Since not all (predicted) eligible people are actual claimants, we have two main concerns:(1) Sample selection in the "take up"/claim of WFTC and (2) Problems with "switchers" and new entrants to WFTC which may distort the sample. Neither of these issues would be a problem if the WFTC dummy variable was exogenous. In this section, we first discuss these two issues and then try to test the endogeneity of the WFTC dummy variable using the Smith-Blundell (1986) procedure.

7.2.1 Sample Selection in the Take-up Rate

A well known phenomena in any analysis on tax credits is that the take-up rate is not 100% and there is often selectivity associated with who claims. In Brewer (2003) a full literature review is given on the work done to explain non-take up. The main explanations given for why eligible people do not claim their tax credit are that there are distortions in the budget constraint; stigma costs associated with receipt and/or costs of time to proceed with the claim (relative to the gain). Although we know that the WFTC recipients will be a select group in general, the two-stage method used in this paper should control for this by comparing people with the same pre-WFTC wage. However, we may still be concerned by the sample selection associated with which of the eligible workers actually claim. Assuming that the calculated number of eligible, using the method in Section 5.3, are the correct number of eligible and that those who report claiming WFTC in the LFS do actually claim WFTC, we could try to set up a sample selection model to correct for it. However, in order to do this we need some sort of instrument which would determine take-up but not be in the wage equation and it is not entirely obvious what instrument should be used.

7.2.2 Entrants, Switchers & Other Compositional Changes

Throughout the paper we assume that the composition of claimants and non-eligible (and/or non-claimant) remain the same. This is not to say that we assume that the labour supply remained unaltered, given that one of the main aims of the policy is to encourage participation. Instead we were assuming that the average observed and unobserved characteristics in each sub-group remains the same.

However, the entry of previously unemployed or inactive workers may threaten the compositions and/or change in behaviour (modification of characteristics) of a previously ineligible worker to become eligible. For example, the variation for eligibility comes from the presence of children, a low household income and a minimum working hours requirement of 16 hours. Although in the short-run it may be difficult for a worker to adjust the former two factors to become eligible, she can (possibly) alter the household hours of work to maximise a gain from WFTC or moreover, to even secure eligibility.

According to Battistin and Rettore (2003) if there is an entry effect, stronger conditions for identification are needed. One way to test to see if entry/switching alter the compositions would be by using a panel dataset, such as the Five Quarter (LFS) Longitudinal Dataset. Using a panel data set framework, we can estimate the wage growth of workers, controlling for the factors that determine eligibility as well as all the other controls used in the analysis. We expect that the wage growth will be low for those receiving WFTC but who were not previously. However, there is one main problem here: we only have quarter 4 1998 to quarter

4 1999 which would give us data before the introduction of the NMW and WFTC and data afterwards and so the sample size is too small to give us any credible results.

7.2.3 Endogeneity Test for the *WFTC* Variable: Smith-Blundell Procedure

Given that it is not entirely obvious how we can "solve" the two problems mentioned above, we instead test to see if the WFTC variable is endogenous. If the WFTC variable is not endogenous, the two problems would not be an issue.

If it is the case that the LFS WFTC claim variable, $WFTC^I$, is endogenous in the censored regression model, such that:

$$W_i = \max(w_{\min}, \beta_0 + \beta_1 \hat{w_i} + \beta_2 WFTC_i^I + \beta_3(W\bar{F}TC * \theta) + u_i)$$

$$\text{Where } WFTC_i^I = \alpha_0 + \alpha_1 \hat{w_i} + \alpha_2 HHInc_i + \alpha_3 Hours_i + \alpha_4 Children_i + v_i$$

In the $WFTC_i^I$ equation we know that the latter three explanatory variables are part of the eligibility criteria and since both household income, $HHInc$, and hours worked, $Hours$, are potentially endogenous, for identification we assume that the presence of children, $Children$, is exogenous. For identification we need the rank condition $\alpha_4 \neq 0$.

In this section we use a two-step procedure proposed by Smith and Blundell (1986) that will deliver a simple test for the endogeneity of the WFTC variable. Under bivariate nomality of (u, v) we can write:

$$u_i = \phi v_i + e_i$$

Where $\phi = \eta/\tau^2, \eta = Cov(u, v), \tau^2 = Var(v)$, and e is independent of v with zero mean normal distribution and variance, say τ_1^2. Further, because (u, v) are independent of $\hat{w_i}, e$ is independent of $(\hat{w_i}, v)$. Thus plugging this into the Tobit gives:

$$W_i = \max(w_{\min}, \beta_0 + \beta_1 \hat{w_i} + \beta_2 WFTC_i^I + \beta_3(W\bar{F}TC * \theta) + \phi v_i + e_i)$$

where $e|\hat{w}_i, v \sim Normal(0, \tau_1^2)$. It follows that, if we knew v we could estimate all coefficients by standard censored Tobit. Since we don't, we follow the Smith-Blundell procedure such that: (a) Estimate the reduced form of TC by OLS; this step gives $\hat{\boldsymbol{\alpha}}$. Define the reduced-form OLS residual as $\hat{v}_i = WFTC_i^I - \hat{\alpha}_0 - \hat{\alpha}_1\hat{w}_i - \hat{\alpha}_2 HHInc_i - \hat{\alpha}_3 Hours_i - \hat{\alpha}_4 Children_i$. (b) Estimate a standard Tobit of W_i on $\hat{w}_i$, $WFTC_i^I$ and $\hat{v}_i$.

Table 5 shows that since $\hat{v}_i$ is insignificant, there is little evidence to suggest that the WFTC variable is endogenous in the equation[34].

8 Discussion & Policy Implications

The main aim of this paper was to analyse the impact of a tax credit on wages in a general equilibrium framework. By using this set-up, we could encapsulate the effect on the economy as a whole and not solely on the claimant. Moreover, we accounted for how changes in the design of the policy altered modelling assumptions. For example, the WFTC was not only more generous than Family Credit (its predecessor), but it was paid through the wage packet and this in turn altered the amount of information to the employer.

The results presented in Section 6 imply that there was a significant shift in the burden of tax credits, in line with the theory presented. This is of critical policy importance as we can no longer assume that it is the case that the person eligible for such a tax credit is the sole beneficiary. When calculating the share of incidence using the weekly wage and average weekly WFTC amount, we find that for men almost 35% incidence is shifted to the employer. In terms of spillover effect onto the wage of both eligible and similarly skilled ineligible, as the amount of WFTC (weighted by the fraction of eligible) rises in an industry and/or education group, there is a -0.2% fall in the wage (given the predicted wage) by industry and -0.1% fall by education group for men. For women, the spillover effect is -0.3% by industry and -0.7% by education group.

[34] Under $\phi = 0, e = u$, normality of v plays no role: as a test for endogeneity of $WFTC^I$, the Smith-Blundell approach is valid without any distributional assumptions on the reduced form of $WFTC^I$.

Moreover, the increase in generosity does not explain the shift in incidence, indicating that the change in payment method played an important role. Finally, it is not clear why there is no significant direct effect on women. One possible explanation may be that women have a lower average wage than men and they work, on average, fewer hours and so the potential incidences from WFTC are smaller. Alternatively, it may be that women are more likely to be "protected" from a wage (growth) cut because of the NMW barrier.

These results are important in their own right since they highlight the consequences of the expansion, application and generosity of tax credits. However, in the case of the UK, they are important with respect to the new changes in tax credit policy. In April 2003 the government's new tax credit (Child Tax Credit and Working Tax Credit) was introduced. Essentially, the new system divides the old WFTC into these two parts. Child tax Credit is paid to low income families with children, regardless of whether the parents are in work. The Working Tax Credit, on the other hand, works in a similar way to WFTC (i.e. contingent on working a minimum of 16 hours and earning below a certain threshold) but unlike WFTC, the Working Tax Credit is not just restricted to those with children. The idea is to make work pay for non-parents as well as parents. For the purpose of future research, investigating these changes would be interesting.

In addition, it may be interesting to look closer at the institutional role with regard to extracting tax credit incidence. In the case of minimum wages, it has been discussed that they act as a barrier such that they reduce the power of the employer to cut the gross wage. Perhaps looking at the public versus private sector and/or unionised versus non-unionised firms can help to shed some more light on whether institutions either prevent or encourage the employer to extract the tax credit incidence.

9 Conclusion

The increased use of tax credits as a method of "in work benefits" has raised a great deal of popular interest in the UK and in many other countries where they have been initiated. The move to integrate the social security system within the tax system was favoured as a means to reward people who are in work and to "make work pay"[35]. This paper focuses on looking at the indirect consequences of such a policy by focusing on the effect on gross equilibrium wages in the UK following the introduction of the Working Families' Tax Credit in October 1999. There is evidence to suggest that the employer does share in the incidence of the tax credit by cutting the wage of claimant workers relative to non-claimants and through a spillover effect on all (similarly skilled) workers.

[35] Statement made by Chancellor Gordon Brown, 1998.

References

[1] Atkinson, A.B. & Stiglitz, J.E. (1980) "Lectures in Public Economics", McGraw-Hill Book Company (UK) Ltd.

[2] Battistin, E. & Rettore, E. (2003) "Another Look at the Regression Discontinuity Design", Institute for Fiscal Studies, CeMMAP Working Paper CW01/03.

[3] Berg, G.D. (1998) "Extending Powell's Semiparametric Censored Estimator to Include Non-Linear Functional Forms and Extending Bucninsky's Estimation Technique", Center for Economic Analysis, University of Colorado WP98-27.

[4] Bingley, P. & Lanot, G. (1999) "Labour Supply & The Incidence of Income Tax on Wages", Centre for Labour Market & Social Research.

[5] Blundell, R., Brewer, M. & Shephard, A. (2005) "Evaluating the labour market impact of Working Families' Tax Credit using difference-in-differences", HM Revenue and Customs

[6] Blundell, R. & Hoynes, H. (2001) "Has 'In-Work' Benefit Reform, Helped the Labour Market ", National Bureau of Economic Research, 8546.

[7] Blundell, R. & Walker, I. (2001) "Working Families' Tax Credit: A Review of the Evidence, Issues and Prospects for Future Research", Inland Revenue.

[8] Blundell, R., Duncan, A.S. & Meghir, C. (1998) "Estimating Labour Supply Responses using Tax Policy Reforms", Econometrica, 66, 827-861.

[9] Brewer, M. (2003) "Estimating Models of Benefit Take-up", Inland Revenue Working Paper 1b.

[10] Brewer, M., Duncan, A., Shephard, A. & Jose-Suarez, M. (2005) "Did Working Families' Tax Credit work? The final evaluation of the impact of in-work support on parent' labour supply and take-up behavioyr in the UK", HM Revenue and Customs.

[11] Brewer, M. & Gregg, P. (2001) "Lone Parents, the Working Families' Tax Credit and Employment in Households", The State of Working Britain (Update 2001), Centre of Economic Performance.

[12] Brewer, M., Clark, T. & Wakefield, M. (2002) "Five Years of Social Security Reforms in the UK", Institute for Fiscal Studies, Working Paper W02/12.

[13] Brown, C. & Medoff, J. (1989) "The Employer Size-Wage Effect", The Journal of Political Economy, vol. 97, 1027-1059.

[14] Cossa, R., Heckman, J. J. & Lochner, L. (2002) "Learning-by-Doing vs. On-the-Job Training: Using Variation Induced by the EITC to Distinguish between Models of Skill Formation", National Bureau of Economic Research, 9083.

[15] Cossa, R., Heckman, J. J. & Lochner, L. (1999) " Wage Subsidies & Skill Formation: A Study of the Earned Income Tax Credit, Working Paper.

[16] Deaton, A., (1997) "The Analysis of Household Surveys: Microeconometric Analysis for Development Policy", John Hopkins University Press.

[17] Eissa, N. (1995) "Taxation and Labour Supply of Married Women: The Tax Reform Act of 1986 as a Natural Experiment", National Bureau of Economic Research, 5023.

[18] Eissa, N. & Leibman, J. B. (1996) "Labour Supply Response to the Earned Income Tax Credit", The Quarterly Journal of Economics, vol 111, 605-637.

[19] Fullerton, D. & Metcalf, G. E. (2002) "Tax Incidence", National Bureau of Economic Research, 8829.

[20] Goodman, A. (2001) "Inequality and Standards of Living in Great Britain: Some Facts", Institute for Fiscal Studies Briefing Note No. 19.

[21] Harberger, A. C. (1962) "The Incidence of the Corporation Income Tax", The Journal of Political Economy, vol 70, 215-240.

[22] Hausman, J. A. (1978) "Specification Tests in Econometrics", Econometrica 46, 1251-1271.

[23] Inland Revenue, "Working Families' Tax Credit & Family Credit Statistics", Quarterly Enquiry, November 1999.

[24] Leigh, A. (2004) " Who Benefits from the Earned Income Tax Credit? Incidence Among Recipients, Coworkers & Firms", Working Paper.

[25] Leigh, A. (2005) "Earned Income Tax Credits and Labour Supply: New Evidence from a British Natural Experiment", (formerly "Optimal Design of Earned Income Tax Credits: Evidence from a British Natural Experiment", Australian National University Centre for Economic Policy Research Discussion Paper 488), Working Paper.

[26] Lydon, R. & Walker, I. (2004) "Welfare-to-Work, Wages and Wage Growth", IZA Discussion Paper 1144.

[27] Meyer, D.B. & Rosenbaum, D.T. (1999), "Welfare, the Earned Income Tax Credit & the Labour Supply of Single Mothers", National Bureau of Economic Research, 7363.

[28] Rothstein, J. (2004) "Estimation if Tax Incidence from Variation Across the Wage Distribution: The Earned Income Tax Credit", Working Paper.

[29] Smith, R. & Blundell, R. (1986) "An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labour Supply", Econometrica 54, 679-685.

Table 1a: CLAIMANTS/ELIGIBLE BY INDUSTRY

	No. of Eligible	Average WFTC Rate	No. of Claimants
Agriculture & Fishing	174	0.37	66
	1.1%		0.8%
Energy & Water	57	0.2	58
	0.3%		0.7%
Manufacturing	1585	0.28	1052
	9.6%		12.8%
Construction	507	0.28	254
	3.1%		3.1%
Distribution, Hotels & Restaurants	5369	0.64	2274
	32.7%		27.7%
Transport & Communication	776	0.33	519
	4.7%		6.3%
Banking, Finance, Insurance	1576	0.37	871
	9.6%		10.6%
Public Admin, Education & Health	5331	0.44	2675
	32.4%		32.5%
Other Services	1068	0.61	455
	6.5%		5.5%

Table 1b: CLAIMANTS/ELIGIBLE BY EDUCATION GROUP

	No. of Eligible	Average WFTC Rate	No. of Claimants
High	572	0.01	405
	3.4%		4.9%
Medium	5181	0.13	2893
	31.6%		35.3%
Low	7818	0.23	3603
	47.7%		43.9%
No Qualifications	2828	0.11	1291
	17.2%		15.8%

Note: These figures show the averages by combining men and women. In the analysis we use the averages for each group separately

Table 1c: DESCRIPTIVE STATISTICS

	Ineligible		Eligible	
	Before 1999	After 1999	Before 1999	After 1999
Age	38.67	39.32	35.34	34.53
	[11.91]	[11.83]	[8.94]	[9.18]
White	0.96	0.96	0.93	0.92
	[0.18]	[0.19]	[0.25]	[0.27]
No Qualifications	0.12	0.10	0.18	0.17
	[0.32]	[0.30]	[0.38]	[0.37]
Public Sector	0.28	0.29	0.27	0.25
	[0.44]	[0.45]	[0.44]	[0.43]
Married	0.62	0.61	0.65	0.54
	[0.48]	[0.48]	[0.47]	[0.49]
Hours of Work	36.82	36.78	28.05	25.23
	[13.58]	[13.73]	[14.44]	[12.97]
Hourly Wage	8.24	8.88	6.68	6.01
	[5.21]	[5.55]	[4.58]	[3.58]
Tenure	33.69	33.31	25.71	27.62
	[29.04]	[27.88]	[25.78]	[25.69]
Experience	92.62	95.64	78.48	55.89
	[98.02]	[100.25]	[85.15]	[58.31]
% in Small Firms	25%	24%	36%	40%
% in Medium Firms	17%	17%	19%	21%
% in Large Firms	56%	56%	44%	38%
Observations	**79288**	**234693**	**9111**	**21973**

Table 2a: STAGE TWO REGRESSION RESULTS (MEN)

A - WFTC (LFS)

	ALL			***SINGLE***			***MARRIED***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.976	0.98	0.973	0.927	0.933	0.922	1.012	1.015	1.007
	[0.004]**	[0.004]**	[0.004]**	[0.006]**	[0.006]**	[0.007]**	[0.004]**	[0.005]**	[0.006]**
Pr(Claim WFTC)	-0.157	-0.186	-0.203	-0.072	-0.079	-0.138	-0.129	-0.172	-0.177
	[0.020]**	[0.022]**	[0.029]**	[0.039]	[0.039]*	[0.046]**	[0.030]**	[0.031]**	[0.036]**
Spillover (Education)	-0.055	-0.051	-0.058	0.087	0.093	0.098	-0.125	-0.122	-0.144
	[0.009]**	[0.010]**	[0.011]**	[0.017]**	[0.015]**	[0.018]**	[0.013]**	[0.012]**	[0.014]**
Spillover (Industry)	-0.056	-0.058	-0.051	-0.138	-0.14	-0.125	-0.023	-0.026	-0.029
	[0.011]**	[0.010]**	[0.012]**	[0.015]**	[0.019]**	[0.020]**	[0.013]	[0.013]*	[0.015]*
Constant	0.046	0.018	0.023	0.13	0.352	0.123	-0.053	0.365	-0.04
	[0.015]**	[0.012]	[0.013]	[0.022]**	[0.002]**	[0.020]**	[0.018]**	[0.001]**	[0.017]*
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	89992	89992	89740	30261	30261	30158	59731	59731	59671

B - WFTC Rate

	ALL			***SINGLE***			***MARRIED***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.977	0.981	0.971	0.932	0.938	0.922	1.012	1.015	1.003
	[0.003]**	[0.004]**	[0.005]**	[0.006]**	[0.007]**	[0.007]**	[0.005]**	[0.005]**	[0.006]**
WFTC rate	-0.114	-0.175	-0.248	-0.072	-0.099	-0.12	-0.106	-0.187	-0.242
	[0.026]**	[0.033]**	[0.045]**	[0.054]	[0.054]	[0.065]	[0.037]**	[0.038]**	[0.059]**
FC Generosity	-0.001	0.063	0.108	0.19	0.235	0.005	-0.136	-0.068	-0.053
	[0.078]	[0.096]	[0.114]	[0.139]	[0.110]*	[0.164]	[0.120]	[0.120]	[0.151]
Spillover (Education)	-0.107	-0.101	-0.148	0.277	0.286	0.228	-0.261	-0.257	-0.325
	[0.031]**	[0.033]**	[0.035]**	[0.049]**	[0.057]**	[0.055]**	[0.042]**	[0.044]**	[0.046]**
Spillover (Industry)	-0.057	-0.061	-0.057	-0.161	-0.164	-0.15	-0.011	-0.014	-0.017
	[0.013]**	[0.012]**	[0.017]**	[0.025]**	[0.028]**	[0.027]**	[0.018]	[0.018]	[0.021]
Constant	0.009	0	0.033	0.113	0.352	0.122	-0.044	-0.078	-0.028
	[0.016]	[0.012]	[0.013]*	[0.022]**	[0.002]**	[0.021]**	[0.019]*	[0.001]**	[0.018]
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	89994	89994	89710	30261	30261	30159	59733	59733	59632

Table 2b: STAGE TWO REGRESSION RESULTS (WOMEN)

A - WFTC (LFS)

	ALL			***SINGLE***			***MARRIED***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.991	1.007	1.021	0.939	0.952	0.957	1.021	1.037	1.054
	[0.004]**	[0.004]**	[0.004]**	[0.005]**	[0.006]**	[0.006]**	[0.004]**	[0.004]**	[0.005]**
Pr(Claim WFTC)	0.071	0.065	0.027	0.018	0.011	-0.041	0.092	0.09	0.059
	[0.009]**	[0.007]**	[0.010]**	[0.011]	[0.012]	[0.011]**	[0.016]**	[0.015]**	[0.021]**
Spillover (Education)	-0.041	-0.025	-0.026	0.059	0.074	0.084	-0.107	-0.092	-0.096
	[0.009]**	[0.009]**	[0.009]**	[0.012]**	[0.011]**	[0.013]**	[0.011]**	[0.004]**	[0.011]**
Spillover (Industry)	-0.085	-0.09	-0.042	-0.055	-0.057	-0.026	-0.105	-0.111	-0.052
	[0.008]**	[0.006]**	[0.009]**	[0.012]**	[0.015]**	[0.013]*	[0.012]**	[0.015]**	[0.011]**
Constant	0.01	-0.025	-0.111	0.106	0.069	0.052	-0.057	0.341	-0.129
	[0.021]	[0.012]*	[0.012]**	[0.020]**	[0.002]**	[0.016]**	[0.021]**	[0.006]**	[0.014]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	82278	82278	81244	30272	30272	29913	52006	52006	51388

B - WFTC Rate

	ALL			***SINGLE***			***MARRIED***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.991	1.005	1.018	0.94	0.952	0.952	1.022	1.037	1.053
	[0.003]**	[0.003]**	[0.004]**	[0.006]**	[0.006]**	[0.007]**	[0.004]**	[0.004]**	[0.005]**
WFTC rate	0.069	0.052	0.009	0.052	0.032	-0.012	0.071	0.057	0.02
	[0.010]**	[0.009]**	[0.011]	[0.012]**	[0.016]*	[0.015]	[0.014]**	[0.015]**	[0.014]
FC Generosity	-0.072	-0.02	0.025	-0.077	-0.02	-0.006	-0.077	-0.032	0.018
	[0.033]*	[0.032]	[0.040]	[0.050]	[0.056]	[0.060]	[0.050]	[0.058]	[0.050]
Spillover (Education)	-0.048	-0.029	-0.043	0.092	0.11	0.101	-0.128	-0.11	-0.124
	[0.012]**	[0.014]*	[0.013]**	[0.021]**	[0.023]**	[0.021]**	[0.014]**	[0.017]**	[0.016]**
Spillover (Industry)	-0.138	-0.148	-0.092	-0.081	-0.088	-0.058	-0.173	-0.187	-0.114
	[0.013]**	[0.014]**	[0.014]**	[0.021]**	[0.018]**	[0.022]**	[0.019]**	[0.019]**	[0.017]**
Constant	-0.026	-0.024	-0.074	0.105	0.073	0.074	-0.071	-0.104	-0.162
	[0.020]	[0.009]**	[0.011]**	[0.019]**	[0.002]**	[0.017]**	[0.020]**	[0.013]**	[0.013]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	82283	82283	81253	30272	30272	29922	52011	52011	51376

Table 3a: NMW IDENTIFICATION RESULTS (WFTC (LFS))

	WFTC (LFS)		
	All	**Single**	**Married**
Predicted wage	1.061	1.018	1.066
	[0.005]**	[0.009]**	[0.007]**
Pr(Claim WFTC)	-0.012	-0.075	0.043
	[0.016]	[0.019]**	[0.029]
Spillover (Education)	0.008	0.14	-0.074
	[0.008]	[0.013]**	[0.010]**
Spillover (Industry)	-0.072	-0.028	-0.093
	[0.008]**	[0.014]*	[0.011]**
Pr($W^*<w_{min}$)	2.908	2.685	2.56
	[0.078]**	[0.114]**	[0.113]**
$\phi(.)$	0.966	0.973	0.722
	[0.050]**	[0.073]**	[0.069]**
Pr($W^*<w_{min}$)*Predicted wage	-2.392	-2.244	-2.034
	[0.071]**	[0.104]**	[0.101]**
Pr($W^*<w_{min}$)*Pr(Claim WFTC)	0.162	0.249	-0.051
	[0.050]**	[0.058]**	[0.100]
Pr($W^*<w_{min}$)*Spillove (Education)	0.225	0.024	0.27
	[0.053]**	[0.077]	[0.075]**
Pr($W^*<w_{min}$)*Spillove (Industry)	-0.537	-0.373	-0.542
	[0.066]**	[0.092]**	[0.093]**
Constant	-0.171	-0.107	-0.15
	[0.015]**	[0.024]**	[0.019]**
Year Dummies	Yes	Yes	Yes
Observations	185592	63887	121705

Table 3b: NMW IDENTIFICATION RESULTS (WFTC Rate)

	WFTC Rate		
	All	**Single**	**Married**
Predicted wage	1.068	1.025	1.075
	[0.005]**	[0.009]**	[0.007]**
WFTC rate	-0.034	-0.111	0.026
	[0.019]	[0.028]**	[0.026]
FC Generosity	-0.096	0.098	-0.246
	[0.057]	[0.089]	[0.075]**
Spillover (Education)	0.051	0.281	-0.088
	[0.015]**	[0.023]**	[0.019]**
Spillover (Industry)	-0.124	-0.051	-0.163
	[0.015]**	[0.025]*	[0.019]**
$Pr(W^*<w_{min})$	2.933	2.722	2.58
	[0.082]**	[0.119]**	[0.116]**
$\phi(.)$	1.035	1.003	0.853
	[0.050]**	[0.073]**	[0.067]**
$Pr(W^*<w_{min})$*Predicted wage	-2.44	-2.269	-2.141
	[0.072]**	[0.105]**	[0.100]**
$Pr(W^*<w_{min})$*WFTC rate	-0.003	0.18	-0.191
	[0.047]	[0.064]**	[0.072]**
$Pr(W^*<w_{min})$*FC Generosity	0.842	0.27	1.304
	[0.181]**	[0.253]	[0.266]**
$Pr(W^*<w_{min})$*Spillove (Education)	0.22	-0.194	0.487
	[0.106]*	[0.150]	[0.150]**
$Pr(W^*<w_{min})$*Spillove (Industry)	-0.622	-0.516	-0.548
	[0.099]**	[0.139]**	[0.140]**
Constant	-0.197	-0.121	-0.186
	[0.015]**	[0.024]**	[0.019]**
Year Dummies	Yes	Yes	Yes
Observations	185592	63887	121705

Table 4a: STAGE TWO REGRESSION RESULTS – *FIRM SIZE* (MEN)

A - WFTC (LFS)

	SMALL			*MEDIUM*			*LARGE*		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.882	0.892	0.89	0.98	0.983	0.981	1.025	1.027	1.016
	[0.008]**	[0.008]**	[0.009]**	[0.011]**	[0.011]**	[0.010]**	[0.005]**	[0.005]**	[0.007]**
Pr(Claim WFTC)	-0.225	-0.277	-0.334	-0.113	-0.122	-0.072	-0.11	-0.113	-0.097
	[0.026]**	[0.041]**	[0.042]**	[0.058]	[0.067]	[0.066]	[0.049]*	[0.050]*	[0.058]
Spillover (Education)	0.002	0.011	0.019	-0.022	-0.019	-0.067	-0.047	-0.046	-0.056
	[0.023]	[0.030]	[0.024]	[0.026]	[0.022]	[0.027]*	[0.014]**	[0.013]**	[0.016]**
Spillover (Industry)	-0.019	-0.026	-0.042	-0.007	-0.008	0.02	-0.087	-0.088	-0.085
	[0.023]	[0.020]	[0.026]	[0.021]	[0.026]	[0.028]	[0.015]**	[0.013]**	[0.018]**
Constant	0.241	0.391	0.167	0.048	0.041	0.02	-0.103	-0.116	-0.101
	[0.029]**	[0.018]**	[0.026]**	[0.031]	[0.003]**	[0.030]	[0.019]**	[0.017]**	[0.021]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20191	20191	20096	14321	14321	14283	44272	44272	44245

B - WFTC Rate

	SMALL			*MEDIUM*			*LARGE*		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.868	0.879	0.867	0.982	0.985	0.983	1.037	1.039	1.026
	[0.008]**	[0.008]**	[0.010]**	[0.010]**	[0.012]**	[0.010]**	[0.007]**	[0.006]**	[0.008]**
WFTC rate	-0.132	-0.199	-0.246	-0.093	-0.138	-0.261	-0.189	-0.203	-0.502
	[0.031]**	[0.048]**	[0.052]**	[0.103]	[0.124]	[0.117]*	[0.163]	[0.151]	[0.179]**
FC Generosity	-0.203	-0.153	-0.151	0.024	0.062	0.277	0.374	0.384	0.684
	[0.111]	[0.159]	[0.152]	[0.297]	[0.309]	[0.272]	[0.296]	[0.251]	[0.345]*
Spillover (Education)	-0.166	-0.154	-0.286	-0.05	-0.05	-0.152	0.026	0.029	0.005
	[0.086]	[0.067]*	[0.074]**	[0.081]	[0.076]	[0.077]*	[0.047]	[0.044]	[0.054]
Spillover (Industry)	-0.051	-0.056	-0.063	0.025	0.023	0.068	-0.094	-0.096	-0.104
	[0.031]	[0.036]	[0.034]	[0.038]	[0.033]	[0.036]	[0.022]**	[0.026]**	[0.027]**
Constant	0.28	0.255	0.24	0.035	0.353	0.004	-0.157	0.353	-0.148
	[0.029]**	[0.003]**	[0.027]**	[0.032]	[0.003]**	[0.029]	[0.023]**	[0.019]**	[0.023]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20191	20191	20072	14322	14322	14282	44273	44273	44242

Table 4b: STAGE TWO REGRESSION RESULTS – *FIRM SIZE* (WOMEN)

A - WFTC (LFS)

	SMALL			***MEDIUM***			***LARGE***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.95	0.981	0.991	1.019	1.033	1.049	1.02	1.027	1.04
	[0.009]**	[0.008]**	[0.008]**	[0.009]**	[0.008]**	[0.010]**	[0.006]**	[0.007]**	[0.006]**
Pr(Claim WFTC)	0.052	0.04	0.008	0.081	0.081	0.034	0.08	0.079	0.028
	[0.016]**	[0.010]**	[0.016]	[0.022]**	[0.023]**	[0.024]	[0.017]**	[0.019]**	[0.017]
Spillover (Education)	-0.058	-0.035	-0.066	0.041	0.058	0.058	-0.048	-0.04	-0.033
	[0.017]**	[0.019]	[0.017]**	[0.019]*	[0.023]*	[0.023]*	[0.014]**	[0.014]**	[0.013]*
Spillover (Industry)	0.042	0.034	0.087	-0.035	-0.039	-0.007	-0.183	-0.183	-0.123
	[0.018]*	[0.017]*	[0.017]**	[0.019]	[0.023]	[0.023]	[0.013]**	[0.011]**	[0.013]**
Constant	0.075	0.008	-0.03	-0.062	-0.097	-0.146	-0.028	0.325	-0.145
	[0.029]**	[0.023]	[0.021]	[0.026]*	[0.023]**	[0.028]**	[0.030]	[0.002]**	[0.019]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22961	22961	22458	15484	15484	15292	35087	35087	34971

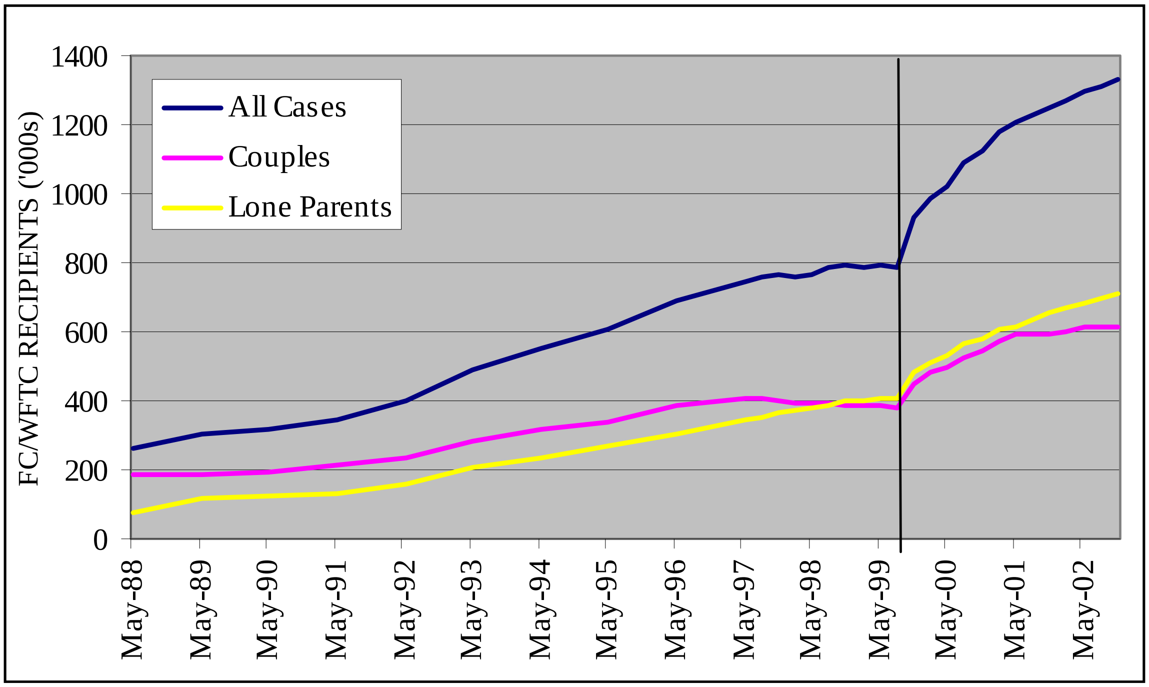
B - WFTC Rate

	SMALL			***MEDIUM***			***LARGE***		
	OLS	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**	**OLS**	**Tobit**	**C-LAD**
Predicted wage	0.958	0.986	0.995	1.008	1.021	1.036	1.014	1.021	1.035
	[0.008]**	[0.008]**	[0.009]**	[0.007]**	[0.009]**	[0.009]**	[0.006]**	[0.006]**	[0.006]**
WFTC rate	0.049	0.025	-0.025	0.047	0.039	0.001	0.089	0.084	0.022
	[0.014]**	[0.023]	[0.016]	[0.024]*	[0.024]	[0.024]	[0.022]**	[0.021]**	[0.022]
FC Generosity	-0.005	0.076	0.141	-0.063	-0.031	0.026	-0.098	-0.079	-0.021
	[0.059]	[0.082]	[0.065]*	[0.085]	[0.068]	[0.086]	[0.072]	[0.072]	[0.071]
Spillover (Education)	-0.067	-0.04	-0.084	0.029	0.051	0.031	-0.054	-0.043	-0.046
	[0.022]**	[0.029]	[0.025]**	[0.029]	[0.029]	[0.030]	[0.019]**	[0.021]*	[0.019]*
Spillover (Industry)	-0.02	-0.041	0.004	-0.048	-0.055	-0.023	-0.268	-0.27	-0.189
	[0.025]	[0.025]	[0.027]	[0.035]	[0.036]	[0.035]	[0.019]**	[0.020]**	[0.020]**
Constant	0.064	0.006	-0.065	-0.032	0.329	-0.108	-0.066	-0.082	-0.137
	[0.026]*	[0.002]**	[0.022]**	[0.019]	[0.004]**	[0.025]**	[0.025]**	[0.018]**	[0.017]**
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22962	22962	22428	15484	15484	15297	35091	35091	34970

Table 5: TEST OF EXOGENEITY (SMITH-BLUNDELL PROCEDURE)

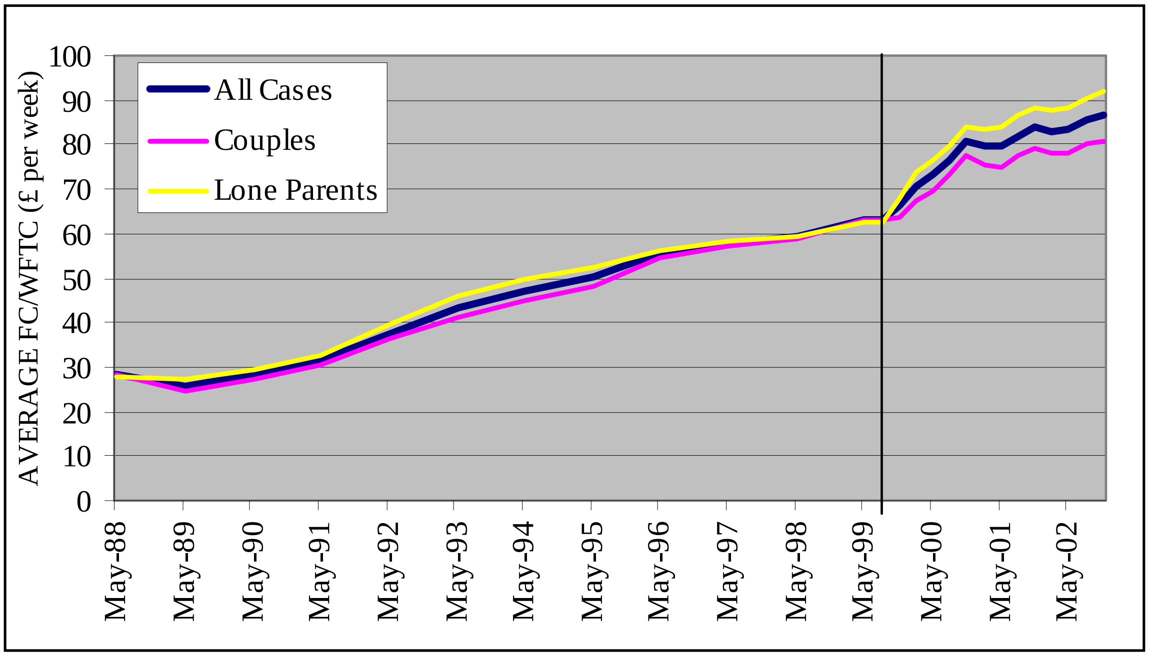
	Smith-Blundell: Stage 2
Predicted wage	0.999
	[0.002]**
WFTC Dummy	-0.065
	[0.014]**
Spillover	-0.073
	[0.006]**
Residual	0.014
	[0.015]
Constant	-0.019
	[0.005]**
Observations	183224
Censored	*7352*
Uncensored	*175872*

Figure 1: FC/WFTC RECIPIENTS BY FAMILY TYPE, MAY 1988 - NOVEMBER 2002*



* Working Families' Tax Credit Statistics, Inland Revenue Quarterly Enquiry (2003)

Figure 2: AVERAGE FC/WFTC WAWARD BY FAMILY TYPE, MAY 1988 - NOVEMBER 2002*



* Working Families' Tax Credit Statistics, Inland Revenue Quarterly Enquiry (2003)

Figure 3: DISTORTION BETWEEN ACTUAL & PREDICTED WAGES AFTER THE INTRODUCTION OF THE NMW

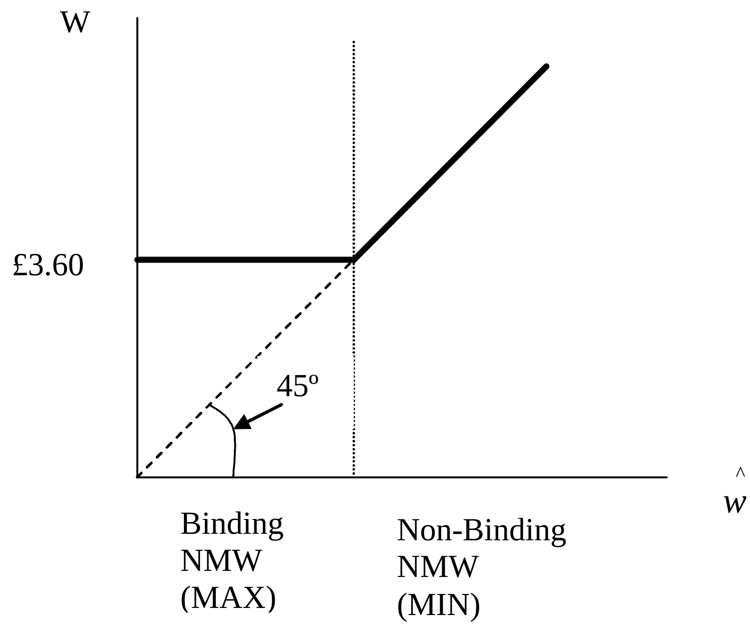


Figure 4: SPILLOVER EFFECT

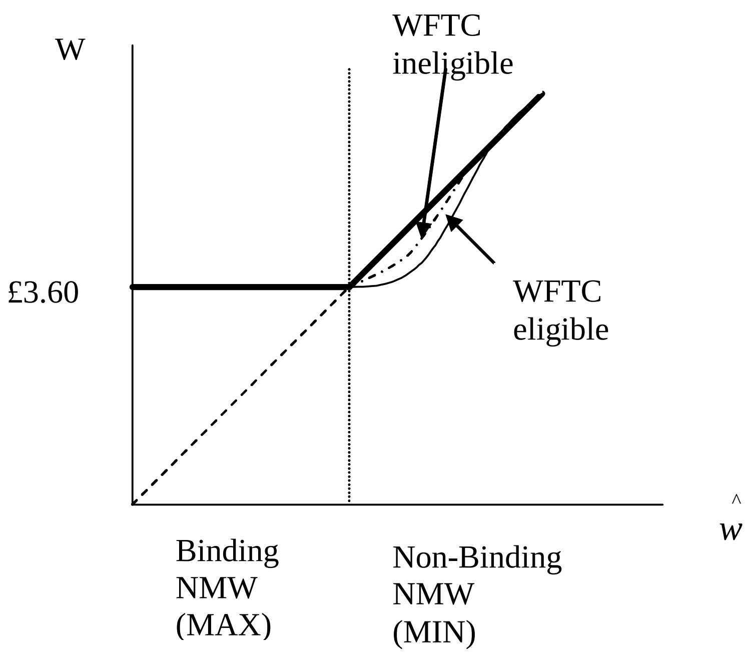


Figure 5: FRACTION CLAIMING WFTC BY PREDICTED WAGE

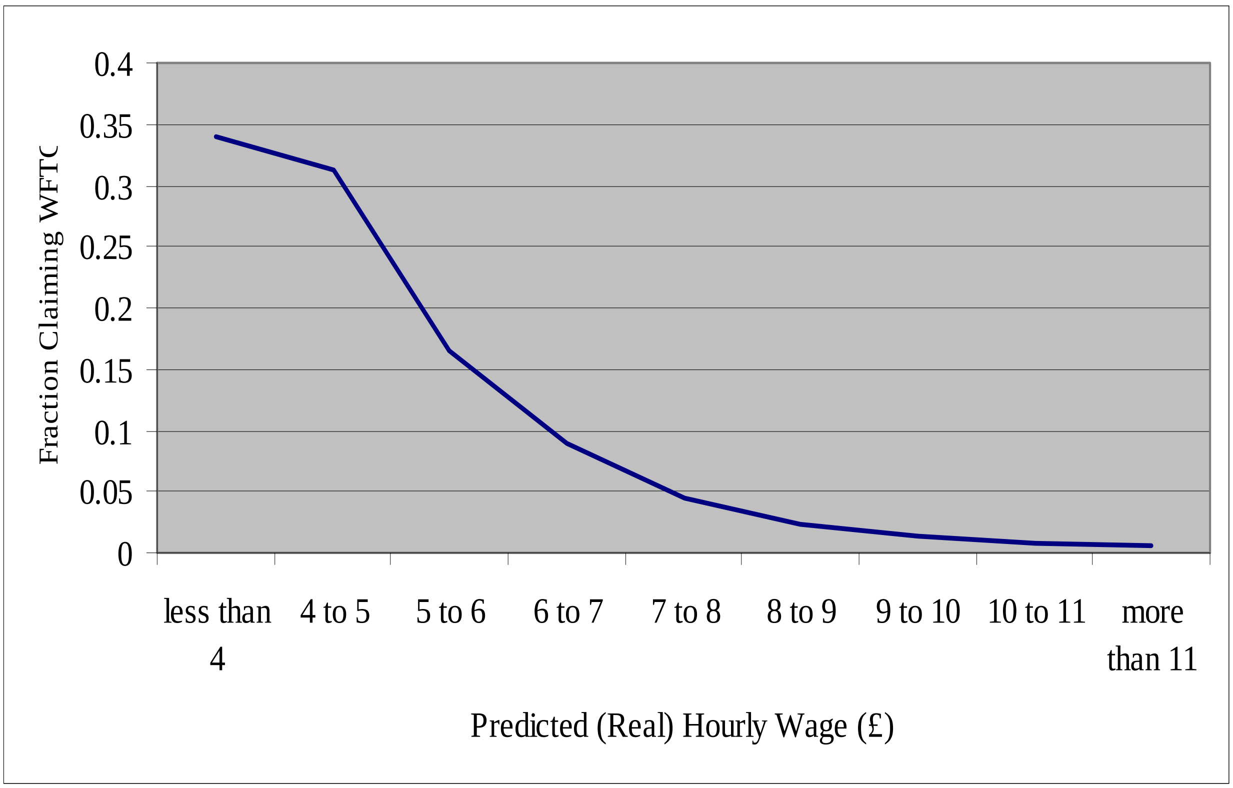


Figure 6: AVERAGE WFTC RATE BY HOURLY PREDICTED WAGE

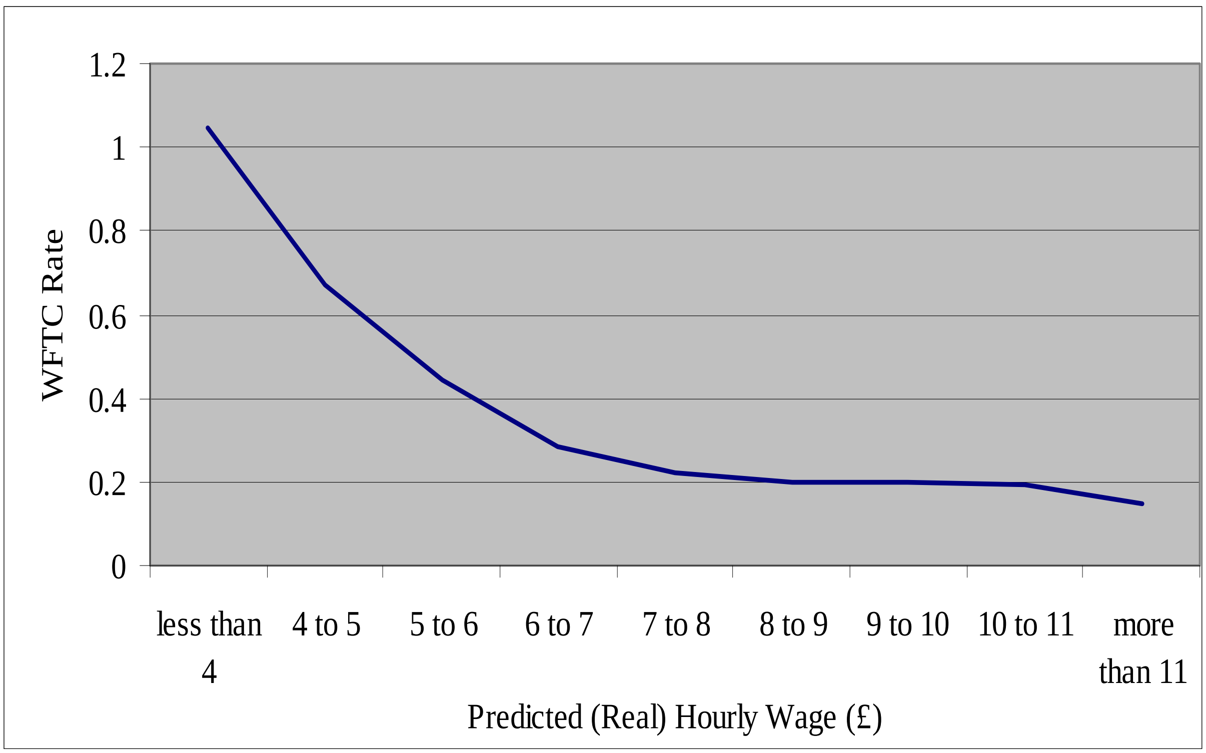


Figure 7: FRACTION ELIGIBLE FOR WGFTC BY PREDICTED HOURLY WAGE

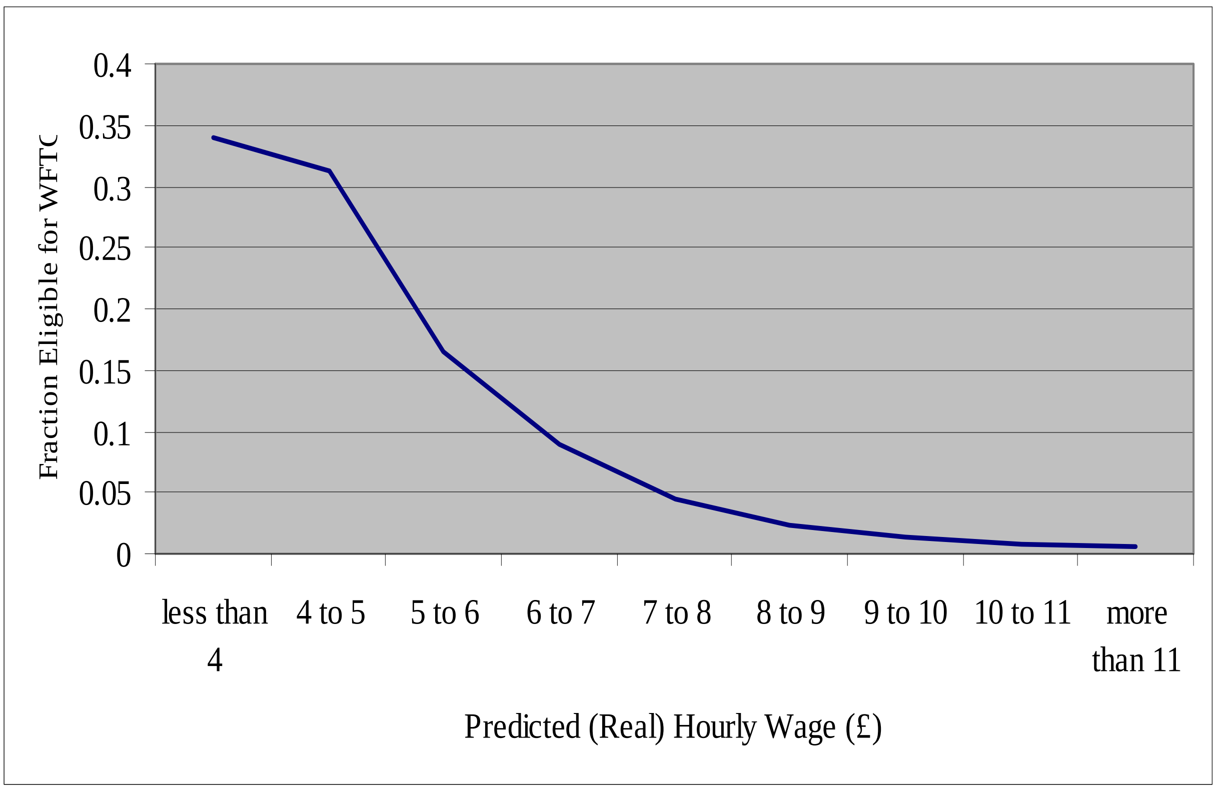


Figure 8: FRACTION OF RECIPIENT EARNING BRACKETS (GROSS WEEKLY) - ALL CASES

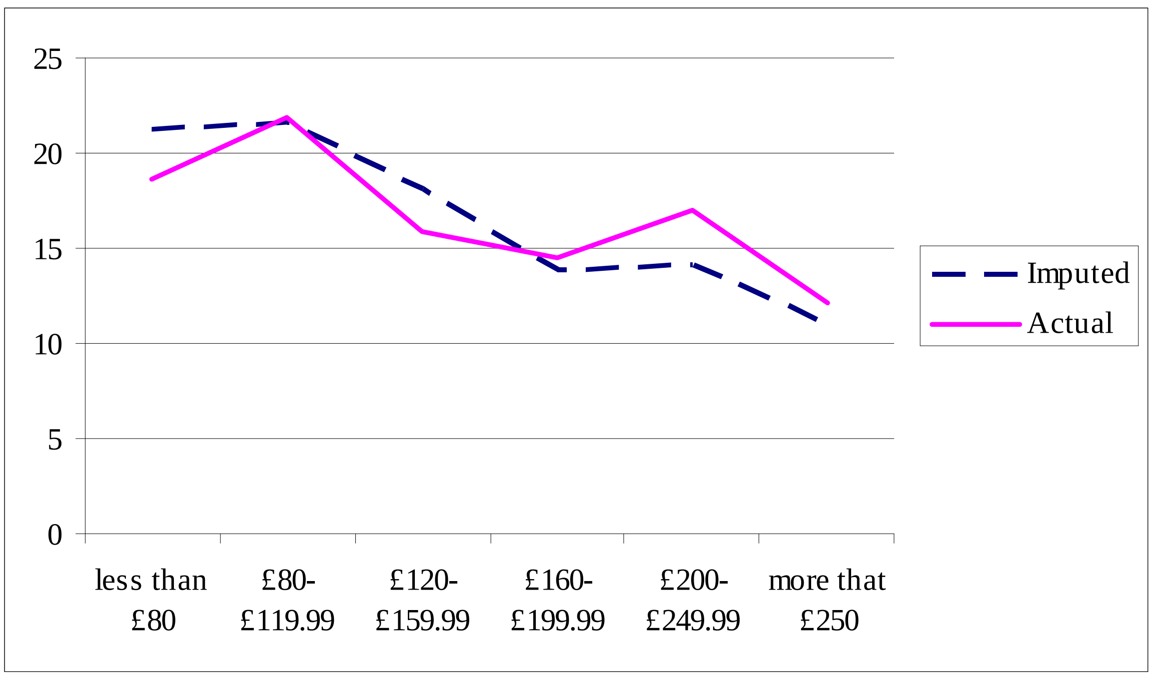


Figure 9: FRACTION OF RECIPIENT EARNING BRACKTS (GROSS WEEKLY) - LONE PARENTS

1 Appendix A

1.1 PROOFS FROM SECTION 3:

1.1.1 Proof 1:

Let labour demand equal labour supply:

$$N^d(w(s)) = N_1^s(w(s)(1+s)) + N_2^s(w(s))$$

Differentiate with respect to s:

$$\frac{\partial N^d}{\partial w}\cdot\frac{\partial w}{\partial s} = \left[\frac{\partial N_1^s}{\partial w}\cdot\frac{\partial w}{\partial s} + \frac{\partial N_1^s}{\partial w}.w + \frac{\partial N_1^s}{\partial w}\cdot\frac{\partial w}{\partial s}.s\right] + \frac{\partial N_2^s}{\partial w}\cdot\frac{\partial w}{\partial s}$$
$$\frac{\partial N^d}{\partial w}\cdot\frac{\partial w}{\partial s} = \left[w + (1+s)\frac{\partial w}{\partial s}\right]\frac{\partial N_1^s}{\partial w} + \frac{\partial N_2^s}{\partial w}\cdot\frac{\partial w}{\partial s}$$
$$\frac{w}{N^d}\cdot\frac{\partial N^d}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s} = \left[1 + \frac{[1+s]}{w}\cdot\frac{\partial w}{\partial s}\right]\frac{w}{N^d}\cdot\frac{\partial N_1^s}{\partial w} + \frac{w}{N^d}\cdot\frac{\partial N_2^s}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s}$$

Since:

$$N^d = N_1^s + N_2^s$$

Re-write the above results:

$$\frac{w}{N^d}\cdot\frac{\partial N^d}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s} = \left[1 + \frac{[1+s]}{w}\cdot\frac{\partial w}{\partial s}\right]\frac{w}{N_1^s+N_2^s}\cdot\frac{\partial N_1^s}{\partial w} + \frac{w}{N_1^s+N_2^s}\cdot\frac{\partial N_2^s}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s}$$
$$\frac{w}{N^d}\cdot\frac{\partial N^d}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s} = \frac{N_1^s}{N_1^s+N_2^s}\cdot\frac{w}{N_1^s}\cdot\frac{\partial N_1^s}{\partial w}\left[1 + \frac{[1+s]}{w}\cdot\frac{\partial w}{\partial s}\right] + \frac{N_2^s}{N_1^s+N_2^s}\cdot\frac{w}{N_2^s}\cdot\frac{\partial N_2^s}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s}$$

Let:

$$\theta = \frac{N_1^s}{N_1^s+N_2^s}$$

And so:

$$\frac{w}{N^d}\cdot\frac{\partial N^d}{\partial w}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s} = \theta.\frac{\partial N_1^s}{\partial w}\cdot\frac{w[1+s]}{N_1^s}\left[\frac{1}{[1+s]} + \frac{1}{w}\cdot\frac{\partial w}{\partial s}\right] + (1-\theta)\frac{\partial N_2^s}{\partial w}\cdot\frac{w}{N_2^s}\cdot\frac{1}{w}\cdot\frac{\partial w}{\partial s}$$
$$\eta^d.\frac{1}{1+s}\cdot\frac{\partial\ln w}{\partial\ln(1+s)} = \theta\eta_1^s\left[1 + \frac{\partial\ln w}{\partial\ln(1+s)}\right] + (1-\theta)\eta_2^s.\frac{1}{1+s}\cdot\frac{\partial\ln w}{\partial\ln(1+s)}$$
$$\left(\frac{\eta^d}{1+s} - \theta\eta_1^s - (1-\theta)\frac{\eta_2^s}{1+s}\right)\frac{\partial\ln w}{\partial\ln(1+s)} = \theta\eta_1^s$$
$$\frac{\partial\ln w}{\partial\ln(1+s)} = \frac{\theta\eta_1^s}{\frac{\eta^d}{1+s} - \theta\eta_1^s - (1-\theta)\frac{\eta_2^s}{1+s}}$$
$$\frac{\partial\ln w}{\partial\ln(1+s)} = -\frac{\theta\eta_1^s}{\theta\eta_1^s + (1-\theta)\frac{\eta_2^s}{1+s} - \frac{\eta^d}{1+s}}$$

1.1.2 Proof 2: Proposition

Assume a general equilibrium model with two types of labour i. Where $i = 1, 2$.

Labour is the only factor of production and labour demand for each factor is given by:

$$N_1^d(w_1, w_2) \text{ and } N_2^d(w_1, w_2)$$

The production of one good, X, occurs in a constant return to scale environment:

$$X = F[N_1, N_2]$$

The model is developed using equations of change (i.e. using the log-linearisation method of Jones (1965)). Fully differentiate to get:

$$dX = F_{N_1}.dN_1 + F_{N_2}.dN_2$$

Where F_{N_i} is the marginal product for $i = 1, 2$.Divide through by X:

$$\tfrac{dX}{X} = \tfrac{F_{N_1}.N_1}{X}.\tfrac{dN_1}{N_1} + \tfrac{F_{N_2}.N_2}{X}.\tfrac{dN_2}{N_2}$$

Let θ be the factor share for group and w_1 be the factor payment (gross wage) for group 1 such that:

$$\theta = \left(\tfrac{w_1}{p_X}\right)\tfrac{N_1}{X}$$

By profit maximisation:

$$w_1 = p_X F_{N_1}$$

Let $(1-\theta)$ be the factor share for group 2 and w_2 be the factor payment (gross wage) for group 2 such that:

$$(1-\theta) = \left(\tfrac{w_2}{p_X}\right)\tfrac{N_2}{X}$$

By profit maximisation:

$$w_2 = p_X F_{N_2}$$

And so:

$$\tfrac{dX}{X} = \theta.\tfrac{dN_1}{N_1} + (1-\theta).\tfrac{dN_2}{N_2}$$
$$\hat{X} = \theta\hat{N}_1 + (1-\theta)\hat{N}_2$$

The elasticity of subsitution between the two groups can be given by:

$$\sigma_X = \frac{d(\frac{N_1}{N_2})/(\frac{N_1}{N_2})}{d(\frac{w_2}{w_1})/(\frac{w_2}{w_1})}$$

Where the differentiation in the numerator is:

$$\frac{N_2.dN_1 - N_1.dN_2}{N_2^2}.\frac{N_2}{N_1} = \frac{dN_1}{N_1} - \frac{dN_2}{N_2} = \hat{N_1} - \hat{N_2}$$

And so (with a similar differentiation to the denominator):

$$\sigma_X = \frac{\hat{N_1} - \hat{N_2}}{\hat{w_2} - \hat{w_1}}$$
$$\hat{N_1} - \hat{N_2} = \sigma_X(\hat{w_2} - \hat{w_1})$$

So far, the resulting system of equations are given by:

$$(1)\ \hat{N_1} - \hat{N_2} = \sigma_X(\hat{w_2} - \hat{w_1})$$
$$(2)\ \hat{X} = \theta\hat{N_1} + (1-\theta)\hat{N_2}$$

Assuming constant returns to scale the value of output in each industry must equal the factor payment:

$$(3)\ p_X X = w_1 N_1 + w_2 N_2$$
$$w_2 N_2 = p_X X - w_1 N_1$$
$$w_2 = \frac{p_X X}{N_2} - \frac{w_1 N_1}{N_2}$$
$$dw_2 = -dw_1 \frac{N_1}{N_2}$$
$$\frac{dw_2}{w_2} = -\frac{dw_1}{w_1}\frac{N_1 w_1}{N_2 w_2}$$
$$\hat{w_2} = -\hat{w_1}\frac{N_1 w_1/p_X X}{N_2 w_2/p_X X}$$
$$\hat{w_2} = -\left(\frac{\theta}{1-\theta}\right)\hat{w_1}$$

Substitute into (1):

$$\hat{N_1} - \hat{N_2} = \sigma_X(-\left(\frac{\theta}{1-\theta}\right)\hat{w_1} - \hat{w_1})$$

Turning now to the labour supply of each group. It is here that the tax credit is incorporated because the tax is placed on the worker rather than on the employer (such that the the gross wage for group 1 is w_1 and the net wage is $w_1(1+s)$) and for group 2 the gross and the net wage is w_2.

The labour supply for group 1 is given by:

$$(4)\ N_1^s(w_1(1+s)) \Longrightarrow \hat{N_1} = \eta_1^s\left[1 + \hat{w_1}\right]$$

The labour supply for group 2 is given by:

$$(4') \; N_1^s(w_2) \Longrightarrow \hat{N_2} = \eta_2^s \hat{w_2}$$

Using (1)

$$\eta_1^s \left[1 + \hat{w_1}\right] - \eta_2^s \hat{w_2} = \sigma_X(\hat{w_2} - \hat{w_1})$$

Since

$$\hat{w_2} = -\left(\frac{\theta}{1-\theta}\right)\hat{w_1}$$

This implies

$$\eta_1^s \left[1 + \hat{w_1}\right] + \eta_2^s \left(\frac{\theta}{1-\theta}\right)\hat{w_1} = -\frac{\sigma_X}{1-\theta}\hat{w_1}$$

$$(1-\theta)\eta_1^s + [(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X]\hat{w_1} = 0$$

$$(5) \; \hat{w_1} = \frac{\partial \ln w_1}{\partial \ln(1+s)} = -\frac{(1-\theta)\eta_1^s}{(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X}$$

For group 2:

$$(5')\left(\frac{1-\theta}{\theta}\right)\hat{w_2} = \frac{(1-\theta)\eta_1^s}{(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X}$$

$$\hat{w_2} = \frac{\partial \ln w_2}{\partial \ln(1+s)} = \frac{\theta\eta_1^s}{(1-\theta)\eta_1^s + \theta\eta_2^s + \sigma_X}$$

TABLE A1: NATIONAL MINIMUM WAGE (ARCHIVED RATES)*

Aged 22 years & older		
	1st April 1999 to 30th September 2000	£3.60
	1st October 2000 to 30th September 2001	£3.70
	1st October 2001 to 30th September 2002	£4.10
	1st October 2002 to 30th September 2003	£4.20
Aged 18 - 21 years, inclusive		
	1st April 1999 to 30th May 2000	£3.00
	1st June 2000 to 30th September 2001	£3.20
	1st October 2001 to 30th September 2002	£3.50
	1st October 2002 to 30th September 2003	£3.60

* HM Revenue & Customs: National Minimum Wage

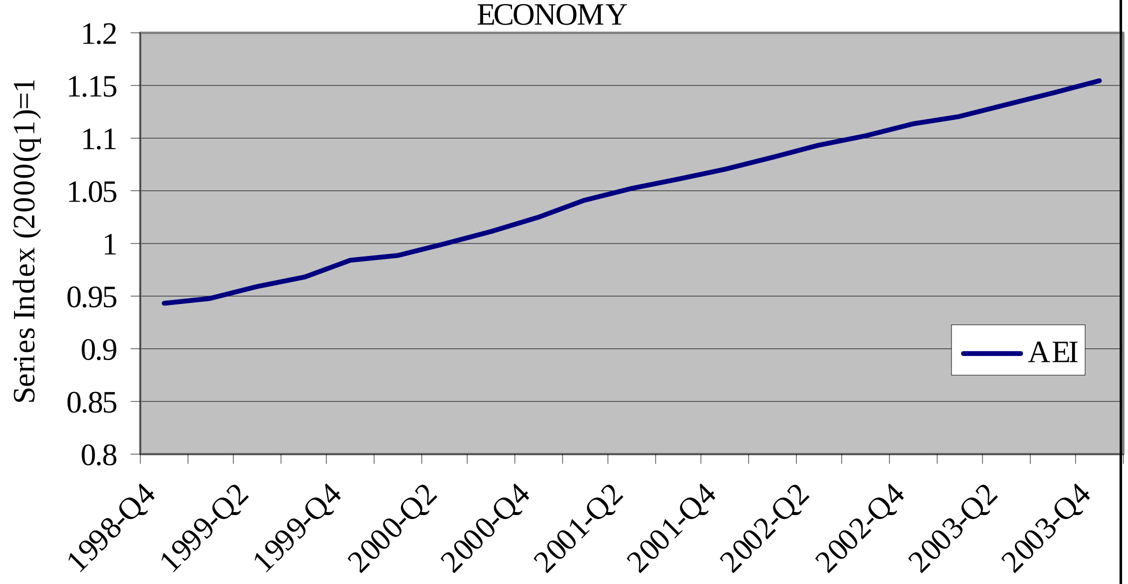
* Office of National Statistics

TABLE A2: WORKING FAMILIES' TAX CREDIT RATES & THESHOLDS, 1999-2003*

			1999-00	2000-01	2001-02	2002-03
	BASIC TAX RATE	£ per week	52.3	53.15	59	62.5
	30 HOUR TAX CREDIT	£ per week	11.05	11.25	11.45	11.65
	PER CHILD CREDIT	£ per week	20.9	25.6	26	26.45
REDUCTION						
	INCOME THRESHOLD	£ per week	90	91.45	92.9	94.5
	INCOME TAPER		55%	55%	55%	55%
	MINIMUM AWARD	£ per week	0.5	0.5	0.5	0.5

* Working Families' Tax Credit Statistic, Inland Revenue Summary Statistics (Feb 2003)

FIGURE A1: AVERAGE EARNING INDEX FOR THE WHOLE ECONOMY



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