Empirical Essays on the Economics of Labour Supply

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Declaration

I hereby declare that the contents of this dissertation are, unless indicated by appropriate referencing, my own work. and the dissertation has not been submitted in any form for the award of a higher degree elsewhere.

To Pei Liu and Elim Qiao

For being the love of my life and teaching me to love and to be loved.

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Empirical Essays on the Economics of Labour Supply

By Ke Qiao

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Abstract

This thesis consists of three self-contained essays on the economics of Labour Supply.

Chapter 2 surveys the Labours Supply behaviour in the UK over the past four decades (LFS 1975 – 2016) on three different aspects: static labour supply, life cycle labour supply and labour supply in trade unions. Over static and life cycle labour supply, I explore both the intensive margin and the extensive margin across different demographic characteristics: gender, marital status, economic activity, industry, occupation, education, ethnicity and sector. In the context of trade unions, I only explore the intensive margin, since the union premiums are conditional on people having positive working hours/wage.

Our results suggest that Education affects working hours, but only for women. Whereas, men`s working hours are hardly different on average across all education levels; Despite the fact that men are much more likely to work full time than women, the proportion of part-timers amongst men has increased dramatically over time; The historically persistent hours gap between single and married workers has been closed in the recent decade due to the steady increase in married women`s working hours; The best remunerated workers are most likely to work a standard full-time working week, those working longer or shorter hours than standard are significantly less well paid.

Education`s effects on lifecycle labour supply again are obvious only amongst women, where the higher the educational attainment, the higher the lifecycle profile lies. The effect of marital status on the lifecycle profiles can be understood by the division of

labour within a family: it pushes up the lifecycle hours profiles of married men and lowers that of married women.

Both union membership and union coverage rates have been falling over time, though the fall in the rates of male workers are more pronounced. The patterns are consistent by education, sector, industry and occupation; The union premiums (wage and hours) are consistent in patterns, with membership premium decreases and coverage premium increases over time.

Chapter 3 provides renewed evidence for married couples` labour supply responsiveness to the change in their wages and nonlabour income in the UK. Taking advantage of the time series of reforms, I apply the difference-in-differences techniques to elicit the causal effect of tax and benefit on couples` labour supply behaviour at both margins (intensive and extensive). I find that women are more responsive than men at all margins. and wage changes have larger effects on the decision to work, and smaller effect on hours of work. The fact that women have much larger intertemporal substitution effects than their spouse, implies that women, especially the lowly educated are more prone to smooth their consumption across lifecycle.

Union coverage has been declining over the past four decades. However, collective bargaining and trade unions are still of crucial importance concerning the regulation of many issues in labour market, such as wage setting; hours` regulating, especially overtime hours; and fringe benefits. Chapter 4 “Estimating trade union effects on working hours: Evidence from the UK 1996-2016” examines the effects of trade unions on people`s working hours. I explore the effects in three hours` dimensions: total usual hours, standard hours and overtime hours, all in weekly terms. I also differentiate the membership effects from the coverage effects, which proves to be important. There are three primary findings from the analysis. First, there are consistent and significant union effects on working hours, the size of the effects ranges from -6 hours to 6 hours depending on characteristics, such as gender, types of effects, groups of people etc., Secondly, the size of the effects are falling overtime, this may reflect the declining

densities of unions. Lastly, our results also suggest that trade unions do use overtime as a means to stabilize working hours and expand membership. And trade unions do alleviate firms` greed on workers in terms of unpaid overtime hours.

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Chapter **1**

Introduction

"Those who work their land will have abundant food, but those who chase fantasies have no sense."

—— *Proverbs 12 : 11*

Our understanding of the economic determinants of labour supply behaviour has not changed substantially over the last few decades. The focus of recent work has continued to be on the effect of the nature of budget constraints on hours of work and participation. While earlier work was structural and exploited the nonlinearities in budget constraints to identify Maximum Likelihood estimates of wage and income elasticities, recent work has shifted to reduced form research that explores the effects of some reform to budget constraints using natural experimental variation in pooled cross-section or, in the case of lifecycle labour supply, panel data. Yet the overwhelming majority of the literature has continued to find that these effects are small, and often statistically insignificant. Indeed, the explanatory power of these models, both static and the lifecycle versions have not been encouraging. At best, they account for very little of the observed variations in work behaviour; at worst, the key implications of these models are refuted – for example, many instances are inconsistent with positive compensated differentials (Blundell et al., 2000).

Moreover, there have been important institutional changes in the labour market over the last few decades that have not been explored at all in the labour supply context. Two phenomena in particular, have been the dramatic fall in unionization and the dramatic

rise in the education levels of individuals. It is surprising that these labour market phenomena have passed the literature by. In the case of unionization, one of the important features of the standard model of the behaviour of unions (Lewis, 1986) is that they raise wages through reducing labour supply. Yet, despite the central role of unions, there has been virtually no empirical literature that allows for a role for unionization in the determination of hours of work. In the case of unionization – only a few exceptions come to mind (Perloff and Sickles 1987; Earle and Pencavel, 1990; DiNardo, 1991; Trejo 1993). Indeed, it is very peculiar that part of the empirical literature of the effects of union status uses log earnings (usually weekly) as the dependent variable, while the other part of the literature uses the log wage (usually hourly) and no attention appears to be paid to how unionization affects hours despite the fact that log earnings are additive in log wage and log hours. In the case of education, it is very surprising that the literatures on short-run labour supply in terms of hours of work and participation at a point in time never appears to meet the literature on long-run dimension of labour supply – in the form of education. Not only does education play no role at all in the determination of labour supply, where it does appear in empirical modelling, it is used as an exclusion restriction – that is, it is deliberately excluded from labour supply modelling so as to reserve its role as an instrument for wages. Yet, short-run labour supply is effectively the utilization rate of the stock of human capital that embodies education. This seems like an unsatisfactory state of affairs and it is the purpose of this thesis to try to redress these omissions from the existing literature.

The analysis is motivated by the need to shine some light on these two neglected factors in the hope that they provide some improvement in our understanding of labour supply behaviour. Thus, our primary objective is to complement existing thinking about labour supply. Given our complete ignorance of the empirical relationships between labour supply, individual union status (membership and coverage), and education levels we first dedicate a chapter to simply describing the trends in the UK`s workhorse labour market dataset, the Labour Force Survey (LFS). The LFS is a large cross-section survey

(with only a short panel element to it) that describes labour supply in great detail. This dataset is the UK equivalent of the US Current Population Survey (CPS), LFS has been in existence since the 1970s and contains information on unionization and education levels as well as hours, in great detail and wages.

Chapter 2, "Survey on Labour Supply Behaviour in the UK: Evidence from LFS & QLFS1975-2016", surveys trends in Labour Supply behaviour in the UK over the past four decades (LFS & QLFS 1975 – 2016) focusing on three different aspects: Static/ Life cycle labour supply; education; and labour supply in trade unions.

The time seems right to shine some light on these two important gaps in our understanding – while we know that unions raise log earnings (Anderson et al., 1990) and they raise log wages (Blanchflower and Bryson, 2003 etc.), no one appears to have explored the possibility that the two effects may be different – that would imply that unions directly affect hours, and we have experienced a pronounced drop in unionization and coverage over the period covered by LFS. We find that both the union membership rate and the union coverage rate have been falling over time in LFS, and the fall in the rates of union coverage is more pronounced. The patterns are consistent by education, sector, industry and occupation; Older cohorts are more likely to be a non-union member yet covered by a collective agreement.

Similarly, with education. Some research uses earnings as a dependent variable (Blundell et al., 2001) and some uses an hourly "wage" (obtained mostly from dividing earnings by hours) (Harmon and Walker, 1995). On average, graduates work longer hours than non-graduates and this is reflected in the differences in the returns to education defined in terms of earnings, compared to the wage returns. Again, it is a good time to explore this – the UK has experienced a rapid growth in education levels over the last couple of decades.

With respect to static and life cycle labour supply, we explore both the intensive margin and the extensive margin across different demographic characteristics: sex, marital status, economic activity, industry, occupation, education, ethnicity, sector and full-time/part-time. In the context of trade unions, we only explore the intensive margin,

since the union premiums are conditional on people having positive working hours/wage.

We offer this work in the spirit of "shining a light" on two neglected and important aspects of labour supply. Note that nothing here denies the validity of previous research providing that work is based on structural estimation or quasi-experimental methods. The work here complements the existing literature.

Our results have uncovered some interesting, yet undocumented, trends. For example, despite the fact that men are much more likely to work full time than women, the proportion of part-timers amongst men has increased dramatically over time; The working hours of non-white workers have decreased, while that of white workers are fairly consistent in time, however, the composition have changed: a fall in white men`s working hours and a rise in white women`s hours; Overtime hours shows a similar pattern where the overtime hours series is consistent in time, while the composite has changed, with unpaid overtime increases, and paid overtime decreases both proportion and hours; Although the inactivity rate in the UK has roughly maintained at 25 to 20 percent level over time, the make-up of the inactive has changed. Men have dropped out of the labour force in unprecedented numbers, whilst women have entered the labour force to such an extent that the two trends broadly offset each other; With respect to lifecycle education`s effects again are obvious only amongst women, where the higher the educational attainment, the higher the lifecycle profiles lie. Within the union context, the union premium (wage and hours) are consistent in patterns, with membership premium decreases and coverage premium increases over time. This may offer an incentive to free-ride the collective good trade unions produce, exacerbating the free-riding problem.

The rest of the results confirm what has been known in the literature. In terms of static labour supply, working hours are cyclical, though the fall in working hours during the recent 2008 great recession has been unexpectedly small; Education affects workings, but only for women. The higher education a woman receives, the more she is going to work. The gap is particularly large between degree level and below. Whereas, men`s

working hours hardly vary on average across all education levels; The historically persistent hours gap between single and married workers has been closed in the recent decade due to steady increase in married women`s hours of work; The hours of non-white workers have decreased, while that of white workers are fairly consistent in time, however, the composition have changed: a fall in white men`s hours of work and a rise in white women`s hours; The best remunerated workers are most likely to work a standard full-time working week, those working longer or shorter hours than standard are significantly less well paid.

As for participation, the findings are that the inactivity rate in the UK has roughly maintained at 20 to 25 per cent level over time. Education works as a driver for labour market participation, the higher the level of educational attainment, the more likely an individual participates; White people are much more likely than ethnic minority to participate.

The lifecycle labour supply profiles are found to be roughly an inverse "U" shape for both hours and participation. However, if decomposed by gender, men`s lifecycle profiles form an inverse U shape, peaking during the age of 35 to 50. While women`s lifecycle profiles form an M shape curve, where the dip in the middle happens at the late 20s to mid-30s, reasonably coinciding with the pregnancy and child-rearing period. Factors such as education and marital status can cause the lifecycle profiles to shits. Education`s effects again are obvious only amongst women, where the higher the educational attainment, the higher the lifecycle profiles lie. The effect of marital status on the lifecycle profiles can be understood by the division of labour within a family. Since it pushes up the lifecycle profiles of married men and lowers the lifecycle profiles of married women, indicating women on average still act as the main care provider within a family.

We also find that both the union membership rate and the union coverage rate have been falling over time, though the fall in the rates of male union/covered workers are more pronounced. The patterns are consistent by education, sector, industry and occupation;

Older cohorts are more likely to be a non-union membership yet covered by a collective agreement.

Although the primary contribution to the literature here is to document the relevance of the effects of education and union status on labour supply, we also look at the role of budget constraints. This is confined to chapter 3 where we explore and extend the seminal work by Blundell and others (1998). We intend to bring their evidence up-to-date with LFS data (2002-2016). We seek to address this issue by exploiting the time series tax and benefit reforms in the UK during the data period. Their grouping method is applied to elicit the causal effect of wages at both margins (intensive and extensive). In line with previous empirical literature, we find that women are more responsive than men at all margins, and wage changes have larger effects on the decision to work, small effects on hours of work. The fact that women have much larger intertemporal substitution effects than their spouses, implies that women, especially the low educated, are more prone to smooth their consumption across lifecycle.

Yet, understanding how policy affects work incentives, through budget constraints, remains a primary driver of research in labour economics. While, exploiting education as a source of exclusion restrictions has become passé, the literature has moved to difference in difference analysis of responses to policy changes that affect some groups differently than others, and interpreting the effects as if they were structural findings on labour supply elasticities that could be parachuted across the policy arena. We adopted the Blundell etc (1998) method, where rather than looking for the full solution to taxes and benefits, we simplify the problem by exploiting the discontinuity at tax kinks, then exploit the change in the UK wage structure and the numerous tax and benefit reforms that occurred to control for the endogeneity of wages and taxes. In the history of the LFS there have been important reforms of both kinds. There is little merit in exploiting only one side of the government budget constraint as Blundell et al., (1998), because tax and welfare reforms go hand in hand and may even be jointly determined.

Another phenomenon that is missing from the traditional discourse of hours of work

are institutional constraints. One of the most important institutional phenomena of the past several decades has been the diminishing influence of trade unions. And strangely, trade unions in labour economics continues to be harnessed by labour demand and not supply. We have few reasons to believe that institutional phenomena would leave supply considerations unaffected. Unions are a case in point. There is a huge literature on the effects of unions on log earnings and we think of this relationship being driven through wage rates, indeed a significant minority of the literature is concerned with log wage rates. Yet log earning is the sum of log wage and log hours. There is very little literature that attempts to explore the hours and union relationship conditional on wage. Therefore, we attempt this in chapter 4 of this thesis as a prelude of exploring the unconditional relationship in more detail in future. Union coverage has been declining over the past four decades. However, collective bargaining and trade unions are still of crucial importance concerning the regulation of many issues in labour market, such as wage setting; hours` regulating, especially overtime hours; and fringe benefits. Chapter 4 "Estimating trade union effects on working hours: Evidence from the UK 1996-2016" examines the effects of trade unions on people`s working hours. I explore the effects in three different hours` dimensions: total usual hours, standard hours and overtime hours, all in weekly terms. I also differentiate the membership effects from the coverage effects, which proves to be important. There are three primary findings from the analysis. First, I find that there are consistent and significant union effects on working hours, the size of the effects ranges from -6 hours to 6 hours depending on characteristics, such as gender, types of effects, groups of people etc., Secondly, the size of the effects are falling overtime, this may reflect the declining coverage of unions. Lastly, our results also suggest that trade unions do use overtime as a means to stabilize working hours and expand membership. And trade unions do alleviate firms` greed on workers in terms of unpaid overtime hours.

All three essays are analysed in the context of UK data. Cautions must be exercised in extrapolating the conclusions reached in this thesis to other countries, as the analysis carried out in these essays are tied with the institutional backgrounds. This means that

the findings can provide input for labour market policies in developed countries which exhibit similar institutions and labour market structure as the UK.

Chapter **2**

Survey of Labour Supply Behaviour in the UK

---Evidence from LFS & QLFS 1975-2016

2.1 Introduction

The primary objective of this PhD thesis is to complement existing thinking about labour supply. However, given our relative ignorance[1] of the empirical relationships between labour supply, individual union status, and education levels, we therefore decide to dedicate this first substantive chapter to simply describing the trends in the UK`s workhorse labour market dataset, the Labour Force Survey (LFS), and so lay the foundation for the chapters to come. We constrain our analysis to the UK data because the UK is an interesting laboratory for such work and the LFS is the only dataset that contains the requisite variables.

Our analysis is done from three different perspectives: The static labour supply, the life cycle labour supply and the labour supply in the context of trade unions. We particularly choose the first two aspects because they are the crucial theoretical distinctions that have been made in the study of labour supply so far (Heckman, 1993). Unionization is highlighted because there has seen a large drop in trade union coverage, union increases hourly wages and earnings, and so seem likely to have effects on hours of work. We believe that incorporating unions into empirical labour supply analysis is novel.

By the static and life cycle labour supply, both the intensive margin and the extensive margin are explored across different demographic characteristics, such as gender,

[1] The majority of the empirical trends documented in the literature are unemployment trends, very few looks at participation or hours of work. Even amongst these very few works, many studies the specific sub-groups of the population or period, such as youth, single parent, older men, participation and hours over recessions etc (Gregg and Wadsworth 1999 and 2011).

education, marital status, full-time/part-time, sector, industry, occupation and ethnicity. In the context of trade unions, we only explored the intensive margin due to the fact that the premiums are conditional on people having a positive working hours or wage. We therefore describe the characteristics of the union densities in the UK, then go on to establish the time series trends of the densities, and finally estimate the union premiums: membership premium and coverage premium as well as wage premium and hours premium.

Although in this chapter, we have focused on the working behaviour (participation and hours of work), we also show trends on inactivity stratified by reason, unemployment and self-employment in the appendix (Figure 2.34 – Figure 2.38) as further information. Amongst the four reasons stratified: student, housewife, retired and other; the proportion of the housewives has decreased dramatically, echoing our findings of the increase in married women`s labour market participation and attachment. The unemployment trends shown are in line with those already known in the literature (Gregg and Wadsworth, 1999 and 2011). Moreover, the self-employment rates rise steadily from 10 per cent to 15 per cent, and the percentage increase doubles amongst men.

In terms of working behaviours, our results have uncovered some interesting yet undocumented trends. For example, despite the fact that men are much more likely than women to work full time, the proportion of part-timers amongst men has increased dramatically over time; The hours of work of non-white workers` have decreased, whilst hours of white workers are fairly consistent in time, though the composition has changed greatly: a fall in white men`s working hours and a rise in white women`s hours. The overtime hours show a similar pattern as in that the aggregate overtime hours` series being consistent in time, the unpaid overtime increases, and paid overtime decreases for both proportion and hours.

As for participation, although the inactivity rate in the UK roughly maintains at 25 to 20 percent level over time, the make-up of the inactivity has changed. Men have

dropped out of the labour force in unprecedented numbers, and women have entered the labour force to such an extent that the two trends broadly offset each other; With respect to lifecycle education`s effects, they are only obvious amongst women, where the higher the educational attainment, the higher the lifecycle profiles lie. Within the union context, the union premium (wage and hours) are consistent in pattens, with membership premium decreases and coverage premium increases over time. This may offer an incentive to free-ride the collective good trade unions produce, exacerbating the free-riding problem.

2.2Data

The data used in this paper are drawn from three data sources: LFS (1975-1991), QLFS (1993-2016) and a combination of seasonal and quarterly data of QLFS[2](1993 – 2016). The QLFS is the largest regular household survey in the UK. It is based on a country-wide random sample of almost 53 thousand households for each quarter. Although it is not panel data, it provides consistent and accurate micro level information over a long period of time.

In the hours of work analysis, we restrict our sample to include workers with age between 25 and 60 whose normally weekly hours are non-zero. Self-employed persons are excluded as well as those who did unpaid work for their family. In the participation analysis, we restrict our sample in similar principles but the age range extended to between 16 and 65 to reflect the working age population. The details of the data are described in table 2.1, we have collapsed the information for each decade for the ease of presentation.

[2] The reason for two data sources is that the UNION variables are only present in the QLFS public release data files from 2009 onwards. We therefore requested seasonal data from UK Data Service, which contains UNION variables as early as 1993, discontinues from 2005 onwards. Therefore, we consolidated both data sources and formed our data for trade union analysis which starts from 1996 to 2016, with 2006-2008 missing.

2.3Static Labour Supply

In this section, we will first lay out the theory at work on labour supply, then we go on to explore the time series trends of labour supply over different demographics in our datasets at both the intensive margin (Working Hours) and the extensive margin (Participation), with discussions of findings and implications thereof.

2.3.1 Theory at work

The framework that economists typically use to analyze labour supply behavior is called the neoclassical model of labour-leisure choice (Cahuc et al., 2004). The model isolates the factors that determine whether a particular person works and, if so, how many hours he/she chooses to work. By isolating these key factors, the model helps to understand and explain how labour supply decisions are made.

The notion that an economic agent`s labour supply decision is based on the trade-offs between consumption and leisure can be summarized by the utility function:

$$U = f(C, L) \tag{1}$$

Where U represents the economic agent`s utility level, the higher the level of U, the happier the person. C is consumption, and L is leisure. Consumption and leisure are both assumed to be monotonic increasing in utility, which means the more the better. They are also constrained by the economic agent`s income and time respectively, known as the budget constraint.

$$C = wh + Y \tag{2}$$

Where w is the hourly wage rate, h represents the hours worked, and Y is the non-labour income[3]. With the behavioral assumption that the economic agent wishes to choose the particular combination of goods and leisure that maximizes his/her utility. Therefore, the labour supply decision is thus a utility maximization problem against the budget constraint. Solving for this problem, we should find the first order condition which implies that

$$\frac{MU_L}{MU_C} = w \tag{3}$$

This means that at the chosen level of consumption and leisure, the marginal rate of substitution equals the wage rate. That is to say that the rate at which a person is willing to give up leisure hours in exchange for additional consumption equals the rate at which the market allows the

[3] The specification of the budget constraint implies that the worker does not save in this model. The worker spends all the income in the period under analysis.

work to substitute one hour of leisure time for consumption. If we express equation (2) into a function of labour supply h. It is clear that there are two factors (w and Y) in play which affects labour supply. The impact of the change in nonlabour income (holding wage constant) on hours worked is thus an income effect. And the impact of the change in wages is the substitution effect, which illustrates what happens to the worker`s consumption bundle as the wage increases, holding utility constant. In below sections, we explore the empirical evidence in our dataset with the theory in mind.

2.3.2 Participation

we will explore the behavior of labour market participation in this section. First and foremost, as with participation, we use the definition from ILO/OECD, as measured by the proportion of people who are either working or actively seeking to work among the working age population[4].

As the left panel of figure 2.19 illustrates, the labour force participation rate in the UK over the past four decades has been fairly consistent at more or less an 80 percent level. However, if we look at men and women separately, the picture becomes interesting. Where the participation rate of men has been decreasing steadily over time, whilst that of women rises sharply from mid-1970s to early 1990s, after which still rising but at a milder rate. Another interesting feature is the sudden significant rise in participation for both men and women, from 2010 onwards. This reflects recovery from the 2008 crisis.

Participation rate is an important indicator of the labour market performance. However, it is the opposite of participation, the inactivity which is often the focus of analysis and policy interest. Economic inactivity measures people without a job but who are not classified as unemployed because they have not been actively seeking work within the last four weeks and/or they are unable to start work within the next two weeks by ILO/OECD standards.

The right panel of figure 18 depicts the time series trend of inactivity rate. We exclude students from the sample because of inconsistencies in classification of the LFS over time, and the fact that though inactive in the labour market, students are actively gaining skills. The figure shows that inactivity in the UK roughly maintains at 20 to 25 percent, though slightly decreased over time. The make-up of the inactive is radically different now because the composition has shifted dramatically toward men. Men have dropped out of the labour force in unprecedented numbers, while women have entered the labour force to such an extent that these two trends

[4] Working age is defined as males aged 16-64 and females aged 16-59.

broadly offset each other (see figure 18).

In contrast, the inactivity rate for women has fallen sharply from 42 percent in 1975 to 35 percent in 1990, then 30 percent in 2016. an almost equal and opposite swing compared with men. Indeed, most of the net rise in female employment over this period has been met by increased economic activity from those previously outside the labour force. The proportion of the inactive that are male has been more than doubled since 1975, from 8 percent to 18 percent.

2.3.2.1 Participation and Age

Who are the inactive? There has been wide speculation that the increase in male inactivity simply reflects the increase in early retirement. We therefore tabulated the inactive sample by age and gender as can be seen in table 7 below.

Male inactivity has risen for all age groups to some extent (Table 7). The most dramatic increase has been amongst the 25 to 49 and 50 to 64 age groups. 24 percent of men over 50 are now economically inactive, some 1.3 million, compared with less than 15 percent in 1975. However, this is not only a problem for older workers. Around 7 percent of non-student men between age 25 and 49 are now inactive. In 1975, the figure is less than 3 percent. For women, most of the rise in participation has been amongst women aged between 25 and 49. For this group, inactivity fell from 32.5 percent to 20 percent, i.e., 10 to 6.5 million. Significantly there is a smaller, but definite fall in inactivity amongst women over the age of 49, in complete contrast to the trend for men of a similar age.

2.3.2.2 Participation and Education

Labour force participation is also heavily dependent on educational attainment (Keane and Wasi, 2015). The lower the level of qualifications held, the more likely it is that an individual will be economically inactive. More than 38 percent of men with no formal qualifications are now inactive, on the contrary, less than 10 percent of men with degrees are outside the labour force. As can been seen from table 2.8 and figure 2.20a and 2.20b, for men, inactivity has risen amongst all education groups in roughly equal proportions, so that the share of different skill groups in the inactive stock is little different than in 1975. In contrast, the fall in inactivity rates amongst women has come entirely from within the more highly educated group. For less educated women (below NVQ3) inactivity rates have either remained constant or in the case of those with no qualifications have risen sharply.

Therefore, the perception that male inactivity is simply a reflection of an increase in early

retirement is unfounded. Our data shows that several factors suggest that this is not the principal cause. First, inactivity is not exclusive to older men. Inactivity rises and fall for men under 50 in much the same way as the pattern of inactivity amongst older men. Second, inactivity is greatest amongst the least educated. If inactivity were simply an early retirement effect, we would expect to see inactivity concentrated amongst the wealthier groups of the workforce, i.e., the more highly educated. However, this is not the picture we observe in our data.

2.3.2.3 Participation and Ethnicity

Ethnicity may also have a role to play in the variations in labour market participation. The empirical evidence in literature often suggest that people of ethnic minority background tend to have different labour market outcomes, such as wage, employment etc. for reasons of language deficiency (Miranda and zhu, 2013; Di Paolo and Raymond, 2012 etc.), cultural difference (CSI[5] report 2016) and more. We therefore, are interested to see whether there are different patterns in labour market participation rate amongst people of different ethnic background. In figure 2.21, we firstly show the participation rate time series of white and non-white (left panel), then we go on to detailed comparisons between different ethnic minorities and white (right panel).

Overall, the participation rates of both white and non-white rise slightly over time, though, non-whites are (more than 10 percent) less likely to participate in the labour market than their white counterparts. Decomposing the trend by gender, we see that the pattern is consistent in a sense that the participation rate of non-whites, men and women, are lower than their white counterparts. However, what is worth noting is that the gap between white men and non-white men are a lot smaller than that between white women and non-white women. Also, the gap between white men and non-white men is narrowing significantly in time, while the gap between white women and non-white women is widened at the early 1990s, then kept consistent since then at a 15 percent level.

The patterns between specific ethnic minority and white are generally in line with those found between non-white and white. We also find that men of Chinese background and men of other ethnic background are less likely to participate; amongst women, those of Indian, Pakistan and Bangladesh background are the least likely to participate, followed by women of Chinese background and women of other ethnic background.

[5] Centre for Social Investigation, University of Oxford

To sum up, while the numbers of economically inactive have not changed much in the last four decades, the composition of inactivity has changed radically. There are now some 6 million men of working age, excluding students, who are economically inactive according to LFS; Forty years ago, there were only around 2.6 million. The inactivity rate has risen for all men, but is concentrated amongst those aged 50 and over and amongst the least educated and ethnic minorities. At the same time, inactivity rates for women have fallen significantly. Most of this rising labour force participation is concentrated amongst more highly educated women aged between 25 and 49. When the economy expands the incidence of economic inactivity normally falls. However, this effect has been much more muted and confined to women.

2.3.3 Hours of work

Figure 1 shows the total usual hours series for the whole sample (left panel), and men and women separately (right panel) between 1975 and 2016. The shaded areas are the periods of recessions. It is typical in recessions for total hours to fall (Gregg and Wadsworth 2011), but the magnitude varies greatly in the data. Amongst the recent four recessions, the fall in working hours are much more pronounced in the first three, other than a very minor drop in the last one as shown clearly in the left panel of figure 1. The reasons suggested and documented are a combination of supportive monetary and fiscal policies of the government and BoE (Bank of England) during the recession and high profitability levels among firms going into the recessions (Gregg and Wadsworth, 2011). It is evident that from the end of the early 1990s recession till 2008, the British economy has experienced a continued expansion in output, alongside low and stable inflation and high and growing employment. The improved macroeconomic stability and increased market flexibility, combined with greater opportunities in a growing global economy, has prepared the companies more resilient when entering into the recession. Decomposing the trend by gender, we observe different patterns of working behaviors between men and women. First and foremost, the working hours of men is centered around a mean of 44 hours, whereas a mean of 30 hours for women.

The most common reason for this is that women remain the major care provider within a family despite the increase in women`s participation in the labour market in the past decades. This leads to greater proportions of women working part-time compared with men, this is supported by figure 4 in section 3.1.2 below. There could also be a preference explanation behind, which suggest that women prefer less hours than men do, especially married women, when combined family incomes are high (Mitchell, 1984; Hakim, 1996 etc.).

Secondly, apart from the cyclical changes, the long-term hours patterns are very different between two genders as well. the working hours of men are falling down slightly (7%) before mid-1980s, then picking up (10%) until early 1990s and falling down again (6.5%) afterwards. In contrast, the working hours of women was almost level (recessions excluded) before mid-1980s, and it rises steadily afterwards (13% increase in total). Complementary to the widely documented increasing trend of women`s participation in the labour market (Goldin, 1995; Blau and Kahn 2005; World Bank 2019; ILO, 2018 etc.), this series offer the evidence of women`s increasing effort in the labour market at the intensive margin (working hours), completes the picture.

2.3.3.1 Hours of Work and Education

The level of education affects working hours (Blundell et al 2016), particularly so for women. Plenty empirical evidence shows that the length of time women work in the labour market varies according to their level of education (Macran, Joshi and Dex, 1996 etc.). The channel known in literature between education and hours of work is mainly through wage rate, this is well researched and documented in human capital literature that education increases wage rate (Becker, 1964; Mincer, 1974; Heckman 1974 etc.).

The time series trend of educational attainment during the period of our data[6] are shown in figure 2.2. There are more and more people demand higher education (NVQ5[7]), more than 20 percent increase throughout the whole period. Whilst, higher education below degree level (NVQ4), such as nursing[8] and teaching certificate, see a mild decrease in the early 1980s and leveling off thereafter. Decomposing by gender, it is clearly noticed that both genders have increased their demand for higher education (NVQ5), but the increase amongst women are stronger, which catches up with and surpasses that of men in mid-2000s and still rises at a faster speed.

Figure 2.3 confirms the empirical evidence by showing clearly that there is not much difference in men`s working hours across different educational levels. However, as for women, the

[6] 1975 and 1977 are excluded from the data, based on the fact that the sample sizes are significantly smaller in these two years, causing the percentages deviating too far from the general trend, confuses the interpretation of the graph.

[7] NVQs (National Vocational Qualifications). In the paper, we follow the equivalences used by London School of Economics`s research lab, where there are five levels, NVQ5: degree level and above; NVQ4: higher education diploma below degree, teaching and nursing certificates; NVQ3: A levels or equivalent; NVQ2: O levels or GCSE equivalent: NVQ1: other qualifications. To simplify the analysis, we collapsed NVQ1 to 3 to form NVQ1-3.

[8] Nursing became an all-degree profession in 2009, and the degree path for an aspiring registered nurse is four years. This means that the first cohort graduate with a nursing degree is in 2013. Since our data is from 1975 to 2016. The impact of this change on our trend is minimal.

difference between different educational levels are far more significant. Those with NVQ5 qualifications are on average working 36 hours, around 4 hours more per week than their NVQ4 counterparts (32 hours), and around 6 hours more per week than their NVQ1-3 counterparts (30 hours), such gaps are more obvious and consistent from mid-1980s onwards. This may suggest that for men the income effect and substitution effect are of similar magnitude for all educational levels, they cancel each other. However, for women, the higher they are educated, the more dominant substitution effects are. The human capital literature has overwhelmingly relied on wage as the sole explanatory channel between education and labour supply. The underlying implication of our finding suggests that there is a greater commitment to the labour market associated with higher education, at least amongst women. That is, an increase in hour of work increases the utilization rate of human capital.

2.3.3.2 Hours and Full time/Part time

Full-time/Part-time working is an important dimension where people adjust their working hours. Comparative studies have demonstrated that the shift to part-time work is most dramatic in the UK compared to other countries (Bardasi and Gornick 2000) Our data does confirm such a trend in the UK. Figure 2.4 below shows the Full-time/Part-time working trend in our dataset. One of the most obvious highlights of the series is that the share of part-time working has risen significantly (10 percent) in recent decades. After decomposing by gender, it suggests that such increase in part-time working is mainly brought about by male workers, female workers also see an increase in percentage of part-time working, but much less pronounced (3.5%).

There have been many known disadvantages attached to part-time working. The most crucial one of which, perhaps, is that such jobs tend to be in low paying, low status, feminized occupations (Blackburn et al, 2001). A shift from full-time to part-time work after childbearing often involves a downward shift to a lower status occupation (Blackwell, 2001). Why part-time then? Hakim (1996) argues that most part-time workers `voluntarily` choose part-time work despite the above-named disadvantages, because part-time work is a convenient way for people, mostly women to reconcile work and family. Moreover, she claims that female part-time workers have different tastes, commitments and preferences about work compared to female full-time workers, who are more like their male counterparts. The LFS variable FTPTW asks people why they work part-time. Although there are recognized problems with this question in that it provides too superficial an analysis of the possible reasons. With this caveat in mind, it shows that the majority of people say they work part-time because it is their preferred option;

they did not want a full-time job.

It can be seen from figure 2.5[9] above that this statement is made by the vast majority of women working part-time. Whist for men, the percentage is a lot lower. And it is expected that the rate for "Could not Find FT job" is cyclical, and that the rate for "Did not want FT job" is counter-cyclical for both genders.

However, other researchers (Bardasi and Gornick, 2000) has questioned what `voluntary` really means. Burchell, Dale, and Joshi (1997) observe that while LFS attempt to distinguish between voluntary and involuntary part-time work, they do not ask why respondents might state a preference for part-time work, that is whether this was a forced choice or their own preference. It is recognized that preferences are expressed from the vantage point of current circumstances, needs the range of perceived alternatives, and therefore would be expected to change in different circumstances (Fagan, 2001). Therefore, it could be argued that, rather than working part-time voluntarily, some women may choose to work part-time because there is no realistic alternative.

In addition, researchers argue that work-time attitudes have to be interpreted in the context of society and at an individual level. For example, at the individual level both men and women`s employment commitments are influenced by occupational position and domestic circumstances (Fagan, 2001). It is therefore misleading to use employment status and gender as an explanation for their commitment to work. At then societal level, differences are observed in relation to preferences, part-time work patterns and child rearing across countries, which questions the homogeneity of part-time women`s working time preferences and suggests that social policies, gender norms and working time regimes are all influential (Fagan, 2001). In the UK, a lack of adequate and affordable childcare provision (Cohen, 1993) prevents feasible alternatives to women who work part-time. To illustrate this, Burchell, Dale and Joshi (1997) point to a UK survey that found that "14 percent of women part-timers would like full-time work but were prevented from seeking it by domestic commitments".

Moreover, family considerations also affect men`s evaluation of the conveniences of work schedules, although women are more likely to be influenced by childcare and domestic responsibilities (Fagan, 2001). Full-time working hours are very long in Britain and part-time hours are very short compared with other developed economies, as can be seen in figure 2.6.

[9] The variable FTPTW only starts in 1994. In our analysis, we excluded the reason for being in FT education, which contains majority of the underaged (16-20) when we investigate the behavior of working hours (the sample is truncated between age 20-60).

Fagan (2001) also find that when questions about working hours are asked, both male and female part-timers, especially those in low paid manual jobs invariably want to work longer hours, whilst both male and female full-timers, especially those in well paid managerial and professional roles want their hours shortened. This not only questions the assumed gender differences in working patterns but also highlights that the choice for women, particularly mothers, is to undertake either very long or very short hours when neither alternative is actually the preferred option.

Figures 2.6 shows the mean hours series by full-time/part-time. It confirms the fact that there is a huge gap (more than double) between full-time/part-time hours. Decomposing by gender, we can see that full-timers in both genders works a lot harder than their part-timer counterparts. Men full-timers on average works 5 hours more than women full-timers, men part-timers follow a similar pattern in the 1970s and early 1980s, but the gap narrows since, and closes up since mid-2000s. An interesting trend here, is the increase in men working part-time which is only noticed recently, the reasons documented so far are the "hollowing out"[10] of mid-skilled jobs in the male labour market, as they move to other parts of the world, or disappearing altogether as a result of automation, such as manufacturing. This compositional change together with the increase in the intensity of female workers` labour market attachment has made the average part-time hours of both sexes converge.

2.3.3.3 Hours and Marital Status

Over the past several decades, there has been a major transformation undergoing in family structure in the western world, this change can be characterized by a large increase in the labour force participation of women, a sharp increase in the rate of divorce, a drop in the fertility rate and an increase in the number of female-headed households and never-married men and women (van de Klaauw, 1996; Eckstein and Lifshitz, 2015). These changes have led to growing awareness that both marital status and fertility decisions are strongly interrelated with labour supply decisions (van de Klaauw, 1996), again particularly with women. In our analysis, we explore the degree to which marital status (Single and married) accounts for differences in working hours in the labour market. Here we only look at the comparisons between single and married individuals, based on the fact that the widowed and the divorced are very small in number.

[10] Resolution Foundation Report 2018.

Figure 2.7 presents the hours series of the single and the married. On the aggregate level, people who are single on average works (3 hours) more than the married, though the difference is disappearing in time. This can be attributed to the increase in female participation and effort in the labour market (Goldin, 1995; Blau and Kahn 2004; World Bank 2009, 2011; ILO, 2018 etc.). After the decomposition by gender, the disappearing difference as observed between the two marital groups is further confirmed by the significant increase in mean working hours (22%) amongst the married women across the period, though single women`s hours have not changed much. Amongst men, the married are working 2-4 hours more than their single counterpart, and the gap is fairly consistent throughout time. The findings are in line with the empirical evidence in literature (Ahituv & Lerman, 2005) that entry into marriage exerts positive and significant impact on men`s working hours. Fertility decisions are often seen as a main driver for the changes in labour supply decisions within households (van de Klaauw, 1996). We therefore explore further on how working times vary across different family types in terms of the existence of children and small children (aged under 2 years old). Table 1-2 shows the hours parents work with or without the presence of children in the past four decades, to make it easier to report, we group the hours into five groups: less than 20, 20-29, 30-40, 41-50 and above 50. Children under the age of two are believed to be heavily dependent on their parents which may reduce their parents` labour supply intensity further, we therefore report separately in table 3 the hours of parents with children under the age of two as a comparison.

Across Table 1 to 3, the general patterns are that parents` working hours are becoming more dispersed in time, with a big shift from the range of 30-39 hours to over 50 hours amongst men without children; and from 40-49 hours to over 50 hours amongst men with children. Meanwhile, there is a smaller proportion moves to lower hours brackets. As for women, the shift is from 40-49 bracket to 20-29 when they have children, which suggest that the presence of children affect mothers` working hours more than it does to that of fathers. Amongst women without children in their family, we see the proportions are moving from the 30-39 brackets to 40-49 and over 50 hours significantly in time, this confirms what we see in figure 1 that women increase both their participation and their work intensity in the labour market.

The UK government has working time regulations which stipulate that average weekly working hours should largely be within 48 hours. This suggest that the over 50 hours bracket should mostly be overtime hours, paid or unpaid. From tables 1-3, we see that more fathers are working over 50 hours with or without children. Fathers with children are 5 percent more likely to work over 50 hours than those without. And for mothers, they are much less likely to work over 50

hours than their male counterpart. However, in time, the number of women who work over 50 hours has doubled. Where there are small children (less than the age of 2) present in a family, fathers are more likely to work overtime, but only within 50 hours, while the mothers are less likely to work overtime. This may suggest that though mothers in such circumstances are the main care provider, fathers may also help in home production in some less intensive way.

2.3.3.4 Hours and Ethnicity

For a variety of cultural and other reasons, as well as differences in characteristics such as education etc., average working hours vary between people of different ethnic groups in the UK. Figure 2.8 compares the average working hours of White and non-white. The average working hours for non-white decreases by 14% in our data period while for the White they largely level off at around 37 hours. Gender-wise, the average working hours vary for both genders at different times. Amongst men, the average hours of non-whites are decreasing more significantly than those of the whites forming a gap of 5 hours in recent decade. Amongst women, there has been a historical gap between that of white and non-white. However, the gap closes from 2010 onwards, with the average working hours of white women still on the rise.

Further into ethnicity details, there is no significant correlation between race and working hours, but there is suggestive evidence that both men and women of the Chinese background were working more hours on average than people of other ethnic background. However, the general pattern remains consistent and clear across different ethnicities that men of ethnic minority background in the UK are working less intense than they used to be. With women, figure 2.9 suggests that the average working hours of white women have been historically lower than that of their ethnic minority counterparts, however, they are catching up in the recent decade, and the gap is closed completely in recent five years.

Figure 2.10 shows the full-time & part-time proportions by ethnicity, which is an important dimension where people adjust their working intensity. It is easy to find that women are much more likely than men to work part-time, and this is the case across all ethnic groups. The proportion of ethnic minority women working part-time is slightly lower than that of white women, so although their employment rate is lower overall, once in employment ethnic minority women are slightly more likely than white women to work full-time. And again, we see that percentage of part-time working white women are decreasing steadily, therefore the percentage of full-time increasing to roughly the same level as ethnic minority women. On the

other hand, ethnic minority men are more likely to work part-time than white men (less likely to be in full-time employment) and this is also consistent across ethnic groups.

2.3.3.5 Hours and Occupation (White and Blue collar)

If we believe that the changes in working hours happen mostly for those at the top and bottom of the wage distribution, as Bell and Freeman (1994) and Gregg and Manning (1997) suggest, then we would expect to see significant differences in the number of hours across occupations. In figure 2.11, we do see that this seems to be the case more and more so in recent decades than before 1980s. When gender difference is considered, working hours are fairly homogeneous across occupations[11] amongst men, though the gap is widening somehow since late 2000s. Amongst women, the distribution of hours across occupations varies considerably, a gap of roughly eight hours has been very consistent between white-collar and blue-collar workers.

Those in blue-collar occupations much more likely to work short hours, and they are more likely to work part-time as well. On the contrary, those in white-collar occupations such as managerial occupations and clerical workers are predominantly full-time. Also, it is important to account for full and part-time working status in gender difference as well, since women has been known for high concentration in the part-time work (Blackburn et al., 2001).

2.3.3.6 Hours and Industry[12]

Due to possible reasons of industry specific characteristics, such as requirement of frequent overtime and presence/lack of presence of trade unions etc, we do observe that there have been wide differences in average working hours across industries.

Men working in Agriculture/Forestry/Fishing/Hunting are the most intensively working group, with an average of 55 weekly working hours, and men in the rest of the industries have more or less the same average hours (45 hours). Amongst women, the average hours are between 27 and 37 hours across different industries. Women in energy & mining and Engineering & Manufacturing mostly work longer hours. to a lesser extent, those working in services and construction work fewer than average hours.

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[11] Due to inconsistency in occupation specifications in our data, in order to be consistent and to simplify the analysis, we group the nice categories into two groups: white collar and blue collar.

[12] The industry variable originally contains 11 different classifications, to simplify the analysis, we re-classified the variable into five different industry groups: Agriculture/Forestry/Fishing/Hunting, Energy & Mining, Engineering and Manufacturing, Construction and Services.

2.3.3.7 Overtime Hours

In addition to the above patterns of usual working hours, we look at overtime hours separately in this section. to be precise, how overtime varies across different demographics in the past decades. Our analysis focus on the dimensions of percentage who are working overtime and mean overtime hours worked. Figure 12 below offers the bird view of overall time series of unpaid and paid overtime in our sample. It is worth noting that the overtime sample starts from 1984, when the overtime variable POTHR and UOTHR was first introduced in LFS.

The top two panels of figure 2.13 are the series of mean overtime hours worked, unpaid and paid. it suggests that unpaid overtime hours have been rising in recent decades, and the difference between two genders has been persistently narrowing. whilst mean paid overtime hours are roughly levelling off in past decades. However, different genders behave differently. Male workers` mean overtime hours are falling slightly, and female workers` mean overtime hours are rising contrarily. The lower panels picture the time series of the percentage of working people in the sample, it is not difficult to find the rapid increase in the percentage of people working unpaid overtime, and the sharp fall in the percentage working paid overtime. To explore the possible reasons behind this trend, we decompose the trend further by demographics, such as education levels, marital status, family types and occupation.

We outline the overtime trends by education levels, measured by NVQs in figures 2.14 & 2.15. Figure 2.14 present the percentage of male and female workers in each education level working paid or unpaid overtime. The most prominent features of the figure are that people with NVQ5 & NVQ4 education levels are more likely to work unpaid overtime rather than paid overtime. Yet people with NVQ1-3 levels are more likely to work paid overtime, especially so for male workers in this category. One interpretation for this could be that unpaid overtime proportion is high among the highly educated, because workers see this as increasingly important to their career prospects in the face of increasing labour market competition, particularly for female workers. while paid overtime has been more common among lowly educated workers as they need to work extra hours in order to make ends meet (Harkness 1999), it could also be that the wider presence of trade unions among blue collar occupations which alleviate the greed of corporations.

Figure 2.15 depicts the mean overtime hours series (paid & unpaid) by education levels. Comparing this with figure 2.14, we can see that, though the percentage of people who work

overtime varies much across different education levels, the difference in mean overtime hours worked is small (1-3 hours per week). And there is a pattern revealed consistent between paid and unpaid overtime hours series, being that the overtime hours gap is narrower for highly educated, and wider for lowly educated between two genders. This is somehow expected, amongst female workers, the higher educational attainment they have, the similar their working behaviors are compared with those of their male counterparts.

Figure 2.16 presents the overtime series by marital status (single or married). The left panel shows the trend of percentage of overtime workers, and the right panel the mean overtime hours worked.

The patterns are in line with previous findings (figure 12) of increasing percentages of unpaid overtimers and decreasing percentages of paid overtimers. Amongst the workers who are single, there are roughly 20 percent work unpaid overtime, rarely any difference between genders; though the percentage is on a mild rise in time. When it comes to paid overtime, the percentage is flat at 20 percent for female single workers, but for male single workers, it is way higher, but trending downwards from 50 percent to 30 percent. Amongst the workers who are married, we see that the increase percentage in unpaid overtimers are mainly female workers, and the decrease in paid overtimers are mainly male workers.

Regarding the average overtime hours, both male and female workers, single or married are working harder in the past decades. Tough the increase in unpaid overtime hours is more significant than that in paid overtime hours. Gender-wise, amongst the overtimers who are single, there is a small gender gap (1 hour roughly), which is closed in unpaid overtimes after 2010 and closing in paid overtimes. The gender gaps are greater amongst the married than they are amongst the single. This may suggest the traditional family structure where women are the main care provider, in terms of childcare and home production, still plays an important role in many families.

Another important factor that affects labour supply within a family is the presence of children. Therefore, we further explore the overtime hours based on family types in terms of whether children/small children present in the family in tables 4 to 6. “Small children” here is defined as children under the age of two. They are analysed separately, because they require more intensive care which normally translates into more hours and energy dedicated by their parents.

Table 2.5 looks at the overtime in families without children; table 2.6 overtime in families with children; and table 2.7 overtime in families with small children. Generally, the presence of

children in a family affects women`s overtime more than it does to men in both the dimensions of percentage and mean overtime hours. However, men who have children, particularly small children, are (2% - 3%) more likely to work overtime than those without. Whilst, women who are with children are (4% - 6%) less likely to work overtime. This is expected with the traditional family structure in mind. It is not a surprise to find that men are more likely than women to do overtime, and that men`s mean overtime hours are higher than that of women in all cases. However, when the paid and unpaid overtime are looked separately, men are more likely to work paid overtime, and women unpaid overtime. And the increase in the percentage of women working overtime are only reflected in the unpaid overtime trend.

The fact that different occupations behave differently has long been documented in literature as occupational segregation in terms of pay (Crompton, 1997) and total hours as evidenced in figure 2.11 in previous section. Although the changes in occupational segregation are sensitive to methods of measurement (e.g. Blackburn et al., 1993), the overall segregation has remained largely stable (Hakim, 1996; Blackburn et al., 1993; Blackburn et al., 2001). In this section, we explore the overtime trend by occupations – White collar and Blue collar, paid and unpaid.

The time series of percentage working overtime (left panel) and mean overtime hours (right panel) by occupation: white collar (WC) and blue collar (BC) are shown in figure 2.17. Amongst those in white-collar occupations, the percentage of working unpaid overtime has been almost constant in time at around 40 percent, however the composition has changed, with the percentage of male unpaid overtimers decreasing and female unpaid overtimers increasing, thus closing the gap from the year 2000 onwards. And the trend for white-collar paid overtimers has been falling slightly in time from 20 percent to 17 percent, with no gender difference noted. Contrary to white-collar overtimers, the blue-collar overtimers are a lot more likely to work paid overtime, especially male workers (50% to 70%), though the series is trending down significantly.

2.3.3.8 Hours of Work and Earnings

We have seen that hours of work have become increasingly dispersed over the past decades. An interesting and related question arises, what does the relationship between hours of work and earnings look like. Unfortunately, LFS wage data only goes back to 1993. Figure 2.18 plots the mean hourly earnings for men and women across hours.

For both men and women, earnings rise steadily with hours up to around forty-eight hours a

week before starting to fall. This indicates that those who are best remunerated are most likely to work a standard full-time working week. Those working longer or shorter hours than this are significantly less well paid. This fits well with earlier work of Harkness (1996) which has shown a growing gap between the earnings of full-time and part-time employees. It should, however, be noted that the chart does not control for any differences in the characteristics of workers and therefore does not tell us anything about any causal relationship between hours of work and earnings.

This relationship between hours and earnings holds even after account is taken for occupational differences. The only exception is amongst professionals, whose earnings are inversely related to hours of work. These professionals who work relatively short paid hours, may include those who hold more than one job or who are paid high consultancy rates for a relatively short number of working hours.

2.4 Life-cycle Labour Supply

In the previous section, the patterns we show on labour supply have been static, i.e., the decisions of whether to work and how many hours to work from the viewpoint of a worker who allocates his time in a single time period (Year, in this case) and ignores the fact that he will have to make similar choices continuously over many years. In fact, because consumption and leisure decisions are made over the entire working life, workers can trade some leisure time today in return for additional consumption tomorrow as the basic lifecycle discussions (see Heckman, 1974) suggest.

For instance, a person who devotes a great deal of his/her time to working today can save up some of the earnings and use these savings to increase his/her consumption tomorrow. Or in another case, an individual makes a decision to delay entering into the labour market by getting more years of education, with the expectation of a higher wage which improves his/her lifetime consumption profile. The latter example is the case that economists regard as the driver of demand for education and training which is widely recognized today.

Empirically, in the following sections, we will explore the lifecycle hours profile, lifecycle participation profile, as well as how they variable by characteristics such as education and marital status.

2.4.1 Lifecycle participation

The life cycle approach suggests a link not only between wages and hours of work, but also

between wages and labour force participation rates. The literature (see Borjas 1996) describes such relationship as the labour force participation decision depends on a comparison of the reservation wage to the market wage. In each year of the life cycle, therefore, the worker will compare the reservation wage to the market wage. Suppose initially that the reservation wage is roughly constant over time. The person is then more likely to enter the labour market in periods when the wage is high. As a result, participation rates are likely to be low for young workers, high for workers in their prime working years, and low again for older workers. Our data does support this prediction, as can be seen in figure 2.27.

The reservation wage measures the cost required to enter the labour market. Therefore, the participation decision also depends on how reservation wages vary over the life cycle. For instance, the presence of small children in the household increases the value of time in the household production for the person most responsible for child care (mainly mothers) and, hence, also would increase the reservation wage for mothers. Therefore, it is not surprising to find the dip in the middle of women`s life cycle participation profile. Many married women choose to participate in the labour force intermittently. They work prior to the arrival of the first child, withdraw from the labour market if not entirely when the children are small and need intensive care, and return once the children enrol in school.

2.4.1.1 Lifecycle participation by education & marital status

The dominance of substitution effect over income effect due to education is also observed in lifecycle participation decisions, as can be seen in figure 2.28 a & b, again, particularly in women. And by marital status, we can see a surge in participation rate of the married, which even exceeds the participation rate of the single after the age of 30. Decomposing by gender, it shows that the main contribution to such surge in the participation rate of the married is from married women. This should be attributed to the rise in female labour market participation in recent decades as well as the recent family friendly labour market policies in the UK, such as child benefit, child tax credit etc.

Overall, the trends illustrated in the figure are consistent with the theoretical prediction that participation rates should be highest when the wage is high (that is, when workers are in their thirties and forties). The decline in labour force participation rates observed after age 55, however, is much too steep to be explained by the wage decline that is typically observed as workers near retirement age. The rapid decline is participation rates at older ages may be health related, may also be attributable to the work disincentive effects of various retirement and disability insurance programs.

2.4.2 Lifecycle Hours

Figure 2.22 illustrates the actual relationship between mean hours of work and age. Hours of work rise rapidly at early 20s, peak at 25, then fall slightly before peak again at around age 45 to 50. After decomposed by gender, the lifecycle hours profiles are very different between men and women. For men, it is an inverse "U" shape profile, hours rise rapidly at early 20s, then slow down but still rising, until peak at age 45 to 50, decline as retirement age approaches. In contrast, hours of work amongst working women form a "M" shape profile, hours rise at the same rate as that of men at early 20s, peak at 25, rise again at late 30s, peak again at 50s, though at a lower level than the previous one, then decline as retirement approaches. One possible explanation for this would be that women work as hard at the beginning of their career, as soon as they start a family and child rearing, their hours drop significant (some young women work in part-time jobs if not totally out of the labour market while they have small children in the household). Their work intensity recovers only after their children are old enough to go to school.

2.4.2.1 Lifecycle hours by education and marital status

Education has an important role in labour supply, we therefore illustrate and elaborate this role in figure 2.23 and 2.24 before go on to the data. Where there are four axes: C_1, C_2, L_1, L_2 represents consumption and leisure respectively in period 1 and 2. And therefore four quadrants are formed in each period. Quadrant C_1, L_1 represents the labour supply decision in period one. And Quadrant C_2, L_2 represents the labour supply decision in period two. Quadrants C_1, C_2, and L_1, L_2 offer the budget constraints for consumption and leisure.

Figure 2.23 repsents the two period labour supply decision of an economic agent with low level education. In period 1, he/she has a wage w_1, time endowment T. In period 2, a wage w_2 and time endowment T, where $w_2 > w_1$. With the original budget constraint in period 1, the economic agent must work for H` hours, and achieve a life-time utility at point D_3. Since at D_3, the marginal utility of wage for period 1 is higher than that for period 2, he has the incentive to smooth consumption from period 2 to period 1 by borrowing B. By so doing, he achieves a higher utility at D_4, where the marginal utility of period 1 equals the marginal utility of period 2. It has been well researched and documented in human capital literature that education increases wage rate, if we take education into consideration, building on top of this analysis, we shall find that labour supply decision of an economic agent with high level education looks like figure 2.24 below.

Both w_1 and w_2 are higher than the previous case, we can see the effect after smoothing out consumption. The lifetime budget constraint has been shifted out, showing a wealth effect. If education only changes wage and not preference, we should expect that the number of working hours for the highly educated to be lower than the lowly educated in every age period. However, this analysis only reflects the income effect of education, however, a wage increase could also generate a substitution effect in the consumption-leisure trade-off decisions. If income effect dominates, then the inference above should be observed, if substitution effect dominates, then we should expect that highly educated work more than their lowly educated counterparts, since their leisure is much more expensive than that of the lowly educated. Our data (Figure 2.25) does reflect that the substitution effect domination is the case; particularly for women, the more they are educated, the more they work across the whole lifecycle. If we link the "high substitution effect" to hard-working, this suggests either that education change people`s preference for hard work, or that hard-working people self-select into higher education.

Marital status is also an important factor which influences labour supply decisions (see Killingsworth and Heckman 1986). Figure 2.26 confirms such claim. People who are single on average works more than their married counterparts throughout the lifecycle. However, if we look at men and women separately, the patterns are different. Across the lifecycle, men who are married work more than those who are single. But married women work significantly less than those who are single. This shows us a picture where traditional family division of labour still applies to the labour supply of men and women who are married.

2.4.2.2 Life-cycle Hours and Earnings

The age-wage profile (figure 2.29) of a typical worker rises rapidly when the worker is young, reaches a peak at around age 45, for women, the peak is earlier at around 35. And then wages either stop growing or decline slightly. The changing price of leisure over the life cycle implies that the worker will devote relatively more hours to the labour market when the wage is high and fewer hours when the wage is low[13].

This approach to life cycle labour supply decisions implies that hours of work and the wage rate should move together over time for a particular worker, as illustrated in the figure. This implication differs strikingly from our earlier conclusion that a wage increase generates both income and substitution effects, and that there could be a negative relationship between wage

[13] A detailed explanation of the model is given by James J. Heckman, "Life cycle consumption and Labour Supply: An explanation of the Relationship between income and consumption over the life cycle," *American Economic Review* 64(March 1974): 188-194.

and hours of work if income effects dominates. This important difference between the models arises because the two models mean very different things by a change in the wage. In the static model, an increase in the wage expands the worker`s opportunity set and hence creates an income effect that increases the demand for leisure. In the life cycle model, an evolutionary wage change- the wage change that workers expect as they age, does not change the total lifetime income available to a particular worker, and leaves the lifetime opportunity set unchanged.

Empirically, many studies have attempted to estimate the interactions between hours of work and wage in a lifecycle frame. i.e. how hours of work change to the wage change over the life cycle[14]. These studies typically use a longitudinal sample of workers to estimate how a given worker adjusts his/her hours of work to the evolutionary wage changes that occur as the worker ages. The intertemporal substitution hypothesis implies that the correlation between changes in hours of work and changes in the wage should be positive: As a worker ages, an increase in the wage rate should increase hours of work. Figure 2.29, however, also reveal the stickiness of hours of work over a long stretch of working life. For example, mean hours of work barely changed between the ages of 35 and 50, despite the fact that the wage rises substantially during this period. Because hours of work tend to be sticky, many studies (MarCurdy, 1981; Blundell et al, 2002 etc) conclude that the response of hours of work to evolutionary wage changes is small: a 10 percent increase in the wage leads to less than a 1 percent increase in hours of work. Therefore, labour supply over the life cycle may not be very responsive to changes in the wage[15].

2.5 Labour Supply in Trade Unions

The industrial relations literature on unionism usually ascribes an important role to trade unions (Pencavel, 1990) in the setting of labour supply, and certainly most unions have identified control over the hours worked by their members as a primary goal of their activities. At one time, unions focused their activities on the length of the workday and workweek. More recently, issues concerning the length of vacations, the number of holidays and leaves of absence have been emphasized. Yet research in labour economics on unionism tends to neglect this

[14] Thomas E. MaCurdy (1981) "An Empirical Model of Labour Supply in a Life-cycle setting", *Journal of Political Economy* 89:1059-1085. See also Joseph G. Altonji (1986) "Intertemporal Substitution in Labour Supply: Evidence from Micro Data", *Journal of Political Economy*, 94:S176-S215; Casey Mulligan (1998) "Substitution over Time: Another Look at Life Cycle Labour Supply", *NBER Macroeconomics Annual*, 13:75-134.

[15] There is a lot of debate over the validity of this conclusion. The magnitude of the labour supply response to life cycle changes in the wage (the intertemporal elasticity of substitution) has important implications in macroeconomics. Some macroeconomic models require sizable intertemporal elasticities to explain the behaviour of employment over the business cycle. As a result, there is heated disagreement over the evidence suggesting that the intertemporal elasticity is small.

dimension of influence on labour supply.

In this section, we set to explore labour supply behavior in the context of trade unions in the UK over the past four decades. We start by describing the union density and union coverage characteristics, then we explore the union density and coverage time series by demographic characteristics, such as gender, sector, education, industry, occupation and cohort. Finally, we explore the hours and wage differentials between union and non-union workers, and finish with concluding remarks.

2.5.1 Characteristics of union membership and coverage densities in the UK

As shown in table 9, union density varies by demographic, job and workplace related characteristics. It varies little by gender or ethnic origin but rises with age, falling off slightly past age 50, then sharply at 65. Those with higher education have density levels substantially above those with lower or no educational attainments. However, people with NVQ level 4 are the most likely to be union members, since these are mostly teachers, nurses and other professional workers. Density rises sharply by tenure; this confirms the general knowledge that labour turnover is lower in workplaces with union presence.

Public sector aggregate membership is more than three times that of the private sector. People who work in transport, communications, public administration, education and health services are far more likely to be members than those employed in business services, distributive services and hotels, construction, agriculture, forestry, fishing and hunting. Manufacturing has a union density more and more down below that for the whole economy. Smaller workplaces (under 50 employees) have density levels less than half those of larger establishments. And an individual is much more likely to belong to a union if she or he lives in Scotland, Wales and Northern Ireland than in England.

Union coverage measures the percentage of those whose wage or working conditions are affected by union collective agreement no matter what union status they are, members or non-members. In other countries where industrial relations are simpler such as the US, union membership and union coverage mostly measure the same thing, however, in the UK, this is not necessarily the case. Many non-members work in workplaces that are covered by union agreements and conversely, more union members are employed in workplaces where unions are not engaged in bargaining (Bryson 2002). The fact that union coverage densities reported in table 10 are higher than the union membership densities in table 9, does prove that this, normally referred to as the free riding problem, is true.

The union coverage density pattern is comparable to that of membership density, apart from the fact that they are larger mostly. The only exception noted in table 10 is the coverage density in agriculture, forestry, fishing and hunting from 2009 to 2016. It is 2 percentage point lower than the membership density during the same period. This suggests that the number of union worker whose wage or working conditions are not affected by union collective agreement is on the rise in recent years.

2.5.2 Union membership and coverage densities trends

After having a description of the characteristics concerning the union membership and coverage densities, it would be interesting to know how the densities have changed in time. We therefore explore the time series trends of these densities[16] below across demographic characteristics, such as gender, education, sector, industry, occupation and cohort. Figure 2.30 presents the trends for the densities at aggregate level and at decomposed level by gender.

Membership and coverage densities have both fallen throughout the decades by around 6 percent, equivalent to 4m people. The coverage density is 8 to 9 percent higher than the membership density, such gap estimates the lower bound of the free riding problem, owing to the fact that the pay and working conditions of some union members are not covered by union collective agreements. The findings are twofold: The magnitude of the free-riding problem seems to be greater in male workers. And the density gaps between genders are widening in time due to much sharper falls in male densities.

What`s more, by sector, as presented in figure 2.31 (left panel) reflects the general real-life experience where public sector is far (three times) more unionized than private sector. In private sector, a higher percentage of male worker are union members, though the difference between genders is diminishing in time. The same patterns are found in the coverage density as well. In public sector, the membership density amongst female workers are fairly stable across time at a level of around 60 percent, while the membership density for men is on a fall from 65 percent to 50 percent.

Historically, unions have been known for its representation of workers with lower levels of education, a more working-class population. However, unions increasingly represented workers with more education (Farber et al., 2018). It is probably because of the combination of several reasons, such as the structural change of industries in the UK, where you see a shift

[16] Details on union membership and coverage status have been collected by LFS since 1989 and 1996 respectively. We have excluded the first few years of data for due to a mis-classification problem which classified some not-covered individuals as dna, causing the proportion trend very misleading to interpret.

from manufacturing to services, and the exerted attacks on unions` ability to organize with the overall restricting of the labour market, outsourcing and subcontracting isolated low-skill workers. Unions were not able to maintain their representation of the workers who would benefit the most from collective bargaining.

the densities series by education (right panel in figure 2.31) suggest that membership and coverage densities are higher at NVQ4 and NVQ5 levels than those at NVQ1-3 levels. The densities at NVQ1-3 are similar across gender, whereas the densities at NVQ4 and NVQ5 levels differ greatly: the densities for female workers are (15 to 18 percent) higher than those for their male counterparts.

Variations in union densities by industry and occupation are widely acknowledged. The evidence in our data are plotted in figure 2.32. It is interesting to find that the gap between coverage and membership densities are higher in industries where the union presence is bigger, such as Transport and communications, other services that comprises education, healthcare and public admin. In terms of occupation, we simplified the analysis by collapsing the occupations into two categories: white collar and blue collar, and the findings are that white-collar workers enjoy a higher membership and coverage densities; the gap between two collars is enlarging slightly in time due to sharper falls in blue collar workers densities. Decomposing by gender, we find that the fall in blue collar workers density is largely caused by male workers; the female white-collar workers are much more likely than their female blue-collar counterparts to be either a union member or collective agreement covered. Such gap is not clear amongst male workers.

There has long been speculation that older cohorts are more likely to be unionized than younger cohorts. We therefore decomposed the union membership and coverage time series according to birth cohort as presented in figure 2.33 a & b. Since our sample are restricted from 25 to 60 years old. Therefore, there are gaps shown for some cohort in some years.

Although the membership densities are fairly similar across all cohorts at around 20 percent level. The pattern does show that older cohorts are more likely to be union members than younger cohorts, only at margins (2 to 3 percent). Nevertheless, when it comes to coverage density, the older cohorts[17] are far more (10 to 15 percent) likely to be collective agreement covered than the younger cohorts. This suggest that the free riding problem is much more serious amongst older cohorts. After decomposing by gender, the patterns of membership and

[17] The cohorts are constructed through the age range 25-60.

coverage persists. Though women have a slightly higher density than men across all cohorts in both membership and coverage.

2.5.3 Union wage premium

One of the principle benefits for union members has been the delivery of a wage premium over similar non-members through unions` collective bargaining activities (Bryson and Forth, 2011). The widely documented decline in union membership and collective bargaining coverage over the past several decades has often been assumed as the reason for a lower union wage premium. However, it is not necessarily so, as the level of union wage premium depends upon the balance of the bargaining power of the remaining trade unions in the market. Whereas, the increase in free-riding is one problem that points towards a weakening of union power in organizations where unions remain present, and our results do suggest an increase in coverage wage premium. In the section, we update the picture of the union wage premium in the UK using the QLFS data (1993-2016). We have tabled the coverage wage premium separately from the membership wage premium to offer a more detailed insight into the patterns. Table 11 below shows that the membership wage premium has been declining in recent decades, while the coverage wage premium has been on a rise steadily. Having stood at around 10 percent across the 90s. the wage premium enjoyed by union members (after controlling for other characteristics) dropped to single digit at around 6 to 7 percent from 2000 to 2016.

Female union members have typically enjoyed a larger wage premium (more than double) over their male counterparts. Female union members enjoy a wage premium over female non-members of around 7.5 percent (down from 11.2 percent in the 90s), whereas among male employees the premium has fallen from around 6 percent to just 3 percent over the past decades.

The coverage premiums are smaller in size compared with membership premiums; however, the differences are diminishing. The coverage premium itself does not reflect the seriousness of the free-riding problem, though the increase in the size of the coverage premium does pose as an incentive to free-riders of taking advantage of such collective goods trade unions produce.

2.5.4 Union hours premium

The bargaining between management and trade unions in practice, do not only focus on the level of wages, working hours is another important dimension where unions exert their influence in workplaces. This may happen in different forms though, such as the length of a working week, the length of paid holidays, the number of sick leaves and so on (Booth 1995). The focus of this research in on labour supply, we therefore, are more interested to know

whether such a premium exists in working hours between union worker and non-union workers.

There are very few empirical evidences on union hours premium, yet majority of these work are based on US data (Perloff and Sickles 1987; Earle and Pencavel 1990; DiNardo 1991). In this section, we explore the union hours premium with our data, in an attempt to shed some light on this topic.

Table 12 suggest that the hours premium indeed exists, and the patterns are similar to the wage premium; in that membership premium declines over time, while the coverage premium rises steadily. Again, female union members enjoy a significantly larger premium (3 to 4 times) over their male counterparts. Female union members enjoy an hours` premium over female non-members of around 11 to 17 percent, if valued at a mean of 30 hours, this amounts to 3.3 to 5.1 hours per week. Amongst male employees the premium has fallen slightly from around 4.2 percent to 3.7 percent over the decades. The coverage premiums are a lot smaller in size, especially for male covered workers; for whom the coverage premium was negative up until 2008, turned positive after 2009 but very small in size (0.6 percent). That means that in the years up to 2008, male union workers work (1.9 to 2.6 percent) less on average each week. If valued at a mean of 40 hours, it is 0.76 to 1.04 hours per week.

2.6 Conclusion

In this paper, we set out to explore the labour supply behavior in the UK over the past four decades with our LFS and QLFS data. We have done so through three different perspectives: static labour supply, life cycle labour supply and labour supply in the context of trade unions.

In terms of the static labour supply, we have explored the behavior of working hours (total hours and overtime) and participation. The findings show that working hours are cyclical, though the fall in working hours during the recent 2008 great recession has been unexpected low; Education affects working hours, but only for women. The effect is particularly large between NVQ5 and NVQ4. Whereas, men`s working hours are hardly different on average across all education levels; Despite the fact that men are much more likely to work full time than women, the proportion of part-timers amongst men has increased dramatically over time; The historically persistent hours gap between single and married workers has been closed in the recent decade due to the steady increase in married women`s working hours; The working hours of non-white workers have decreased, while that of white workers are fairly consistent in time, however, the composition have changed: a fall in white men`s working hours and a

rise in white women`s hours; The overtime hours shows a similar pattern where the overtime hours series is consistent in time, while the composite has changed, with unpaid overtime increases, and paid overtime decreases both proportion and hours; The best remunerated workers are most likely to work a standard full-time working week, those working longer or shorter hours than standard are significantly less well paid.

As for participation, the findings are that the inactivity rate in the UK roughly maintains at 25 to 20 percent level over time. The make-up of the inactivity has changed, where men have dropped out of the labour force in unprecedented numbers, while women have entered the labour force to such an extent that the two trends broadly offset each other; The lower the level of educational attainment, the more likely an individual will be economically inactive; White people are much more likely than ethnic minority to participate.

The lifecycle labour supply, again we have approached the analysis from margins of hours and participation both. We find that the lifecycle working hours profile is roughly an inverse "U" shape with a small dip in the middle, if decomposed by gender, men`s lifecycle hours profile form an inverse U shape, peaks at around the age of 35 to 50. While women`s lifecycle hours profile is more of an M shape curve, where the dip in the middle happens at the late 20s to mid-30s, reasonably coincide with the pregnancy and child-rearing period. This pattern also applies to the lifecycle participation profile. Factors such as education and marital status can cause the lifecycle profiles to shift. Education`s effects again are obvious only amongst women, where the higher the educational attainment, the higher the lifecycle profile lies (working hours and participation). The effect of marital status on the lifecycle profiles can be understood by the division of labour within a family. Since it pushes up the lifecycle profiles (working hours and participation) of married men and lowers the lifecycle profiles of married women.

Labour supply in the context of trade unions, i.e. hours determination with bargaining have not been given much attention in labour supply research. With limitation and constant failing of the traditional models, such perspective has become of great value. In our analysis, we describe and estimate the membership premium and coverage premium separately. We find that both membership rate and coverage rate have been falling over time, though the fall in the rates of male union/covered workers are more pronounced. The patterns are consistent by education, sector, industry and occupation; Older cohorts are more likely to be a non-union membership yet covered by a collective agreement. The union premium (wage and hours) is consistent in patterns, with membership premium decreases and coverage premium increases over time. This may offer an incentive to free-ride the collective good trade unions produce, exacerbating the

free-riding problem.

Our findings suggest potential developments in the current theoretical framework of the role of human capital on the determination of hours of work. The transfer mechanism between education and labour supply has been solely attributed to wage, as majority of the labour supply literature suggests[18]; our findings show a taste-shifting story through the increase in human capital utilization rate. This is particularly the case amongst female workers between degree level and those below. Our findings also confirm the role of trade unions in regulating hours of work through overtime hours and premium. However, the effects have been eroding away by the decreasing influence of trade unions and the increasing problems of free-riding.

In this chapter, we have offered a comprehensive survey of the trends across different demographic characteristics which on one hand shows the impact relevant to each variable and on the other, the time series fluctuations in time. Different from the existing descriptive trends (as seen from Dickens et al., (1999); Gregg and Wadsworth (1999, 2011); Blundell et al.,(2011) among others) we focus on showing the extensive and the intensive margins across the characteristics used in existing labour supply models, and describe the long-term trends to better understand the relationship before modelling them in the later chapters.

[18] Imai and Keane (2004); Pencavel (2015); Blundell, Costa-Dias and Meghir (2015); Blundell, French and Tetlow (2016); Blundell (2016); Kean and Wasi (2016); Keane (2016); Keane and Iskhakov (2018).

Tables:

Table 2.1: Descriptive Statistics

	Men				Women			
Year	1975-1985	1986-1995	1996-2005	2006-2016	1975-1985	1986-1995	1996-2005	2006-2016
Hours	42.501	44.032	44.436	42.707	29.393	29.986	31.596	32.509
Wage	n/a	8.826	11.096	15.486	n/a	6.443	8.226	12.089
Age	38.821	39.923	41.169	42.428	38.421	39.607	41.2	42.571
NVQ5	17.50%	18.70%	21.65%	30.59%	10.51%	12.02%	17.21%	30.65%
NVQ4	15.20%	10.00%	9.95%	10.22%	14.43%	14.71%	12.90%	12.50%
NVQ1-3	67.10%	63.50%	59.23%	53.34%	64.80%	60.15%	56.55%	50.81%
No qual.	0.20%	7.80%	9.17%	5.84%	10.25%	13.12%	13.35%	6.04%
Obs.	92,595	316,999	303,845	251785	54,610	258,760	323,576	283,045

Note: Wages in 2016 prices.

Table 2.2: Hours worked by parents without children

Men	Without children			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	1.03	1.98	2.90	3.80
% working 20-29 hrs	1.51	2.08	3.00	4.16
% working 30-39 hrs	37.32	29.55	24.45	28.45
% working 40-49 hrs	44.16	43.02	44.36	43.25
% working >50 hrs	15.98	23.31	25.29	20.34
Mean total hours	42.49	43.75	43.63	41.85
Women	**Without children**			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	13.75	13.91	12.60	11.29
% working 20-29 hrs	13.67	13.29	13.09	13.05
% working 30-40 hrs	48.19	43.50	38.18	39.64
% working 41-50 hrs	20.69	23.12	27.41	27.23
% working >50 hrs	3.70	6.18	8.72	8.79
Mean total hours	33.13	33.95	34.98	35.15

Note: Figures are a percentage of the chosen sample. Source: LFS & QLFS.

Table 2.3: Hours worked by parents with children

Men	With children			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	1.07	1.13	1.73	2.70
% working 20-29 hrs	1.41	1.19	2.09	3.71
% working 30-40 hrs	22.19	24.46	19.94	24.63
% working 41-50 hrs	54.9	42.85	44.72	44.63
% working >50 hrs	20.21	30.17	31.52	24.33
Mean total hours	43.41	45.67	45.49	43.21
Women	**With children**			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	23.73	34.24	28.40	24.36
% working 20-29 hrs	21.04	22.94	25.21	25.38
% working 30-40 hrs	31.45	26.57	27.55	30.42
% working 41-50 hrs	21.30	12.34	14.21	14.98
% working >50 hrs	2.48	3.91	4.63	4.86
Mean total hours	28.82	26.19	27.69	28.83

Note: Figures are a percentage of the chosen sample. Source: LFS & QLFS.

Table 2.4: Hours worked by parents with <2 years old children

Men	With children aged less than 2 years old			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	1.14	0.99	1.55	2.41
% working 20-29 hrs	1.71	1.30	2.06	3.75
% working 30-39 hrs	20.90	24.40	19.73	25.66
% working 40-49 hrs	56.25	43.75	46.16	46.15
% working >50 hrs	20.00	29.52	30.50	22.03
Mean total hours	43.32	45.60	45.37	42.71
Women	**With children aged less than 2 years old**			
	1975/1985	1986/1995	1996/2005	2006/2016
% working < 20 hrs	21.69	36.86	31.55	23.84
% working 20-29 hrs	20.65	20.82	25.29	25.60
% working 30-39 hrs	32.22	27.02	26.30	30.34
% working 40-49 hrs	22.98	12.20	13.45	16.05
% working >50 hrs	2.46	3.1	3.41	4.17
Mean total hours	29.42	25.57	26.67	28.94

Note: Figures are a percentage of the chosen sample. Source: LFS & QLFS.

Table 2.5: Overtime in family without children

	1975/1985	1986/1995	1996/2005	2006/2016
Mean overtime hours:				
Mean paid overtime hrs	6.85	7.8	7.83	7.3
Mean unpaid overtime hrs	7.02	7.6	7.78	7.83
Overtime percentage:				
% work paid overtime	32.37	31.58	25.99	18.77
% work unpaid overtime	18.65	21.61	20.27	19.06
	1975/1985	1986/1995	1996/2005	2006/2016
Mean overtime hours:				
Mean paid overtime hrs	4.56	5.13	5.48	5.75
Mean unpaid overtime hrs	5.38	5.99	6.66	7.07
Overtime percentage:				
% work paid overtime	15.83	18.97	16.99	12.89
% work unpaid overtime	17.36	22.33	22.89	22.69

Note: the numbers shown are percentages, source: LFS & QLFS

Table 2.6: Overtime in family with children.

Men	1975/1985	1986/1995	1996/2005	2006/2016
Mean hours:				
Mean paid overtime hrs	7.67	8.63	8.53	7.44
Mean unpaid overtime hrs	7.28	8.34	8.39	8.42
Overtime percentage:				
% work paid overtime	33.32	31.29	25.45	16.76
% work unpaid overtime	23.04	25.08	22.69	21.63
Women	1975/1985	1986/1995	1996/2005	2006/2016
Mean hours:				
Mean paid overtime hrs	4.37	4.93	5.13	5.14
Mean unpaid overtime hrs	4.94	5.57	5.86	6.19
Overtime percentage:				
% work paid overtime	14.37	16.85	15.93	11.1
% work unpaid overtime	13.65	18.02	18.08	19.24

Note: the numbers shown are percentages, source: LFS & QLFS

Table 2.7: Overtime in family with children aged <2 years old.

Men	1975/1985	1986/1995	1996/2005	2006/2016
Mean hours:				
Mean paid overtime hrs	7.85	8.76	8.41	7.22
Mean unpaid overtime hrs	6.97	7.96	7.94	8.08
Overtime percentage:				
% work paid overtime	36.11	34.18	26.98	18.21
% work unpaid overtime	23.89	24.81	23.3	20.9
Women	1975/1985	1986/1995	1996/2005	2006/2016
Mean hours:				
Mean paid overtime hrs	4.17	4.85	4.73	5.05
Mean unpaid overtime hrs	4.91	5.05	5.33	6.19
Overtime percentage:				
% work paid overtime	11.28	14.69	13.39	8.61
% work unpaid overtime	14.87	17.82	16.91	17.6

Note: the numbers shown are percentages, source: LFS & QLFS

Table 2.8: Inactivity by gender and age

Gender	Age group	Decades			
		1975-1985	1986-1995	1996-2005	2006-2016
Male	16-24	5.41	4.21	5.32	5.8
	25-49	2.68	5.26	6.85	6.73
	50-64	14.33	27.18	26.98	23.94
	65+	89.13	92.4	92.42	87.1
Female	16-24	18.41	14.81	13.23	11.62
	25-49	32.49	25.83	22.62	19.84
	50-64	46.83	50.79	45.46	38.28
	65+	96.12	96.85	96.57	92.83

Source: LFS & QLFS

Table 2.9: Inactivity by gender and education

Gender	Education	Decades			
		1975-1985	1986-1995	1996-2005	2006-2016
Male	NVQ5	3.32	5.08	6.13	9.95
	NVQ4	4.28	6.04	8.3	14.5
	NVQ1-3	4.15	8.59	10.12	14.64
	No qual.	23.14	22.66	28.58	38.14
Female	NVQ5	18.29	10.84	9.91	14.39
	NVQ4	22.69	15.04	13.01	23.33
	NVQ1-3	23.51	22.21	20.04	25.2
	No qual.	38.47	39.98	44.02	59.86

Source: LFS & QLFS

Table 2.10: Characteristics of union membership density UK (1989-2016)

Characteristics	Density (%)			Characteristics	Density (%)		
	1989-1998	1999-2008	2009-2016		1989-1998	1999-2008	2009-2016
All	33.8	27.69	22.01				
Gender				***Sector***			
Male	32.84	26.17	20.37	Private	19.17	16.86	13.25
Female	29.45	27.95	26.91	Public	60.92	58.79	55.39
Age				***Firm size***			
<20	9.16	4.8	3.17	<50 employees		18.9	16.62
20-29	26.56	18.36	14.99	50-249 employees		34.68	31.98
30-39	33.58	27.69	22.51	>250 employees		44.05	39
40-49	36.69	33.57	27.16				
50-64	35.26	31.65	29.39	***Occupation***			
65+	9.77	10.6	12.79	White collar	32.33	30.52	27.29
				Blue collar	28.51	23.06	18.93
Ethnicity							
White	31.11	27.2	23.89	***Selected industries***			
Non-white	29.53	23.9	20.22	Agr/For/Fis/hunting	14.62	10.38	10.17
				Energy & water	48.83	34.8	31.71
Highest qualification				Manufacturing	31.95	24.57	17.85
NVQ5	38.23	35.85	30.52	Construction	17.03	13.27	9.82
NVQ4	48.72	41.29	31.53	Transport & comm.	47.83	38.11	24.39
NVQ1-3	28.15	23.23	19.21	Other services	45.72	43.32	32.79
None	25.87	20.52	14.89				
				Country			
Tenure (Length of service)				England	29.83	25.73	22.18
<2 years	13.2	13.22	11.4	Scotland	36.83	32.11	29.12
2-10 years	28.24	24.74	20.92	Wales	39.99	34.93	31.97
10+ years	54.9	42.49	34.94	Northern Ireland	41.34	34.39	30.97

Note: Firm size only enters the QLFS in 2002, therefore, the average in 1999-2008 column is actually from 2002-2008.

Table 2.11: Characteristics of union Coverage density UK (1989-2016)

Characteristics	1996-2008	2009-2016	Characteristics	1996-2008	2009-2016
All	36.14	30.12			
Gender			***Sector***		
Male	34.71	27.87	Private	22.2	16.73
Female	37.56	32.28	Public	71.83	63.28
Age			***Firm size***		
<20	16.96	10.49	<50 employees	22.43	17.23
20-29	26.64	20.95	50-249 employees	41.31	34.76
30-39	35.84	29.11	>250 employees	56.09	49.6
40-49	42.87	33.7			
50-64	41.59	36.13	***Occupation***		
65+	16.77	19.72	White collar	30.98	25
			Blue collar	56.09	49.6
Ethnicity					
White	36.34	30.57	***Selected industries***		
Non-white	32.47	25.47	Agr/For/Fis/hunting	13.19	7.98
			Energy & water	40.88	39.64
Highest qualification			Manufacturing	29.46	23
NVQ5	43.69	36.81	Construction	22.43	16.85
NVQ4	46.79	36.21	Transport & comm.	47.98	32.79
NVQ1-3	33.21	26.06	Other services	54.95	39.78
None	29.07	21.27			
			Country		
Tenure (Length of service)			England	34.41	28.23
<2 years	22.65	17.07	Scotland	42.27	36.51
2-10 years	36.89	31.45	Wales	43.03	38.83
10+ years	59.58	49.94	Northern Ireland	51.59	44.72

Note: The union coverage variable TUCOV only enters QLFS in 1996.

Table 2.12: Union wage premium.

Year	All		Male		Female	
	Raw wage premium	Regression adjusted	Raw wage premium	Regression adjusted	Raw wage premium	Regression adjusted
Membership premium:						
1993-1999	0.281	0.096	0.179	0.060	0.363	0.112
2000-2008	0.237	0.071	0.145	0.040	0.321	0.097
2009-2016	0.212	0.057	0.143	0.030	0.292	0.075
Coverage premium:						
1993-1999	0.075	-0.025	-0.009 (ns)	-0.068	0.169	0.014
2000-2008	0.154	0.030	0.092	0.016	0.227	0.044
2009-2016	0.170	0.048	0.121	0.041	0.232	0.052

Notes: 1. Raw wage premium is the premium results without any controls. 2. Regression adjusted premium are based on models with following controls: gender, age, age squared, qualifications (5 NVQ levels), white/non-white, white collar/blue collar, temporary/permanent, tenure (6 categories), full-time/part-time, firm size (5 categories), private/public, industry (9 categories). 3. ns=not statistically significantly different from zero. Source: QLFS.

Table 2.13: Union hours premium

Year	All		Male		Female	
	Raw hours premium	Regression adjusted	Raw hours premium	Regression adjusted	Raw hours premium	Regression adjusted
Membership premium:						
1993-1999	0.158	0.123	0.048	0.042	0.271	0.170
2000-2008	0.136	0.097	0.062	0.040	0.234	0.139
2009-2016	0.117	0.086	0.073	0.037	0.211	0.114
Coverage premium:						
1993-1999	0.054	0.015	0.011	-0.026	0.113	0.041
2000-2008	0.061	0.027	0.017	-0.019	0.127	0.057
2009-2016	0.076	0.049	0.036	0.006	0.140	0.076

Notes: 1. Raw wage premium is the premium results without any controls. 2. Regression adjusted premium are based on models with following controls: gender, age, age squared, qualifications (5 NVQ levels), white/non-white, white collar/blue collar, temporary/permanent, tenure (6 categories), full-time/part-time, firm size (5 categories), private/public, industry (9 categories). 3. Source: QLFS.

Figures:

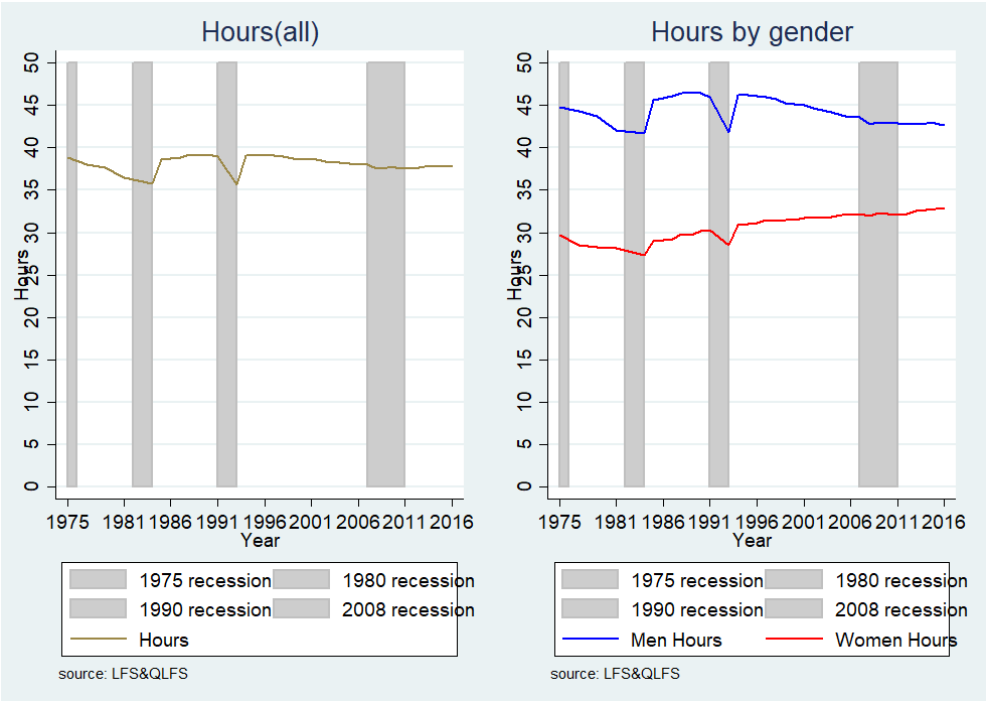

Figure 2.1 Hours of work trend

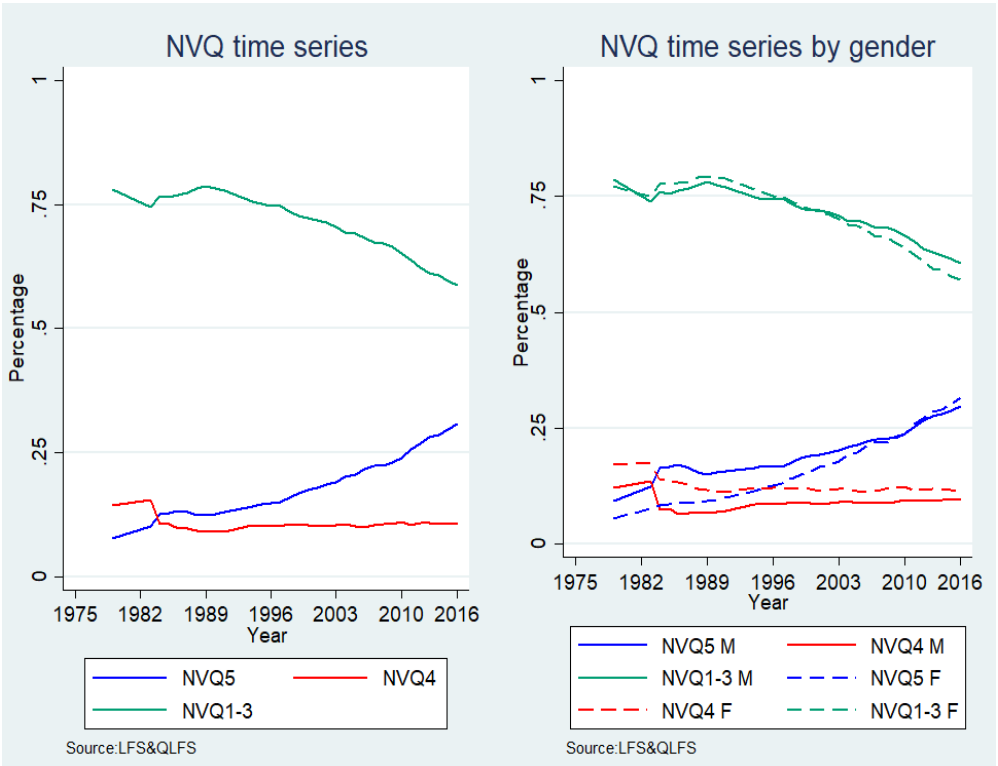

Figure 2.2 Time series of NVQ levels

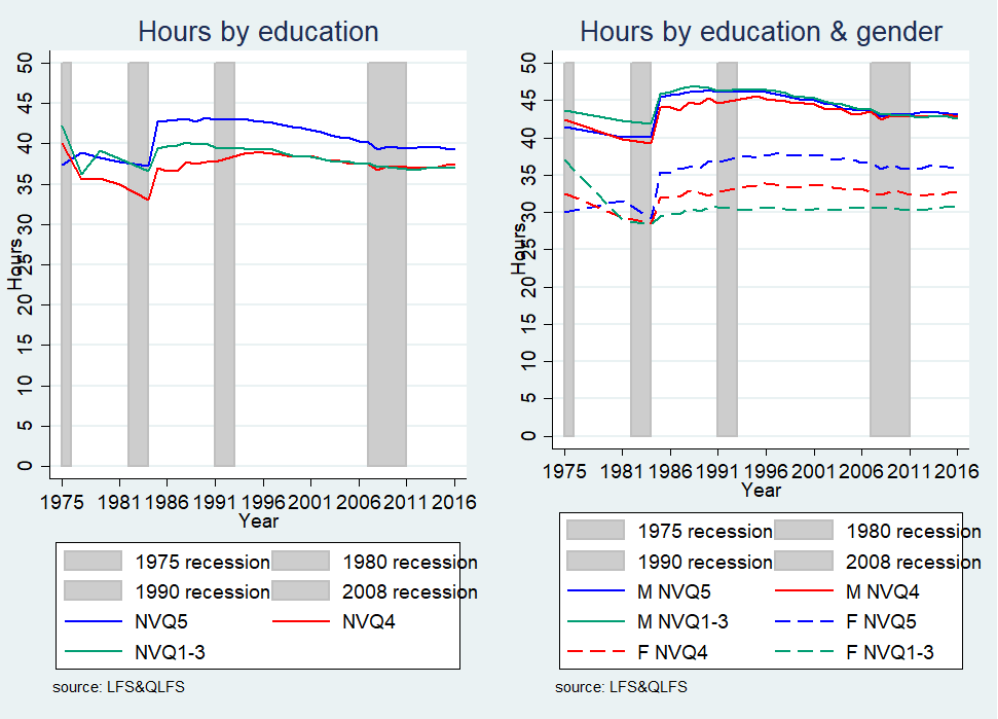

Figure 2.3 Hours of work by education.

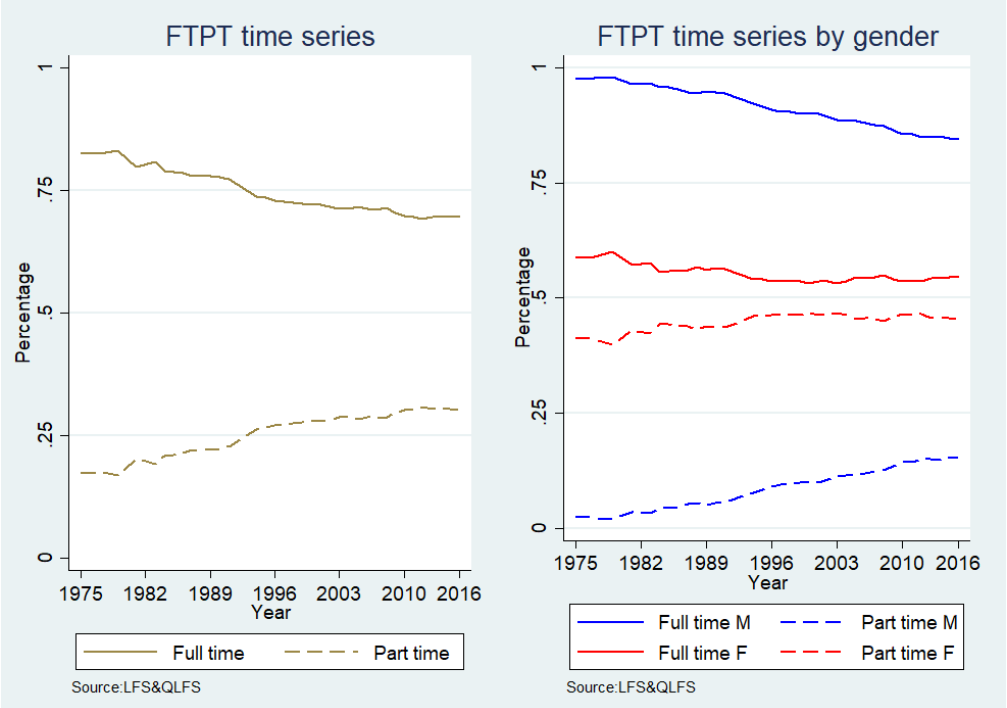

Figure 2.4 Full-time/Part-time working time series

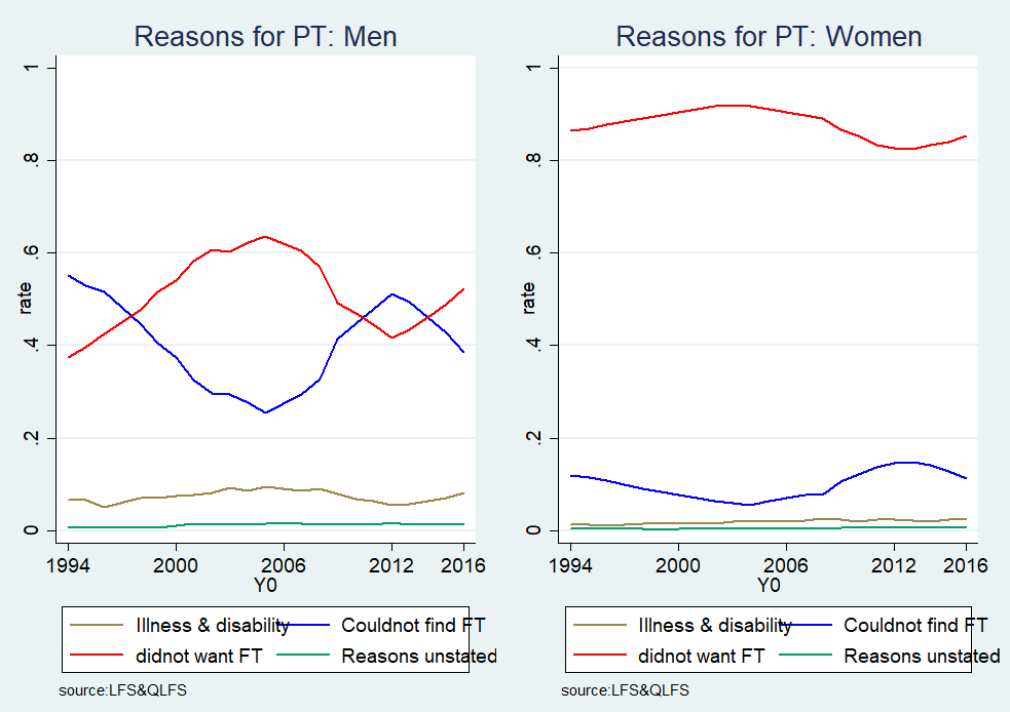

Figure 2.5 Reasons for working part-time

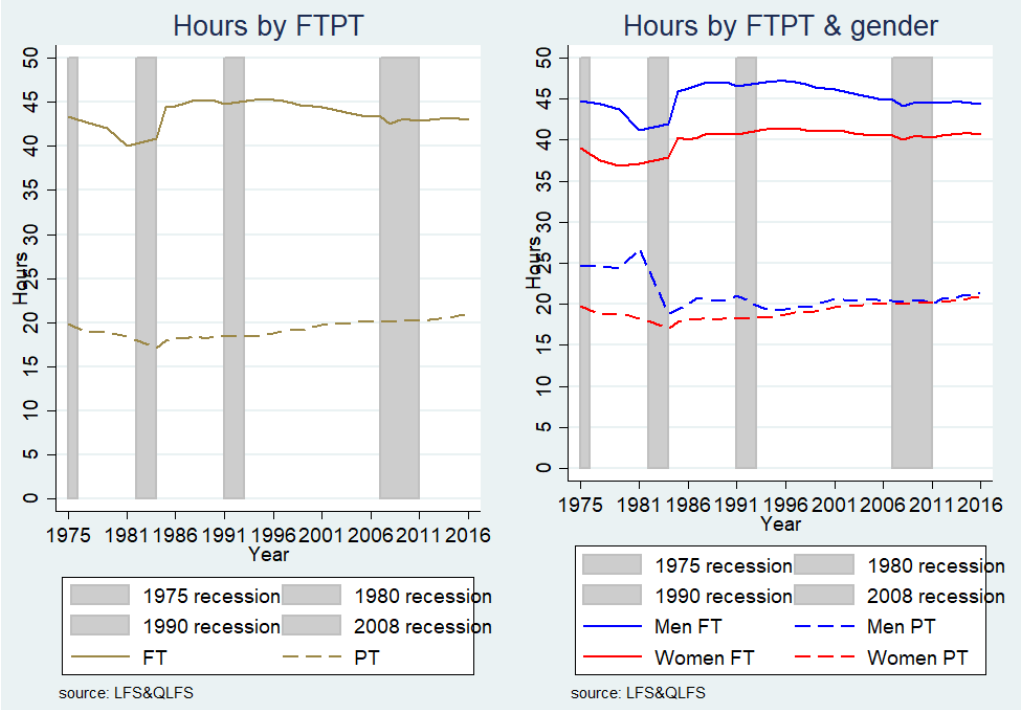

Figure 2.6: Hours of work by Full-time/Part-time

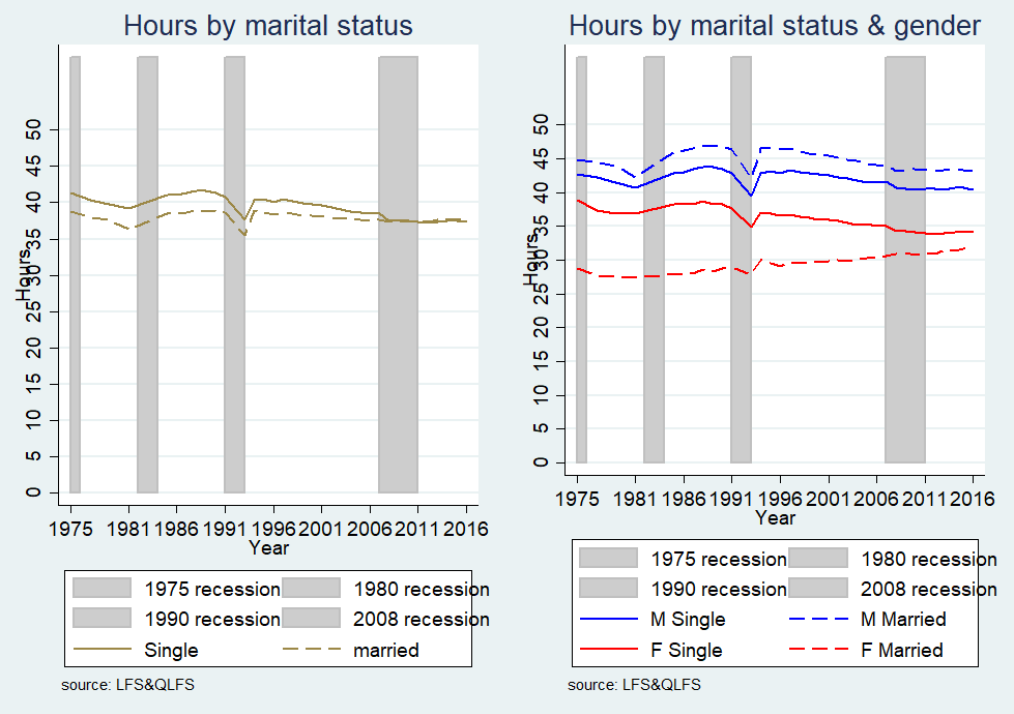

Figure 2.7 Hours of work by marital status

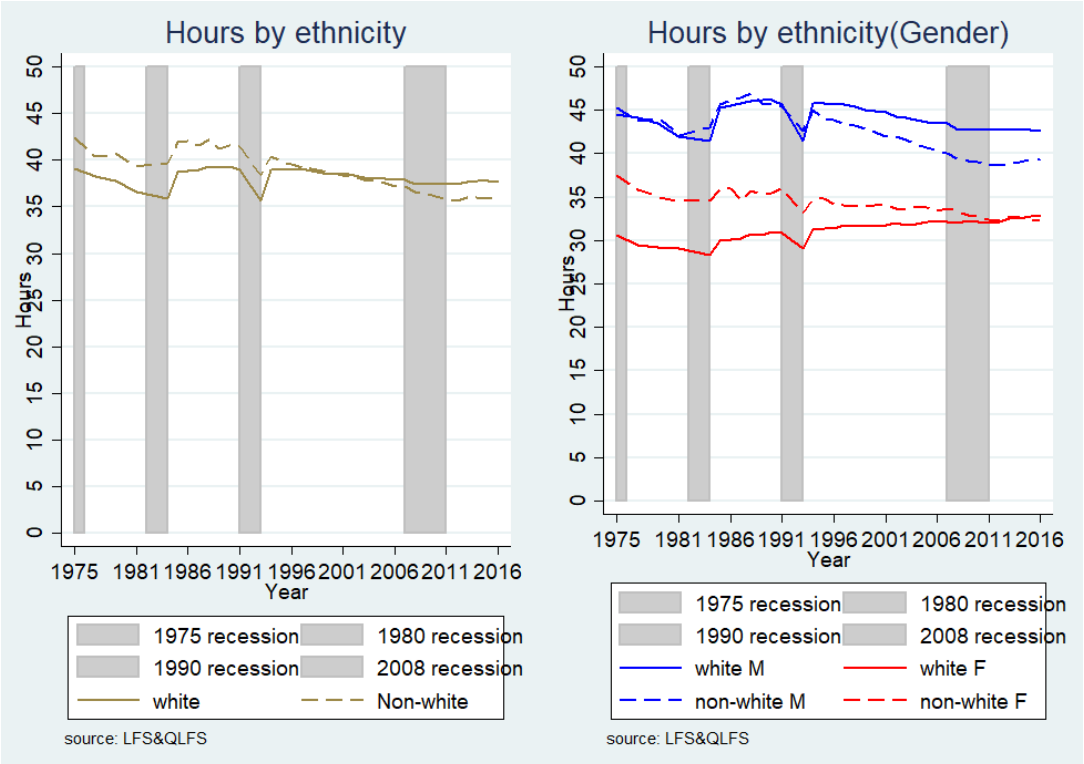

Figure 2.8: Hours of work by ethnicity (White/Nonwhite)

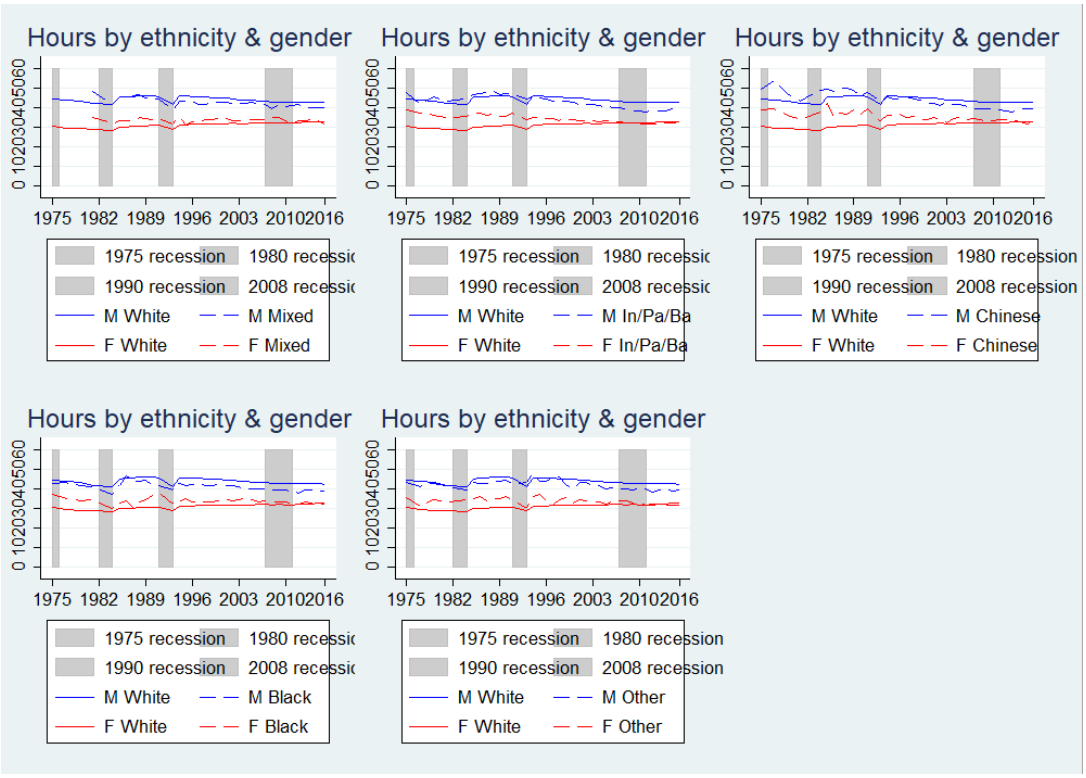

Figure 2.9: Hours of work by ethnicity (White VS Others)

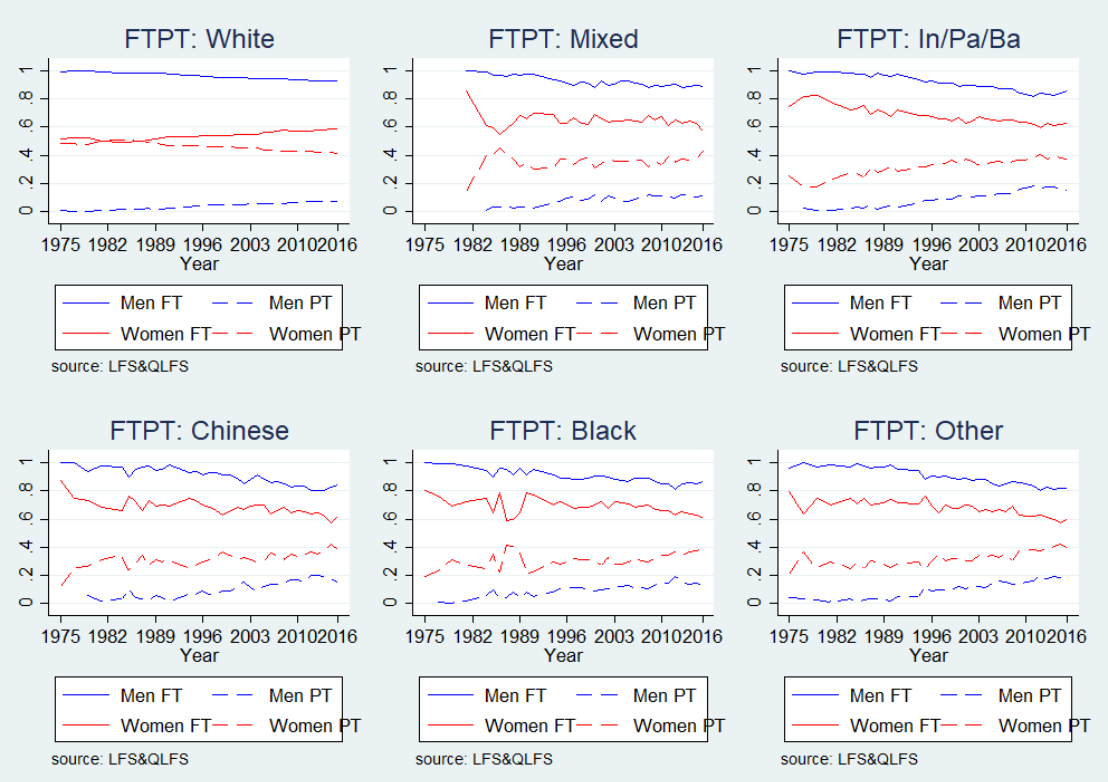

Figure 2.10: Full-time/Part-time by ethnicity

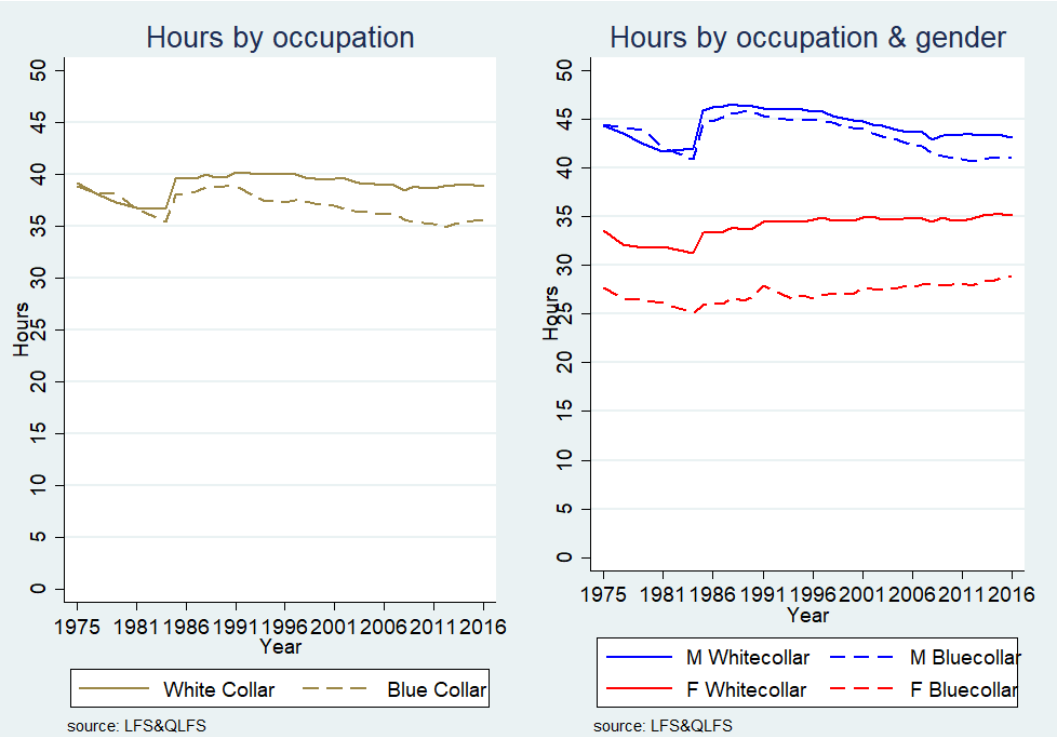

Figure 2.11: Hours of work by occupation (White/Blue Collar)

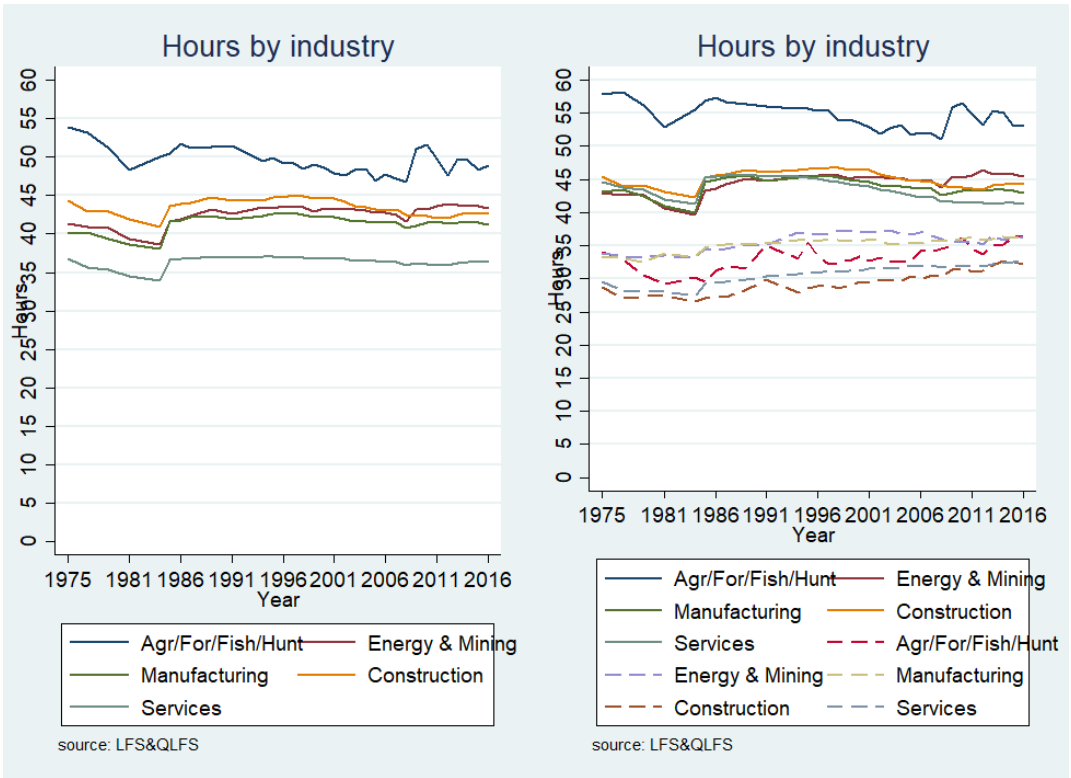

Figure 2.12: Hours of work by Industry

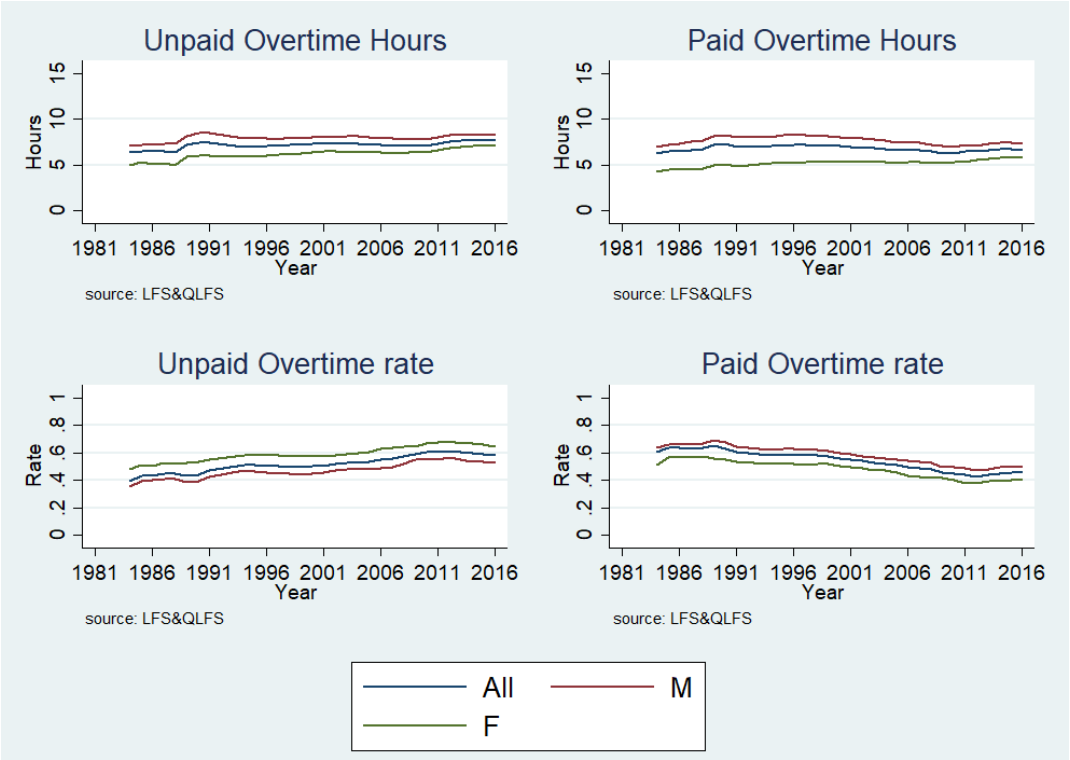

Figure 2.13: Paid/Unpaid overtime series (Percentage & Mean hours)

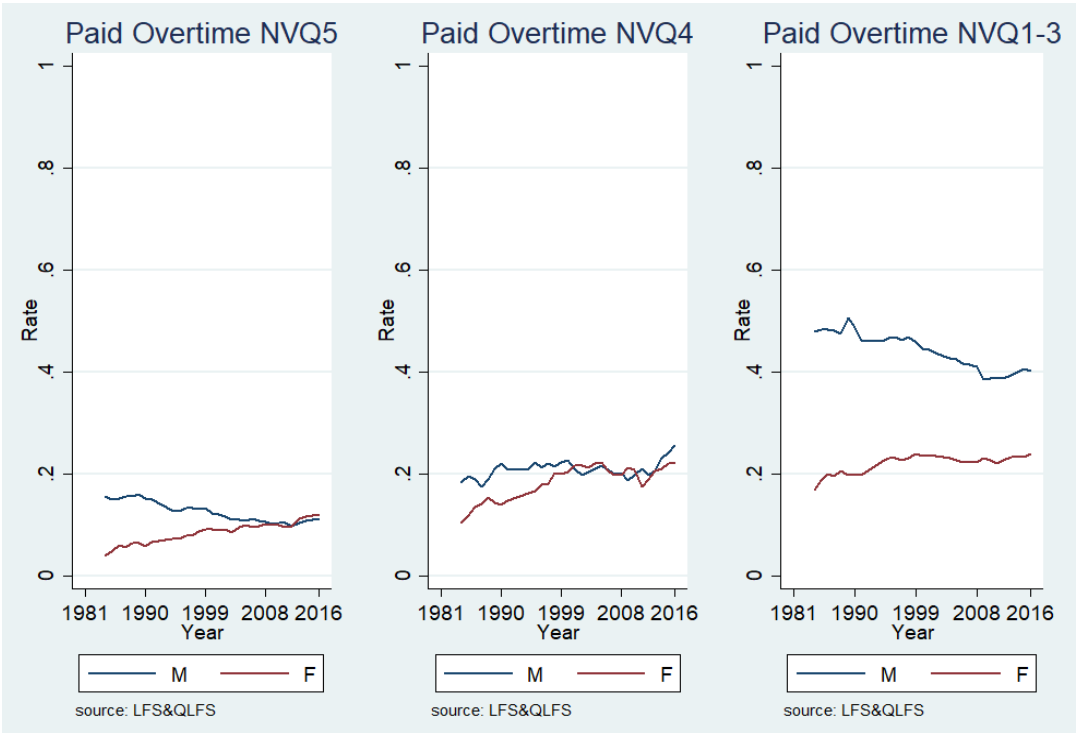

Figure 2.14a: Paid overtime series by education levels (Percentage)

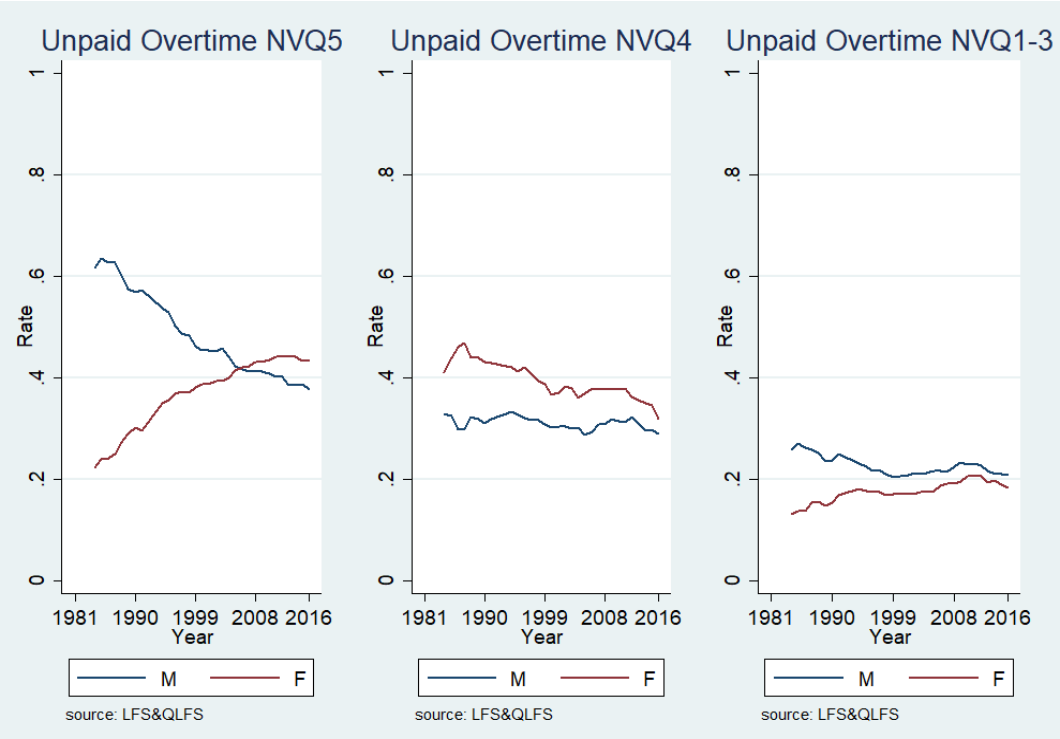

Figure 2.14b: Unpaid overtime series by education levels (Percentage)

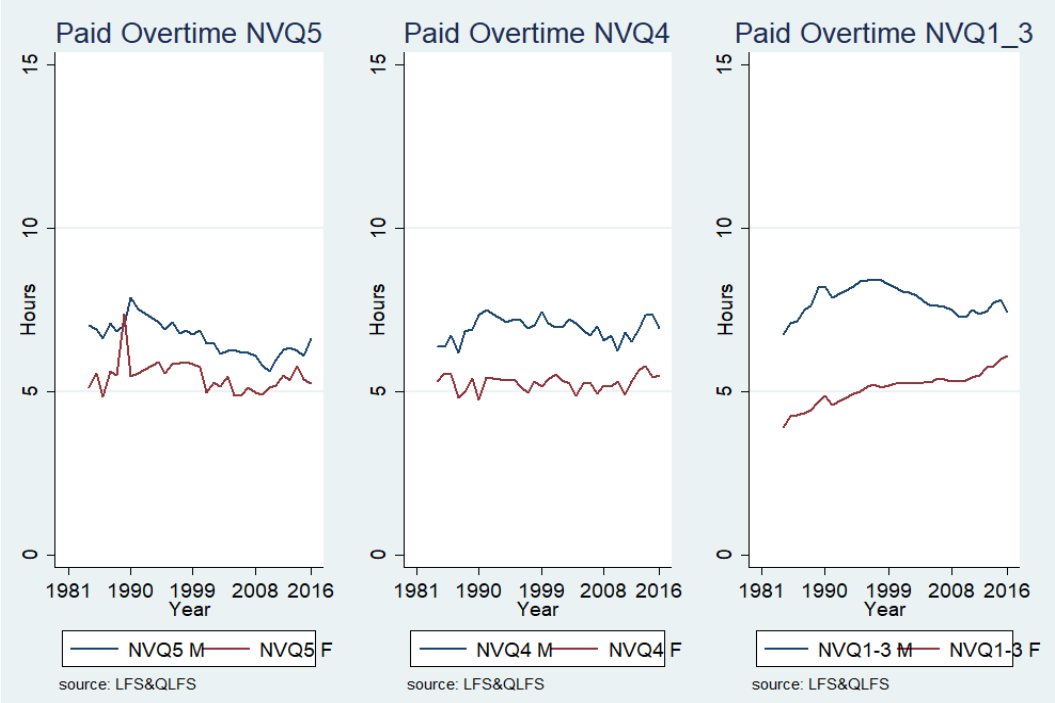

Figure 2.15a: Paid overtime series by education levels (Mean hours)

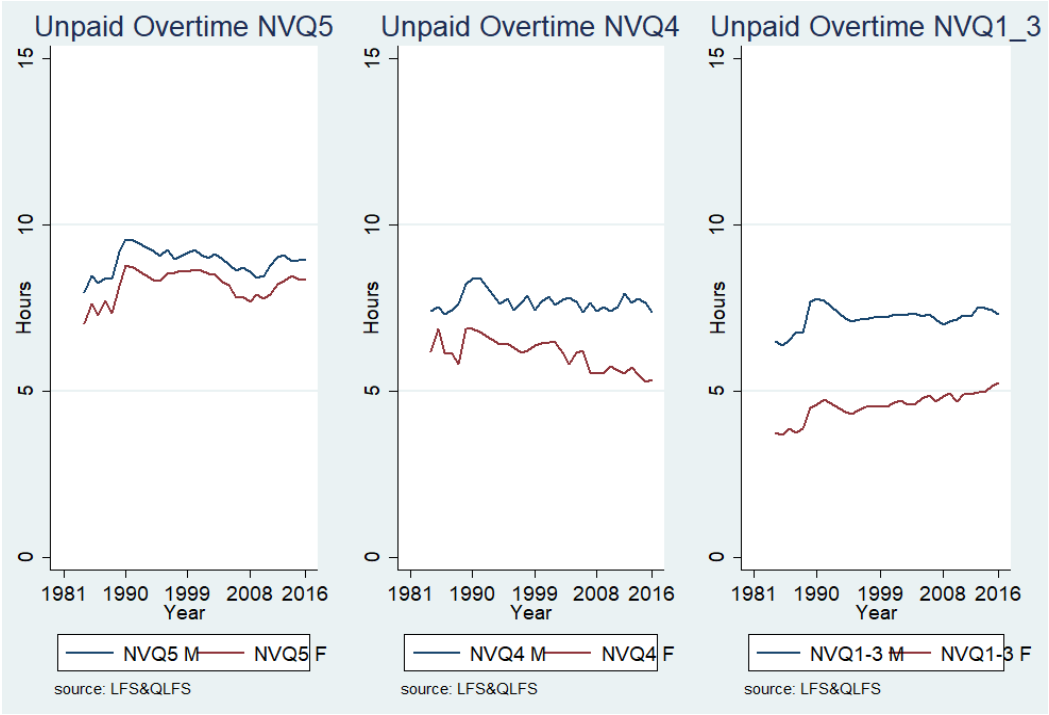

Figure 2.15b: Unpaid overtime series by education levels (Mean hours)

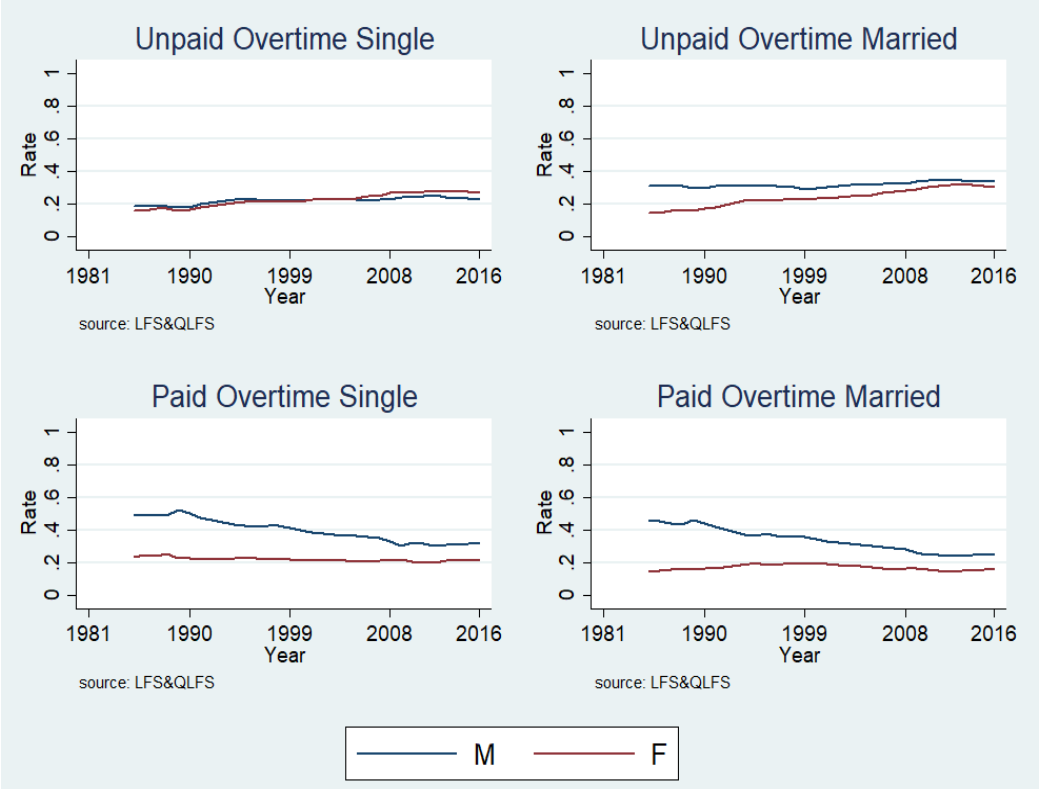

Figure 2.16a: Paid overtime series by marital status (Percentage & Mean Hours)

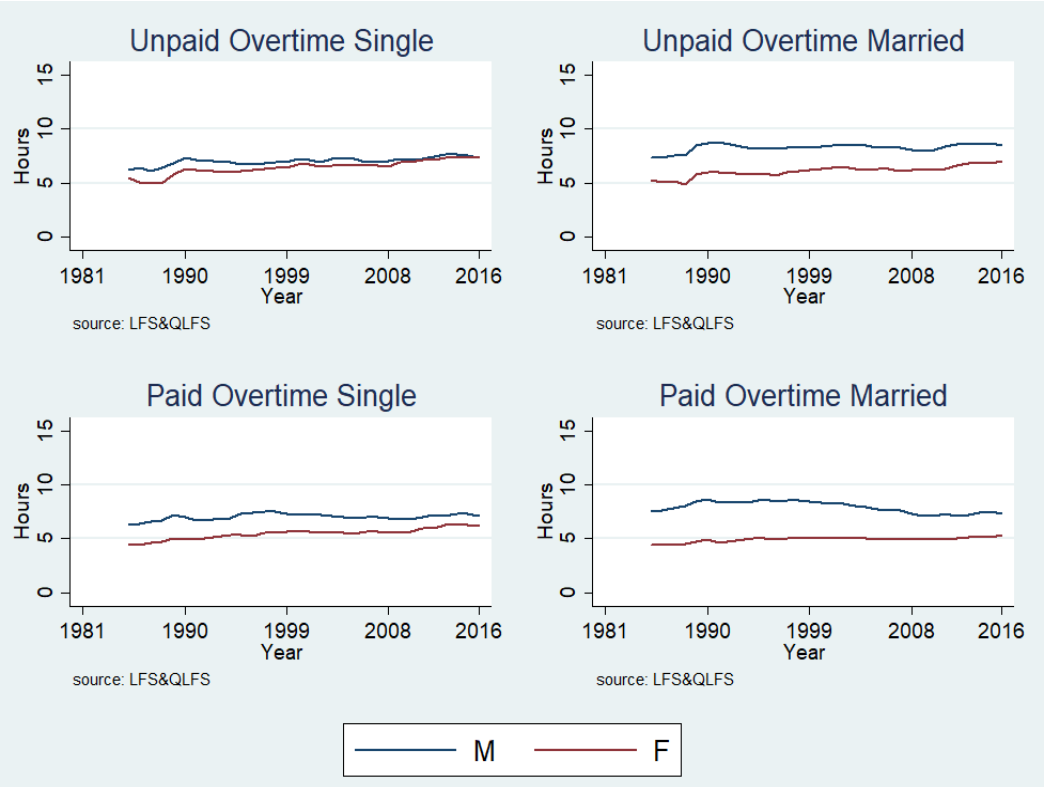

Figure 2.16b: Unpaid overtime series by marital status (Percentage & Mean Hours)

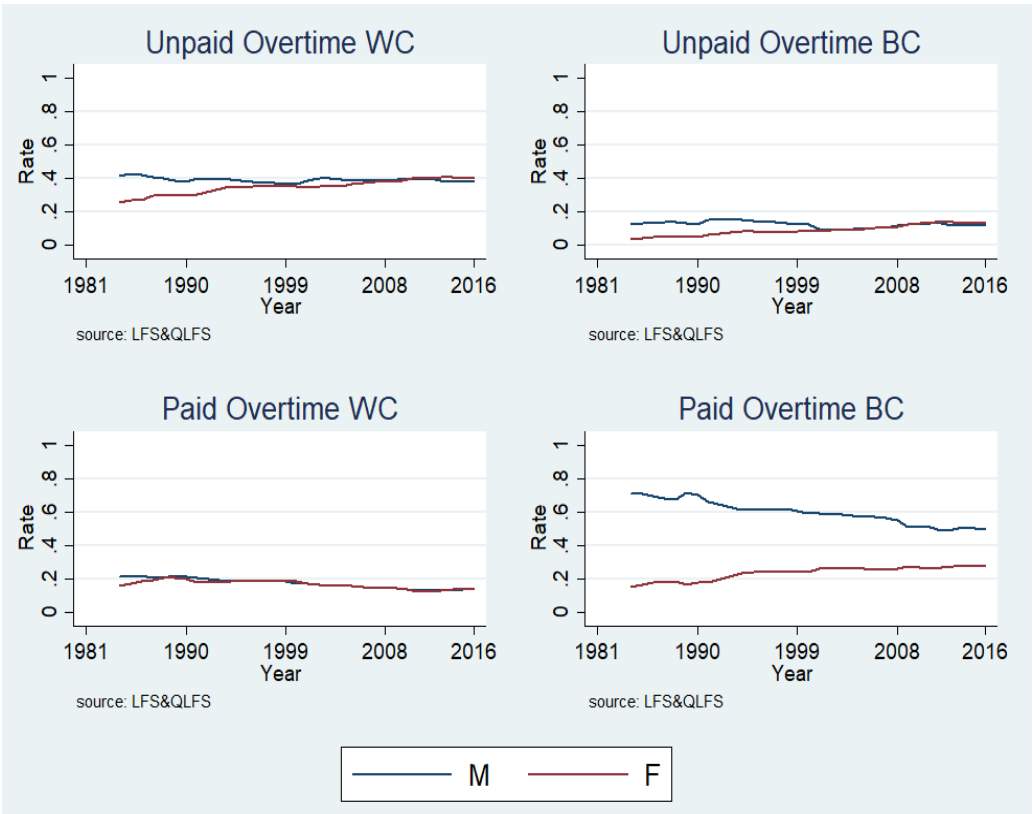

Figure 2.17a: Paid overtime series by occupation (Percentage & Mean Hours)

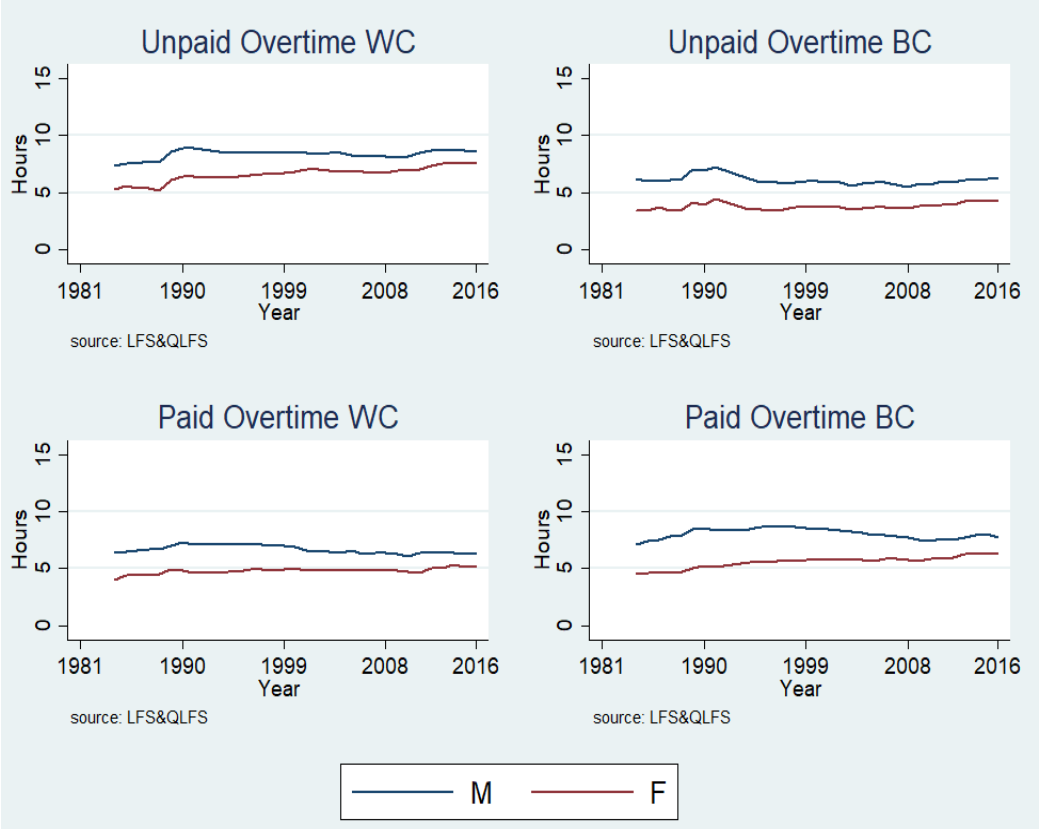

Figure 2.17b: Unpaid overtime series by occupation (Percentage & Mean Hours)

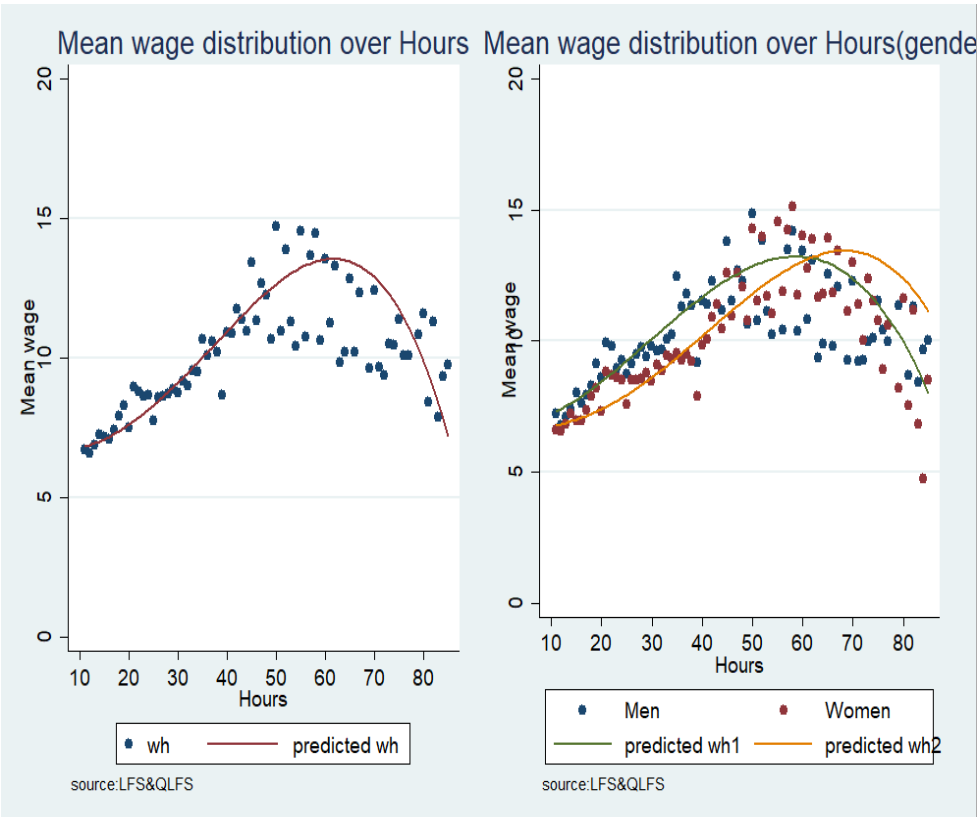

Figure 2.18: Mean wage distribution over hours

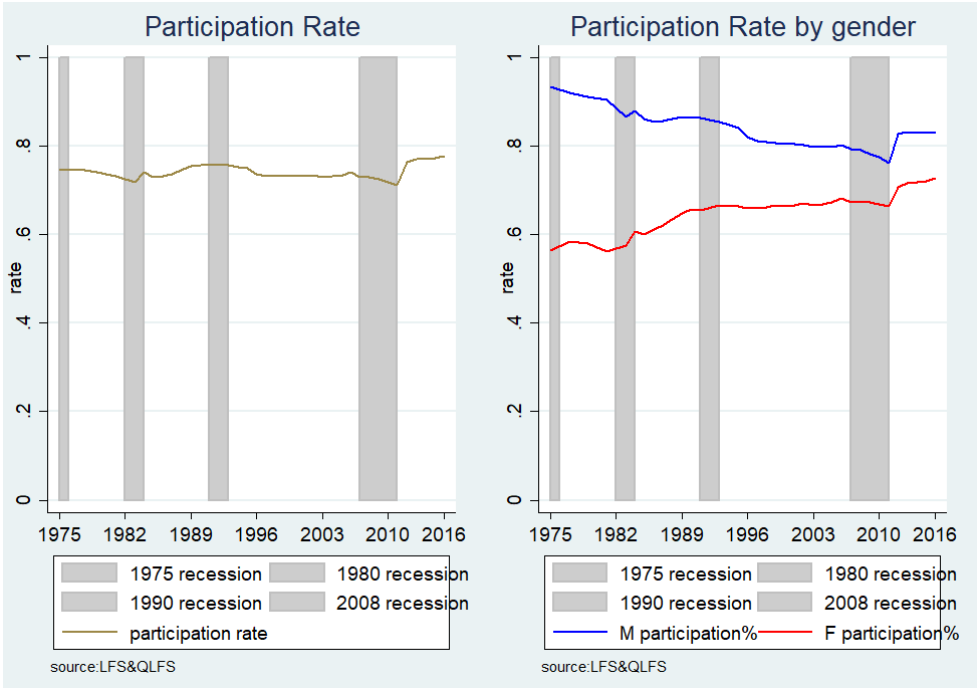

Figure 2.19a: Participation rate series

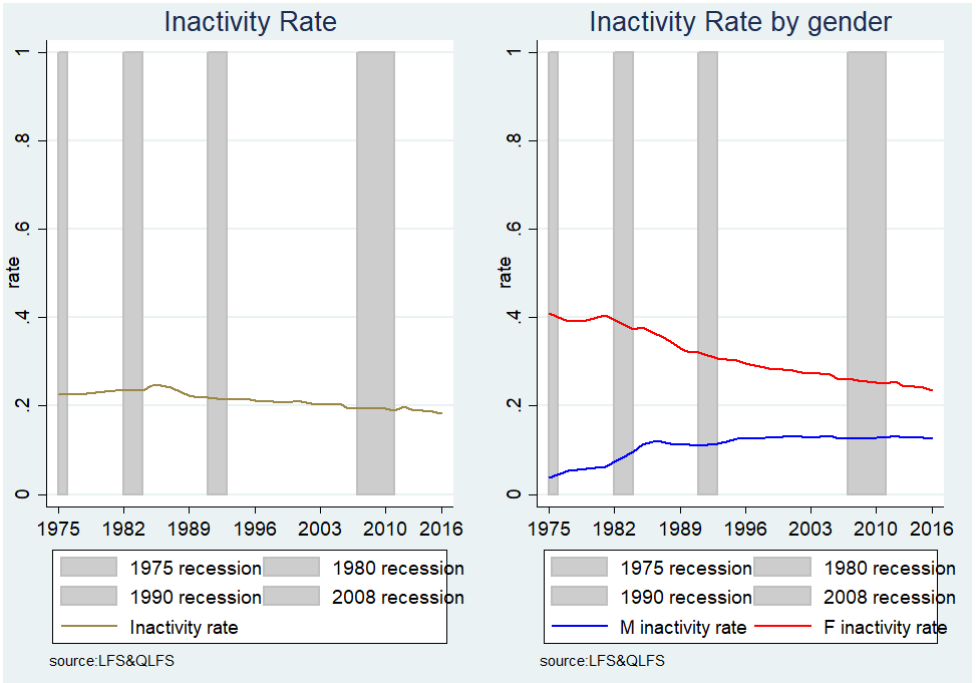

Figure 2.19b: Inactivity rate series

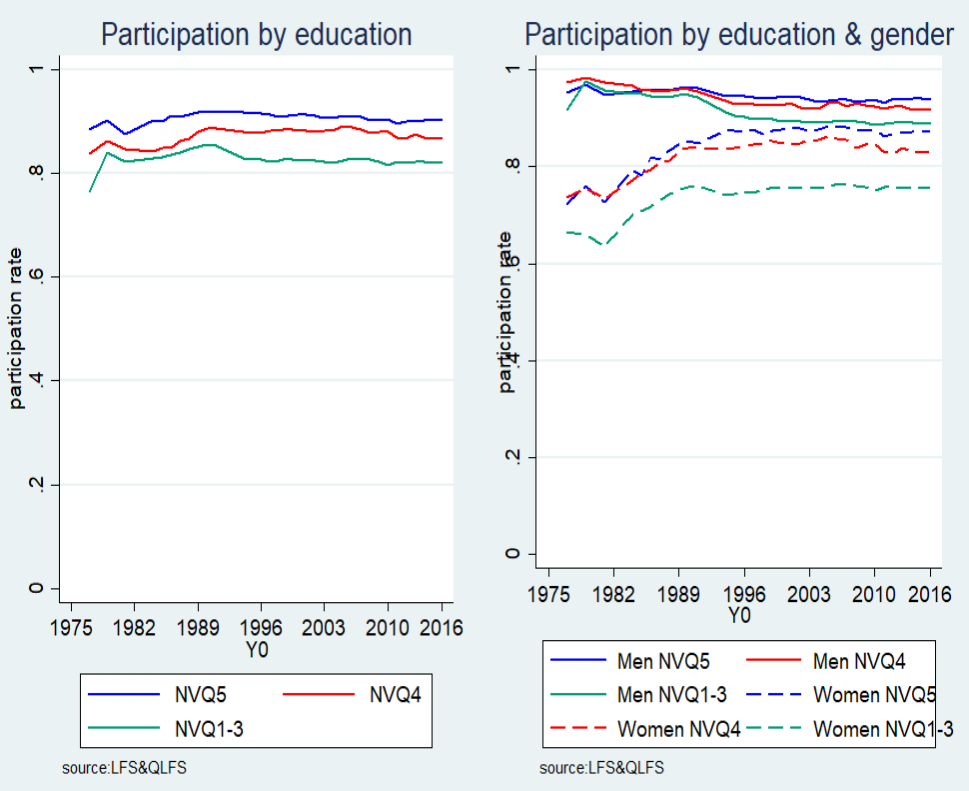

Figure 2.20a: Participation rate by education

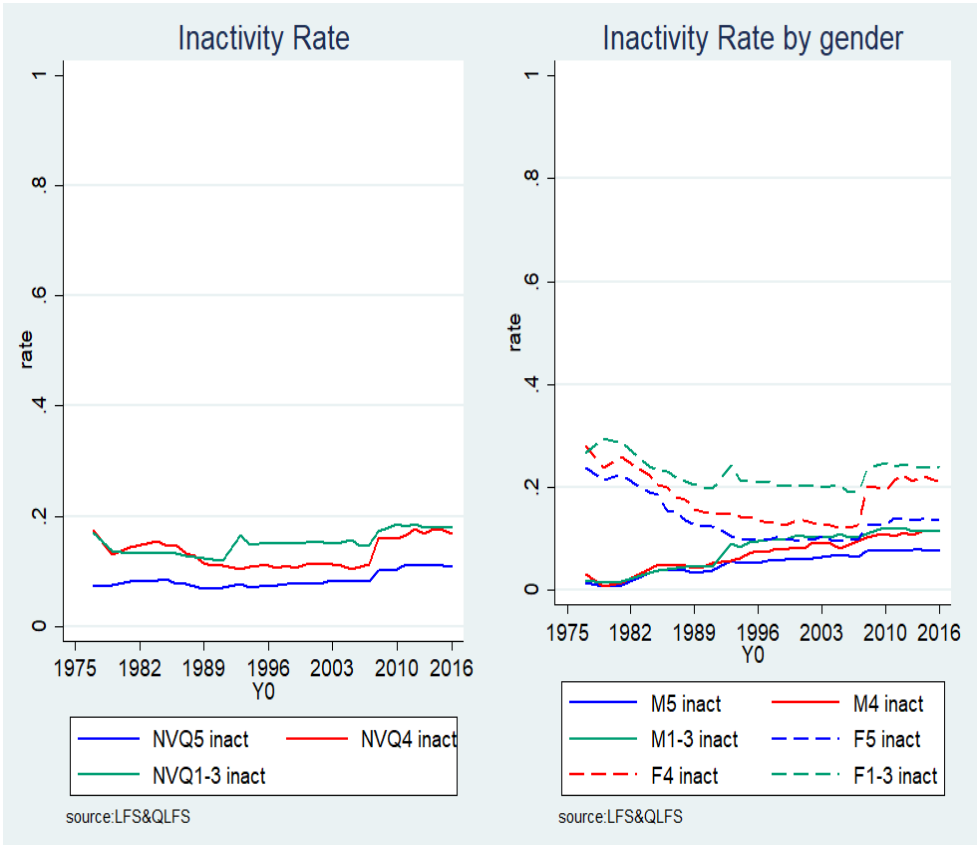

Figure 2.20b: Inactivity rate by education

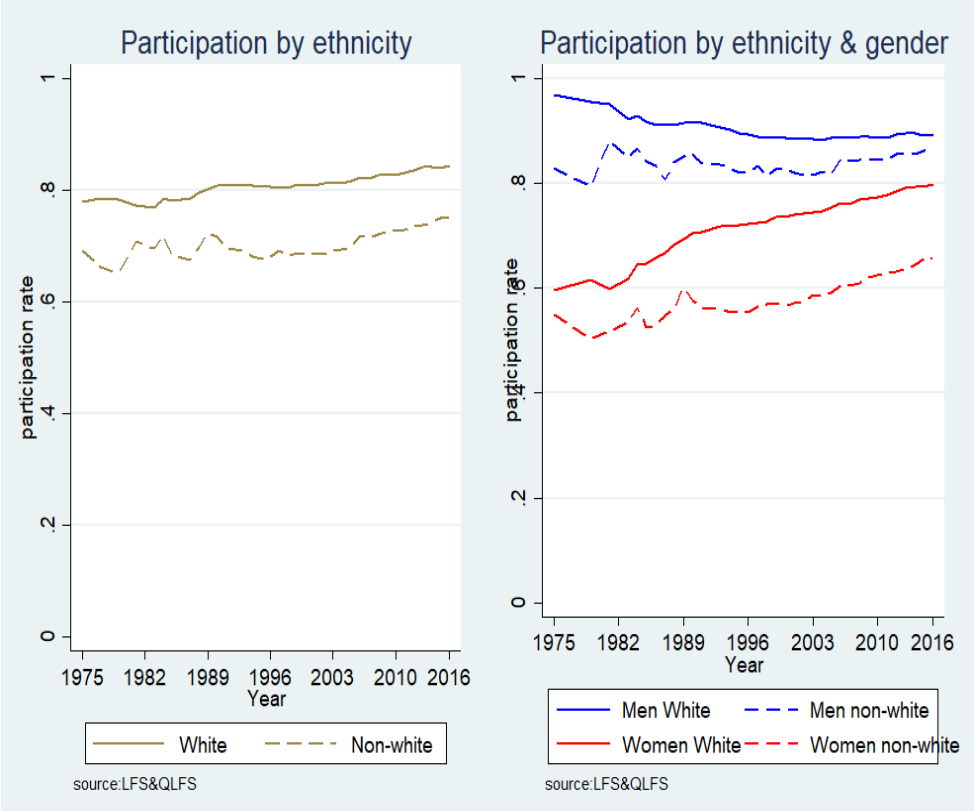

Figure 2.21a: Participation rate by ethnicity

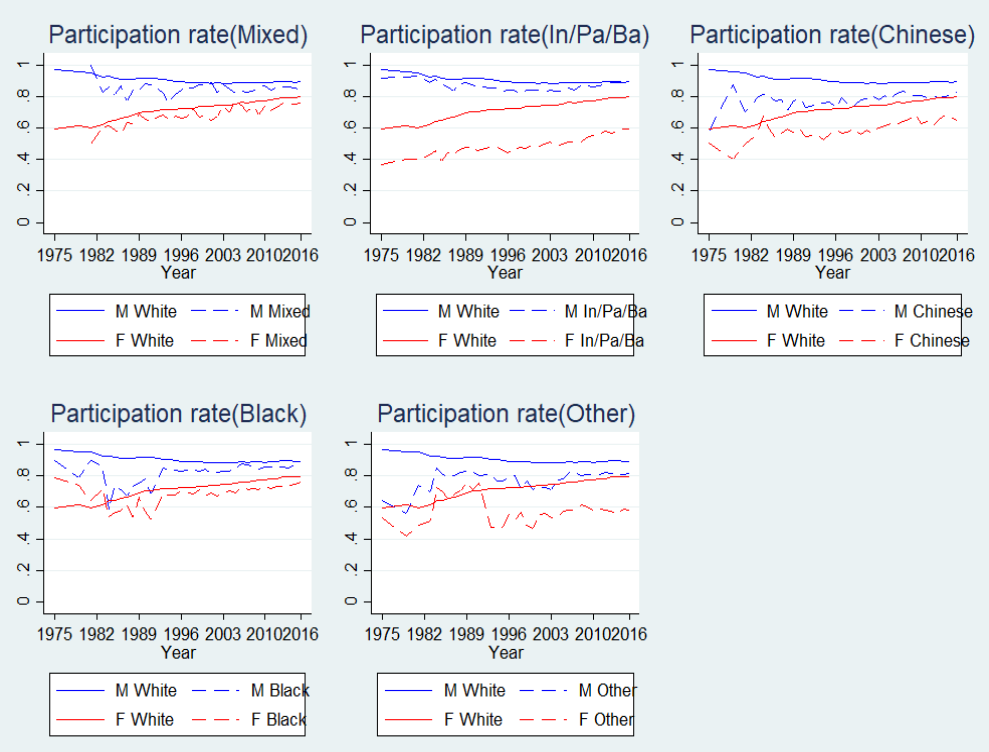

Figure 2.21b: Participation rate by ethnicity

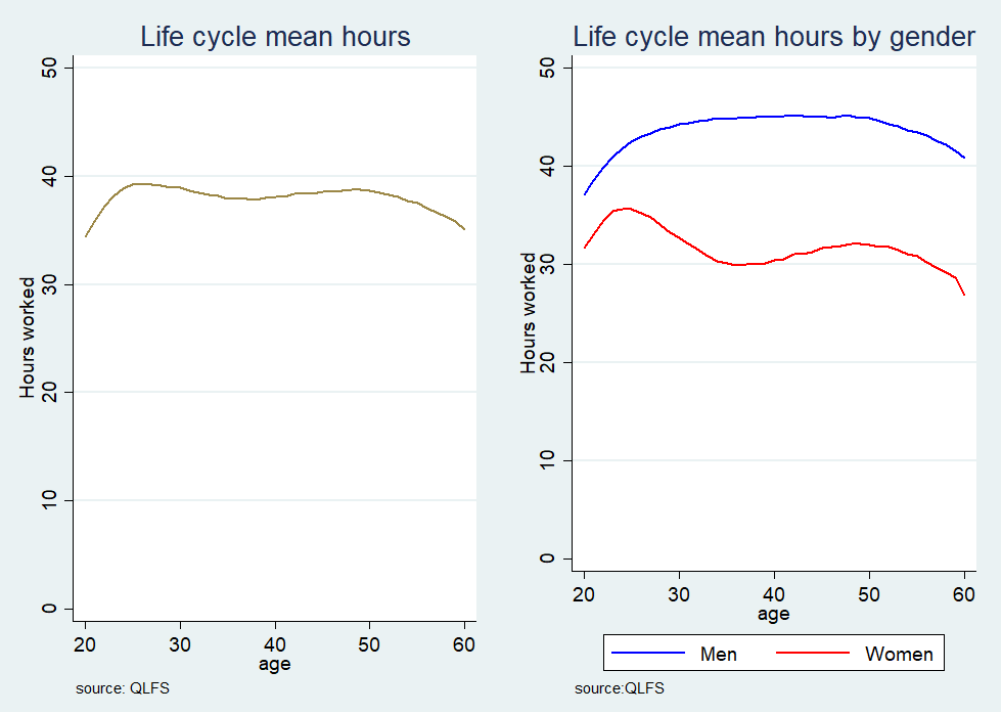

Figure 2.22: Life-cycle hours profile

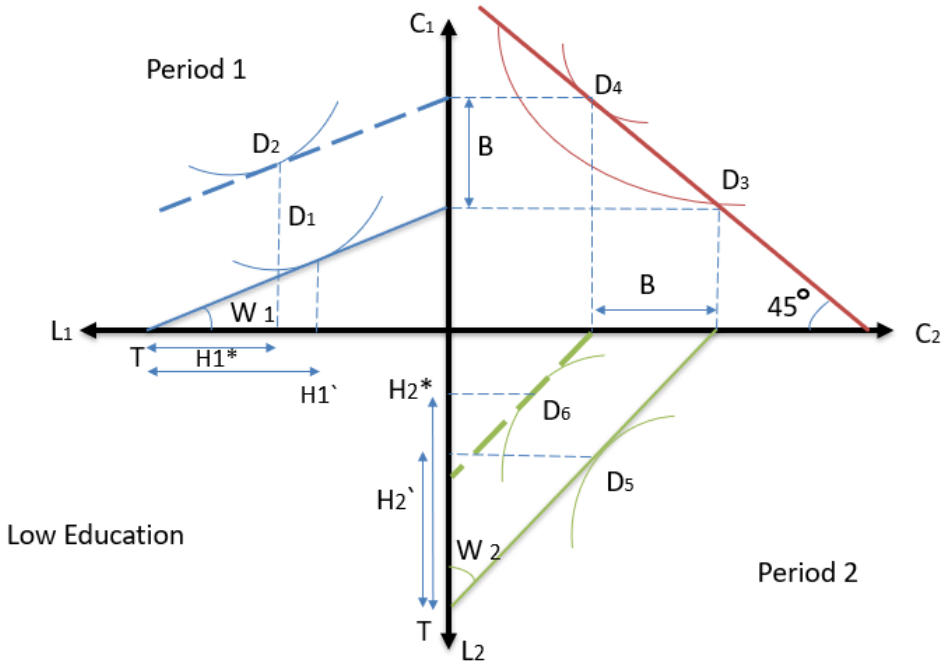

Figure 2.23: Two period labour supply of low education agent

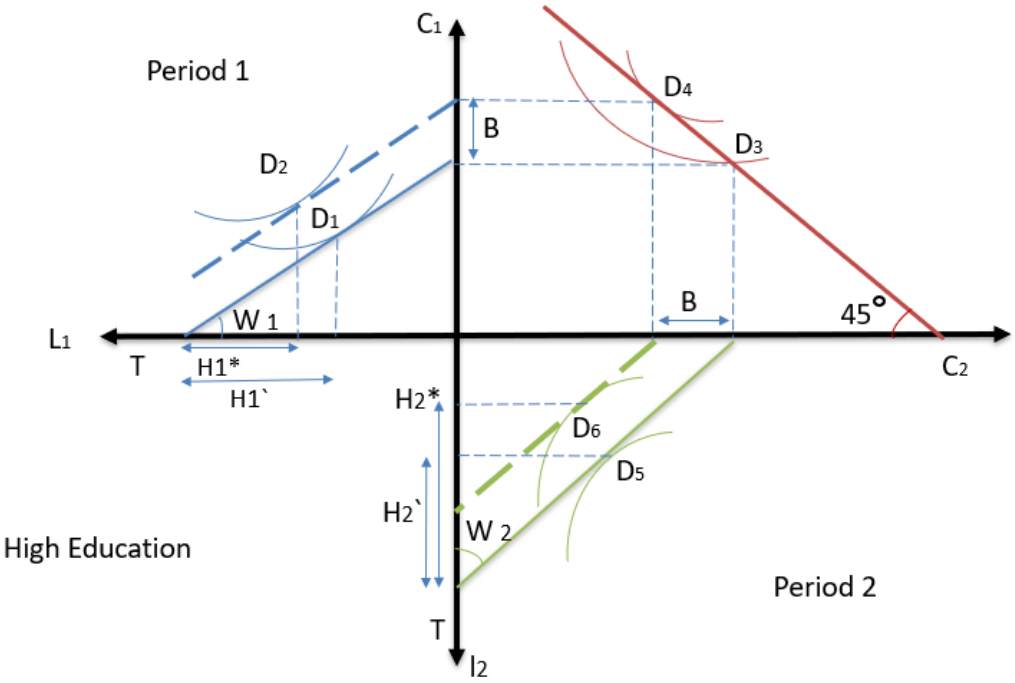

Figure 2.24: Two period labour supply of high education agent

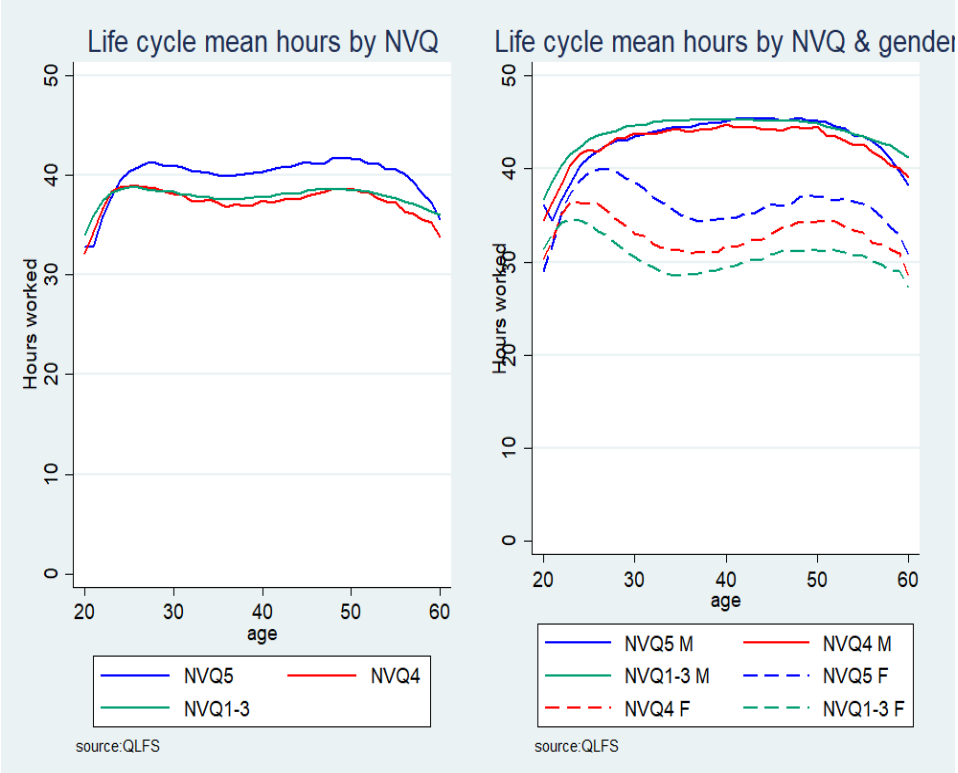

Figure 2.25: Life-cycle hours profile by education levels & marital status

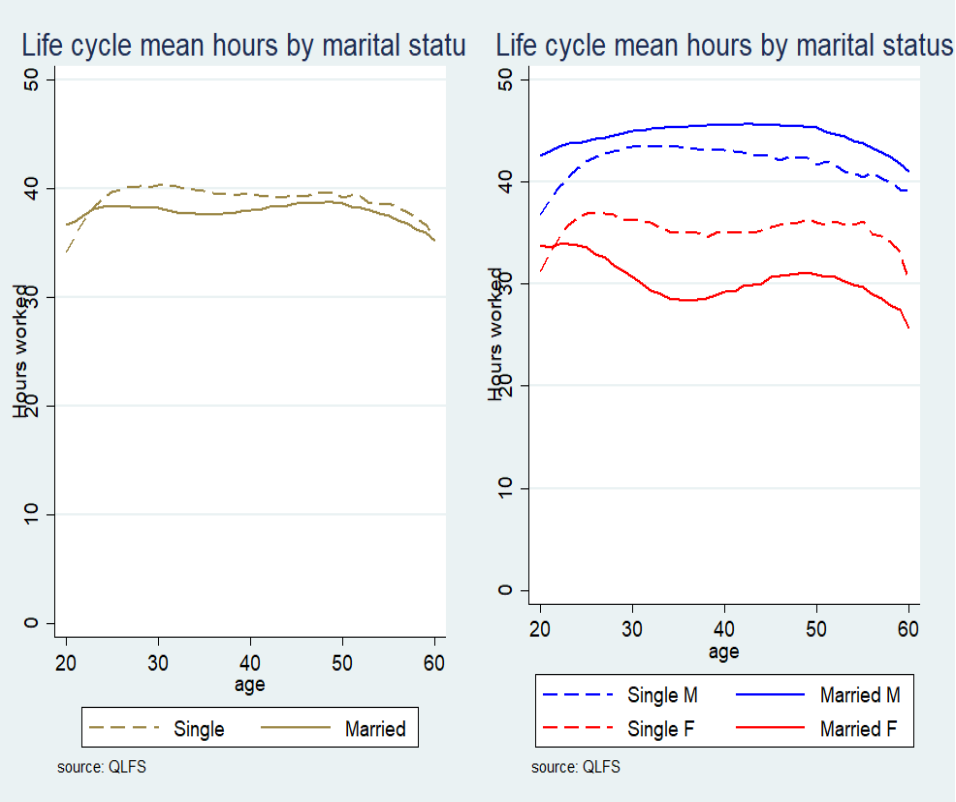

Figure 2.26: Life-cycle hours profile by education levels & marital status

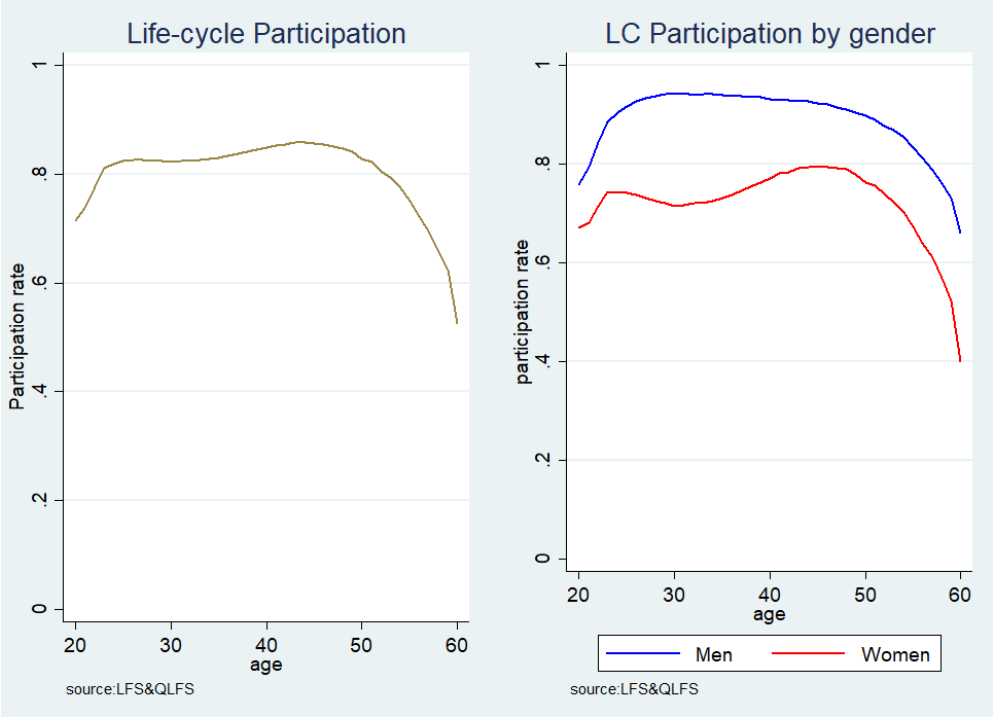

Figure 2.27: Life-cycle participation profile

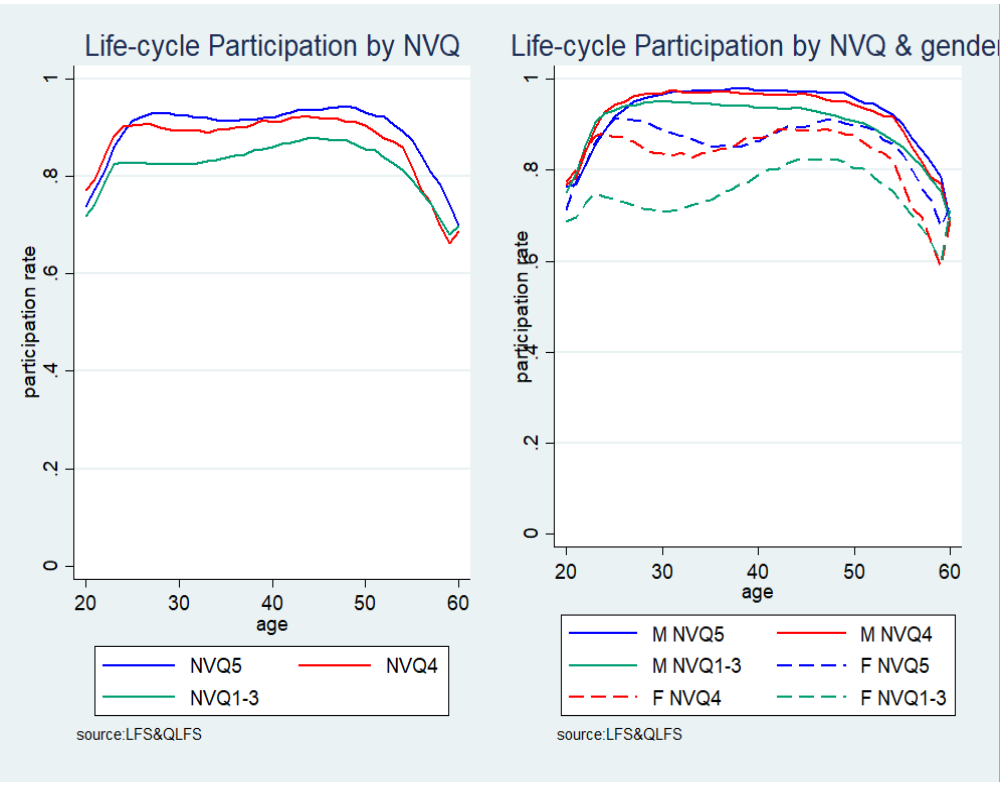

Figure 2.28a: Life-cycle participation profile by education

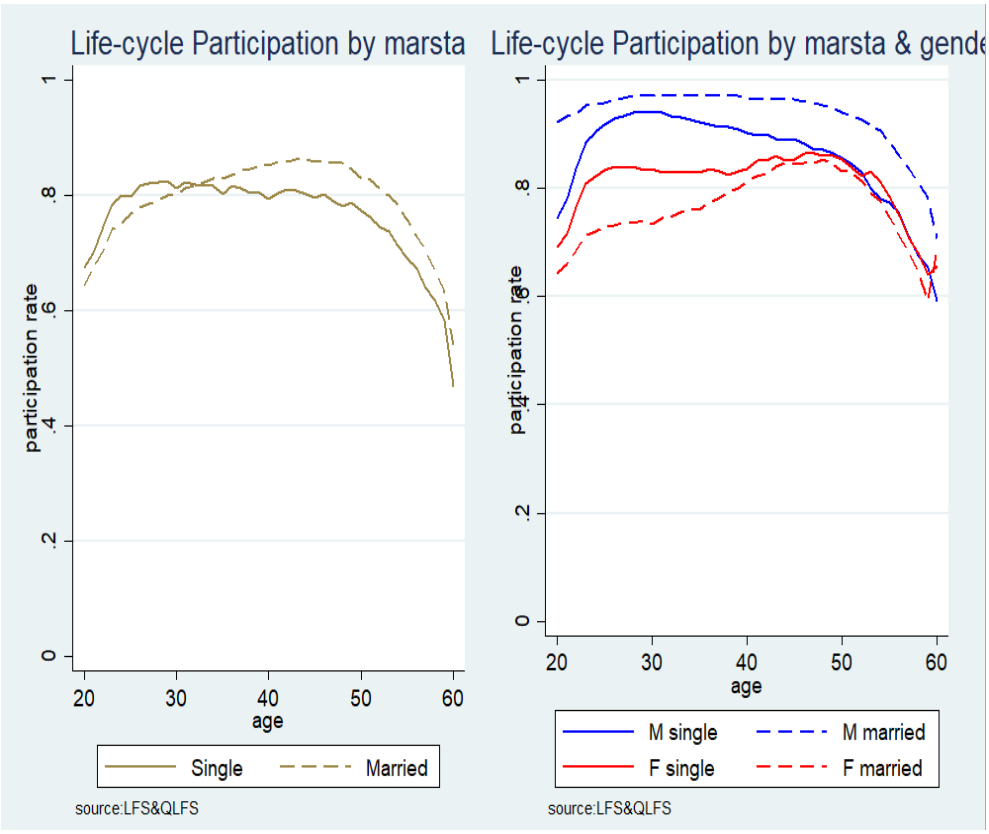

Figure 2.28b: Life-cycle participation profile by marital status

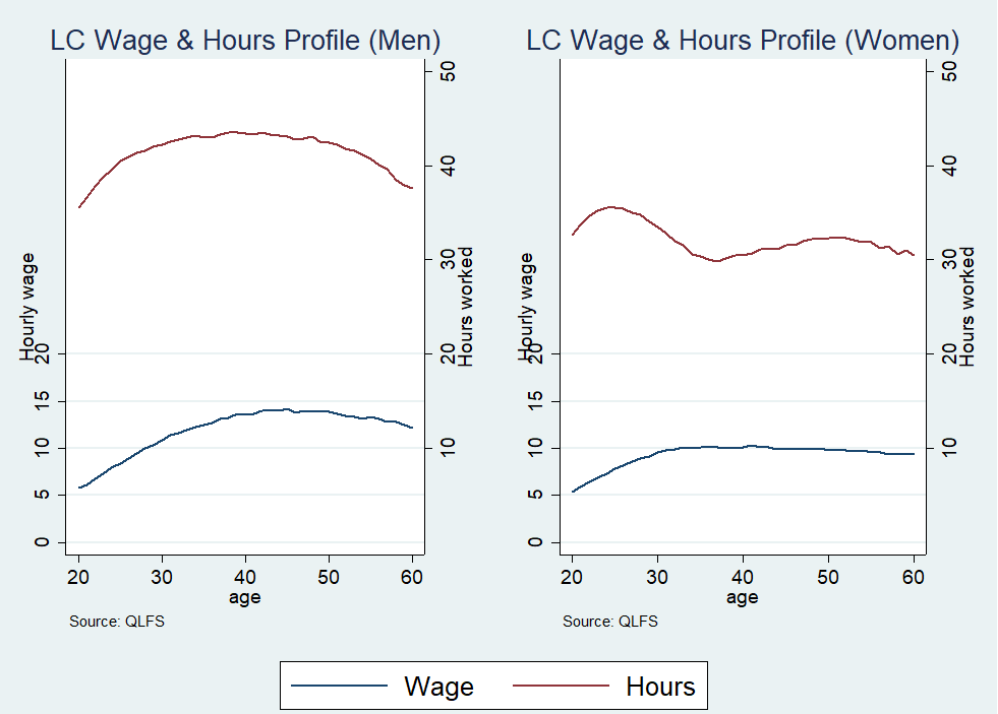

Figure 2.29: Life-cycle Hours/Earnings profiles

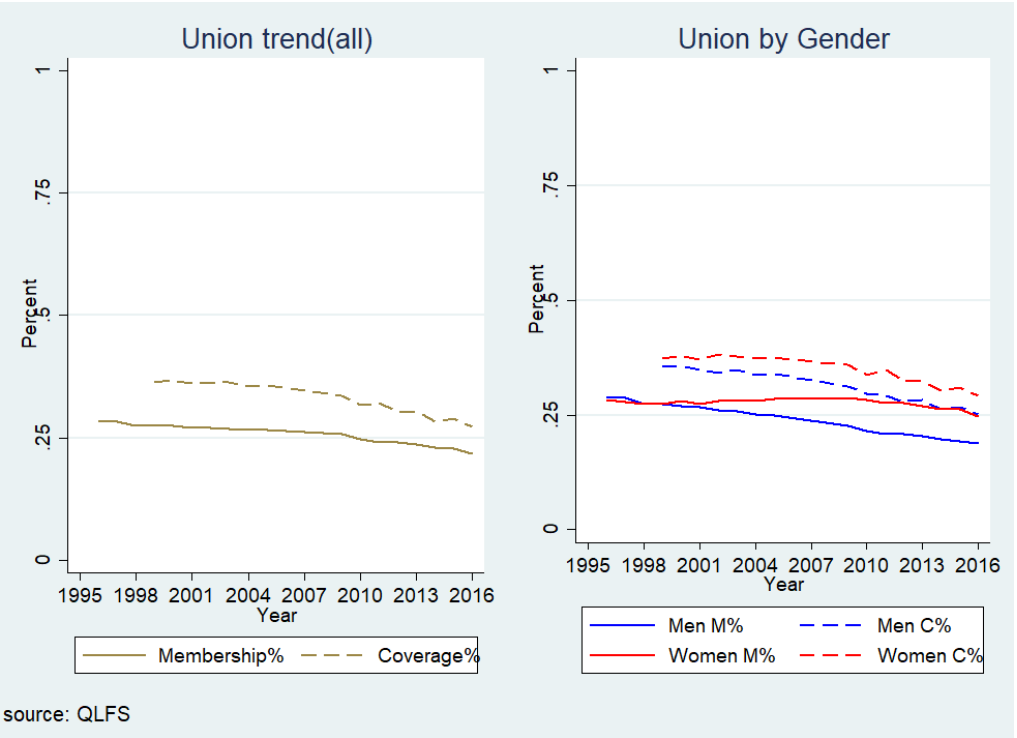

Figure 2.30: Union trend series

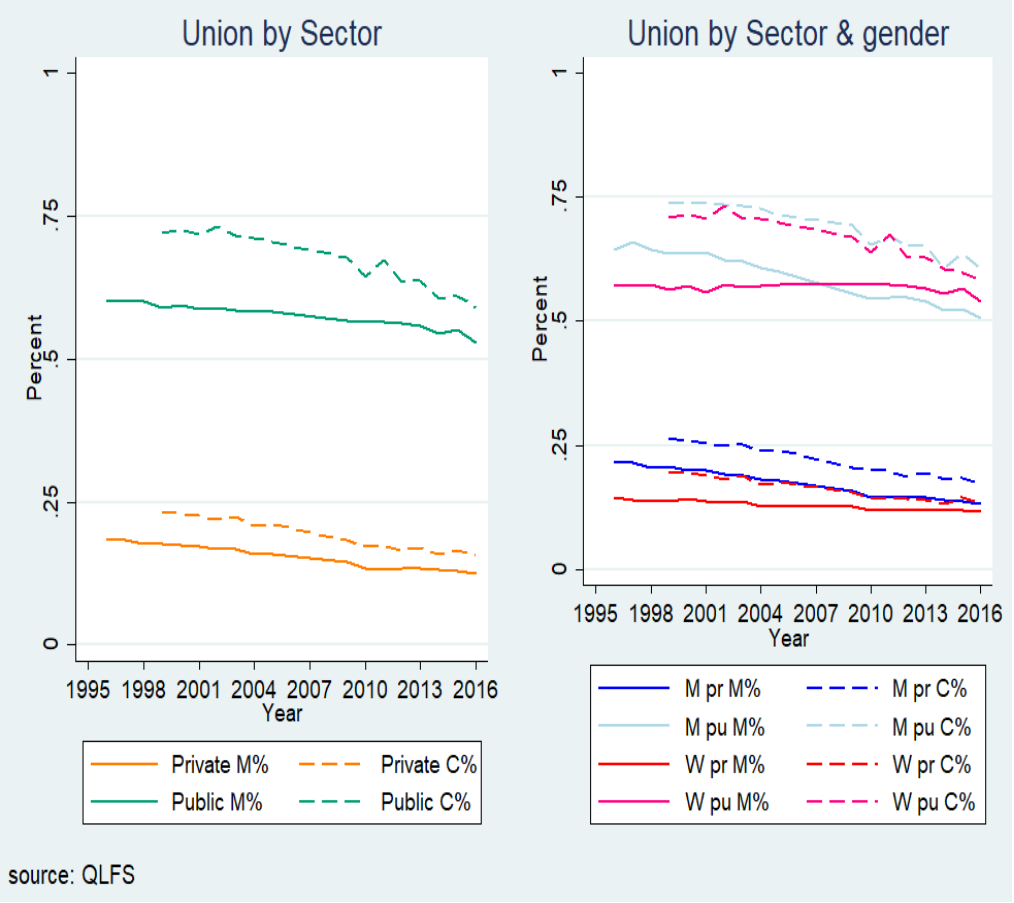

Figure 2.31a: Union trend by sector

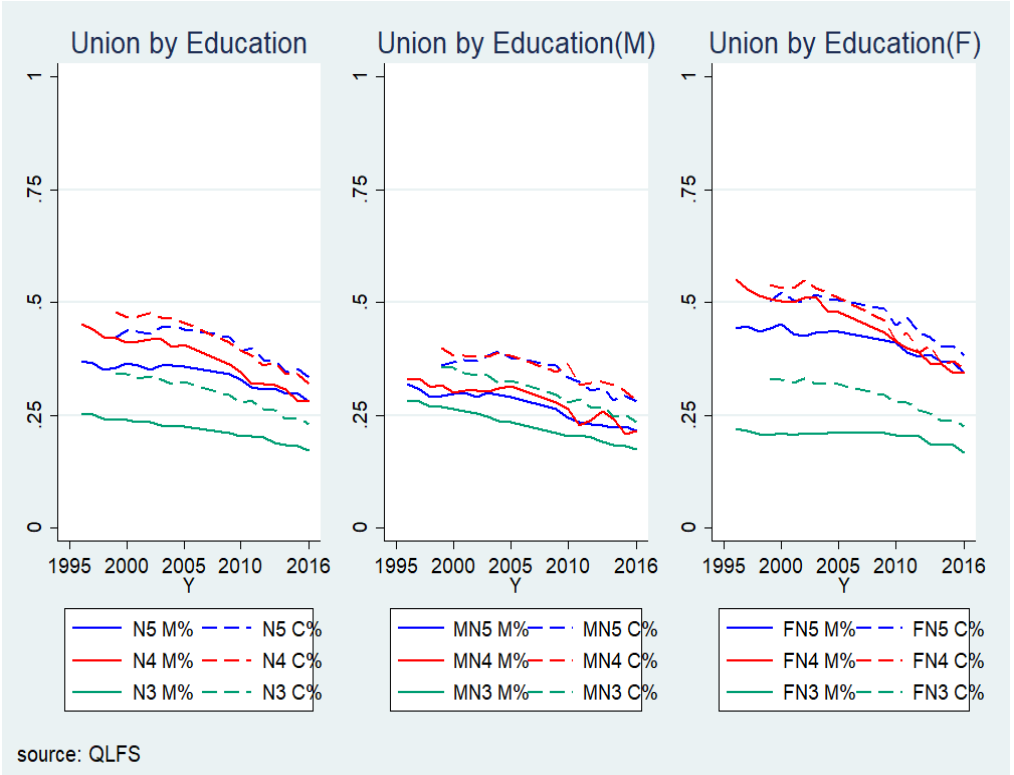

Figure 2.31b: Union trend by education (NVQs)

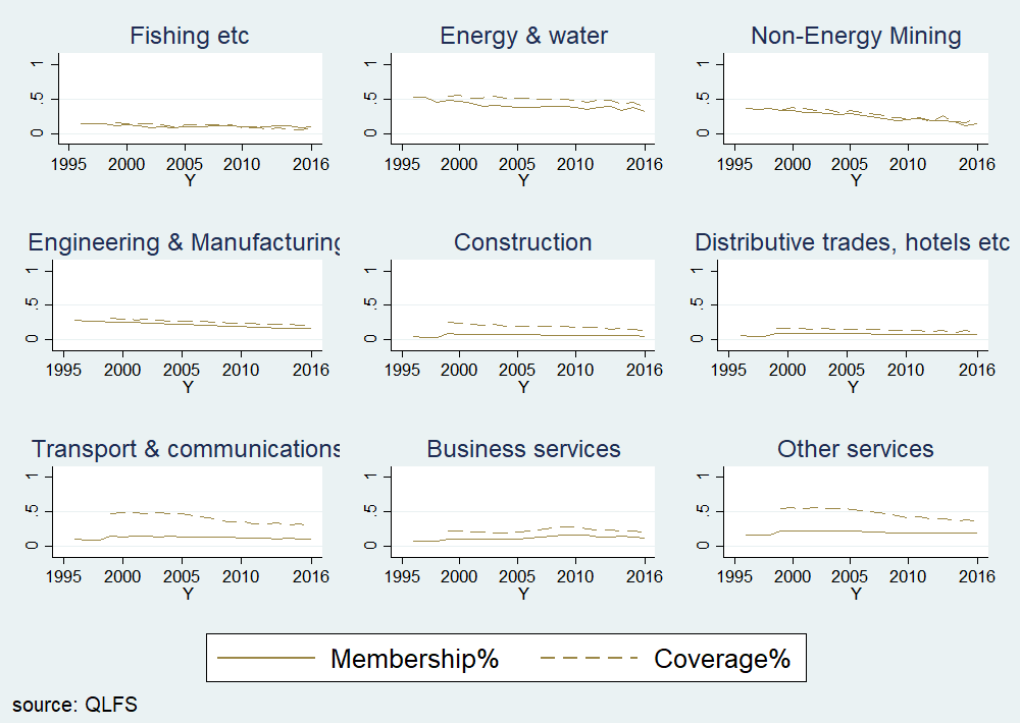

Figure 2.32a: Union trend by industry

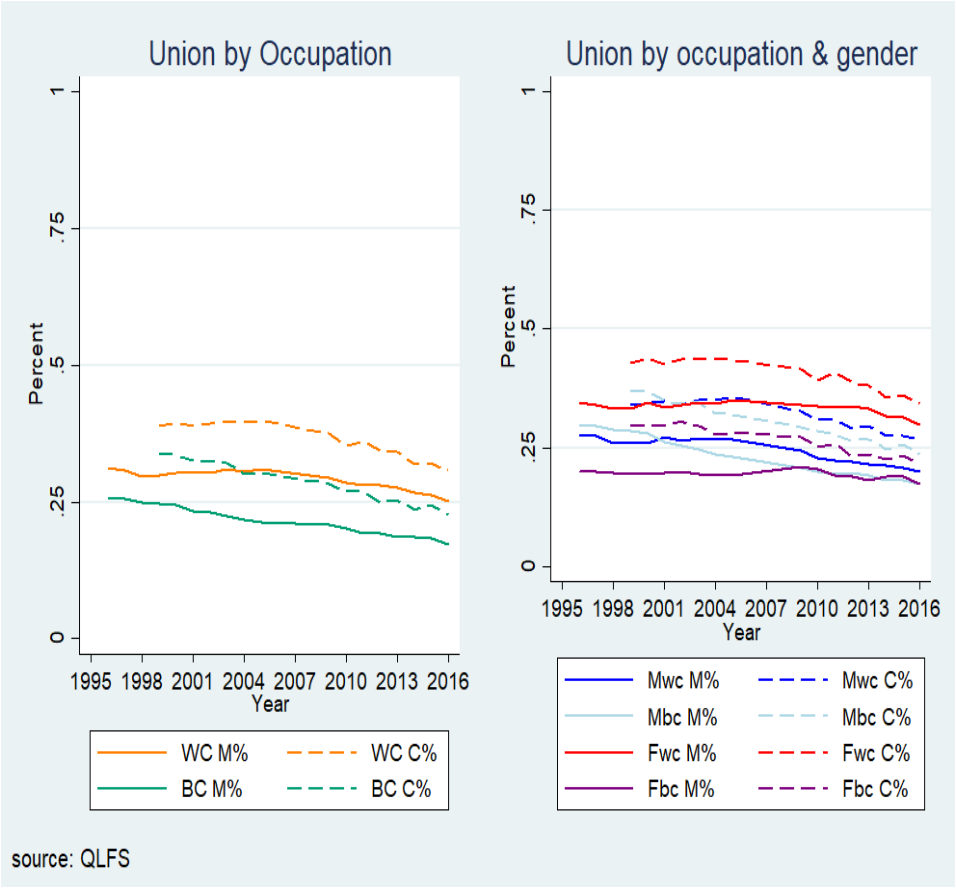

Figure 2.32b: Union trend by occupation (White/Blue Collar)

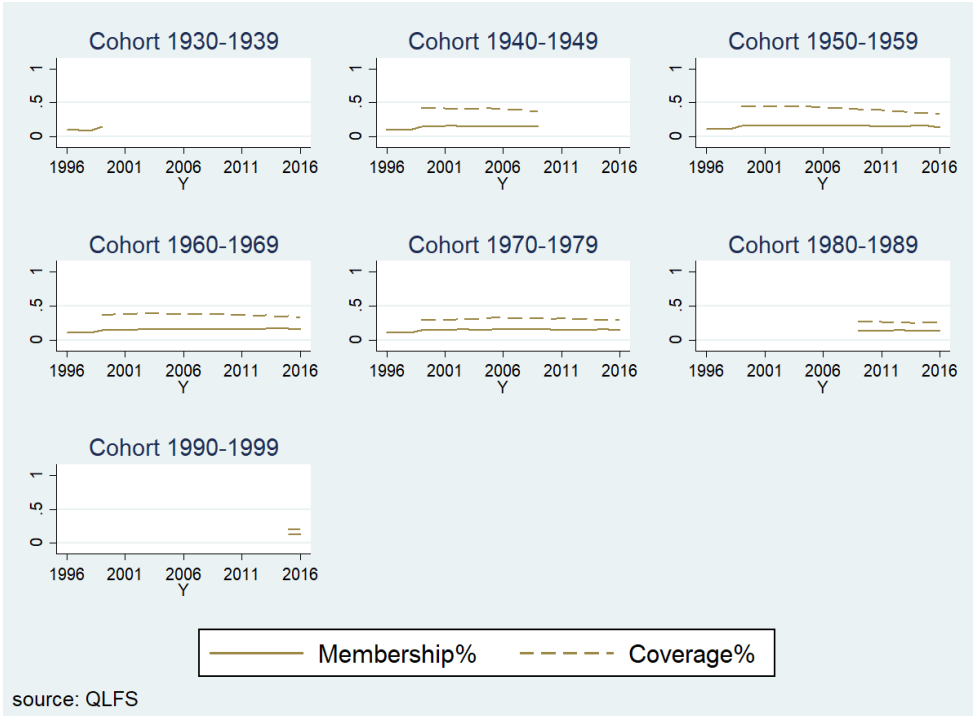

Figure 2.33a: Union trend by Cohort

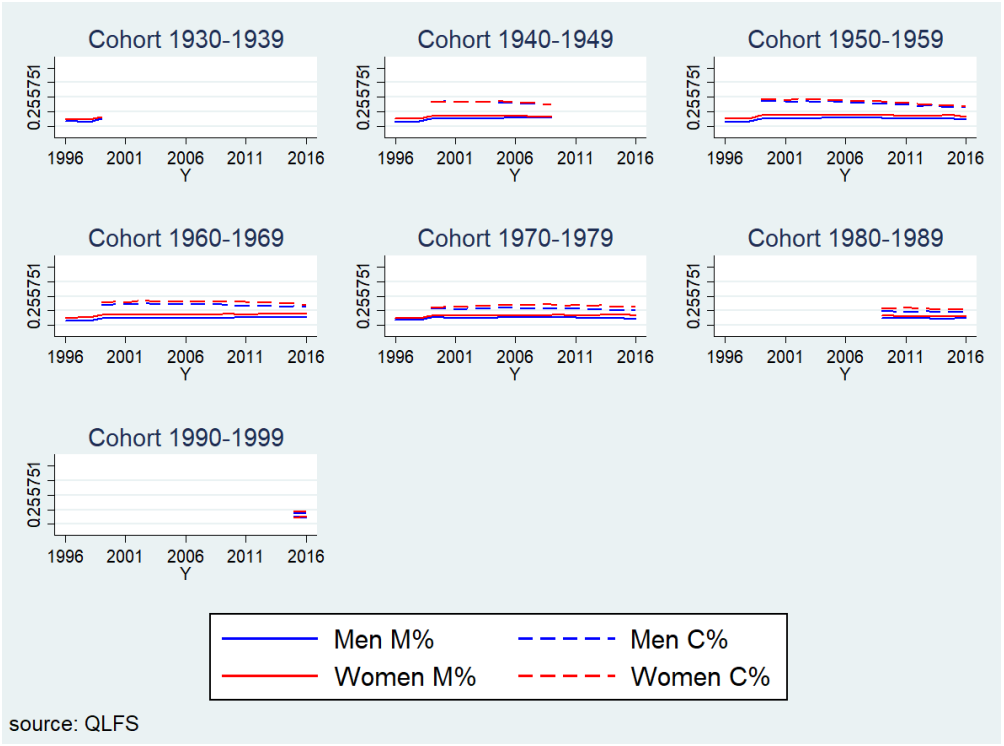

Figure 2.33b: Union trend by Cohort (& Gender)

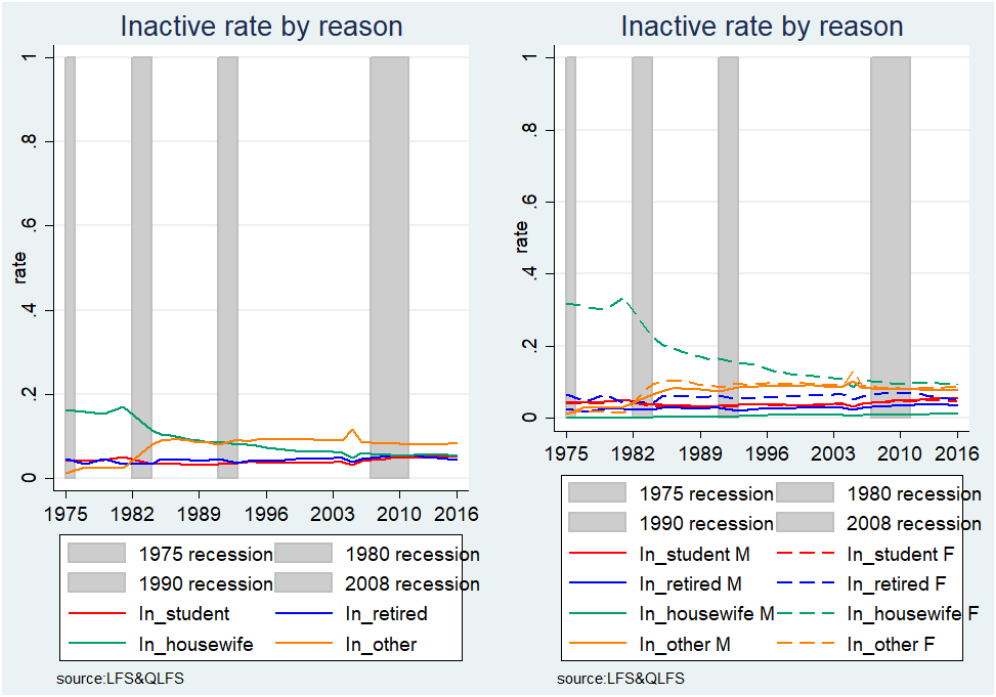

Figure 2.34 Out of labour force by reason

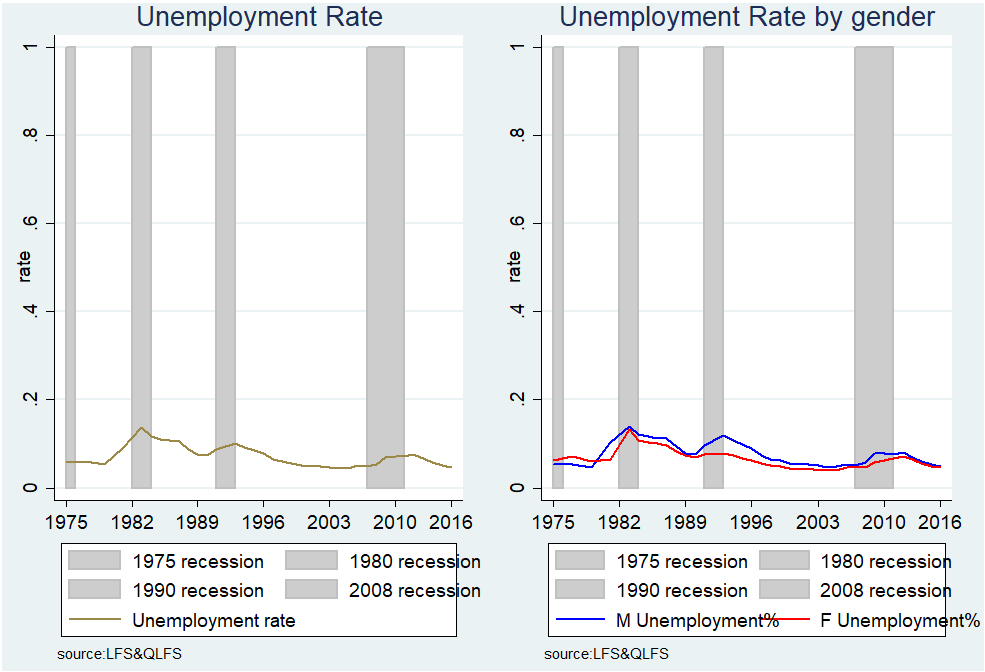

Figure 2.35 Unemployment series (& by gender)

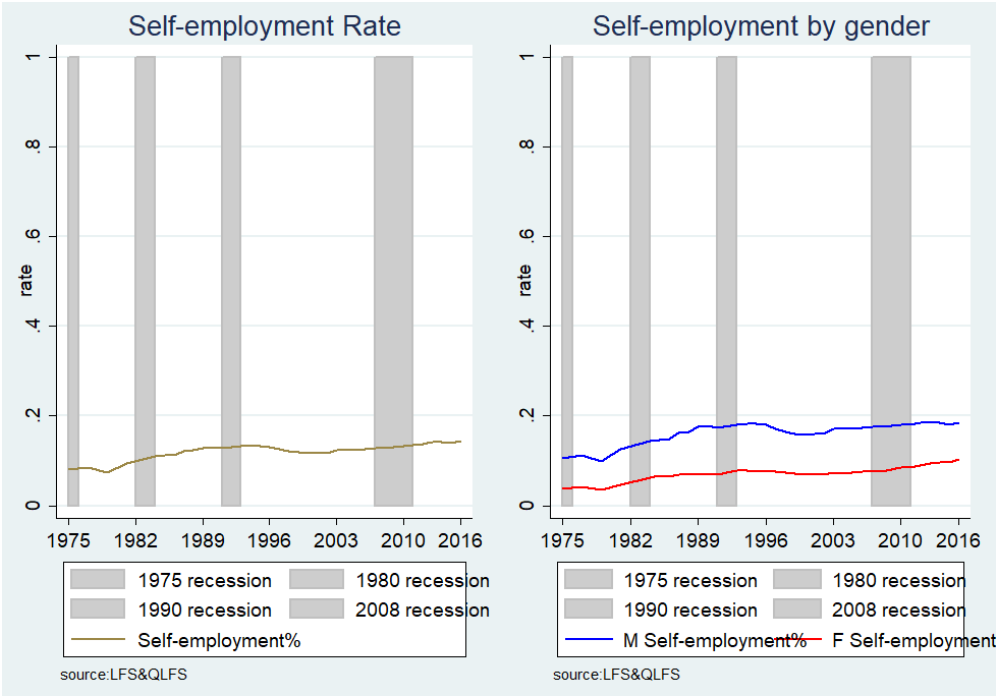

Figure 2.36: Self-employment series (& by gender)

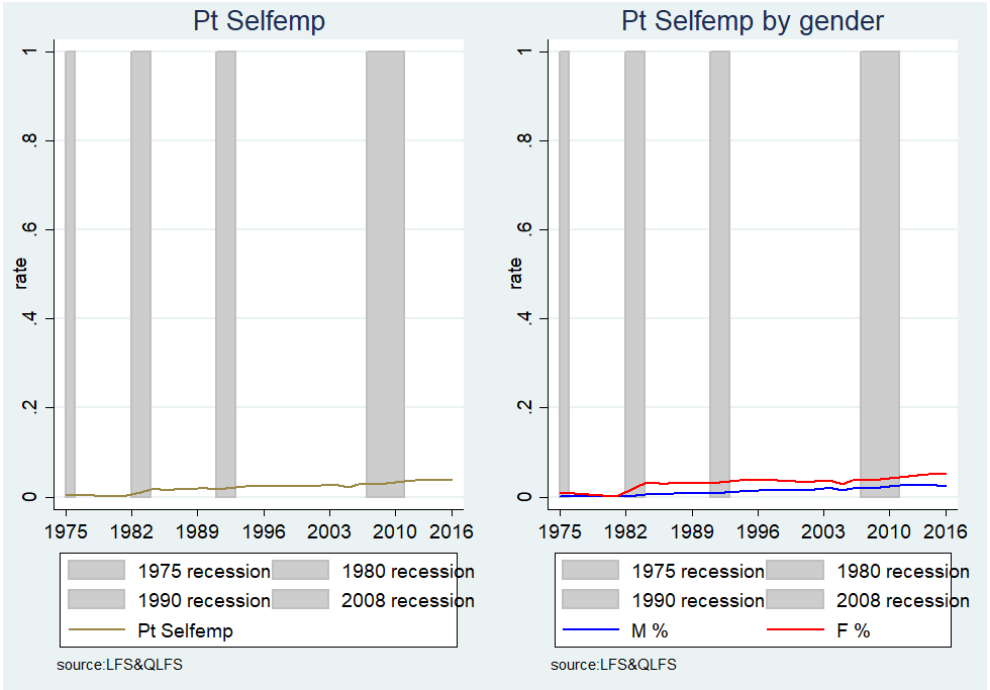

Figure 2.37 Part-time self-employment series

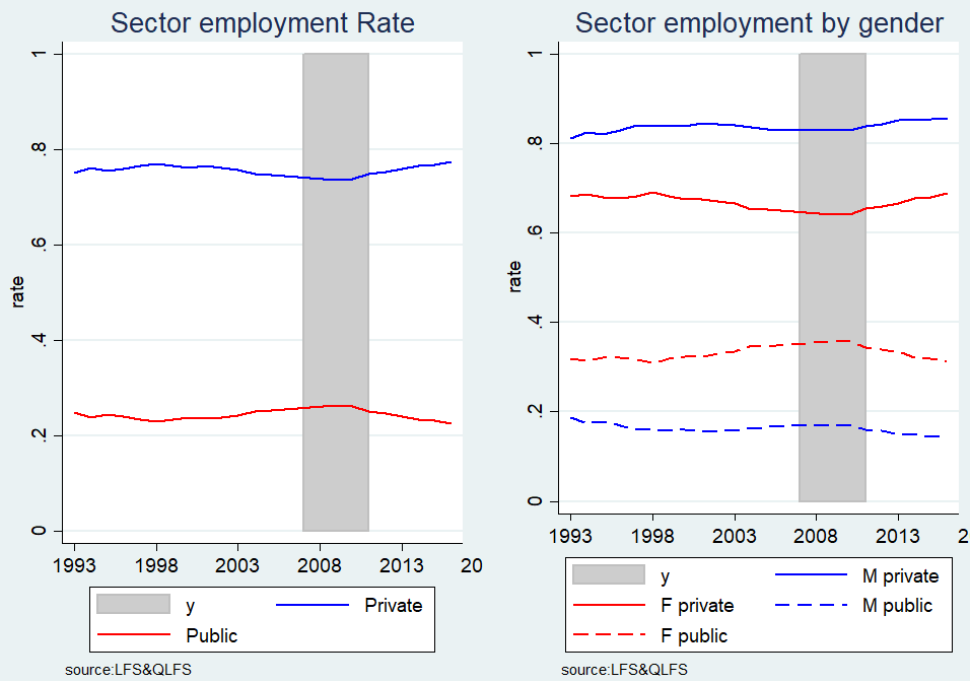

Figure 2.38 Employment series by sector

Chapter 3

Estimating married couples` labour supply responses in the UK using tax and benefit reforms: *Evidence from Quarterly Labour Force Survey 2002-2016*

3.1 Introduction

Understanding how individuals vary their labour supply to changes in economic incentives is of critical importance. Wage effects are crucial to long run issues such as the design of the tax and welfare systems in models of static labour supply. (Graafland et al., 2001); and it contributes to our understanding of the efficiency cost of taxation in general equilibrium models (Ballard et al., 1985; Browning, 1987). The larger the supply response to a change in the tax rate, the higher the excess burden of taxation will be. In a lifecycle model the wage effects speak to intertemporal substitution – a parameter that both lies behind our understanding of savings behaviour and of unemployment, but also to our understanding of the timing of labour supply across the lifecycle.

Given such importance, there has seen a development of an extensive theoretical and empirical literature on this topic since 1970s[19]. After the reviewing, it appears to me that, on the one hand, there exist great variations in the size of the results as well as the approaches to the estimation; and early estimates are afflicted by the inadequate treatment[20] of the selection bias. On the other hand, there seems to be very little work done in the recent decades, especially with UK data[21]. Therefore, we attempt in this paper to use recent developments in estimation techniques to recalibrate this effect and take the empirical evidence to date with QLFS data (2002-2016)[22], the largest survey in the UK, yet used for such purpose.

The theoretical developments on labour supply research through all these years have gained much insights in our understanding of workers` labour supply behavior. The critical developments are the distinction between labour supply choices at the intensive margin and choices at the extensive margin (Heckman, 1993); and the distinction between within period

[19] Heckman (1974), Burtless and Hausman (1978), Hausman (1985), Mroz (1987), MaCurdy, Green and Paarsch (1990), Blundell and Walker (1986), Blundell, Meghir, Symons and Walker (1988), Blundell, Duncan and Meghir (1998) to mention just a few.

[20] Mostly OLS with cross-section data, or using instruments which is probably correlated labour supply decisions, such as education.

[21] The most recent study is Blundell et al., (2016) which used BHPS (1993-2008) and simulation data.

[22] QLFS data dates back to 1992, however, the id variables pid and sppid which are crucial to our derivation of our non-labour income variable in our analysis, are only available from 2002 onwards.

labour supply responses and intertemporal labour supply responses (Blundell et al., 1999). Such distinctions have gained important empirical payoffs since.

The distinction between the intensive and extensive margin are the distinctions of the labour supply effects between hours of work and participation. Concerning hours of work, it is a good proxy for effort in the case of most on-the-clock workers. However, for those with high levels of autonomy on the job and who already work long hours, such as the self-employed and senior executives, they can either adjust their effort or work even when they appear to be at leisure. For this very reason, we have decided to exclude self-employed and people at the top 1% of the income distribution in our analysis.

Furthermore, on the second distinction, much of the empirical work done so far on labour supply and taxes has been placed in a static (within period) framework, however, the labour supply decision could be understood better in a lifecycle context, where variations in real wages, health status and family composition provide incentives for people to smooth their income and to insure the unforeseeable shocks (Blundell et al., 1999). Moreover, recent labour supply works have been dominated by quasi-experimental methods[23], which focus on the effect of a surprise on affected cohort from a policy reform. But the reform is permanent, the associated effects on future cohorts may be quite different from the affected one. Therefore, these estimates do not offer much insight into the structural behavioral conclusions. Life-cycle labour supply models have the potential to deal with this problem and to gain some meaningful insights into the anticipated effects as well as surprises from a given reform.

In this paper, I provide renewed estimates of the labour supply responses to wages and nonlabour income from married men and women, within period as well as intertemporally.
In practice, labour supply responses have been notoriously difficult to estimate in a robust and generally acceptable way (Mroz, 1987). That is probably why the variation in magnitude of labour supply elasticities in literature is huge and there is little agreement among economists on the size of the effects reached. One of the difficulties researchers face relate to the fact that marginal tax rates from the income taxes are a function of work effort, as are transfer program eligibility and benefit levels, in estimation it is necessary to treat the wage, nonlabour income and transfer program participation decisions as endogenous to labour supply choices. To identify model parameters, I exploit the exogenous discontinuities in the tax and benefit schedule, and the differential growth in marginal wages and nonlabour income induced by tax

[23] Leigh (2007); Gregg & Harkness (2003); Francesconi & van der Klaauw (2007); Blundell, Brewer & Shephard (2009); Meghir & Phillips (2010); Blundell, Bozio & Laroque (2011); etc.

and benefit reforms (Blundell, Duncan and Meghir (1998)).

Another difficulty is that individuals` observed decisions represent intertemporal allocations as well as within period allocations. This leads to simultaneity problems with wage rate and nonlabour income. For example, hard workers will be facing higher marginal tax rates and hence lower hourly wages. This causes a downward bias in the wage effects. Instrumental variables based on arbitrary exclusion restrictions, such as education (Altonji, 1986) may not work, since these variables are probably correlated with tastes for work (Blundell et al., (1998)). To solve for the problems mentioned above, we adopt the grouping method developed by Blundell et al. (1998), labour supply effects can be estimated by comparing the responses over time of different groups of individuals (groups defined by cohort, time and education levels) who are affected differently by the reforms. The repeated cross-section nature of our data conveniently allows us to do so by constructing grouping instruments and thereby address these endogeneity issues.

Our results support some of the empirical evidence in the previous literature, such as that female labour supply effects are generally positive whereas male ones are sometimes negative. In particular we find that men`s labour supply effects are consistently negative in our results; this well reflects the falling trend in men`s labour supply in recent decades. However, unlike previous evidence which shows women unilaterally sacrifices labour market commitment for home production and childcare, our results show a picture where men and women shares family responsibilities when small children present, this may be attributed to the family friendly social policies, such as paternity leave. What is more, we find that the effects on participation are much larger than the effects on hours. And in terms of the intertemporal substitution, the effects are again much larger amongst women, rather men, the explanations could be that women`s lifecycle labour supply are much more susceptible to interruptions (childcare and home production) than men do. There may also be reasons from men`s side, for example, they may discount the future too heavily to smooth out consumption.

The paper proceeds as follows. In the next section, we review the empirical literature; followed by section three where we discuss the empirical models we use for the analysis; and in section four, we introduce the dataset we use and the institutional background of UK tax and benefit systems as well as reforms during the data period. Then we go on to discuss the empirical results in section five. Lastly, we conclude in section six.

3.2 Related Literature

In this section, we survey the empirical literature on labour supply in the context of UK,

focusing on the effects of wages, taxes and benefits. This review contains a few seminal articles, but is certainly not meant to be exhaustive. For more complete surveys on the topic, please see Pencavel (1986), Killingworth and Heckman (1986), Blundell and MaCurdy (1999) and Meghir and Phillips (2010).

Much of the empirical analysis on labour supply concentrates on estimating wage elasticities, which reflect the sensitivity of labour supply to small changes in incentives. These measures are not necessarily sufficient for understanding the impact of reforms[24], but they do offer a way of providing coherent comparisons across models.

We present in table 1 the existing evidence on labour supply elasticities in the UK. It includes evidence on married men and women as well as lone mothers (which is the focus of many tax and welfare programs). And both the static and intertemporal evidence are included. We classified them into four groups: 1. Studies on married women; 2. Studies on lone mothers; 3. Studies on married men; and 4. Studies on intertemporal labour supply.

3.2.1 Married Women.

The first group in table 1 presents estimates for married women. It is obvious that the range of estimates is very wide, from 0.11 to 0.71 at the intensive margin. Compared with some of the US studies (Ashenfelter et al., (1974) Hausman (1981) Triest (1990)) at around the same time, these estimates tend to be much smaller, however, the difference should be expected, since these US studies are based on annual hours of work instead of weekly hours that is used in all the UK studies. Annual labour supply can be viewed as combining the effect of adjustment across many different margins: hours per week, weeks per year and participation. Therefore, with similar methods the annual hours adjustments should be more sensitive to wages than weekly hours.

Another important feature is whether the study has allowed for fixed costs of work. In the presence of fixed costs of work, the individual needs to decide whether to work or not. If he/she decides to work, he/she works at least enough hours to make it worthwhile. This is the so called "Reservation hours" (Cogan (1981)). Thus, wage fluctuations can lead to large jumps from zero hour to some large positive numbers, eg: 25 for women, 35 for men in my data. Ignoring such fixed costs will force the model to explain hours and participation changes at the same

[24] Since these approaches are sensitive to several sources of bias, such as "mean reversion", "differential growth at different parts of the income distribution due to inequality" and "possible effect of tax reforms on skill price and hence on earnings." These sources of bias do not all go in the same direction, thus creating some ambiguity on the credibility of the results.

time, this bias the effect of wages on hours upwards, therefore amplifying the labour supply effect. Arellano and Meghir (1992), after allowing for endogeneity of taxes and wages as well as non-labour income, find their elasticities in the range of 0.29 to 0.71 depending on demographic groups. However, their identification strategy is based on the assumption that education is not having an independent effect on hours of work. Blundell, Duncan and Meghir (1998) use long time series variation and allowed for the endogeneity of pre- and post-tax wages as well as fixed cost of work. It is being considered the most reliable estimates (Meghir & Phillips (2010), Blau & Kahn (2006)). Rather than looking for the full solution to taxes, it simplifies the problem by exploiting the fact that most working women are paying a single basic tax rate, after conditioning on having a working husband. They then exploit the change in the UK wage structure and the numerous tax reforms that occurred to control for the endogeneity of wages and taxes. They use the differential time series variation in after tax wages for different cohorts and different education groups. Their identifying assumption is that while preferences for work may be different between different education groups and cohorts, the differences are constant in time. Hence differential changes in the labour supply of these groups can be attributed to differential changes in the price of human capital that they face. However, the cost of their approach is that the sample they use is selected. The elasticities they find are in the range 0.13 to 0.37 depending on the age of children present in the family. They find that women with young children have higher elasticities, women with children aged 0-2 the uncompensated wage elasticity is 0.205, and women with children aged 3-4 the uncompensated wage elasticity is 0.371, and for all other married women, the wage elasticity is around 0.13.

Apart from the wage elasticity, income elasticity is also very important for reasons of measuring welfare effects. A large income effect will translate a modest Marshallian wage elasticity into a large Hicksian wage elasticity, which is the source of deadweight loss. The range of estimates we find in the literature is from -0.4 to -0.06 across all the studies listed, implying small behavioural effects.

Putting all these results together, the picture we have for married women`s labour supply response is that the wage elasticity for hours worked per week is small for most married women, apart from those with pre-school children (under age 4). If a woman works the mean 25 hours per week, it would take a 10% increase in the wage rate to induce an increase of 1.3 hour in the work week. With a mean income elasticity of 0.2, this implies a compensated elasticity (Hicksian) of 0.3. With non-convex budget sets, such as those induced by tax-credits or other

welfare benefits, some individuals may respond to small tax changes by a large change in their hours of work decision. Mean elasticities like these may well imply that the number of such individuals is small, the outcome depends very much on the overall shape of the budget constraint and the distribution of hours of work.

The fact that women has a lower participation rate suggest that the participation margin is more important to women than men. The range of the elasticities in the studies we have on married women is from 0.04 to 1.41. Arrufat and Zabalza (1986) use the 1974 GHS cross section data and find a participation elasticity of 1.41 for married women after allowing for taxes and their endogeneity. Blundell, Ham and Meghir (1987) draw a sample of 2011 married women from the 1981 FES cross section data, after fitting it with a Tobit as well as a double hurdle model, they find participation elasticity in the range from 0.04 to 0.08, which is fairly different from the findings in Arrufat and Zabalza (1986). However, both studies are based on a single cross section, the external validity is to be questioned. However, after comparing these results with the findings from other countries, we find Arrufat and Zabalza`s results are close to other findings. Such as Pencavel (1998) in the US and Aaberge et al., (1999) in Italy. Pencavel (1998) is the most comprehensive study amongst the ones listed here. It covers a long period of time 1975-1994, using the CPS data and estimating the participation effects of wages with various approaches and instruments. The participation elasticities he finds range from 0.7 to 1.8. The drawback is that he does not allow for the tax system and used pre-tax wage rates in his paper. As with Aaberge et al., (1999), he finds evidence that participation is more elastic among women from poorer families. This is line with the studies which look at the labour supply response of the lone mothers, the results are listed as the second group in table 1. There are indeed many studies devoted on the labour supply of lone mothers, since lone mothers has been the focus of many welfare programs, and their labour supply response have been very large especially at the participation margin. However, as far as this study is concerned, we focus on the labour supply responses of married men and women with a working spouse. Therefore, we are not going into depths on these studies.

3.2.2 Married Men

There is a long history of estimating male labour supply. The majority of the empirical evidence are from US data (see surveys of Hausman, (1985) and Pencavel, (1986)). One key characteristic of male labour supply in many countries is that men work primarily full time. This is because of the traditional gender roles among many cultures around the world – men being the main “bread earner” in a family. Although there is some variability in hours worked,

it is small for much of man. And there is a clear lack of individuals working below a certain level of hours, roughly 35 hours in my datasets. See figure one.

Estimates of wage elasticities on hours worked for married men are usually very small, often not significant and sometimes negative. The results of many studies[25] from different countries confirmed these stylized facts for married men. In the UK, Blundell and Walker (1986) use a subset of 1980 FES cross-section on married men and women, it adopted two-stage budgeting method, to obtain a life-cycle consistent within period preference estimates of 0.024 for men. but this study is only based on one cross section. Apart from a small wage elasticity on hours, the income elasticities reported are lower than that of women as well and even close to zero. In all, it would be a fair description to say that male hours adjustment to changes in marginal wages is very low and can be ignored for welfare purposes.

However, the intensive margin is only half of the picture, we still need to look at the extensive margin. Due to a long history of very high participation rates for men, most of the empirical literature has overlooked the participation decision, and there are very few estimates of participation elasticity for men. In the UK, Meghir and Phillips (2010) used discrete choice model on several most frequent hours across the hour's distribution, allow for tax and benefits and the endogeneity of wages, find that the total income elasticity at participation margin are high, especially for lower educated men (0.36).

3.2.3 Intertemporal Estimates

Among the models that recognize intertemporal linkages, many of them are due to savings. The intertemporal substitution effect in such context is measured by the Frisch elasticity, which represents the willingness of individuals to postpone leisure in favor of work during periods of anticipated high wages. The Frisch elasticity itself does not have a direct policy implication, but it is an upper bound for the standard within period uncompensated elasticity. Besides, it is also a component of the full life-cycle specification elasticity.

Across the empirical evidence, Pistaferri (2003) has attracted much attention, because of the unique data he uses. He uses the subjective expectations data of the Italian survey of household income and wealth to decompose actual wage changes into anticipated as well as unanticipated changes. He finds an intertemporal substitution effect for men of 0.7, and an effect on the shift

[25] Macurdy, Green and Paarsch (1990) reports an elasticity of -0.24 to 0.032 for the US married men; Pencavel (2002) reports a number of negative elasticities; Ashenfelter and Heckman (1974) reports a mean elasticity of 0.06; Blomquist and Newey (2002) using Swedish data with results ranges from 0.06-0.08. Kaiser et al. (1992) with German data, having results evaluated at means: -0.04. etc.

of the wage profile of 0.5. Given the quality of the expectations data, the estimates he obtained should be quite robust. However, he does not allow for taxes as other studies did. In the UK, Blundell, Meghir and Neves (1993) investigates the intertemporal response of married women. They use 1970-1984 FES data, their approach is under a two-stage budgeting setup, by first estimating the parameters of the within-period hours of work/consumption substitution effect, followed by estimating an Euler equation for the marginal utility of consumption, then identify the intertemporal estimates. The Frisch elasticities they find ranges from 0.58-1.22 depending on household characteristics. However, these findings are based on repeated cross-sections (a built pseudo-panel), instead of a real panel.

Beyond the intertemporal issues relating to savings, there is growing literature that introduces other important dimensions into the discussion. These models include human capital accumulation on the job, education choices and non-separability over time. They highlight several important points, such as the possible propagation effects of taxation through its impact on experience and wages, and habits etc. However, there is still heated discussions[26] on the interpretations of the findings related to these abovementioned dimensions in the literature. In this study, we decide not to include these further dimensions in our analysis.

Our study extends the empirical literature of labour supply elasticities estimation. Most of the UK evidence are either old (before 2000) or have focused on the quasi-experimental effects of specific groups, such as working tax credit on single mothers[27]. To the best of our knowledge a systematic study of the labour supply responsiveness of the couples is overdue.

3.3 Theoretical and Empirical Framework

In this section we elaborate on the theoretical and empirical frameworks for our analysis. In terms of the theoretical framework,three aspects are detailed below: the intensive margin, the extensive margin and the intertemporal model. And as for the empirical framework, we discuss the problems and the estimation techniques we chose to circumvent them.

3.3.1.1 Intensive margin theoretical framework

Our intensive model is based on the classic static labour supply model, where individuals maximize the utility function U = U(c,h) with respect to consumption c, and labour supply in

[26] For example, as far as the human capital accumulation story is concerned, it is observed that people who work a lot in one period, also tend to work a lot in the next. Furthermore, people who work a lot now tend to have higher wages in the future. It could be a story of human capital accumulation, where people work a lot because they realize that this will increase their skill and hence the future wages. However, it could also be a unobserved heterogenous preference story that people who are productive just choose to work a lot.

[27]

terms of weekly usual hours worked h, subject to the linearized budget constraint c = wh + Y, where w is the gross hourly wage rate and Y is the non-labour income (eg: income of the spouse and capital income).

Due to data limitations on consumption information, we are not able to construct non-labour income from the widely used expenditure approach in many empirical studies Y= C – wh. (Blundell and Walker (1986) and Arellano and Meghir (1992)). Instead, we use the spouse weekly income as a measure for own weekly nonlabour income. Given the fact that in the UK, capital income and other sources of income account only a very small fraction of most individuals` total income.[28] Therefore, spouse income can be a good approximation for own nonlabour income in our analysis. Inspired by Blundell et al. (1998), we specify the following hours of work equation:

$$h_{it} = \alpha + \beta \ln w_{it} + \gamma Y_{it} + \theta X_{it} + \varepsilon_{it} \quad (1)$$

Where i is an individual index and t is a time index. Within the static framework, the uncompensated labour supply elasticity evaluated at mean hours can be obtained by $\beta/\bar{h}$, where $\bar{h}$ is the mean weekly hours worked. Then the income elasticity is $\gamma\bar{w}$, $\bar{w}$ is the mean hourly wage.

3.3.1.2 Intensive margin empirical framework

The main conceptual difficulty in estimating equation (1) is the fact that wages and nonlabour income are endogenous and observed only for workers. Estimating equation (1) by OLS directly will lead to biased estimates for both right-hand side parameters, since they are probably correlated with the error term ε. The most obvious reason recorded is that unobserved variables such as tastes for work and savings etc, might affect hours worked h, the gross wage rate w and the level of nonlabour income Y at the same time[29] (Jantti et al., 2015), causing downward bias of the parameter estimates.

The repeated cross-sectional nature of our dataset allows us to use the grouping method to compare groups of individuals over time and deal with these endogeneity issues by constructing instruments. Following Blundell et al. (1998) we partition our data into groups based on cohort, time and education levels. The key idea behind the grouping procedure is the Difference in

[28] Based on the Family Resources Survey, Department for Work and Pension, documented annual reports on the source of income in the UK. Investment income and Other sources of income only take up 3%-5% of the total income on average.

[29] Hardworking people prefer longer hours, and they accumulate more human capital during work, the accumulated human capital will boost up future wage rates. And the possible assortative mating behaviour on education, may cause tastes for work to covary with spouse education, therefore income (own non-labour income).

Difference setting, which aims to compare similar groups of individuals who have been affected differently by tax and benefit reforms, retaining the ambition to estimate structurally meaningful parameters.

We group our data based on cohort, time and education, to make sure that the number of observations in each group is large, we take four cohorts, consisting of individuals aged 25-34, 35-44, 45-54, 55-59. And three education groups: NVQ1-3, NVQ4 and NVQ5[30]. This gives us twelve groups in total. Our data runs from 2002 to 2016, with 2010 missing, due to the lack of ID variable, 14 financial years in total. Therefore, there are substantially more groups than parameters to estimate.

Let g denote group cell. Suppose that $\varepsilon_{it} = \alpha_g + m_t + \eta_{it}$, where E $[\eta_{it}|h_{it} > 0, g, t] = 0$. Based on this assumption, unobserved heterogeneity, conditional on g and t, can be captured by a permanent group effect α_g and a time fixed effect m_t. This is the exclusion restriction for identification. Moreover, four reduced forms error terms are included in the equation to evaluate the relevance of the instruments.

$$h_{it} = \alpha_g + m_t + \beta \ln w_{it} + \gamma Y_{it} + \theta X_{it} + \delta^w v_{it}^w + \delta^Y v_{it}^Y + \delta^P v_{it}^P + \delta^K v_{it}^K + \eta_{it} \quad (2)$$

Where v are the residuals from reduced forms to control for the endogeneity of wages (v_{it}^w), nonlabour income (v_{it}^Y), participation (v_{it}^P) and selection away from the first tax and benefit kink (v_{it}^K). Smith and Blundell (1986) also used this residual addition method, this computational approach gives identical results to grouping estimator, but the t statistics on the δ parameters directly provide tests of exogeneity.

The four error terms are from the estimation of the reduced forms separately. For wage residual (v_{it}^w), we regress the log after-tax wage on time dummies interacted with group dummies by OLS, over the sample of workers only and compute the residual from the regression. Similar procedure applies to nonlabour income residual (v_{it}^Y). And the participation residual (v_{it}^P) is done by Probit, this is the inverse mills ratio. v_{it}^K is the first order generalized residual from an ordered Probit regression with three groups for women: the working non-taxpayers, those close to the kink, and those above the kink; and four groups for men: the working non-taxpayers, those close to the kink, those pay at a basic rate and those pay at a higher rate. This is to account

[30] NVQs (National Vocational Qualifications) are not formally defined in terms of equivalence to conventional academic qualifications. In the paper, we follow the equivalences used by London School of Economics`s research lab, where there are five levels, NVQ5: degree level and above; NVQ4: higher education diploma below degree, teaching and nursing certificates; NVQ3: A levels or equivalent; NVQ2: O levels or GCSE equivalent: NVQ1: other qualifications.

for the selection away from Tax and NI kink[31]. Ignoring this issue may cause the results uninterpretable from a preference point of view. Moreover, the wage effects would probably be downwardly biased, since for people bunch around the kinks, we would attribute their response to preference rather than the structure of the budget constraint.

For sensitivity analysis, we estimate two versions of the model to compare and contrast the results in order to gain more insight about the variability of the coefficients with demographic characteristics. We firstly estimate the model without the interactions of log w and Y with demographic characteristics, and then with the interactions. The results are listed in table 9 to table 12. The discussions follow in the results section.

3.3.2.1 Extensive margin theoretical framework:

The analysis above is limited to the labour supply response at the intensive margin (for those who supply positive number of hours). In this section, we will model people`s decision on whether to work or not, the so-called extensive margin. In the extensive margin model, people choose between two points in the consumption-earnings space. Individuals can choose either a consumption level at zero earnings or a consumption level if he/she enters the labour market. The traditional framework is largely the hackman two step type of estimator, in our analysis, we adopted the estimator in Meghir and Phillips (2010), where they used the residual from a reduced form to act as an instrument to correct for the endogeneity problems in the wage equation.

Following Meghir and Phillips (2010), we start by defining the utility functions for working and not working as below:

$$U^P = a^P + b^P Y^P + c^P X \quad (6)$$

$$U^{NP} = a^{NP} + b^{NP} Y^{NP} + c^{NP} X + e \quad (7)$$

Where Y^P and Y^{NP} are the measures of total after tax income including any benefits when in work and out of work respectively. The X variables are taste-shifters which affect individual welfare differently when the individual works and when he does not. These include year dummies which reflects preferences over time, education and age, as well as region and ethnicity. Finally, *e* is the usual econometric error term. For simplicity, we assume that it is

[31] It is quite obvious that this tax and NI kink applies to the budget set of women in the UK, since the majority of women are either working non-taxpayers or taxpayers at the basic rate. However, we assume this kink also applies to men based on the findings in Emmanuel Saez (2010) and Richard Blundell and Hoynes (2004). Where Blundell et al., (2004) find clear evidence of benefit-eligible individuals bunching at exact 16 hours per week in the UK with FES data, and Saez (2010) used US tax return data find that there is clear evidence that people (especially self-employed) bunch around the first kink point of the income tax schedule, and no evidence of bunching at any other higher kink points.

normally distributed. Then the condition for working is when $U^P > U^{NP}$, or we can put it as below equation:

$$e < (a^P - a^{NP}) + b^P Y^P - b^{NP} Y^{NP} + (c^P - c^{NP})X \quad (8)$$

Estimating the work probability and identifying the effects of income requires us to observe wages for the entire sample. Moreover, we wish to allow for the possibility that pre-tax wages are correlated with unobserved preferences or work (endogenous pre-tax wages). This is addressed by using predicted wages rather than actual wages for both workers and non-workers. We specify a wage equation of the following form;

$$lnw_{it} = d_t + \beta age_{it} + \delta age_{it}^2 + \gamma region_i + \vartheta ethnicity_i + u_{it} \quad (9)$$

Where d_t is time dummy, *region* is region dummy and *ethnicity* is ethnicity dummy. The wage equation is specific to each education group (NVQ levels).

3.3.2.2 Extensive margin empirical framework

The main difficulty with estimating this equation is that wages are only observed for workers. To correct for such sample selection problem, we use Heckman sample selection model.

The Heckman selection model is an estimation procedure which consists of two interdependent stages, with the first one being a binary probit model of participation choice (decision to work), and the second one analyzing a related continuous variable (wage rate) in the context of a set of regressors. The main advantage of this approach is that it corrects for potential selection bias of the second stage estimator by linking it to the first stage participation choice through a correction term called inverse Mills ratio.

To avoid problems with multicollinearity, it is preferred to have the first stage of the Heckman selection model estimated with a genuine selection variable, which affects the participation decision, but not the censored indicator itself (Cameron and Trivedi, 2005). In the case of wage modelling, we have chosen three selection variables: the first two being the number and age of children in the family, which are frequently used instruments in the participation equation (see Blundell et al., 1992). The third instrument is defined as Z[32], which is adopted from Meghir and Phillips (2010).

$$Z_{it} = Y^{NP} - G_{it}\gamma \quad (10)$$

[32] The rationale behind the instrument Z is that since the key assumption we hold here is that the earnings for people when out of work can be taken as random after taking certain demographic characteristics as given, such as family composition, ethnicity, housing tenure and region.

Where E($Y^{NP}|Family\ composition, housing\ tenure, region, ethnicity, time$) = $G_{it}\gamma$, with G_{it} representing the variables in brackets. By taking the residual rather than the level of non-work income, we avoid the endogeneity problem arising from potential correlation of family composition, region and ethnicity with wages. Hence, estimated wage equation (9) by Heckman Maximum Likelihood Estimator[33], the results are represented in table 10 and table 11.

We then specify a model of probability that someone works as equation (11). This depends on the total income (E_{it}) he would get if he/she enters the labour market.

$$P(work)_{it} = a_{it} + \beta_{ext}E_{it} + \eta_{it} \qquad (11)$$

This total income is a combination of various means-tested welfare benefits, including WFTC, housing benefit, child benefit and child tax credit. In order to obtain this total income variable, we compute one probability of working evaluated at the expected in-work income. Specifically, we split the hours distribution for men and women into intervals respectively[34] and assign a probability for each interval consistent with what is actually observed in our data. We then evaluate income at the average hours of each interval depending on pre-tax earnings at that point and taking into account all taxes and benefits for which the individual is eligible if he were to work that many hours. The measure of in-work income is then the weighted average of post-tax and benefit income at all these points. It should be noted that our in-work income measure also includes the spouse`s actual earnings, without considering the possibility that he/she might change his/her decision as a result of what their spouse does.

3.3.3.1 Intertemporal Labour Supply Theoretical Framework

Although the estimation of labour supply elasticity is often placed in a static framework, the labour supply decision can be understood better in a lifecycle context, where variations in health status, family composition and real wages provide incentives for people to smooth their income and to insure the unforeseeable shocks.

To recover meaningful lifecycle parameter estimates, the estimation is often done with panel data. However, even with cross-sectional data, it is possible to obtain meaningful lifecycle parameter estimates. In the cross-section case, the inclusion of controls is crucial. The interpretation of the wage elasticities differs with different controls used in the specification.

[33] We also estimated the wage equation with Heckman two-step estimator, the results seem to be largely the same.

[34] Women 0, 1-15, 16-29, 30-44 45-54, 55-70, 71+; Men 0, 1-15, 16-29, 30-39, 40-49, 50-60, 61-70, 71+. This is done based on the density of the distribution of their working hours, in order to get as good as possible a representative mean for each interval of hours.

In accordance with Blundell and MaCurdy (1999) handbook chapter, we specify the followings labour supply function for Frisch specification:

$$lnh_t = \alpha lnw_t + F_0 + bt + \rho X_t + \epsilon_t \tag{12}$$

where h_t is weekly hours; w_t is hourly wage rate; $F_0 + bt$ is the time path for $\ln\lambda_t$, λ_t is the marginal utility of wealth for each period, F_0 is the constant component across all individuals and time, bt is the time trend for $\ln\lambda_t$, X_t are demographic controls, ϵ_t includes sums of forecast error terms.

If we have panel data, we could take first difference of equation (12). After cancelling out all the time invariant terms, an estimate of coefficient α will be obtained. This α corresponds to the Frisch wage elasticity, which measures the intertemporal substitution effect, it describes how changes in wages induced by movements along an individual`s wage profile influence hours of work. Since F_0 is fixed, individuals fully anticipate these wage movements.

We further assume that the $\ln\lambda_0$ can be approximated by sums of all expected future wages discounted to period 0, initial endowment, all time-invariant characteristics and an error term as in below equation:

$$ln\lambda_0 = D_0\varphi_0 + \sum_{j=0}^{\tau}\gamma_{0j}E_0\{lnw_j\} + \theta_0 A_0 + a_0 \tag{13}$$

Where D_0 is a vector of demographic characteristics either observed at period 0 or anticipated in future periods, A_0 is initial endowment, a_0 is the error term. Then F_0 in equation (12) can be substituted by $ln\lambda_0$, we will get:

$$\ln h_t = \alpha lnw_t + D_0\varphi_0 + \sum_{j=0}^{\mathrm{T}}\gamma_0 E_{0j}\{lnw_j\} + \theta_0 A_0 + a_0 + bt + \rho X_t + v_t \tag{14}$$

The α estimates we get from fitting this equation will be composed of two effects: $\alpha_I + \gamma_{ot}$, α_I the Frisch wage elasticity and γ_{ot} which determine the impact of a shift in the entire wage profile. and where the disturbance ϵ_t in equation (12) will now be $\epsilon_t = a_0{+}v_t - \gamma_{0t}(lnw_t - E_0\{lnw_t\})$. All the 0 subscript terms in equation (14) includes all start-of-life controls to form λ_0.

In order to estimate equation (14), we need to assume that the lifetime wage path and the non-labour income Y_t path anticipated at period 0 are:

$$E_0\{lnw_t\} = \pi_0 + \pi_1 t + \cdots + \pi_{\mathrm{T}} t^{\mathrm{T}-1} + u_t \tag{15}$$

$$E_0\{Y_t\} = \delta_0 + \delta_t t + \cdots + \delta_{\mathrm{T}} t^{\mathrm{T}-1} + \varepsilon_t \tag{16}$$

By the fact that start of life nonlabour income is a fraction of the initial endowment $Y_0 = \frac{A_0}{1+r_0} r_0$, therefore initial endowment can be predicted by $A_0 = \delta_0 \frac{1+r_0}{r_0}$.

Combining equation (14), (15), (16), we could rewrite equation (14) as:

$$\ln h_t = \alpha ln w_t + D_0\varphi_0 + \pi_0\overline{\gamma_0}t + \pi_1\overline{\gamma_1}t^2 + \cdots + \pi_T\overline{\gamma_T}t^{T-1} + \delta_0\frac{1+r_0}{r_0} + bt + \rho X_t + \mu_t \quad (17)$$

This μ_t is a composite error term depending on the previous errors a_0, u_t and ε_t. This equation relates individual effect to the parameters of his wage and income profile. If we assume that D_0 contains only intercept and the coefficients on age and age squared for the lifetime wage and income path are constant across individuals[35], we can then collect all the similar terms, equation (17) can be written as:

$$\ln h_t = d_1 + d_2 t + d_3 t^2 + \left(\alpha_I + \overline{\gamma_o}\right) ln w_t + \bar{\theta} Y_t + \rho X_t + e_t \quad (18)$$

If we estimate equation (17) by using age squared as an instrument for log wage to account for its endogeneity, then the coefficient on wage rate will be the Frisch elasticity α_I. The intuition behind is that by controlling for individual characteristics across consumers and leaving higher-order age variable to identify lifecycle wage variation. Hence, only evolutionary wage variation along the age-wage path is recovered.

However, if we regress log hours worked on nonlabour income, age, age squared and log wage rate, the coefficient on wage will be the response of labour supply to a parametric wage shift, including both the intertemporal substitution effect α_I, as well as the reallocation of wealth across periods captured by a change in individual effect F. Since most tax and benefit reforms can be described as permanent unanticipated shifts in after-tax real wage today and in the future, therefore, the full lifecycle labour supply elasticity is the most appropriate one to capture such an effect.

3.3.3.2 Intertemporal Labour Supply Empirical Framework

Estimation of the simple parameterization of the full lifecycle model above relies on specifications for both within period utility and the individual marginal utility of wealth effect. However, controls are needed for all of the following: "start of life" characteristics which impact the initial setting of F_o, current-period characteristics which affect the within-period utility function, age, expected wages as of period zero and initial wealth. Expected wages are unobservable and initial wealth is generally not included in the dataset, therefore we replace

[35] knowing that the lifecycle hours and wage path are inversely "U" shaped, see figure 1, we therefore only included age to the quadratic order.

these with the parameters governing the time path of wages and nonlabour income (spouse income), which must be jointly estimated with the labour supply equation.

It is worth noting that the elasticity derived from this static specification, can be placed in an intertemporal setting but is economically meaningful only under a strong assumption of either complete myopia or perfectly constrained capital markets. Otherwise, these elasticities confuse movements along wage profiles with shifts of these profiles and thus, yield response parameters which are a mixture of these effects.

Therefore, under simplifying assumptions, formulation 17 allows to compute the intertemporal substitution elasticity using cross-sectional data alone. In contrast, formulation 18 allows one to estimate the response to a parametric wage shift, required controls here are property income in period t, age and age squared. The controls we included are education, ethnicity, gender, residential area.

3.4 Data

The data we use in this paper come from the Quarterly Labour Force Survey (QLFS), which is the largest regular household survey in the UK. It contains rich socioeconomic information on a country-wide random sample of almost 53,000 households for each quarter. Although it is not panel data, it provides consistent and accurate micro level information over a long period of time.

3.4.1 Sample selection criteria

In the analysis, Labour supply is estimated on married men and women between the age of 25 and 59 who are not self-employed, not disabled (claiming disability benefits), not retired nor in full-time education. The sampling period are from 2002 to 2016. The reason for such selection is to construct the nonlabour income variable[36] which is important in labour supply analysis (Blundell et al., (1998)). As mentioned before, we also excluded men and women at the top 1% of the income distribution, because their labour supply decisions are probably very different from normal wage workers. Such sample restrictions are made so that our analysis is not contaminated by factors such as self-employment, disability, retirement or full-time education where hours of work may not fully represent the level of efforts. The age range of 25 to 59 is chosen in the same manner to exclude the fuzziness at the two ends due to education

[36] QLFS does not have any measure on nonlabour income. We circumvent this problem by matching up head of family with spouse of the family, hence using spousal income as own nonlabour income.

or retirement.

For the intensive and extensive margin analysis, we use grouping method to circumvent the endogeneity issues of the regressors, where groups are based on cohort and education. we take four cohorts, consisting of individuals aged 25-34, 35-44, 45-54, 55-59. And three education groups: NVQ1-3, NVQ4 and NVQ5. In total, this gives us twelve groups. Because the consistency of the grouping estimator is based in part on the number of observations per cell being large, we follow Blundell et al., (1998) and drop cohort-education cells with fewer than 50 observations.

3.4.2 Descriptive statistics

Table 4 and table 5 show the descriptive statistics of the main variables (hours, wage, non-labour income) as well as some of the demographic characteristics (education, age of dependent children) separately on men and women across the years. Two more demographic variables are not included because their descriptive statistics do not mean much. One of them is URESMC the usual residential governmental area, that is consisted of twelve governmental regions[37]. The other is ETHNIC the ethnicity variable, that is consisted of six ethnic groups[38]. Table 4 suggests that in our sample, men are working 43 hours per week on average with a mean wage of £13 to £18. The nonlabour income for men ranges from £270 to £450. This reflects the secular increase in women`s wages. The family types did not change much in time. Whereas, in table 5, we can see that women`s mean working hours and wage are lower than that of men with a mean at around 33 hours and £13 respectively. The nonlabour income is high, simply because of their husband having a higher weekly income. However, the mean education value for women has increased much more than men, this is attributed to the large increase in female participation in higher education (Blau and Kahn, 2006).

3.4.2.1 Basic characteristics of hours, participation and wage distribution

In figure 3.2, we show the distribution of working hours by genders and by taxpayer status. This shows that there is indeed a great deal of variation existing between genders and between the taxpayer status to be explained. Women`s hours are scattered around 30 hours` mean, while men`s hours are rare before 35 hours, this shows that men mainly work full-time. The hours` distribution between taxpayer status indicates that non-taxpayers tend to work less hours than

[37] The 12 governmental areas are: London, Northwest, Yorkshire & Humber, West midlands, East midlands, East Anglia, Northeast, Southeast, Southwest, Wales, Northern Ireland and Scotland.

[38] The 6 ethnic groups are: White, Mixed background, Indian/Pakistani/Bangladeshi, Chinese/other Asian background, Black Caribbean/African/other, and other ethnic groups.

their counterparts.

Figure 3.1 shows the distribution of log wage by gender, the distribution for men`s wage is asymptoticly normal, without the long tail. The distribution for women`s wage is a bit left skewed, showing that women`s wage are on average lower than men.

In this paper, we are also interested in the participation decision. Therefore, the evolution trend for participation by genders are shown in figure three, the participation rate is fairly consistent across the years. Apart from the fact that there is slightly a dip right after 2008, this shows the hit of the great financial crisis. However, we do not see the same dip in women`s participation curve, this is because women`s participation in the labour market has been rising over the past several decades, therefore, even there is some hit, the increase has masked the effect.

And the participation rate being so high has also something to do with our sample selection, where the age range is set from 25 to 59, the prime age for labour market. If we were to consider working age population (16-65), the level should be a bit lower.

3.4.2.2 Lifecycle characteristics of hours, participation and wage distribution

As far as the lifecycle characteristics of the relevant variables are concerned, we show the lifecycle profiles of hours, wage and education across figure four to seven. Figure four describes the lifecycle working hours` profile of men and women. The shapes are quite standard, men with an inverse U-shape hours profile: hours rise quickly for young workers, peak at middle age and decline when retirement approaches. Whilst women`s hours profile features a M-shape, hours increase quickly for young women, after family establishes and children arrives, the hours dip, and then rise again after children are old enough for school, before falling for retirement.

Education is an important factor for decisions at both intensive (hours) and extensive (participation) margins. we show the lifecycle hours (left panel) and participation (right panel) by education levels in figure five. We can see that there is not much dispersion in men`s hours across life. However, the dispersion is huge in women`s lifecycle hours. There is a monotonic increase in hours worked as education levels increase. The effects are remarkably large amongst women, rather than men.

Apart from hours, we also show the lifecycle wage profile by education in figure six. The first thing we notice is the similarity between the lifecycle wage profile and the lifecycle hours profile (if men and women are averaged, then the dip on the women`s hours profile could be averaged out, or at least flattened). With the quantiles, we can see that one principle applies for

both genders are that the higher the education levels are, the higher the wage profiles lie, the higher the quantiles are, the larger the variations across the lifecycle wage profile are.

3.4.5 Institutional Background

The personal tax and transfer system in the UK are consisted of a few simple taxes, mostly levied at the individual level, and many welfare benefits and tax credits, which usually are means tested at family level. Over the period of our data, extending from 2002 to 2016, there have been many reforms happened both in the tax and transfer systems.

3.4.5.1 Tax system and reforms in the UK

First, the tax system in the UK. All individuals irrespective of the total level of household income or consumption, have an income tax allowance. Income up to this amount in each tax year is free of tax. Income above this allowance is subject to tax. Starting from the allowance level, there are two or three different income tax rates applying to different levels of income across the years of my data (2002-2016). This aspect of the British tax system sort individuals into income groups, and the lowest income group can be referred to as non-taxpayers. All the other groups are taxpayers, only differ in the tax rates they pay.

From April 2002 to April 2007, there were three tax rates: starting rate (10%), basic rate (22%) and top rate (40%). In April 2008, the 10% starting rate was removed, and the 22% basic rate dropped to 20%, leaving the top rate remains at 40% level. From 2008 onwards, although the basic rate and the top rate remained at 20% and 40%. There was a new rate introduced in April 2013, called the additional rate, which aims at people who earns more than £150,000 a year. At the same time, the tax allowance decreases for people who earn above £100,000, for every £2 they earn above £100,000, £1 of the personal allowance is lost, it can go down to 0. This basically means that the higher the income is, the higher the marginal and effective tax rates are. The taxes are collected at source through the Pay-As-You Earn system. Reforms were announced on the budget day and implemented immediately. Any changes to the tax system were widely publicized.

In addition to income tax, individuals also pay national insurance contributions (NI). NI is paid on the entire income above a threshold, which is called the primary threshold (PT), up to an Upper Earnings Limit (UEL). Any individual who earns between the PT and UEL, pays the standard NI rate. For individuals, whose earnings is above the UEL, there is an additional contribution rate for the part of earnings above the UEL. Furthermore, there is also a Lower

Earnings Limit (LEL), people who earns between the LEL and PT, get NI credit, which means that they are entitled to NI benefits without paying any NI. However, if people earn below LEL, they will pay no NI and they will not be entitled to any NI benefits.

To obtain a correct measure of the marginal tax rate, both the income tax and NI rates should be accounted. Table 1 presents the main changes to the UK tax system during the period 2002 to 2016.

Many women in our sample lies in the "basic rate group"[39] (plus the NI rate). It seems that they would not be affected much by the reforms. However, the reforms have a greater effect on the incomes earned by men, especially on the middle and higher end of the income distribution. Since our sample is composed of couples, the income of man is the non-labour income for his wife. Therefore, the reforms are important in identifying the labour supply response from women as well. We decide to simplify the analysis by concentrating on men and women with employed partners only. This will help us to avoid the highly nonconvex budget set in the case where the partner is out of work and on benefit.

In summary, the large number of tax reforms over this period, sometimes increasing taxes, other times decreasing taxes, have shifted the tax system and offered us opportunity to identify labour supply response to the changes. Some patterns of the changes can also be observed. For example, the structure of tax system across this period shows a shift away from lower income distribution to the higher end of the distribution. The reforms have been phasing out the NI kink discontinuity as seen in the UK tax system during the 1980s and 1990s. (see Blundell et al., 1998). From 2008, the standard NI rate and the basic tax rate start at the same income level. And the higher NI rate is also on the same income threshold as the top tax rate.

A key variable in the intensive margin analysis is the marginal tax rate. To calculate the marginal tax rate, I exploited the information on segment limits and tax rates provided by the Institute for Fiscal Studies (IFS) as well as the British Government Website[40] through public access. For the extensive margin analysis, the working tax rates are applied to the estimated total in-work income.

Figure 1 depicts the marginal tax rates and effective tax rates used in my analysis. Note that despite of the common trend going upwards, the shape of these two functions are a bit different:

[39] 15 per cent of the working women in our sample do not pay tax.

[40] https://www.gov.uk/government/publications/rates-and-allowances-income-tax/income-tax-rates-and-allowances-current-and-past, accessed on Nov. 1st 2016.

marginal tax rates are increasing in steps, while the effective tax rates are comparatively smoother.

Due to the fact that the slope of an individual`s budget constraint is not only determined by the statutory income tax schedule, but also by the transfer systems in place. Therefore, it is essential to model income tax system together with the welfare system. In next section, we explain the welfare system in the UK as well as the reforms happened during the period of this study.

3.4.5.2 Welfare system and reforms in the UK

The current welfare system of in-work benefits in the UK is the working Tax Credit (WTC). It was introduced in April 2003 to replace the Working Family Tax Credit (WFTC) operated from April 1999 until March 2003. The WFTC was itself a transitional system from the earlier benefit for working families known as Family Credit (FC), which had been in operation since 1986.

Apart from in-work benefits, the UK welfare system contains other types of benefits as well covering people from all ages and economic activities; however, the focus of our paper is on people`s working behaviour, we therefore, are only interested in in-work benefits and tax credits. These include Income Support (IS), Child Benefit (CB), Child Tax Credit (CTC), Working Tax Credit (WTC) and Universal Credit (UC).

CB is a benefit paid to parents or other people who are responsible for bringing up a child. It is non-means-tested. It has been a fixed amount uprating with inflation per week for each additional child in the family since its introduction in April 1977. From 2010 onwards, the government fixed the CB payment for every three-year period. From 2010 to 2013, the payment was £20.3 for the eldest child, and £13.4 for each subsequent child. And from 2014 to 2017 the payment was £20.7 for the eldest child, and £13.7 for each of the rest.

CTC and WTC are the two types of tax credit. CTC is a payment to support families with children under 16 years old and dependent young persons aged from 16 but under 20 years old. WTC is for working people on a low income. Tax credit rates has been decreasing in time. In 2011, the rate of withdrawal for WTC was increased from 39p to 41p for every pound earned above £6420. This means that households with slightly higher income will no longer be eligible for this support. In the same year, the proportion of childcare costs covered by the childcare element of WTC was reduced from 80% to 70%. In 2012, the number of hours a couple with children have to work to become eligible for WTC was increased from 16 to 24 hours a week. Additionally, couples that earn over £41300 (decreased from £50000) no longer qualify for

CTC.

Income support (IS) is a benefit paid to people on low incomes, it is not available to the unemployed and those in full-time paid work. Claimants should be between 16 and the age at which they can get pension credit. The level of IS payable depends on the family`s needs (the 'applicable amount') and its income. The applicable amount is the sum of basic personal allowances and premiums and housing costs for owner-occupiers (support for renters is provided through housing benefit). Therefore, the level of IS payable is just the applicable amount minus income. In 2014, IS is not payable if the claimant and the claimant`s partner together have more than £16000 of capital. Capital up to £6000 is ignored, between these two thresholds, IS entitlement is reduced by £1 for every £250 of capital exceeding the lower threshold.

UC became law as part of the welfare act 2012. When implemented, the new benefit will amalgamate several existing means-tested benefits: IS, JSA, housing benefit (HB), CTC, WTC etc. it is hoped that bringing these diverse benefits together will remove much of the current complexity in the system. However, UC was only piloted in Manchester and Cheshire area in 2013, hoping to roll out nationally in 2017. Given the period of my data, the proportion of UC claimant are very small.

Our data only reports whether an individual receives welfare benefit or not, and which type of benefit he/she receives, the amount of benefit received is not reported. Therefore, we proceed by calculating benefit amount for different types of households. The rates applied are obtained from UK government website by public access[41].

3.5 Results and Discussions

We present and discuss our results in this section. They are organized in such a manner that intensive margin elasticities are presented in tables six to eight with sensitivity checks in tables nine to twelve; extensive margin elasticities are presented in table fifteen and sixteen with estimated wage equations in table thirteen and fourteen; Finally, the intertemporal estimates are presented in table seventeen.

[41] The rates for the related benefits are obtained from Andrew Hood and Laura Oakley (2014) A survey of the GB Benefit system. For some of years, they are obtain from the UK government website: https://www.gov.uk/government/publications/rates-and-allowances-tax-credits-child-benefit-and-guardians-allowance/tax-credits-child-benefit-and-guardians-allowance. https://www.ifs.org.uk/uploads/publications/ff/childben.xls https://www.ifs.org.uk/ff/taxcredits.xls. https://www.ifs.org.uk/ff/is.xls.

3.5.1 Intensive margin:

The intensive margin elasticities are estimated by equation (2). They measure the within period substitution effect between work and leisure. We find that all Marshallian elasticities are highly statistically significant; The consistently negative signs of the elasticities for men across different groups suggest a backward bending labour supply curve; The elasticities increase in magnitude by educational attainments suggest that male workers with lower educational attainments are more likely to respond than their higher educational counterparts to wage changes. If valued at the mean wage rate, the results show that every 10 percent (roughly one pound) increase in after tax and benefit real wage rate leads to an average of 0.83 hours (50 mins) decrease in weekly hours of work for men with NVQ1-3, 0.61 hours (37 mins) decrease for men with NVQ4 and 0.35 hours (21 mins) decrease with NVQ5. On the contrary, women`s Marshallian elasticities are consistently positive, and the magnitude increases with educational attainments. Every 10 percent (roughly one pound) increase in the after tax and benefit real wage rate increases women`s weekly working hours on average by 0.36 hours (22 mins) at NVQ level 1-3, by 0.37 hours (22.2 mins) at NVQ level 4, and by 0.53 hours (32 mins) at NVQ level 5 respectively.

It is commonly acknowledged that the presence of children affects the labour supply of both parents. Previous evidences explain that the presence of children (especially young children) pushes the father to work harder (Blundell & Walker, 1986; Meghir & Phillips, 2010), and the mother to spare more time for home production and childcare (Blundell, et al., 1998; Blundell, et al., 2000). However, our results point to a different picture, where both parents reduce their hours at similar magnitude when there are small children (less than two years old) present in the family. A major reason for this could be the new rules for paternity leave introduced in April 2003, where male employees received paid statutory paternity leave for the first time. This new rule encourages fathers to have more “family time” when children arrive. However, it does not explain the consistency in the signs of male elasticities across all groups. Such consistency together with the fall in female elasticities as documented by Blau and Kahn (2006) reflects the changing dynamics of the labour supply decisions within a family: women takes some of the work pressure off men. The fall in female elasticities is also evidenced in our results, since they are generally smaller than the ones estimated in previous studies. The wage elasticity for women with children aged 0-2 remains to be lowest among all groups for reasons that pre-kindergarten children demand much more time for childcare than children older. However, mothers start to recover their hours after the children hit the age of two.

Given the construction of our nonlabour income by the spouse weekly income, the income elasticities estimated in our analysis measure the wealth effect of spouse income on the other spouse` labour supply. While the effects are statistically insignificant for men in most groups, they are strongly significant for women. This suggests that wives` income does not explain much of the variations in husbands` labour supply, whereas the husbands` income does explain much of the variations in wives` labour supply. The income effects for men are positive implies assortative mating: the higher the wives` income, the more the husband works. The income effects for women are negative, and the size of the effects increase with educational attainments, implying that wives` labour supply does depend on their husbands` income, the higher the education of the husband, hence the income, the larger the effect is. As far as the children are concerned, the income effects are the largest when small children present, the size of the effects decrease as children age, but the effects return when children age ten and above.

We further present results across three education groups by age of children present in the family to cross check the effects in table seven and eight. The Marshallian substitution effects in table seven are consistent with the patterns in table six. However, there are also some other interesting findings: Amongst families without children, the substitution effect for men with NVQ5 are not significantly different from zero, this means that the substitution effects are only with the lowly educated men. Amongst families with children aged 0-2, men with NVQ4 are the group who are most responsive to a change in wage (every one percent wage change for 12.3 mins) compared the other two groups NVQ1-3 (3.72 mins) and NVQ5 (5.94 mins). This may suggest that male teachers, nurses and other similar professions are the ones who are most likely to use the new rules for paternity leaves, or to cut back hours for childcare. However, amongst women with children aged 0-2, women with degree and above are the ones least likely to reduce hours. In terms of the income effects, they are mostly significant only amongst women at degree levels. When small children present, the income effects are only observed amongst NVQ4 and NVQ5.

From table nine to twelve, we present the sensitivity analysis for our results. They include parameter estimates from five different specifications of the model with/without interactions with demographic controls. All specifications include a full set of time dummies and group dummies. Indicatively we present a set of cohort education and time effects in the Appendix (table eighteen to twenty-three). The elasticities can be easily calculated from the parameter estimates by using group mean hours, wage and non-labour income. The parameter estimates are presented in three groups: the intercept estimates, wage effects and income effects.

From model I to IV, we have corrections for the endogeneity of wage, nonlabour income, participation and selection at tax kink. The parameter estimates between model I and III are very similar for men, but not for women. This is expected, since from model I, we know that participation bias only exists in women. And the estimates for model II and IV are very similar for men as well, for women the estimates have dropped noticeably, which implies that bias caused by participation and selection at tax kink both exist amongst women. In model V, we have dropped all the correction terms, therefore it is OLS. The parameter estimates are quite different from the previous four models, the estimated parameters are larger for men, and smaller for women when compared with results from other models. This indicates the importance of controlling for the endogeneity in wage and nonlabour income.

As far as the tax kinks are concerned, we follow Blundell et al., (1998) by only considering the first tax kink, because distinction between non tax payer and tax payer are more significant than other higher tax kinks (Saez 2010). Though we did apply some treatments on the higher tax kinks by excluding the individuals around the higher kinks with a caliper of 50 pounds in income.

3.5.2 Extensive margin

Concerning participation, the most prominent problem is the lack of wage for non-participants. We therefore, firstly estimated the wage equations for men and women separately on equation (10) and (11). Where equation ten is the basic wage equation, and equation eleven is the wage equation after controlling for selection. Results for wage equation are presented in table eleven and twelve. We have omitted the estimates for dummies such as year, region and ethnicity, but the full results can be found in the Appendix.

For both men and women, education matters in the participation decision as well as in the wage determination process. However, it is much more important for women in these aspects. Further into the results, we find that compared with women at NVQ level 1-3, women who have NVQ4 qualifications earn 31.3 percent more, and women who have NVQ5 qualifications earn 57.3 percent more. Moreover, compared to families with no children, men and women in families with dependent children are less likely to work, again the effects on women are much larger. And the wage growth for men and women are different as well; age increase by one year, wage increase by 5.9 percent to 7.2 percent for men, and only by 3.1 percent to 3.5 percent for women. Considering the fact that the average wage of men is larger than that of women, the growth difference in monetary terms can be even greater.

In table thirteen and fourteen, we present the marginal effects of increasing in the two estimated earning measures on the probability of participation by education and by family types. Each estimate represents the increase in the probability of work as a result of a percentage increase in the earnings. The results are sensible. First, earnings incentives matter most for lower educated individuals. The participation probability of highly educated individuals responds less to both earnings measures. The elasticities are larger for women than for men, indicating that welfare benefits have larger effects on the participation decision of women than for men, especially women with lower education levels.

3.5.3 Intertemporal results

In interpreting the effect of changes in wages on labour supply, it is important to separate the parametric change of the sort usually contemplated in comparative static exercises from evolutionary changes due to movement along a lifecycle wage path. A parametric wage change refers to shifts in a lifecycle wage profile, while an evolutionary wage change refers to movements along a given profile. It is apparent from the labour supply function given by equation (17) that the value of parameter α_I determines the hours of work response to evolutionary wage changes, the intertemporal substitution effect, i.e. Frisch elasticity. The theoretical prediction for its sign is positive, since lifecycle hours profile synchronizes with evolutionary wage profile.

The results for Frisch elasticities are presented on the left panel of table seventeen, where we control for all age invariant characteristics determining lifetime wages, preferences and initial permanent income, or we can simply call this the height of the age-wage profile, using age squared to capture the shape of the lifecycle wage path, then the coefficient we get measures the labour supply responses to anticipated changes in wage at any given age. Women have larger Frisch elasticities than men do, this is consistent with previous evidence (Blundell, Meghir & Neves, 1993). It implies that women respond to intertemporal consumption-wage substitutions more than men do. This can be explained by the fact that the labour supply of women, especially in the context of a family, are susceptible to family production and childcare.

$\alpha_I + \overline{\gamma_o}$ in equation (17) measures the labour supply response to parametric wage changes, correspond to the usual concepts of uncompensated substitution effects. Because $\overline{\gamma_o}$ measures the wealth effect, it is unambiguously negative, therefore there is no sign prediction for the uncompensated substitution effects. The results are estimated by controlling for age and age squared, i.e., the width of the age-wage profile, then use individual characteristics which

determines lifecycle income, as instruments for wage. Therefore, the coefficients estimated is the response of labour supply to a parametric wage shift, including both the intertemporal substitution effect and the reallocation of wealth across periods. Estimates for full lifecycle elasticity i.e., the uncompensated substitution effects are presented on the right panel of table seventeen. The sizes of the elasticity estimates are still reasonably within the range of estimates of previous evidence listed in table one, though they are much bigger than our estimates in the static labour supply analysis. We attribute the reason to highly aggregate nature of the estimation method in the lifecycle analysis. However, the patterns do coincide with our finding previously. In addition to this, the difference between the full lifecycle elasticity and Frisch elasticity offers us the estimates for wealth effects. They suggest that amongst men, wealth effects are the highest for lowly educated men, while amongst women, the wealth effects are similar across education levels.

3.6 Conclusion

This paper offers renewed evidence for married couples` labour supply responsiveness in the UK using QLFS data 2002-2016. In our analysis, the variations induced by fundamental reforms to the UK tax and benefit systems during our data period are used to elicit the labour supply effects to wage and non-labour income changes. We also include an intertemporal component in our analysis to reflect the lifecycle dynamic perspective of labour supply decisions. The benefit for such an approach is that the estimates is not specifically tied to one particular reform, but an average of all the reforms happened therein.

With such an approach, we show that the estimated Marshallian elasticities for men are negative across all groups, suggesting that despite the fact that men on average are working harder than women, in recent decades they are somehow on a backward bending labour supply curve where they substitute away labour supply for wage gains. This is also confirmed by the descriptive trends. Furthermore, the magnitude of the effect is larger amongst men within families where small children are present shows the effects of family friendly policies that were introduced in recent decade on men`s labour supply decisions., such as paternity leave. On the contrary, the labour supply responses for women are positive and the effects decreases as education level increases. The positivity of the effects confirms previous evidence of increasing participation amongst women in recent decades (Blau and Kahn, 2006); The effect decrease in education may be somewhat an indicator for preference. Concerning participation, our findings indicate

that welfare benefits have larger effects on the participation decision of women than for men, especially women in lower education levels.

And the lifecycle analysis shows that the intertemporal substitution effects are way smaller amongst men across education and family types in terms of the presence of children. This implies either that credit market constraint is very important for men, they just do not smooth their consumption, or that men discount their future heavily. But for women the effects are very large across education and family types.

Our results are robust to checks across different specifications. However, for future research more work is required to investigate the inter-dependence of the labour supply decisions within a family. The use of desired hours in addition to observed hours may be another improvement since the demand-side constraints may affect the results.

Tables:

Table 3.1: Labour Supply Elasticities literature in UK

Study	Data/Sample	Model	Wage elasticity		Income elasticity
			Intensive	Extensive	
Married women					
Arellano & Meghir (1992)	FES & LFS (1983), Age 20-59	Semi-log labour supply with fixed costs	0.29-0.71		(-0.13) to (-0.4)
Blundell, Duncan & Meghir (1998)	FES 1978-1992, Age 20-50	Semi-log linear labour supply, grouping estimator	0.13-0.37		(-0.06) to (-0.19)
Blundell, Duncan, McCrae & Meghir (2000)	FRS 1994-1996	Discrete choice on hours and particpation	0.11-0.17		
Arrufat & Zabalza (1986)	GHS 1974, Age <60 or 65	CES utility function convex budget constraint		1.41	
Blundell, Ham & Meghir (1987)	FES 1981, 2011, Age 16-60	Tobit labour supply model		0.04-0.08	
Lone Mother					
Blundell, Duncan & Meghir (1992)	FES 1981-1986	Marginal rate of substitution function	0.16-0.34		
Brewer, Duncan, Shephard & Suarez (2005)	FRS 1995-2002, age<60	Discrete choice over 5 positive hours		1.02	
Ermisch & Wright (1991)	GHS 1973-1982	Discrete choice of work and not work		1.2-1.8	
Jenkins (1992)	LPS 1989	Discrete choice over two positive hours points		1.44-1.8	
Walker (1990)	FES 1979-1984	Discrete choice of work and not work		0.7	
Married men					
Blundell & Walker (1986)	FES 1980, Age 19-59	Gorman polar form and translog hours	0.024		(-0.287)
Meghir & Phillips (2010)	FRS 1994-2004, Age 22-59	Discrete choice of work and not work		(-0.006) to 0.364	
Intertemporal studies			***Frisch e.***		
Blundell, Meghir & Neves (1993)	FES 1970-1984, married women	Flexible specification of preferences	0.58-1.22		
Blundell, Costas Dias, Meghir & Shaw (2016)	BHPS 1991-2008 and simulation, married women/lone mother	Dynamic model of employment and human capital	0.43-0.91 2.24		

Note: FES stands for Family Expenditure Survey. LFS stands for Labour Force Survey. FRS stands for Family Resources Survey. BHPS stands for British Household Panel Survey. GHS stands for General Household Survey. LPS stands for Lone Parents Survey.

Table 3.2: Tax Reforms (2002-2016)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Starting r.	10	10	10	10	10	10	-	-	-	-	-	-	-	-	-
Basic r.	22	22	22	22	22	22	20	20	20	20	20	20	20	20	20
Top r.	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Additional r.	-	-	-	-	-	-	-	-	50	50	50	45	45	45	45
Allow. (%Δ)	0.02	-0.01	0.03	0.03	0.02	0.03	0.16	0.12	-0.05	0.15	0.11	0.17	0.07	0.07	0.07
NI (PT-UEL)	10	11	11	11	11	11	11	11	11	12	12	12	12	12	12
NI (>UEL)	-	1	1	1	1	1	1	1	1	2	2	2	2	2	2

Note: "r." denotes rate. "Allow. (%Δ)" denotes the real percentage change in the tax allowance. The starting rate, the basic rate, top rate as well as additional rate, NI (National Insurance) are all in percentage terms. "-" denotes N.A.

Table 3.3: Working Tax Credit and Income Support Reforms -- Married couples with Partner working full-time

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Income Support															
Maximum award	84.7	85.8	87.3	88.2	90.1	92.8	95	101	102.8	106	111.5	112.6	113.7	114.9	114.9
Withdrawal rate	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Working Tax Credits															
Basic credit	74.2	70.1	72.2	74.3	76.6	79.2	82.7	86.9	88.3	89.2	89.5	89.9	90.9	91.6	91.7
Maximum amount (1 Child)	135	135	135	175	175	175	175	175	175	175	175	175	175	175	175
Maximum amount (2 or more)	200	200	200	300	300	300	300	300	300	300	300	300	300	300	300
Child Tax Credit															
1st Income threshold	94.5	97.3	100.4	100.4	100.4	123.5	123.5	123.5	123.5	123.5	123.5	123.5	123.5	123.5	123.5
1st Income threshold (CTC only)	/	254.4	259.2	267.5	272.2	278.8	299.5	308.5	311.3	305	305	306	307.9	309.7	309.7
2nd Income threshold	/	961.5	961.5	961.5	961.5	961.5	961.5	961.5	961.5	769.2	/	/	/	/	/
Family element	/	10.4	10.5	10.5	10.5	10.4	10.5	10.5	10.5	10.4	10.5	10.5	10.5	10.4	10.5
Family element (under 12 months)	/	10.4	10.5	10.5	10.5	10.4	10.5	10.5	10.5	/	/	/	/	/	/
Child element	27.2	27.8	31.2	32.5	33.9	35.4	40.1	42.9	44.2	48.9	51.6	52.2	52.8	53.2	53.4
1st Withdrawal rate	55%	37%	37%	37%	37%	37%	39%	39%	39%	41%	41%	41%	41%	41%	41%
2nd Withdrawal rate	/	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	41%	/	/	/	/	/
Child Benefit															
Eldest/only Child	15.75	16.05	16.5	17	17.45	18.1	18.8	20	20.3	20.3	20.3	20.3	20.5	20.7	20.7
Other children	10.55	10.75	11.05	11.4	11.7	12.1	12.55	13.2	13.4	13.4	13.4	13.4	13.55	13.7	13.7

Notes: Tax and benefit systems as in April each year. Figures for mothers in couples assume partner works full-time. Work requirement is 30 hours per week for 1 adult (rows 3 and 4). Monetary amounts expressed in £ and in weekly terms.

Table 3.4: Descriptive Statistics for the Sample of Workers (Men)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012	2013	2014	2015	2016
Hours	44.540	44.258	44.258	43.719	43.491	43.635	42.428	42.889	43.178	42.812	43.328	42.974	42.745	42.770
Wage	13.082	13.257	13.715	14.093	14.605	14.994	15.306	15.843	16.062	16.560	17.287	16.946	17.162	17.396
Spouse income	277.61	281.73	296.16	310.64	328.09	342.0	358.613	382.493	385.024	398.930	424.021	407.468	409.884	425.022
Age	42.929	43.032	43.570	43.438	43.383	43.591	43.110	42.810	43.777	43.642	44.204	44.042	43.808	42.129
NVQ5	25.22%	25.92%	26.65%	26.49%	27.57%	28.58%	29.32%	29.82%	33.34%	35.35%	37.09%	36.79%	36.39%	36.14%
NVQ4	11.65%	12.36%	12.62%	12.55%	12.49%	12.43%	11.65%	11.66%	12.13%	12.77%	11.85%	11.13%	11.30%	10.59%
NVQ1-3	63.13%	61.72%	60.73%	60.97%	59.93%	58.99%	59.03%	58.51%	54.53%	51.88%	51.07%	52.08%	52.30%	53.27%
Child 0-2	0.083	0.082	0.088	0.092	0.100	0.094	0.101	0.110	0.115	0.115	0.107	0.112	0.128	0.121
Child 3-4	0.140	0.133	0.125	0.131	0.131	0.134	0.135	0.134	0.163	0.172	0.159	0.170	0.186	0.160
Child 5-9	0.234	0.233	0.235	0.227	0.208	0.225	0.210	0.202	0.217	0.233	0.220	0.240	0.267	0.257
Child 10+	0.297	0.288	0.296	0.288	0.288	0.282	0.265	0.250	0.254	0.249	0.241	0.242	0.277	0.273
Obs.	10867	8493	5538	6807	5531	7664	7926	6166	5905	5912	5242	5528	6405	6535

Note: Wages and income are in 2016 prices.

Table 3.5: Descriptive Statistics for the Sample of Workers (Women)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012	2013	2014	2015	2016
Hours	34.063	33.804	33.349	33.320	33.692	33.674	33.177	33.681	32.956	33.009	33.584	33.147	32.874	33.306
Wage	11.110	11.213	11.465	11.677	12.090	12.348	12.627	13.125	13.457	13.746	14.076	14.006	14.322	14.562
Spouse income	525.20	541.74	555.431	578.961	595.287	609.146	626.092	638.139	648.338	679.276	695.849	657.533	651.836	674.581
Age	41.139	41.356	41.672	41.922	42.051	42.165	41.939	41.551	42.637	42.508	43.130	42.957	42.878	42.650
NVQ5	26.30%	28.03%	29.29%	28.82%	30.36%	32.08%	32.29%	33.61%	38.50%	40.67%	42.53%	42.95%	43.69%	44.31%
NVQ4	19.34%	18.52%	17.98%	16.95%	16.43%	15.94%	16.11%	14.35%	14.73%	13.19%	13.23%	13.04%	12.82%	11.39%
NVQ1-3	54.36%	53.45%	52.73%	54.23%	53.20%	51.99%	51.60%	52.04%	46.76%	46.14%	44.24%	44.01%	43.49%	44.30%
Child 0-2	0.092	0.083	0.091	0.090	0.093	0.094	0.092	0.104	0.105	0.108	0.099	0.097	0.106	0.102
Child 3-4	0.139	0.130	0.127	0.127	0.127	0.129	0.126	0.134	0.159	0.165	0.151	0.155	0.164	0.152
Child 5-10	0.211	0.216	0.216	0.209	0.189	0.207	0.197	0.190	0.204	0.217	0.208	0.222	0.255	0.256
Child 11-	0.260	0.258	0.270	0.268	0.267	0.263	0.251	0.241	0.242	0.238	0.229	0.247	0.286	0.281
Obs.	8180	6462	4489	5735	4795	6896	7287	5813	5654	5739	5208	5706	6834	6746

Note: Wages and income are in 2016 prices.

Table 3.6: Results on Static Labour Supply Elasticities (Instruments: Grouping by Cohort and Education)

	Marshallian Elasticity				Income Elasticity				Means					
									Hours		Wage		Income	
	M		F		M		F		M	F	M	F	M	F
Overall	-0.051	***	0.048	***	0.018		-0.133	***	43.832	33.447	11.836	9.717	389.006	670.121
	(0.724)		(0.789)		(0.003)		(0.003)							
NVQ1-3	-0.083	***	0.036	***	0.039	***	-0.062	***	43.206	29.837	9.684	8.818	300.920	564.659
	(0.236)		(0.636)		(0.001)		(0.002)							
NVQ4	-0.061	***	0.037	***	0.022		-0.220	***	42.945	32.165	11.122	9.990	349.117	584.204
	(0.968)		(0.829)		(0.004)		(0.003)							
NVQ5	-0.035	***	0.053	***	0.013		-0.286	***	43.916	35.659	13.227	11.911	455.717	736.473
	(0.614)		(0.791)		(0.001)		(0.004)							
No children	-0.056	***	0.066	***	0.053		-0.038	*	42.862	36.465	10.658	9.583	391.227	605.589
	(0.267)		(0.255)		(0.004)		(0.002)							
Children 0-2	-0.088	***	-0.081	***	0.020		-0.367	***	43.072	29.209	10.182	9.663	347.448	605.721
	(0.540)		(0.446)		(0.002)		(0.005)							
Children 3-4	-0.090	***	0.076	***	0.005		-0.194	***	43.080	26.563	10.121	9.679	319.303	602.945
	(0.505)		(0.457)		(0.002)		(0.004)							
Children 5-9	-0.053	***	0.092	***	0.011		-0.105	***	43.401	28.924	11.178	10.459	315.020	648.823
	(0.242)		(0.325)		(0.002)		(0.003)							
Children 10+	-0.072	***	0.092	***	0.056	***	-0.366	***	43.775	30.964	11.232	9.896	311.947	656.947
	(0.328)		(0.321)		(0.002)		(0.004)							

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from equation 2. The reported effects are calculated elasticities instead of the parameter estimates which can be recovered through the mean values.

Table 3.7: Results on Static Labour Supply Elasticities (Instruments: Grouping by Cohort and Education)

Mashallian E.	NVQ1-3		NVQ4		NVQ5	
	M	F	M	F	M	F
No children	-0.079 ***	0.055 ***	-0.078 ***	0.058 ***	-0.011	0.066 ***
	(0.355)	(0.255)	(0.872)	(0.644)	(0.461)	(0.557)
Children aged 0-2	-0.062 ***	-0.118 ***	-0.205 ***	-0.166 ***	-0.099 ***	-0.038 *
	(0.658)	(0.608)	(2.882)	(1.755)	(1.071)	(0.696)
Children aged 2-4	-0.097 ***	0.068 ***	-0.073	0.122	-0.041 *	0.113 ***
	(0.672)	(0.541)	(1.999)	(2.143)	(0.960)	(0.916)
Children aged 4-9	-0.065 ***	0.090 ***	-0.032 *	0.031	-0.031 ***	0.143 ***
	(0.470)	(0.385)	(0.784)	(1.161)	(0.406)	(0.663)
Children aged 10+	-0.088 ***	0.053 ***	-0.046 **	0.152 ***	-0.043 ***	0.186 ***
	(0.444)	(0.374)	(0.801)	(0.915)	(0.697)	(0.777)

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from equation 2. The reported effects are calculated elasticities instead of the parameter estimates which can be recovered through the mean values.

Table 3.8: Income Elasticities (Instruments: Grouping by Cohort and Education)

Income Elasticities	NVQ1-3		NVQ4		NVQ5	
	M	F	M	F	M	F
No children	-0.0004	0.004	0.125	0.003	0.025	-0.097 **
	(0.009)	(0.003)	(0.008)	(0.007)	(0.005)	(0.004)
Children aged 0-2	-0.0034	-0.054	-0.040	-0.555 ***	-0.063	-0.255 ***
	(0.004)	(0.013)	(0.008)	(0.020)	(0.004)	(0.008)
Children aged 2-4	0.0257	-0.055	-0.030	-0.263 *	-0.154 ***	-0.181 **
	(0.003)	(0.008)	(0.007)	(0.015)	(0.004)	(0.007)
Children aged 4-9	0.0439	0.044	-0.095	-0.110	-0.092 *	0.059
	(0.003)	(0.006)	(0.006)	(0.013)	(0.004)	(0.008)
Children aged 10+	0.0442 *	-0.056	0.033	-0.063	0.080	-0.339 ***
	(0.003)	(0.006)	(0.005)	(0.015)	(0.004)	(0.010)

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from equation 2. The reported effects are calculated elasticities instead of the parameter estimates which can be recovered through the mean values.

Table 3.9: Sensitivity Analysis for Male Estimates: (with interactions)

	I		II		III		IV		V	
Constant	52.579	***	49.210	***	52.439	***	49.146	***	52.167	***
	(0.829)		(0.519)		(0.820)		(0.499)		(0.280)	
Child0-2	0.350		0.516		0.353		0.526		0.569	
	(0.758)		(0.758)		(0.757)		(0.756)		(0.756)	
Child3-4	-1.310	**	-1.190	*	-1.169	*	-1.047	*	-1.171	*
	(0.612)		(0.611)		(0.610)		(0.610)		(0.607)	
Child5-9	-0.200		-0.010		-0.178		0.011		-0.132	
	(0.478)		(0.477)		(0.478)		(0.477)		(0.466)	
Child10+	0.223		0.526		0.241		0.529		0.118	
	(0.379)		(0.374)		(0.378)		(0.374)		(0.359)	
Wage Effects										
Child0-2	-0.435		-0.465		-0.436		-0.468		-0.534	
	(0.350)		(0.350)		(0.350)		(0.349)		(0.350)	
Child3-4	0.596	**	0.572	**	0.536	*	0.511	*	0.445	
	(0.281)		(0.281)		(0.280)		(0.280)		(0.280)	
Child5-9	0.454	**	0.433	**	0.449	**	0.428	**	0.323	
	(0.211)		(0.211)		(0.210)		(0.210)		(0.210)	
Child10+	0.510	***	0.505	***	0.505	***	0.500	***	0.500	***
	(0.163)		(0.163)		(0.163)		(0.163)		(0.163)	
Nonlabour Income										
Child0-2	0.001		0.001	*	0.001	*	0.001	*	0.001	*
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
Child3-4	-0.001		-0.001		-0.001		-0.001		-0.001	
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Child5-9	-0.002	***	-0.002	***	-0.002	***	-0.002	***	-0.002	***
	(0.0003)		(0.0003)		(0.0003)		(0.0003)		(0.0003)	
Child10+	-0.002	***	-0.002	***	-0.002	***	-0.002	***	-0.002	***
	(0.0003)		(0.0003)		(0.0003)		(0.0003)		(0.0003)	
Residuals										
Wage	-0.092	***	-0.096	***	-0.091	***	-0.094	***		
	(0.014)		(0.014)		(0.014)		(0.014)			
Nonlabour income	-0.005	***	-0.005	***	-0.005	***	-0.005	***		
	(0.001)		(0.001)		(0.001)		(0.001)			
Participation	-0.680		-1.994							
	(3.474)		(3.466)							
Tax & NI kink	2.493	***			2.396	***				
	(0.479)				(0.474)					

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from equation 2. The reported effects are parameter estimates and the implied elasticities are calculated through the means.

Table 3.10: Sensitivity Analysis for Female Estimates: (with interactions)

	I		II		III		IV		V	
Constant	47.208	***	42.603	***	47.567	***	42.676	***	39.228	***
	(0.750)		(0.739)		(0.724)		(0.711)		(0.345)	
Child0-2	1.509	**	0.479		1.284	*	0.254		-0.772	
	(0.738)		(0.741)		(0.729)		(0.732)		(0.733)	
Child3-4	-7.870	***	-10.295	***	-8.002	***	-10.405	***	-10.495	***
	(0.694)		(0.693)		(0.684)		(0.683)		(0.684)	
Child5-9	-9.619	***	-12.636	***	-9.808	***	-12.832	***	-13.281	***
	(0.528)		(0.522)		(0.522)		(0.515)		(0.515)	
Child10+	-3.252	***	-6.211	***	-3.471	***	-6.442	***	-7.290	***
	(0.429)		(0.420)		(0.424)		(0.415)		(0.413)	
Wage Effects										
Child0-2	-3.478	***	-3.466	***	-3.400	***	-3.393	***	-2.972	***
	(0.343)		(0.345)		(0.339)		(0.341)		(0.341)	
Child3-4	0.337		0.365		0.387		0.404		0.483	
	(0.325)		(0.327)		(0.321)		(0.323)		(0.324)	
Child5-9	1.537	***	1.434	***	1.631	***	1.517	***	1.611	***
	(0.244)		(0.245)		(0.241)		(0.242)		(0.242)	
Child10+	0.630	***	0.568	***	0.750	***	0.681	***	0.793	***
	(0.203)		(0.204)		(0.200)		(0.201)		(0.202)	
Nonlabour Income										
Child0-2	0.002	***	0.002	***	0.002	***	0.002	***	0.002	***
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Child3-4	-0.001		-0.001	*	-0.001		-0.001	*	-0.001	**
	(0.0004)		(0.0004)		(0.0004)		(0.0004)		(0.0004)	
Child5-9	-0.001	***	-0.0005	***	-0.001	***	-0.0005	***	-0.001	***
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Child10+	-0.002	***	-0.002	***	-0.002	***	-0.002	***	-0.002	***
	(0.0002)		(0.0002)		(0.0002)		(0.0002)		(0.0002)	
Residuals										
Wage	-0.293	***	-0.268	***	-0.289	***	-0.266	***		
	(0.013)		(0.013)		(0.013)		(0.013)			
Nonlabour income	0.021	***	0.020	***	0.020	***	0.019	***		
	(0.001)		(0.001)		(0.001)		(0.001)			
Participation	13.437	***	4.890							
	(4.373)		(4.387)							
Tax & NI kink	8.149	***			8.152	***				
	(0.260)				(0.256)					

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from equation 2. The reported effects are parameter estimates, the implied elasticities are calculated through the means.

Table 3.11: Sensitivity Analysis for Male estimates: (without interactions)

	I		II		III		VI		V	
Constant	52.468	***	49.166	***	52.343	***	49.113	***	52.151	***
	(0.812)		(0.494)		(0.803)		(0.475)		(0.228)	
Child0-2	-0.295	*	-0.205		-0.295	*	-0.205		-0.328	**
	(0.152)		(0.151)		(0.151)		(0.150)		(0.146)	
Child3-4	-0.274	*	-0.216		-0.257	*	-0.199		-0.481	***
	(0.141)		(0.141)		(0.141)		(0.141)		(0.122)	
Child5-9	0.100		0.240	*	0.109		0.246	*	0.125	
	(0.138)		(0.135)		(0.138)		(0.135)		(0.099)	
Child10+	0.613	***	0.903	***	0.621	***	0.894	***	0.489	***
	(0.141)		(0.129)		(0.139)		(0.128)		(0.077)	
Log Wage	-2.723	***	-2.678	***	-2.74	***	-2.694	***	-3.561	***
	(0.147)		(0.147)		(0.147)		(0.147)		(0.076)	
Implied elasticity	-0.062		-0.061		-0.063		-0.062		-0.081	
Nonlabour Income	0.006	***	0.006	***	0.006	***	0.006	***	0.0007	***
	(0.001)		(0.001)		(0.001)		(0.001)		(0.0001)	
Implied income effect	0.060		0.060		0.060		0.060		0.007	
Residuals:										
Wage	-0.091	***	-0.095	***	-0.09	***	-0.093	***		
	(0.014)		(0.014)		(0.014)		(0.014)			
Nonlabour income	-0.005	***	-0.005	***	-0.005	***	-0.005	***		
	(0.001)		(0.001)		(0.001)		(0.001)			
Participation	-0.768		-2.085							
	(3.473)		(3.464)							
Tax kink	2.455	***			2.363	***				
	(0.479)				(0.474)					

Note: Asymptotic standard errors in brackets. These results are from equation 2, the reported effects are Parameter estimates, the implied elasticities are calculated through the means.

Table 3.12: Sensitivity Analysis for Female Estimates: (without interactions)

	I		II		III		VI		V	
Constant	47.105	***	42.583	***	47.329	***	42.535	***	38.843	***
	(0.720)		(0.709)		(0.695)		(0.681)		(0.268)	
Child0-2	-4.661	***	-5.68	***	-4.709	***	-5.741	***	-5.973	***
	(0.188)		(0.187)		(0.185)		(0.183)		(0.182)	
Child3-4	-7.499	***	-9.908	***	-7.528	***	-9.938	***	-9.996	***
	(0.173)		(0.156)		(0.170)		(0.153)		(0.151)	
Child5-9	-6.725	***	-9.907	***	-6.727	***	-9.940	***	-10.209	***
	(0.164)		(0.129)		(0.162)		(0.126)		(0.122)	
Child10+	-3.044	***	-6.118	***	-3.015	***	-6.115	***	-6.760	***
	(0.146)		(0.108)		(0.144)		(0.106)		(0.096)	
Log Wage	1.961	***	1.645	***	1.901	***	1.603	***	-0.870	***
	(0.156)		(0.157)		(0.153)		(0.153)		(0.093)	
Implied elasticity	0.060		0.050		0.060		0.050		-0.030	
Nonlabour Income	-0.021	***	-0.02	***	-0.021	***	-0.020	***	-0.001	***
	(0.001)		(0.001)		(0.001)		(0.001)		(0.0001)	
Implied income effect	-0.182		-0.174		-0.182		-0.174		-0.009	
Residuals:										
Wage	-0.286	***	-0.262	***	-0.282	***	-0.260	***		
	(0.013)		(0.013)		(0.013)		(0.013)			
Nonlabour income	0.02	***	0.02	***	0.020	***	0.019	***		
	(0.001)		(0.001)		(0.001)		(0.001)			
Participation	13.301	***	4.753							
	(4.378)		(4.391)							
Tax kink	8.115	***			8.113	***				
	(0.261)				(0.256)					

Note: Asymptotic standard errors in brackets. These results are from equation 2, the reported effects are Parameter estimates, the implied elasticities are calculated through the means.

Table3.13: Wage Equation by Heckman MLE: (Instruments: Age and No. of Children)

	Men				Women			
Variable	Probit		Wage		Probit		Wage	
Constant	0.659	***	0.809	***	-0.736	***	1.394	***
	(0.108)		(0.036)		(0.090)		(0.028)	
age	0.044	***	0.073	***	0.098	***	0.034	***
	(0.005)		(0.002)		(0.004)		(0.002)	
age2	-0.0007	***	-0.0008	***	-0.001	***	-0.0004	***
	(0.00006)		(0.00002)		(0.00005)		(0.00002)	
Education								
NVQ4	0.083	***	0.257	***	0.181	***	0.315	***
	(0.013)		(0.005)		(0.011)		(0.004)	
NVQ5	0.039	***	0.493	***	0.183	***	0.570	***
	(0.009)		(0.003)		(0.008)		(0.003)	
Children								
aged 0-2	-0.309	***			-0.395	***		
	(0.021)				(0.004)			
aged 3-4	-0.349	***			-0.406	***		
	(0.019)				(0.017)			
aged 5-9	-0.318	***			-0.273	***		
	(0.018)				(0.016)			
aged 10+	-0.271	***			-0.072	***		
	(0.017)				(0.015)			
No. dep child	-0.082	***			-0.281	***		
	(0.007)				(0.006)			
Year	√		√		√		√	
Region	√		√		√		√	
Ethnicity	√		√		√		√	
rho	0.082				-0.097			
sigma	0.464				0.457			
lambda	0.038				-0.044			
	(0.008)				(0.009)			
Obs.	133816				155044			

LR test (rho=0): chi2(1) =19.95 Prob >chi2 =0.0000
LR test (rho=0): chi2(1) =28.42 Prob >chi2 =0.0000
These results are from equation 9, the reported effects are Parameter estimates, the controls such as year, region and ethnicity are omitted due to lack of room here, details can be found in appendix.

Table 3.14: Wage Equation by Heckman MLE: (Instruments: Age, Number of Children & Z)

	Men				Women			
Variable	Probit		Earning		Probit		Earning	
Constant	0.504	***	0.883	***	-0.516	***	1.238	***
	(0.121)		(0.035)		(0.096)		(0.030)	
age	0.027	***	0.059	***	0.089	***	0.031	***
	(0.005)		(0.002)		(0.005)		(0.001)	
age2	-0.0004	***	-0.001	***	-0.001	***	-0.0003	***
	(0.0001)		(0.00002)		(0.0001)		(0.00002)	
Education								
NVQ4	0.039	***	0.188	***	0.165	***	0.236	***
	(0.014)		(0.005)		(0.012)		(0.004)	
NVQ5	-0.024	***	0.356	***	0.162	***	0.397	***
	(0.010)		(0.003)		(0.009)		(0.003)	
Children								
aged 0-2	-0.144	***			-0.419	***		
	(0.020)				(0.020)			
aged 3-4	-0.189	***			-0.438	***		
	(0.018)				(0.018)			
aged 5-9	-0.193	***			-0.294	***		
	(0.018)				(0.017)			
aged 10+	-0.166	***			-0.093	***		
	(0.016)				(0.016)			
No. dep child	-0.049	***			-0.273	***		
	(0.007)				(0.007)			
Instrument Z	0.0006	***			0.0001	***		
	(0.00002)				(0.00001)			
Year	√		√		√		√	
Region	√		√		√		√	
Ethnicity	√		√		√		√	
rho	-0.705				0.071			
sigma	0.433				0.381			
lambda	-0.305				0.027			
	(0.004)				(0.003)			
Obs.	133693				153843			

LR test (rho=0): chi2(1) =866.87 Prob >chi2 =0.0000

LR test (rho=0): chi2(1) =7.95 Prob >chi2 =0.0048

These results are from equation 9, the reported effects are Parameter estimates, the controls such as year, region and ethnicity are omitted due to lack of room here, details can be found in appendix.

Table 3.15: Participation Elasticities

	MLE Estimated Income				TS Estimated Income			
	Men		Women		Men		Women	
Overall	0.091	***	0.523	***	0.121	***	0.539	***
	(0.004)		(0.106)		(0.045)		(0.087)	
NVQ1-3	0.159	***	0.462	***	0.172	***	0.468	***
	(0.003)		(0.090)		(0.029)		(0.061)	
NVQ4	0.082		0.600	***	0.041		0.608	***
	(0.006)		(0.223)		(0.073)		(0.147)	
NVQ5	0.067	***	-0.149	***	0.100	**	-0.156	***
	(0.003)		(0.006)		(0.043)		(0.017)	
No Children	0.210	***	1.753	***	0.235	***	1.749	***
	(0.004)		(0.415)		(0.040)		(0.298)	
Children0-2	0.261	***	0.010	***	0.284	***	0.004	
	(0.006)		(0.011)		(0.072)		(0.025)	
Children3-4	0.214	***	1.843	***	0.234	***	1.801	***
	(0.005)		(0.216)		(0.059)		(0.267)	
Children5-9	0.036		1.250	***	0.074		1.232	***
	(0.004)		(0.202)		(0.047)		(0.265)	
Children10+	0.073		0.015		0.098	**	0.012	
	(0.004)		(0.238)		(0.046)		(0.017)	

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively
These results are from the estimation of equation 11. The reported effects are elasticities instead of parameter estimates,
Which can be easily recovered through the mean.

Table 3.16: Participation Elasticities by Education and Children:

Elasticities	NVQ1-3				NVQ4				NVQ5			
	M		F		M		F		M		F	
No children	0.233	***	2.304	***	0.102		2.584	***	0.219	**	-0.297	***
	(0.052)		(0.272)		(0.129)		(0.279)		(0.083)		(0.051)	
Children aged 0-2	0.317	***	0.189	***	0.243		-0.150	***	0.141		-0.116	**
	(0.098)		(0.036)		(0.288)		(0.082)		(0.137)		(0.037)	
Children aged 2-4	0.236	***	0.088	**	0.070		-0.455	***	0.233	*	-0.239	***
	(0.080)		(0.027)		(0.233)		(0.066)		(0.114)		(0.031)	
Children aged 4-9	0.082		0.161	***	-0.173		-0.329	***	-0.021		-0.256	***
	(0.064)		(0.022)		(0.184)		(0.053)		(0.096)		(0.029)	
Children aged 10+	0.247	***	0.165	***	-0.473	***	-0.229	***	-0.144		-0.245	***
	(0.063)		(0.021)		(0.147)		(0.051)		(0.097)		(0.034)	

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from the estimation of equation 11. The reported effects are elasticities instead of parameter estimates, which can be easily recovered through the mean.

Table 3.17: Intertemporal Labour Supply Elasticities

	Intertemporal Substitution				Uncompensated Substitution				Wealth Effect	
	Men		Women		Men		Women		Men	Women
Overall	0.440	***	1.206	***	0.211	***	0.598	***	-0.229	-0.608
	(0.055)		(0.239)		(0.017)		(0.015)			
NVQ1-3	0.545	***	1.266	***	0.129	***	0.717	***	-0.416	-0.549
	(0.047)		(0.260)		(0.006)		(0.013)			
NVQ4	0.378	***	1.136	***	0.24	***	0.604	***	-0.138	-0.532
	(0.076)		(0.280)		(0.020)		(0.022)			
NVQ5	0.338	***	1.004	***	0.294	***	0.443	***	-0.044	-0.561
	(0.043)		(0.076)		(0.014)		(0.018)			
No Children	0.713	***	0.898	***	0.121	***	0.545	***	-0.592	-0.353
	(0.067)		(0.018)		(0.007)		(0.010)			
Children aged 0-2	0.600	***	1.155	***	0.082	***	0.688	***	-0.518	-0.467
	(0.215)		(0.010)		(0.013)		(0.030)			
Children aged 3-4	0.409	***	1.257	***	0.121	***	0.689	***	-0.288	-0.568
	(0.118)		(0.008)		(0.011)		(0.021)			
Children aged 5-9	0.282	***	1.132	***	0.124	***	0.652	***	-0.158	-0.48
	(0.090)		(0.007)		(0.009)		(0.014)			
Children aged 10+	0.256	***	1.146	***	0.13	***	0.642	***	-0.126	-0.504
	(0.071)		(0.006)		(0.008)		(0.013)			

Note: Asymptotic standard errors in parentheses. *, ** and *** denote significance at 10%, 5% and 1% levels respectively. These results are from the estimation of equation 11. The reported effects are elasticities instead of parameter estimates, Which can be easily recovered through the mean.

Figures:

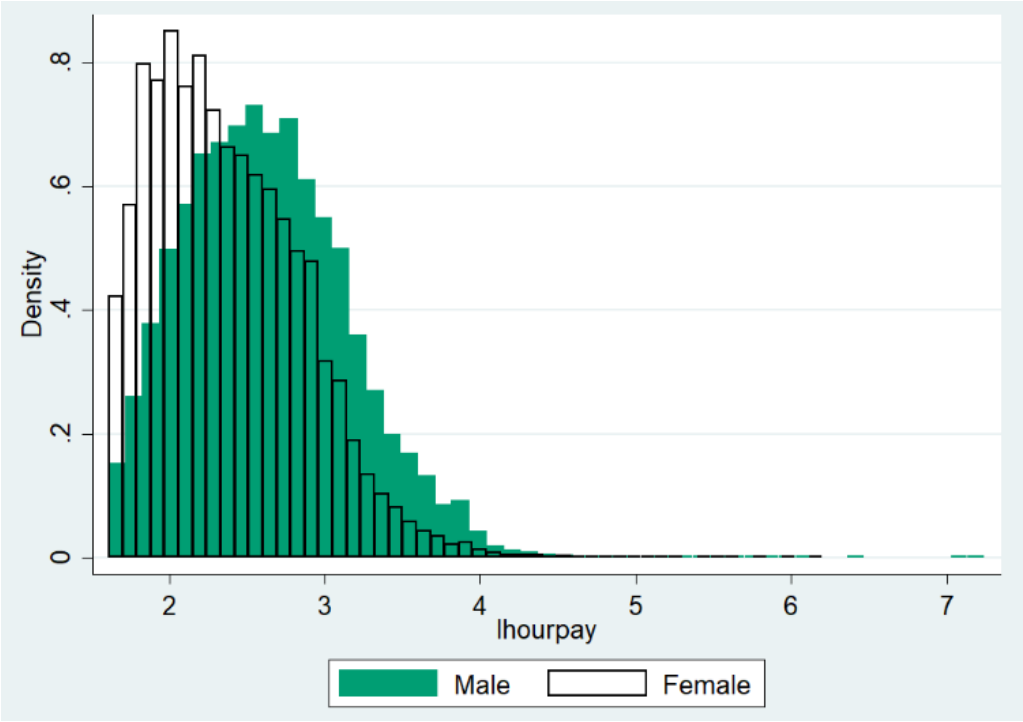

Figure 3.1: Log wage distribution by gender

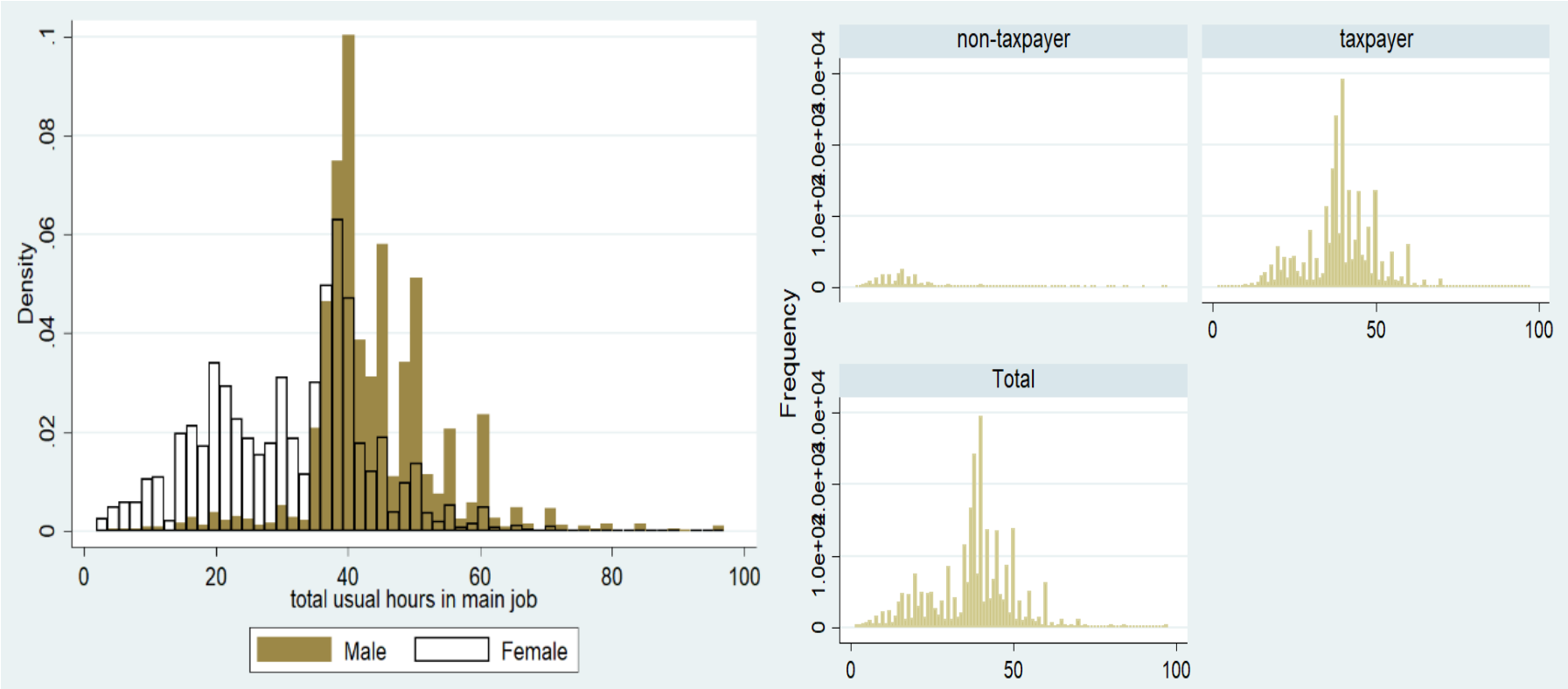

Figure 3.2: *Hours distribution by gender & tax status*

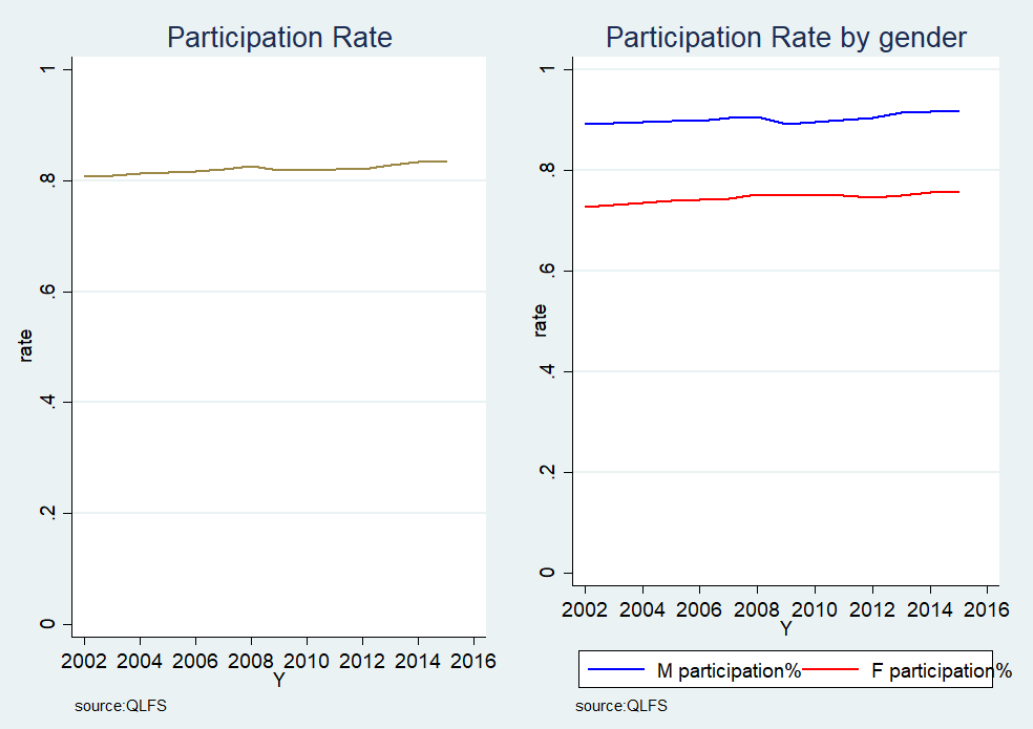

Figure 3.3: Participation by gender

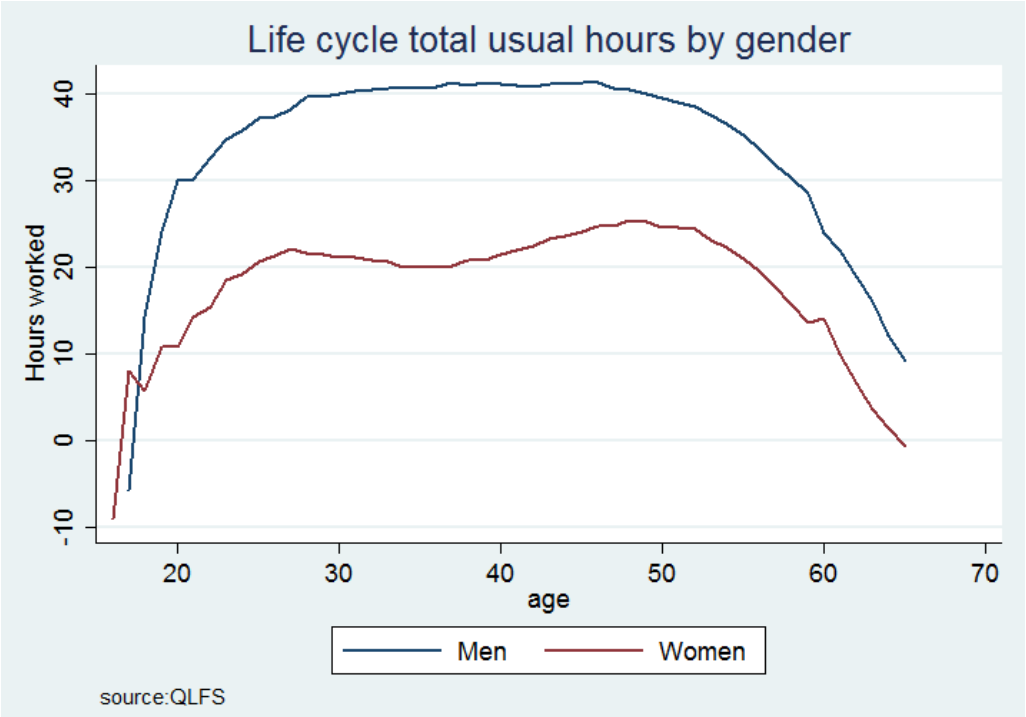

Figure 3.4: *Lifecyle hours of work profiles by gender*

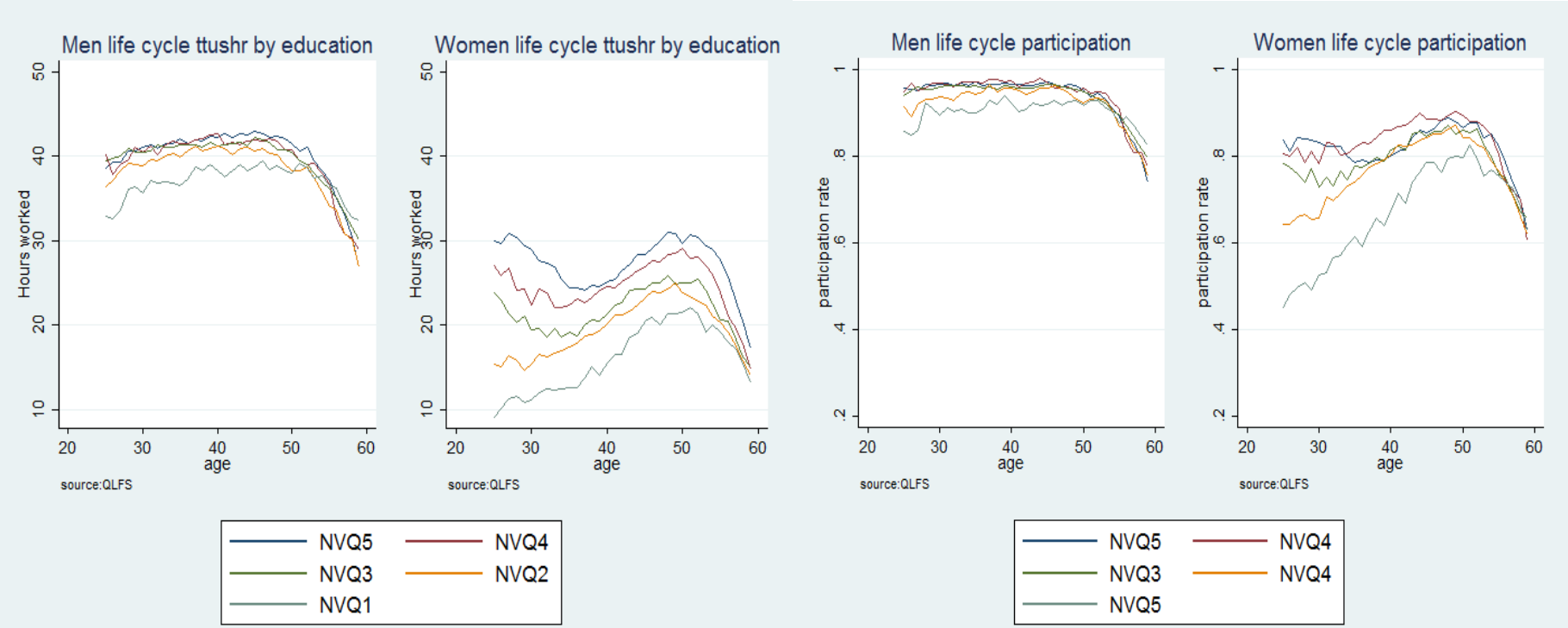

Figure 3.5: lifecycle hours & participation by education

Figure 3.6: Lifecycle wage by education and quantiles

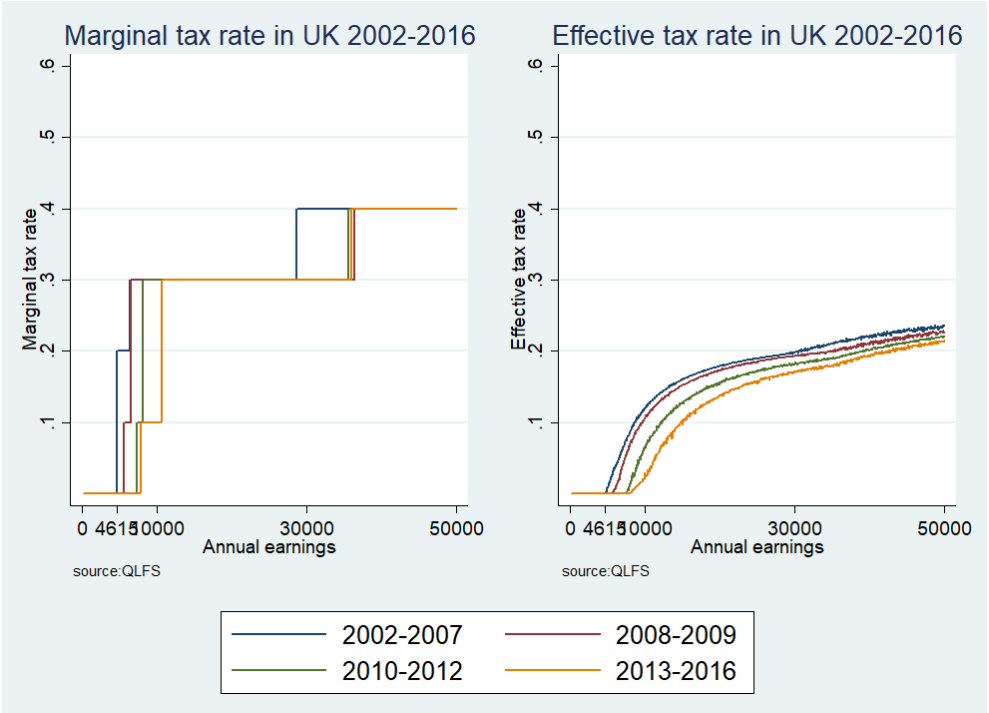

Figure 3.7. Marginal and effective tax rates, UK 2002-2016.

Appendix

Table A.1: Reduced Form for Log Wage (Men)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	-0.08	-0.073	-0.077	-0.089	-0.106	-0.084	-0.112	E	-0.076	-0.08	-0.01	-0.116
	(0.047)	(0.046)	(0.046)	(0.048)	(0.058)	(0.051)	(0.052)		(0.05)	(0.047)	(0.048)	(0.054)
2004	0.028	0.044	0.04	0.02	-0.007	0.019	0.051	0.117	0.042	0.015	0.087	E
	(0.038)	(0.035)	(0.036)	(0.04)	(0.055)	(0.043)	(0.045)	(0.059)	(0.042)	(0.038)	(0.039)	
2005	-0.03	0.008	-0.023	-0.068	E	-0.01	-0.036	-0.035	0.002	-0.022	0.011	-0.074
	(0.044)	(0.043)	(0.043)	(0.046)		(0.049)	(0.05)	(0.063)	(0.047)	(0.044)	(0.045)	(0.052)
2006	-0.07	-0.011	-0.018	-0.065	-0.099	-0.021	-0.053	E	-0.031	-0.037	0.035	-0.071
	(0.052)	(0.05)	(0.05)	(0.053)	(0.064)	(0.056)	(0.057)		(0.054)	(0.051)	(0.052)	(0.06)
2007	0.016	0.064	0.048	0.001	E	0.081	0.04	0.014	0.067	0.043	0.101	0.024
	(0.043)	(0.041)	(0.042)	(0.044)		(0.047)	(0.048)	(0.059)	(0.046)	(0.043)	(0.044)	(0.051)
2008	-0.03	0.059	0.053	0.023	E	0.072	0.086	0.064	0.018	0.062	0.102	0.023
	(0.043)	(0.041)	(0.041)	(0.044)		(0.047)	(0.048)	(0.059)	(0.045)	(0.043)	(0.044)	(0.05)
2009	0.048	0.117	0.135	0.071	E	0.133	0.119	0.164	0.061	0.115	0.221	0.114
	(0.047)	(0.045)	(0.045)	(0.048)		(0.052)	(0.053)	(0.064)	(0.049)	(0.047)	(0.047)	(0.055)
2011	-0.081	0.0004	-0.015	-0.013	-0.106	-0.005	0.022	E	-0.087	-0.016	0.102	-0.008
	(0.05)	(0.048)	(0.048)	(0.051)	(0.066)	(0.054)	(0.054)		(0.051)	(0.049)	(0.05)	(0.056)
2012	-0.178	-0.143	-0.102	-0.094	-0.186	-0.096	-0.096	E	-0.168	-0.144	-0.064	-0.109
	(0.05)	(0.048)	(0.048)	(0.051)	(0.065)	(0.054)	(0.054)		(0.051)	(0.049)	(0.05)	(0.056)
2013	-0.155	-0.044	-0.043	-0.023	-0.142	-0.06	-0.046	E	-0.095	-0.069	0.014	-0.031
	(0.053)	(0.051)	(0.05)	(0.053)	(0.068)	(0.057)	(0.056)		(0.054)	(0.051)	(0.052)	(0.057)
2014	-0.205	-0.105	-0.094	-0.096	-0.155	-0.156	-0.103	E	-0.153	-0.127	-0.043	-0.122
	(0.052)	(0.05)	(0.049)	(0.052)	(0.067)	(0.057)	(0.056)		(0.053)	(0.05)	(0.051)	(0.057)
2015	-0.167	-0.148	-0.099	-0.07	-0.274	-0.119	-0.088	E	-0.155	-0.116	-0.024	-0.094
	(0.051)	(0.049)	(0.049)	(0.052)	(0.067)	(0.056)	(0.055)		(0.052)	(0.05)	(0.05)	(0.056)
Children	0-4	5-9	10+									
	0.024	0.029	0.028									
	(0.004)	(0.003)	(0.003)									

Table A.2: Reduced Form for Nonlabor Income (Men)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	-23.072	-9.559	-20.966	-14.82	E	-33.348	-28.19	8.853	3.783	-23.365	-36.889	-15.014
	(28.530)	(27.507)	(27.612)	(29.193)		(31.622)	(31.936)	(39.606)	(31.205)	(29.224)	(29.242)	(34.665)
2004	-19.726	-13.304	-29.998	-14.836	E	-49.181	-32.037	21.114	-17.807	-22.86	-39.02	-24.367
	(33.252)	(31.802)	(31.877)	(33.629)		(36.149)	(36.548)	(44.817)	(35.743)	(33.68)	(33.784)	(38.645)
2005	-19.14	0.134	-10.3	-5.063	E	-14.22	-22.679	10.372	7.251	10.402	-10.164	20.32
	(31.176)	(29.937)	(30.042)	(31.619)		(34.247)	(34.281)	(42.404)	(33.405)	(31.701)	(31.748)	(36.111)
2006	12.872	38.207	38.246	32.907	27.757	13.768	25.038	43.929	35.321	68.57	29.412	E
	(26.998)	(25.313)	(25.454)	(27.453)	(38.435)	(30.925)	(31.143)	(41.15)	(29.619)	(27.376)	(27.592)	
2007	-62.859	-35.238	-50.319	-42.431	-31.533	-50.588	-46.876	E	-12.737	-39.648	-59.036	-60.386
	(32.285)	(31.119)	(31.159)	(32.607)	(41.569)	(34.968)	(35.249)		(34.236)	(32.497)	(32.64)	(37.017)
2008	-76.666	-52.349	-51.048	-59.753	-55.3	-38.23	-39.925	E	-48.688	-35.766	-10.833	-18.647
	(32.109)	(31.148)	(31.201)	(32.714)	(41.451)	(35.218)	(35.248)		(33.935)	(32.495)	(32.766)	(36.801)
2009	-15.458	8.029	5.904	8.977	E	11.416	31.449	37.72	12.095	45.938	23.578	29.297
	(31.647)	(30.617)	(30.634)	(32.627)		(35.253)	(35.807)	(43.141)	(33.456)	(32.118)	(32.424)	(37.436)
2011	-20.206	-0.756	-1.315	9.615	E	26.498	-6.787	58.103	-3.813	34.875	15.388	28.711
	(35.399)	(34.153)	(34.007)	(35.606)		(38.17)	(38.208)	(45.922)	(36.814)	(35.211)	(35.36)	(39.589)
2012	-54.061	-27.765	-20.693	-21.273	-47.21	-34.687	-23.116	E	-22.963	-21.054	-51.864	-59.706
	(33.548)	(32.347)	(32.144)	(33.892)	(44.072)	(36.53)	(36.485)		(34.827)	(33.257)	(33.603)	(38.301)
2013	-97.176	-62.045	-57.77	-56.73	-87.676	-71.567	-63.062	E	-91.955	-78.129	-96.702	-87.407
	(34.66)	(33.372)	(33.191)	(34.837)	(45.678)	(37.828)	(37.014)		(35.914)	(34.04)	(34.297)	(38.621)
2014	-4.907	23.047	51.574	91.073	E	-16.093	22.473	89.176	-66.892	-71.941	-47.273	13.366
	(28.5)	(27.622)	(27.717)	(29.623)		(31.121)	(31.378)	(40.949)	(30.149)	(28.447)	(28.733)	(33.252)
2015	6.456	28.009	68.415	109.548	E	-34.88	21.5	110.059	-76.091	-82.006	-60.276	50.551
	(25.402)	(24.56)	(24.677)	(26.847)		(27.954)	(28.13)	(37.659)	(27.13)	(25.489)	(25.720)	(30.542)
Children	0-2	5-9	10+									
	-34.972	-45.038	-63.972									
	(2.618)	(1.894)	(1.814)									

Table A.3: Reduced Form for Participation Probit (Men)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	-0.039	-0.003	-0.007	0.048	-0.062	-0.1	0.023	0.042	-0.036	-0.045	-0.005	E
	(0.059)	(0.055)	(0.055)	(0.057)	(0.105)	(0.088)	(0.078)	(0.081)	(0.079)	(0.066)	(0.065)	
2004	-0.144	-0.035	0.044	-0.019	-0.164	-0.244	0.11	-0.025	-0.066	-0.081	-0.075	E
	(0.067)	(0.062)	(0.062)	(0.064)	(0.121)	(0.095)	(0.09)	(0.092)	(0.088)	(0.074)	(0.073)	
2005	-0.015	-0.026	0.081	0.091	0.254	-0.085	0.114	0.17	-0.01	-0.058	-0.045	E
	(0.061)	(0.056)	(0.056)	(0.058)	(0.133)	(0.092)	(0.083)	(0.086)	(0.082)	(0.068)	(0.066)	
2006	0.009	0.007	0.09	0.128	0.43	-0.109	0.249	0.273	0.136	0.038	0.035	E
	(0.066)	(0.06)	(0.06)	(0.062)	(0.153)	(0.096)	(0.09)	(0.092)	(0.089)	(0.072)	(0.07)	
2007	0.037	0.087	0.133	0.153	0.306	0.061	0.232	0.232	0.033	0.096	0.092	E
	(0.061)	(0.056)	(0.056)	(0.058)	(0.129)	(0.092)	(0.081)	(0.084)	(0.079)	(0.067)	(0.065)	
2008	-0.133	-0.103	-0.003	0.031	0.165	-0.2	0.176	0.269	-0.105	-0.076	-0.011	E
	(0.06)	(0.056)	(0.056)	(0.058)	(0.127)	(0.09)	(0.084)	(0.087)	(0.078)	(0.066)	(0.066)	
2009	-0.429	-0.328	-0.269	-0.078	-0.183	-0.478	-0.201	-0.029	-0.286	-0.28	-0.195	E
	(0.065)	(0.061)	(0.061)	(0.065)	(0.123)	(0.094)	(0.087)	(0.093)	(0.081)	(0.071)	(0.071)	
2011	-0.071	-0.116	-0.104	0.06	-0.185	-0.249	0.021	0.186	-0.178	-0.18	-0.006	E
	(0.064)	(0.058)	(0.057)	(0.06)	(0.12)	(0.091)	(0.081)	(0.09)	(0.078)	(0.065)	(0.066)	
2012	-0.116	0.019	-0.036	0.068	-0.208	-0.144	0.116	0.236	-0.131	-0.099	-0.045	E
	(0.063)	(0.058)	(0.056)	(0.06)	(0.117)	(0.093)	(0.083)	(0.089)	(0.075)	(0.065)	(0.064)	
2013	-0.308	-0.223	-0.161	-0.209	-0.213	-0.341	-0.232	0.081	-0.364	-0.205	-0.182	E
	(0.066)	(0.061)	(0.059)	(0.061)	(0.128)	(0.099)	(0.081)	(0.093)	(0.078)	(0.068)	(0.067)	
2014	-0.231	-0.226	-0.138	-0.212	-0.197	-0.359	-0.188	0.1	-0.327	-0.175	-0.151	E
	(0.067)	(0.061)	(0.059)	(0.061)	(0.135)	(0.101)	(0.084)	(0.093)	(0.08)	(0.068)	(0.067)	
2015	-0.015	-0.053	-0.037	-0.033	-0.131	-0.187	0.034	0.169	-0.108	-0.128	-0.155	E
	(0.067)	(0.06)	(0.058)	(0.06)	(0.129)	(0.103)	(0.083)	(0.089)	(0.081)	(0.066)	(0.065)	
Children	0-4	5-9	10+									
	-0.076	-0.075	-0.016									
	(0.008)	(0.007)	(0.007)									

Table A.4: Reduced Form for Log Wage (Women)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	-0.072	-0.024	-0.082	-0.019	-0.045	-0.068	-0.036	E	-0.052	-0.047	-0.092	0.028
	(0.04)	(0.039)	(0.04)	(0.043)	(0.047)	(0.042)	(0.042)		(0.042)	(0.041)	(0.042)	(0.056)
2004	-0.084	-0.058	-0.108	-0.075	-0.077	-0.092	-0.061	E	-0.095	-0.052	-0.103	-0.001
	(0.046)	(0.044)	(0.045)	(0.049)	(0.054)	(0.048)	(0.048)		(0.047)	(0.046)	(0.047)	(0.06)
2005	-0.093	-0.054	-0.096	-0.039	-0.102	-0.022	-0.05	E	-0.089	-0.037	-0.048	-0.037
	(0.041)	(0.04)	(0.04)	(0.044)	(0.049)	(0.043)	(0.043)		(0.042)	(0.042)	(0.043)	(0.054)
2006	-0.05	0.009	-0.054	-0.022	-0.035	0.041	-0.044	0.001	-0.045	0.011	-0.024	E
	(0.045)	(0.044)	(0.044)	(0.048)	(0.055)	(0.048)	(0.048)	(0.058)	(0.046)	(0.046)	(0.047)	
2007	0.024	0.086	0.024	0.066	E	0.08	0.049	0.058	0.017	0.087	0.08	0.07
	(0.035)	(0.033)	(0.034)	(0.038)		(0.037)	(0.037)	(0.049)	(0.036)	(0.035)	(0.037)	(0.048)
2008	-0.114	-0.058	-0.088	-0.04	-0.119	-0.057	-0.078	-0.029	-0.086	-0.033	-0.023	E
	(0.04)	(0.039)	(0.039)	(0.042)	(0.048)	(0.042)	(0.042)	(0.052)	(0.041)	(0.04)	(0.042)	
2009	-0.144	-0.082	-0.109	-0.077	-0.088	-0.057	-0.102	0.017	-0.107	-0.046	-0.008	E
	(0.042)	(0.041)	(0.041)	(0.044)	(0.05)	(0.045)	(0.045)	(0.056)	(0.043)	(0.042)	(0.043)	
2011	-0.157	-0.073	-0.113	-0.095	-0.147	-0.078	-0.108	E	-0.143	-0.065	-0.034	-0.0004
	(0.041)	(0.039)	(0.039)	(0.043)	(0.053)	(0.044)	(0.043)		(0.041)	(0.04)	(0.041)	(0.052)
2012	-0.032	0.061	0.042	0.068	E	0.065	0.012	0.091	0.018	0.053	0.07	0.156
	(0.04)	(0.038)	(0.038)	(0.042)		(0.043)	(0.042)	(0.052)	(0.04)	(0.039)	(0.04)	(0.051)
2013	0.007	0.071	0.069	0.091	E	0.043	0.089	0.1	0.019	0.105	0.133	0.066
	(0.044)	(0.042)	(0.041)	(0.044)		(0.047)	(0.045)	(0.054)	(0.043)	(0.042)	(0.043)	(0.053)
2014	-0.078	-0.01	-0.006	0.012	-0.081	-0.036	0.018	E	-0.071	0.034	0.062	0.011
	(0.043)	(0.041)	(0.041)	(0.044)	(0.055)	(0.047)	(0.045)		(0.043)	(0.042)	(0.043)	(0.053)
2015	-0.095	0.026	0.002	0.028	E	0.014	0.029	0.016	-0.058	-0.016	0.054	0.045
	(0.044)	(0.042)	(0.041)	(0.044)		(0.047)	(0.045)	(0.054)	(0.043)	(0.042)	(0.043)	(0.053)
Children	0-4	5-9	10+									
	0.067	0.008	-0.043									
	(0.004)	(0.003)	(0.003)									

Table A.5: Reduced Form for Nonlabor Income (Women)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	15.674	13.159	26.962	20.164	-2.934	44.158	51.921	E	1.531	38.452	23.090	107.965
	(73.632)	(72.164)	(73.069)	(80.178)	(83.231)	(76.699)	(77.322)		(75.501)	(74.49)	(77.222)	(103.72)
2004	-98.136	-124.734	-96.816	-132.378	-169.764	-92.238	-96.464	-83.971	-128.513	-109.129	-80.353	E
	(82.587)	(80.533)	(81.426)	(89.103)	(93.658)	(85.652)	(86.693)	(109.503)	(84.219)	(83.057)	(85.758)	
2005	-66.677	-58.34	-43.353	-120.456	-100.241	-35.487	-63.979	-75.209	-23.718	-52.026	-28.404	E
	(73.511)	(71.449)	(72.202)	(79.995)	(85.153)	(76.875)	(77.255)	(98.328)	(74.846)	(74.144)	(76.927)	
2006	-26.177	-1.787	16.229	-9.27	-66.854	67.689	-11.127	-0.471	-25.389	46.803	31.741	E
	(80.920)	(78.737)	(79.448)	(86.187)	(94.809)	(84.19)	(84.884)	(104.049)	(81.817)	(81.175)	(83.907)	
2007	-29.337	15.707	6.196	2.901	-113.643	4.984	-1.435	-105.753	16.996	12.000	18.855	E
	(70.463)	(68.359)	(68.981)	(75.733)	(81.909)	(73.397)	(74.073)	(94.746)	(71.342)	(70.411)	(73.022)	
2008	-8.116	30.051	22.959	20.783	-54.697	68.861	4.216	-1.691	40.074	64.551	60.595	E
	(68.997)	(67.035)	(67.518)	(74.343)	(79.544)	(71.972)	(72.705)	(92.663)	(69.646)	(69.1)	(71.809)	
2009	-129.235	-56.458	-95.916	-96.916	-193.492	-77.381	-81.393	-114.043	-93.186	-45.811	-40.758	E
	(74.295)	(72.385)	(72.825)	(80.325)	(85.514)	(78.952)	(78.972)	(100.29)	(74.795)	(74.584)	(76.977)	
2011	-37.907	6.132	40.755	-34.042	-77.907	60.79	20.384	E	-1.379	47.216	86.920	82.388
	(73.433)	(70.706)	(70.852)	(78.551)	(90.77)	(77.391)	(76.129)		(72.997)	(71.985)	(74.68)	(94.553)
2012	-8.943	7.624	86.025	15.256	-53.781	74.043	40.474	E	84.964	48.558	69.553	223.958
	(75.798)	(73.567)	(73.557)	(80.445)	(90.106)	(80.651)	(79.475)		(75.48)	(74.446)	(77.037)	(96.445)
2013	-138.701	-58.655	-68.341	-120.36	-131.732	-52.576	-78.370	E	-95.074	16.286	-16.491	23.089
	(75.371)	(72.593)	(72.114)	(78.518)	(92.442)	(80.496)	(77.985)		(74.209)	(73.000)	(75.551)	(93.92)
2014	-183.964	-147.493	-114.898	-144.812	-208.451	-116.1	-128.956	E	-132.516	-80.718	-65.424	17.911
	(74.436)	(72.243)	(71.846)	(78.147)	(90.479)	(79.414)	(77.834)		(73.896)	(72.754)	(75.112)	(93.557)
2015	27.233	63.364	113.656	201.129	E	116.643	126.178	180.564	114.401	89.493	135.250	276.999
	(63.501)	(60.754)	(60.751)	(67.835)		(68.03)	(67.072)	(89.973)	(62.948)	(61.629)	(64.289)	(84.284)
Children	0-4	5-9	10+									
	16.381	17.388	25.664									
	(5.278)	(4.928)	(4.668)									

Table A.6: Reduced Form for Participation Probit (Women)

	NVQ1-3				NVQ4				NVQ5			
	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59	25-34	35-44	45-54	55-59
2003	0.109	0.071	0.116	0.159	0.066	0.107	0.114	0.135	0.089	0.055	0.128	E
	(0.069)	(0.068)	(0.069)	(0.071)	(0.086)	(0.079)	(0.078)	(0.085)	(0.076)	(0.073)	(0.078)	
2004	-0.054	-0.012	0.052	0.05	0.036	0.001	0.001	0.134	0.062	-0.001	0.119	E
	(0.074)	(0.073)	(0.074)	(0.076)	(0.095)	(0.086)	(0.086)	(0.092)	(0.082)	(0.079)	(0.085)	
2005	-0.106	-0.105	-0.016	-0.009	0.033	-0.088	-0.074	0.084	-0.069	-0.052	-0.106	E
	(0.068)	(0.067)	(0.068)	(0.07)	(0.09)	(0.079)	(0.079)	(0.085)	(0.075)	(0.073)	(0.077)	
2006	0.093	0.04	0.136	0.18	-0.018	0.091	0.16	0.294	0.211	0.129	0.103	E
	(0.07)	(0.069)	(0.07)	(0.072)	(0.092)	(0.082)	(0.083)	(0.089)	(0.077)	(0.075)	(0.079)	
2007	-0.099	-0.075	0.017	0.109	-0.061	-0.064	-0.021	0.19	0.025	-0.008	-0.05	E
	(0.065)	(0.064)	(0.065)	(0.067)	(0.084)	(0.075)	(0.075)	(0.083)	(0.071)	(0.069)	(0.073)	
2008	-0.063	-0.074	0.083	0.134	-0.027	-0.035	-0.003	0.217	0.103	-0.005	-0.009	E
	(0.064)	(0.063)	(0.064)	(0.066)	(0.084)	(0.074)	(0.075)	(0.081)	(0.07)	(0.068)	(0.072)	
2009	-0.031	0.009	0.129	0.238	0.062	-0.008	0.159	0.245	0.188	0.117	0.062	E
	(0.067)	(0.066)	(0.067)	(0.07)	(0.089)	(0.079)	(0.08)	(0.086)	(0.073)	(0.071)	(0.076)	
2011	-0.029	-0.062	0.081	0.184	-0.151	-0.104	0.008	0.248	0.01	-0.063	-0.133	E
	(0.064)	(0.062)	(0.063)	(0.065)	(0.086)	(0.075)	(0.074)	(0.081)	(0.068)	(0.066)	(0.07)	
2012	-0.028	-0.054	0.067	0.153	-0.108	-0.098	-0.047	0.206	-0.007	0.045	-0.046	E
	(0.063)	(0.062)	(0.062)	(0.065)	(0.086)	(0.075)	(0.073)	(0.081)	(0.067)	(0.065)	(0.069)	
2013	-0.121	-0.213	-0.039	0.104	-0.254	-0.118	-0.064	0.23	-0.063	-0.019	-0.129	E
	(0.065)	(0.063)	(0.063)	(0.066)	(0.087)	(0.078)	(0.075)	(0.081)	(0.068)	(0.066)	(0.07)	
2014	-0.096	-0.177	-0.002	0.155	-0.337	-0.148	-0.03	0.216	0.032	0.016	-0.025	E
	(0.064)	(0.063)	(0.062)	(0.065)	(0.086)	(0.078)	(0.075)	(0.081)	(0.068)	(0.066)	(0.07)	
2015	-0.01	-0.091	0.009	0.246	-0.212	-0.158	-0.024	0.297	0.059	0.067	0.09	E
	(0.063)	(0.061)	(0.061)	(0.064)	(0.086)	(0.075)	(0.073)	(0.08)	(0.066)	(0.064)	(0.068)	
Children	0-4	5-9	10+									
	-0.674	-0.341	-0.169									
	(0.005)	(0.005)	(0.005)									

Note: Table A.1 to A.6. Asymptotic standard errors in parentheses. "E" stands for the eliminated estimates where observations are less than 50.

Chapter 4

Estimating trade union effects on hours of work

—Evidence from the UK, QLFS 1996-2016

4.1Introduction

Another phenomenon that is missing from the traditional discourse of hours of work, which says that it is everywhere and always a labour supply phenomenon, are institutional constraints. One of the most important institutional phenomena in the past several decades has been the diminishing influence of trade unions. Indeed, strangely, our knowledge of trade unions in labour economics continues to be harnessed to labour demand, and not to labour supply. Indeed, lifecycle labour supply even managed to become the dominant narrative to understand cyclical variations in the labour market in the past decades, virtually without reference to institutional driven constraints. We have few reasons to believe that institutional phenomena would leave supply considerations unaffected. Unions are a case in point, even though we think that what unions do is to raise wages, along the demand curve, by restricting supply. Thus, examining the relationship between unions, hours and participation seems well past time. Again, we try to restrict ourselves to exploring these relationships in reduced forms to first develop the stylized facts as a prelude to understanding them.

Despite the decline in the membership and coverage of trade unions over the past five decades, collective bargaining and trade unions are still of crucial importance concerning the regulation of many issues in labour market (Andrews et al., 1998) such as wages, hours of work, fringe benefits and so forth. Given their potential importance,

the extent to which trade unions and collective bargaining could drive differences between comparable union and non-union workers in terms of the above issues seems to be paramount for the understandings for policy purposes.

Having reviewed the literature on trade unions, the picture revealed is that there is a voluminous amount of work trying to quantify the effect of unions on a range of topics, heavily on wage and employment[42]. but almost no work has been done to measure the effect of unionism on hours worked, none in the context of the UK. This chapter is motivated by the desire to fill this important gap in the literature and to shed some light on the magnitude of the effect of unions on hours worked.

Bargaining between management and unions in practice, do not only focus on the level of wages, but working-hours is also often included in such packages. This may happen in different forms though, such as the length of the standard working week, the length of paid holidays, the number of public holidays and sick leave arrangement etc. Therefore, it seems reasonable to expect some differences in the hours worked between workers in the union and non-union sectors (Booth 1995, p221).

Moreover, several studies (see Freeman, 1981; Lewis, 1963 and Lewis, 1986) suggest that there are positive union-nonunion differentials for fringe benefits such as health insurance, pensions, supplementary unemployment insurance and the like. The presence of such fixed employment costs can reduce the relative flexibility of the unionized firm in managing workforce reductions. Thus, it is reasonable for the unionized firms to find ways of transferring these costs onto employment and hours to offset the effects on wage rates (Booth 1995, p221).

Based on these arguments, there is reason to expect that there would be an impact of unionism on their employees` working hours. The focus of our paper is to estimate the size of such an impact. However, before we start, it is good to clarify what we are estimating. There have been two main dimension of trade union effects considered in the literature — union membership and union coverage. We need to distinguish between

[42] See surveys Lewis (1963, 1986), Pencavel (1991), Booth (1995) for reviews of the work done on these topics.

these two effects in our analysis, based on the UK LFS data. Because industrial relations in the UK is more complex than that of other countries such as the United States. In the US, membership and coverage are highly correlated – plants are often effectively "closed shops" – all workers are members of the union that cover the plant. But in the UK, many more non-members work in workplaces that are covered by union agreements and conversely, more union members are employed in workplaces where unions are not engaged in bargaining (Bryson 2002). In our study, we use the Quarterly Labour Force Survey data, ranging from1996 to 2016. The *UNION* variable askes people whether they are a member of trade unions or staff associations. The *TUCOV* variable askes people whether their pay or working conditions are affected by collective bargaining agreements. The data confirms the widely documented declining trend of the trade union presence in the working population over this period (see figure 4.1). Interestingly, the pattern of the trend for membership and coverage are quite different from each other. The percentage of the union membership decrease significantly across the period, from 31.3% in 1996 to 25.2% in 2016. While the percentage of covered workers are fairly consistent at around 10% to 12.3% therefore, there appear to be a good reason to differentiate these two effects.

The literature exploring union effects on labour market outcomes is one of the oldest and most extensively studied topics in economics and industrial relations. The advancement in technology in recent decades has made large and good quality data available, encouraging good numbers of empirical research flourish. However, majority of them concentrates on wage differentials, employment, job satisfaction, fringe benefits, but very few studies the impact on hours of work. And they are very old, may not be relevant anymore in the light of the dramatic changes in trade unions in recent decades. Some of these studies look at the union effect on total hours of work, per week or per annual (Perloff and Sickles 1987; Earle and Pencavel 1990; DiNardo 1991), some look at the union effect on overtime hours (Ehrenberg 1971; Miller and Mulvey 1991; Trejo 1993). In this study, we investigate the unionism effect on three different

dimensions of work hours: total usual hours, standard hours[43] and overtime hours. All measured in weekly terms.

One of the major difficulties in the union differential estimation is the endogeneity of the union status determination, there has been a general agreement in literature regarding this (Robinson 1989; Card 1996; Raphael 2000 etc). while methods for dealing with endogenous selection are interesting conceptually, in practice existing studies in the current context are unconvincing as they are unable to find credible identifying instruments (Andrews et al 1998) and estimates produced from these studies tend to be large and unstable (Blanchflower and Bryson 2002). Thus, this remains a contentious issue, and so we prefer to concentrate on other methodological issues. In our analysis, we use several methods both parametric and non-parametric, as well as several model specifications to cross check the sensitivity of the results.

However, an alternative approach is to use estimators that form estimates of counterfactuals, i.e., How many hours would union workers work if they were not unionized? This approach is known as the potential-outcomes framework, including methods such as matching and treatment effects (TE). Matching has been used widely in labour economics, and TE in health economics. Under the potential outcome framework, we consider our study as a social experiment, where union membership and union coverage are two separate treatments done to people in our sample `randomly`[44]. To obtain the effect of the treatments, we need to construct the counterfactuals for each individual, were they treated otherwise. We adopt a particular type of treatment effect method for our study, the inverse-probability weighting (IPW) method. The IPW method uses the inverse (reciprocal) of the probability of being in the observed treatment group as weights to eliminate the bias incurred in the estimation process. These probabilities are obtained by modelling the observed treatment as a function of

[43] The standard hours are derived by taking difference between total usual hours and overtime hours.

[44] The endogeneity of the union status remains a contentious issue. Through many attempts in the past decades (Farber, 1982; Abowd and Farber, 1982; Robinson 1989), some understandings have been made, such as individual characteristics, wage differential, industry characteristics (union coverage, capital labour ratio, firm size etc) do help explain some variations in the union status determination, but limited.

subject characteristics that determine the treatment group.

The key findings are that as a whole, union workers work 1 to 1.7 hours more than their non-union/not-covered counterparts. And the effects are different between men and women, for men, union workers work roughly 1 hour less than the non-union/not-covered men, and the effects diminishes over time, becoming not significant from 2010 onwards. For women union workers, the effects are significant and large and consistent over time at around 3 to 4 hours per week. These are large effects relative to the standard deviation of hours: an estimate 1.7 for men is.

If the effects are further decomposed into membership effects and coverage effects, we find that the membership effects are positive, and are larger among the covered workers (2 to 6 hours) than those among the not-covered workers (1 to 2.5 hours). The coverage effects are negative, and are larger in size among the non-union workers (-4 to -5 hours) than those among the union workers (-1 to -0.5 hours).

We also analysed the effects of union on the prevalence of overtime hours. We find that union membership/coverage increase the prevalence of paid overtime by approximately 13.9 percent, but decrease the prevalence of unpaid overtime by 2.3 percent. After controlling for individual characteristics such as industry and occupation and firm characteristics such as firm size, the effect decreases to 8.7 percent and 0.8 percent respectively, but still significant.

Our results also suggest that unions reduce the chance of their members working unpaid overtime, and increases the chance of more paid overtime. Our results echo the story that unions use overtime hours to stabilize working hours and highlight the value of their membership.

The paper is structured as follows. The next section reviews the literature. Section III explains the empirical frameworks we use in our analysis. Section IV describes the data we use for this study as well as the basic patterns concerning hours of work that are evident in our dataset. Section V presents the results from our estimation and the discussions relevant. Finally, section VI summarizes and concludes.

4.2 Related literature

In this section, we review the related past literature, where we first briefly allude to the theoretical developments and then explore the empirical findings. There are two strands of literature found relevant to the matter of hours determination in the context of unionized labour market: industrial relations and labour economics.

4.2.1 *Theoretical developments*

The industrial relations literature on unionism usually ascribes an important role on trade unions in the setting of work hours (Farber 1982; Abowd and Farber 1982; William K. 1987; Miller and Mulvey 1991; etc.), and most certainly unions have identified control over the hours worked by their members as an important goal of their activities. However, the traditional economic model of hours determination has been largely focused on the classic labour supply model where each individual employee selecting his or her hours of work to maximize a well-behaved utility function subject to a budget constraint. Although the contract curve model (Oswald and Walker 1993) does incorporate collective bargaining into the hours` determination process, there has hardly been any empirical evidence followed from this.

The purpose of this section is to sketch some union-management bargaining models that help organize our thoughts with respect to the determination of hours of work in unionized labour markets. We adopt the bargaining framework from Earle and Pencavel (1990). First, we neglect issues presented by overtime hours and the overtime wage premium. Then we consider the complications raised by such issues.

We start by specifying the objectives of the firm and the union. For the firm we posit profit maximization with profits defined as

$$\Pi = R(L, h) - whL - cL \qquad (1)$$

Where R denotes gross revenues; L, the number of workers employed; h, hours worked per employee; w, the wage rate per hour per employee; and c, the per-worker fixed costs of employment, such as hiring and training costs and certain fringe expenditures. We

assume the union maximizes a well-behaved objective function Γ, which includes three arguments: *e* earnings; *h* hours of work; and *L* employment;

$$\Gamma = g(e, h, L) \tag{2}$$

Here $e=wh$ and $\frac{\partial g}{\partial e} > 0$, $\frac{\partial g}{\partial h} < 0$, and $\frac{\partial g}{\partial L} > 0$.[45] The objective function is the union leadership`s. The classical bargaining model for economists is to assume that wages, hours and employment take on the values that lie on the parties` contract curve, which means one party cannot improve its welfare without reducing the other party`s welfare. This model involves *w*, *h* and *L* being selected such that the function Ω_1 is maximized,

$$\max_{w,h,L} \Omega_1 = \Gamma + B\Pi \tag{3}$$

Where $B>0$ represents management`s bargaining strength relative to the union. In other words, the value of *B* reflects the relative weight placed on the firm`s objectives in the bargaining problem.

Given the objectives of the parties, consider the determination of wages, hours and employment. As in all bargaining situations, a crucial issue is whether the parties share some control over all the variables or whether one party possesses unilateral power to set one or more variables. The contract-curve model above assumes that all three decision variables *w*, *h* and *L* are negotiated jointly by the union and management. However, there are many other cases where one party has unilateral power over one or more of the variables. We now consider models where at least one of the parties is able to determine one or other of the variables unilaterally. Mathematically, there are 27 possible permutations considering the determination of the three variables *w*, *h* and *L*. Each may well be an appropriate description in a particular labour market. The maximization problem can then be written as,

$$\max_{w,h,L,\lambda,\mu} \Omega_2 = \Gamma + B\Pi + \lambda(R_1 - wh - c) + \mu(R_2 - wL) \tag{4}$$

Where $\lambda>0$ and $\mu>0$ are Lagrange multipliers, $R_1 = \partial R/\partial L$ and $R_2 = \partial R/\partial h$. This

[45] Trade unions objectives are for higher pay, shorter hours and more employment.

model nests other models: in the contract curve model, $B>0$ and $\lambda=\mu=0$, all three decision variables w, h and L are negotiated jointly by the union and management; if B>0, $\lambda>0$ and $\mu=0$, then the management sets employment unilaterally; if $B=0$, $\lambda>0$, and $\mu>0$, then wages are set by the union, then the management sets the hours of work and employment; if $B=\mu=0$ and $\lambda>0$, then the union determines both wages and hours of work while management unilaterally sets employment; so on so forth. The first order conditions for a maximum are as follows:

$$\begin{cases} \dfrac{\partial g}{\partial e}h - BhL - \lambda h - \mu L = 0 \\ \dfrac{\partial g}{\partial e}w + \dfrac{\partial g}{\partial h} + B(R_2 - wL) + \lambda(R_{12} - w) + \mu R_{22} = 0 \\ \dfrac{\partial g}{\partial L} + B(R_1 - wh - c) + \lambda R_{11} + \mu(R_{12} - w) = 0 \\ \lambda(R_1 - wh - c) = 0 \\ \mu(R_2 - wh) = 0 \end{cases} \tag{5}$$

Where $R_1 \equiv \frac{\partial R}{\partial L}$, $R_2 \equiv \frac{\partial R}{\partial h}$, $R_{11} \equiv \frac{\partial^2 R}{\partial L^2}$, $R_{12} \equiv \frac{\partial^2 R}{\partial L \partial h}$ and $R_{22} \equiv \frac{\partial^2 R}{\partial h^2}$. In the efficient contract model, where the three variables are jointly determined, the first order condition for hours can be derived from the first two conditions by setting $\lambda=\mu=0$. Then we could find that an efficient contract requires hours to be set such that the marginal disutility of hours in the union`s objective function be proportional to the firm`s marginal revenue of hours, the factor of proportionality being the bargaining power parameter B,

$$\frac{\partial g}{\partial h} = -B\frac{\partial R}{\partial h} \tag{6}$$

In the models where management has exclusive control over hours of work, which is normal case seen at workplace, the first order condition for hours of work is

$$\frac{\partial R}{\partial h} = wh + c \tag{7}$$

The above models ignored the fact that one possible dimension of the union-management bargaining, the overtime hours and overtime wage premium. To accommodate these, let`s define the parameter δ as either taking the value zero when

overtime hours are worked or one when no overtime is worked. and rewrite the firm`s profits as

$$\Pi = R(L,h) - \delta(whL) - (1-\delta)\left[w\bar{h}L + \gamma w\left(h-\bar{h}\right)L\right] - cL \qquad (8)$$

Where $\bar{h}$ denotes normal hours of work and $\gamma \geq 1$ is the premium rate applied to wages for each overtime hours worked. In the UK, the working time regulations stipulates that the maximum weekly hours are 48 hours a week on average. However, workers can choose to work more than this limit, and the overtime wage premium is not compulsory. Given the same objective function, equation (2) for the union, various bargaining models may be identified, although now the decision variables embrace $\bar{h}$ and γ in addition to *w*, *h* and *L*. And the maximization problem will become as follows,

$$\max_{w,h,\bar{h},L,\gamma,\lambda,\mu} \Omega_2 = \Gamma + B\Pi + \lambda\left\{R_1 - \delta wh - (1-\delta)[w\bar{h} + \gamma w\left(h-\bar{h}\right)] - c\right\} + \mu(R_2 - wL) \qquad (9)$$

In principle, it is straightforward to amend the models above to take account of many bargaining outcomes. The difficulty is discriminating among them in any given empirical situation, because the more variables are incorporated, the more possibilities of complications associated with corner solutions to the constrained maximization problems there will be. And these corner solutions appear to be highly relevant in view of the fact that many bargaining outcomes in the UK stipulate $\bar{h}$= 35 or 40 and γ ranges from 1 to 2 or even 3 in some cases. The above are the theoretical frameworks on how the determination of hours and other labour market outcomes happen in the negotiation process between unions and firms. In the next sections, we are going to brief the empirical evidence and the possible channels between unions and hours worked.

4.2.2 *Empirical evidence*

There are few existing studies suggest that unions may influence hours of work, none have real causal interpretations. The difficulty has been in finding meaningful exogenous variance in unionization. Union members may be highly selected, and the direction of selection is not clear: less motivated workers are more likely to queue for

union jobs because they gain more from union efforts to less hours and more job security, but because the supply of union jobs exceeds demand for those jobs, employers can pick the best workers from those queueing for the union jobs (Abowd and Farber, 1982). Regardless of the direction of the selection, it has proven difficult to come up with a research design that convincingly deals with this problem. To my knowledge only DiNardo and Lee(2004) and the follow up studies by Lee and Mas(2012), Frandsen(2012), Sojourner and co-authors(2015) and Barth and co-authors(2017) have offered credible evidence on causal effects; with a quasi-experimental research design, regression discontinuity design related to union recognition in the US. While, Barth and co-authors(2017) innovatively exploit tax-induced exogenous variation in the price of union membership to identify the effects of changes in firm union density on firm productivity and wages using Norwegian firm level data(2001 to 2012). The empirical association of unionization and hours of work are generally found to be a negative correlation, though different dimensions of hours are measured. which is in line with the story that unionization protects the workers by depressing the hours of work as vigorously claims by most unions in their marketing pitch. Perloff and Sickles (1987) use three waves of CPS data (1973-1975) to estimate markups of wage, hours and earnings in the construction industry. They find that unionized construction workers have a slightly shorter workweek (-4%) than their non-union counterparts. Earle and Pencavel (1990) report both time-series and cross-section estimates which imply that unionization reduces annual full-time hours of work, but their cross-section estimates indicate that both the sign and magnitude of union hours effects vary across employment sectors. DiNardo (1991) finds that unionization depresses both annual weeks worked and average weekly hours. However, none of these studies distinguishes between standard hours and overtime hours, a distinction that is likely to be important because of union effects on overtime pay. Along these lines, Ehrenberg (1971) finds that unionized firms assign fewer overtime hours than do comparable non-union firms. Miller and Mulvey (1991), in contrast, report that union membership raises the incidence of overtime in their sample of young Australian workers. The evidence seems

to agree that in terms of total hours worked, union status depresses the hours of their members when compared with that of non-members. But when it comes to overtime hours, union members are more likely to work overtime than their counterpart. In next section, we explore the possible channels behind the empirical evidence.

4.2.3 *Possible channels of how union status influences hours of work*

Due to such a limited understanding on the determination of hours and the relationship between unionism and hours of work, the possible avenues through which unions may affect hours determination are yet to be fully explored. There may be multiple channels in this relationship, and they may cut in different directions. Unions may self-select the workers that wish to work different hours, for example, less total hours or more paid overtime hours. Booth (1995) has suggested two possible channels through which unions may influence workhours` determination.

First, there are higher fixed cost associated with hiring and firing workers. The advent of unionisation is sometimes associated with a switch to bargaining over issues affecting employment adjustment costs, such as severance or redundancy payments and redeployment. Moreover, Freeman (1981), Lewis (1986) and Hart (1984) suggest that there are positive union/non-union differentials for fringe benefits such as health insurance, pensions, vacations, supplementary unemployment insurance and the like. These are costs that vary with the number of workers and not the number of hours worked, and are therefore fixed employment costs. Thus, unionized firms face greater fixed employment costs relative to variable employment costs than do non-union firms. The presence of these fixed employment costs can reduce the flexibility of the unionized firm in managing workforce reductions. Therefore, it is reasonable to expect to see firms are more prone to changing working workhours than changing employment. And it may also be reasonable to expect differences in hours fluctuations between the union and non-union sectors.

Another way in which unions may affect hours as suggested by Booth (1995) is that in unionized firms, there is often bargaining between management and union over

working hours, this is rarely seen in non-unionized firms. Union bargaining occurs not only over the length of the standard working week, but also over issues affecting annual hours, such as overtime, length of paid holidays, the number of public holidays and sick leave etc. Such direct interference in hours determination is very likely to lead to a difference in hours worked in the union and non-union sectors.

4.3 Data

In this section we first present the source of data that we use, and some information on how the sample selection is done. We then go on to explain the variables we use and how some of them are constructed. And finally, we present the descriptive statistics from the data.

4.3.1 *Data source and variables selection*

The data used in this paper are drawn from a combination of seasonal data files and public release files of the Quarterly Labour Force Survey 1996 – 2016 (QLFS)[46]which are archived at the UK Data Service (UKDS). The QLFS is the largest regular household survey in the UK. It is based on a country-wide random sample of almost 53 thousand households for each quarter. Although it is not panel data, it provides consistent and accurate micro level information over a long period of time.

We restrict our sample to include workers between the ages 25 and 60 whose normal weekly hours worked are non-zero, exclude self-employed persons as well as those who did unpaid work for their family. Such restrictions make sure that our data contains workers only, whose hours are reasonably measured free from fuzziness induced by self-employment, full-time education and retirement. This will render our estimates to be as clean as possible. The QLFS questionnaire makes a distinction between those who are members of a union as well as those who are covered by a collective bargaining agreement. We therefore reconstructed the UNION variable into four groups: union

[46] The reason for two data sources is that the UNION variables are only present in the QLFS public release data files from 2009 onwards. We therefore requested seasonal data from UK Data Service, which contains UNION variables as early as 1993, discontinues from 2005 onwards. And the coverage variable TUCOV starts from 1996. Therefore, we consolidated all the data sources and formed our data which starts from 1996 to 2016, with 2006-2008 missing.

member and covered by a collective bargaining agreement (U-C); union member but not covered by a collective bargaining agreement (U-NC); Non-union member and not covered by a collective bargaining agreement (NU-NC); Non-union member but covered by a collective bargaining agreement (NU-C). The number of workers in the U-NC and NU-C groups are relatively small compared with the other two groups. The sample consists of 305,393 workers, half (157,984) of which are female workers. 55.8% (170,424) are NU-NC, 23.9% (72,892) are U-C, 11.7% (35,793) are NU-C, and 8.6% (26,284) are U-NC.

The variables we include in this study are selected by drawing on previous literature studying the determination of union membership, union wage premium, and hours determination (eg, among others, Farber 1982; Abowd and Farber 1982; Lewis 1986; Abraham and Farber 1987; William K. 1987; Miller and Mulvey 1991; Bryson 2002 etc.,) as well as theoretical considerations and include demographic characteristics, such as age, gender, marital status, ethnicity, educational attainment; job characteristics such as job permanency, industry, occupation; controls for firm size, sector, job tenure and region dummies. We also include regional and industrial union density from UK government public sources for union statistics[47]. The detailed variable definitions are reported in the first two columns in table 1.

4.3.2 *Descriptive statistics*

After filtering out all the non-complying individuals, our final sample consists of 469,931 individuals. The characteristics are summarized by union and coverage status in table 4.1. In general, the data demonstrate differences in a range of characteristics between union and non-union as well as between covered and not-covered individuals. In the following paragraphs, we will explain the differences of these characteristics first, and then we will show the union/non-union, covered/not-covered time series as well as the distributions of hours in detail.

The hours` statistics suggest in table 4.1 that unionized workers on average works 1.691

[47] https://www.gov.uk/government/collections/trade-union-statistics accessed on 28th of May 2018.

hours more than their non-unionized counterparts in terms of weekly total usual hours, 1.038 hours more in terms of weekly standard usual hours and 0.365 hours more in terms of weekly paid overtime hours. Whilst, covered workers and not-covered workers work more or less the same number of weekly total usual hours and paid overtime hours, but there is a positive 0.569 hours` difference in weekly standard hours by the not-covered workers.

As far as the educational attainment is concerned, there are more people with NVQ[48] level 5 and level 4 qualifications in the unionized workers and the covered workers than those in the non-unionized ones as well as in the not-covered ones. And the unionized workers and the covered workers are more likely to be younger, female, married and white than those of the non-unionized and the not-covered ones.

The unionized workers and the covered workers are more likely to stay with their current employer longer in time than their non-unionized and their not-covered counterparts; also, the companies they are working for tend to be larger in size (number of employees) than the those of the non-unionized and the not-covered[49]. The unionized workers are more likely to have a permanent job and more likely to be in regions or industry where union presence and coverage are high. Moreover, the unionized and the covered workers seem more likely to be in public sector, the non-unionized and the not-covered private sector. The unionized and the covered workers are also slightly likely to be in White collar occupations.

The region variable is composed of 12 regions: Northeast, Northwest, Yorkshire and Humber, East midlands, west midlands, East of England, London, Southeast, Southwest, Wales, Scotland and Northern Ireland. And the industry variable is composed of 8

[48] NVQ (National Vocational Qualifications) levels are not formally defined in terms of equivalence to conventional academic qualifications. In the paper, we follow the equivalences used by London School of Economics`s research lab, where there are five levels, NVQ5: degree level and above; NVQ4: higher education diploma below degree, teaching and nursing certificates; NVQ3: A levels or equivalent; NVQ2: O levels or GCSE equivalent: NVQ1: other qualifications. In the descriptive analysis, we consolidate the lower three levels into one group NVQ1_3.

[49] Although `tenure` and `firmsize` are not dummy variables, and each of them has different categories. But their values are in a monotonic increasing manner, therefore, the interpretations are not affected. Variable `tenure` is defined as number of years working for the current employer, and it is composed of 6 categories: less than 1 year, 1-2 years, 2-5 years, 5-10 years, 10-20 years and more than 20 years. And `firmsize` is defined as number of people at work place, and it is composed of 5 categories: under 10, 11-49, 50-249, 250-499 and over 500.

industries: Agriculture, forestry, fishing and hunting, Energy and water, Manufacturing, Construction, Transport and communications, Logistics, retail and hotels etc., Business services and Other services.

The decreasing trend of the union membership has been well documented in literature (Andrews et al., 1998 and Bryson 2002 etc.). Our dataset also confirms this trend does not only exist in the union membership trend but also exist for the union coverage, as shown in the Figure 4.1. The left panel is the trend for the whole sample, the right panel is decomposed by gender. In the left panel, we see that the decreasing trend of the union membership is fairly mild until 2009 where the drop is more pronounced. After decomposing the trend by gender, we see that women enjoy higher proportions in both membership and coverage through most of the years. And the falling trend are less pronounced in women than that in men, especially in membership. In 1996, there are roughly 27% of men and women works in the unionized firm. Up until 2016, the number drops to 20% and 25% for men and women respectively. The union coverage[50] percentages are much larger than that of union membership for both men and women. This may suggest the free rider problem as mentioned in Olson (1965). Throughout time, the falling trend are in line with the trend for membership.

Figure 4.2 presents the union membership and coverage trend by sector (Private/public). The trend reflects the general real-life experience where public sector is more unionized than private sector. In private sector, a higher percentage of men are union members, although the difference is diminishing in time. The same trend applies to the coverage percentage. In public sector, the percentage of membership among women are fairly stable across time at around 60%, however, the percentage for men is on a similar falling trend as that in the private sector from roughly 65% to 50%.

There has long been a speculation that older cohort are more likely to be unionized than the younger cohort. We therefore decomposed the union membership and coverage

[50] We have excluded the first three years of data (1996-1998) for the coverage trend due to a mis-classification problem which classified some not-covered individuals as dna, causing the proportion trend very misleading to interpret in those years.

trend according to birth cohort as presented in figure 4.3 & 4.4. Since our sample are restricted from 25 to 60 years old. Therefore, in the graphs, some of data are absent for some cohort in some years.

Figure 4.3 shows the general trend for all seven cohorts, and figure 4.4 shows the trend decomposed by gender. They suggest that in terms of membership, the percentages are fairly similar across all cohorts at around 20%. However, a way higher proportion of older cohorts tend to work in union covered working condition than that of the younger cohorts. After decomposing by gender, there is a very consistent pattern of women having a slightly higher percentage than men across all cohorts in both membership and coverage. The distributions of hours by gender, union and coverage status are presented in figure 4.2. The hours` distributions by gender (1st row) are in frequency as shown on the Y axis.

While the hours` distributions by union and coverage status (2nd and 3rd rows) are in measured in density. This is because the number of men and women in the sample are more or less the same, but the number of workers in unionized or covered firms are far less than those in the non-unionized or not-covered firms.

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As we can see in the distributions of total usual hours and standard usual hours, women`s hours are flatter and more wide spread than those of men, there are significant number of women works less than 30 hours, comparatively very few men are this far down the left tail of the distribution. Women also work less overtime hours than men. The pattern in the hours` distribution by union and coverage status are not very obvious. Though, as far as the total usual hours and the standard usual hours are concerned, the hours` distribution for the unionized workers seems to be less spread out than that of the non-unionized.

We further explore the time series of hours by union status in figure 4.6 and 4.7. There are obvious gaps as suspected between members and non-members, as well as covered and not-covered; And the mean hours` gap attributed to membership is a lot larger. Decomposing by gender see that the hours difference amongst female workers are significantly more pronounced than those for male workers, implying that the union effects, if any, are greater amongst female workers. Pattern-wise, there is not much difference between total usual hours and standard hours (see appendix 1). Therefore, we decided to do regressions only with total usual hours.

4.4 Empirical Frameworks

Estimates of the union differential can be obtained using a number of alternative estimators. In this section we present those that have been used in the union wage differential literature, as well as those that can improve upon these approaches by using the Potential outcome model framework (POM), i.e. counterfactuals.

4.4.1 *Ordinary Least Squares (OLS)*

Union wage differential literature has heavily used this method[51] and generally estimated a model of the following form, we change the dependent variable to be hours worked, because it is the variable of interest in this paper.

$$lnH_{it} = \beta x'_{it} + \delta Union_{it} + \theta Coverage_{it} + u_{it} \quad (1)$$

Where H denotes hours worked for individual i at time t; x'_{it} is a vector of controls for demographic, socioeconomic and job characteristics; $Union_{it}$ is an indicator variable for union membership status; $Coverage_{it}$ is an indicator variable for union coverage; and u_{it} is a residual term. The coefficient estimates on the union status indicator variable δ and θ are interpreted as the union membership and coverage differential. However, this approximation is valid when δ and θ are small; when they are large it is more appropriate to consider $e^{\delta} - 1$ and $e^{\theta} - 1$as the union hours differential.

As noted above, estimating equation (1) with OLS is the standard approach for

[51] Fixed effect estimators and quantile regression estimators have also been used in the union wage differential literature, but OLS is the predominant method that has been used in the previous literature.

obtaining estimates of the union differential. However, there are some limitations to using this empirical strategy.

First, the OLS estimates of equation (1) assume a linear functional form, which can be strong in cases of non-linear relationship. There can be self-selection into union jobs and this can create biases in the OLS estimates of the union differential (Cahuc, Carcillo, and Zylberberg 2014). In contrast, potential outcome models (POM) estimators are based on a conditional independence assumption (CIA), so that conditioning on observed variables that can influence hours or union membership can lessen the impacts of self-selection on the estimates. If some of the variables in the conditioning set are correlated with unobservables, it can also reduce the impact of selection due to unobservables on the estimates. However, variables that are not included in the conditioning set but affect union status would undermine the CIA and create a bias in the estimates. Third, covariate imbalance, where the distributions of observable characteristics for union and non-union workers do not overlap, can also introduce biases in the estimates of the union hours differential produced by OLS. This imbalance arises because union members may not be a random sample of the population, it makes OLS much more sensitive to the model specification (Bryson 2002; Eren 2007). But the IPW estimator can eliminate this kind of bias because it imposes overlap in the data. In order to circumvent these issues, we take alternative methods to estimate the union hours differentials.

4.4.2 *Propensity Score Matching (PSM)*

PSM compares the hours outcomes for unionized workers with `matched` non-unionized workers, and covered with `matched` not-covered. Let H_u be the hours worked by a union worker and H_{nu} the hours worked by a non-union worker; and let H_c be the hours worked by a covered worker and H_{nc} the hours worked by a not-covered worker. Note that $H_u = H_{nu} + Union * (H_u - H_{nu})$. Therefore, the average treatment effect on the treated (ATT) can be expressed as:

$$E[H_u - H_{nu}|union = 1] = E[H_u|union = 1] - E[H_{nu}|union = 1] \qquad (6)$$

$$E[H_c - H_{nc}|cover = 1] = E[H_c|cover = 1] - E[H_{nc}|cover = 1] \quad (7)$$

Where $E[*|union = 1]$ and $E[*|cover = 1]$ denotes the expectation operator conditional on being unionized and being covered by collective bargaining agreements respectively. The treatment effect here which is the average treatment effect on the treated (ATT) in both equations contain two terms. The first term is the mean hours worked by a union/covered worker, the second term is the mean hours that a union worker would work if he/she was placed in a non-union/not-covered job, i.e. the counterfactuals. The ATT thus provides an estimate of the union hours differential, which reflects the difference in hours between union/covered workers and the counterfactual hours for union/covered workers. In contrast, the OLS estimates of the union differential are not ATT because OLS estimates are bounded by the average treatment effect on the treated and the average treatment effect on the controls (Humphreys 2009)[52].

PSM shares the causal identification assumption of the OLS in that it yields unbiased estimates of the treatment effect where differences between individuals affecting the outcome of interest are captured in their observed attributes. However, matching has three distinct advantages relative to regressions in identifying an unbiased causal impact of union differential. First, it is semi-parametric, so it does not require the assumption of linearity in the outcome equation. Second, it leaves the individual causal effect completely unrestricted so that heterogeneous treatment effects are allowed for and no assumption of constant additive treatment effects for different individuals is required. Effects for sub-groups can be easily estimated by matching on sub-samples. Lastly, matching estimators highlight the problem of common support and thus the short-comings of parametric techniques which involve extrapolating outside the common support. Matching eliminates two of the three sources of estimation bias identified by Heckman, Ichimura and Todd (1997); The bias due to difference in the supports of X in the treated and control groups and the bias due to the difference between the two

[52] The OLS estimate would reflect a treatment effect i.e. the average treatment effect (ATE) in a randomized experiment, but not in observational data, which is the case of this study.

groups in the distribution of X over its common support. The other source of bias is due to selection on unobservables, this highlights the importance of the CIA assumption.

Estimating the ATT defined in equations (6) and (7) requires a few assumptions. First, Conditional Independence Assumption (CIA), conditional on a set of observed characteristics, X, the untreated outcome, H_{nu} and H_{nc} are independent of union and coverage status. The second assumption is that the propensity score, i.e. the conditional probability of receiving the treatment satisfies a common support condition, which means that the characteristics of the treated and untreated individuals have sufficient overlap to be able to find suitable matches in the sample. We assume that the common support condition holds in the sample, and check it through the matching quality graphs, this eliminates biases that arise from extrapolation in OLS estimates. see Appendix 3 for an example, although in some cases, the scores for non-members/not-covered workers are bunched in the lower or upper quartile of the distribution, they nevertheless offer support for members/covered throughout the distribution.

We follow the literature and assume a Probit functional form for the propensity score. The propensity score includes variable that influence both the probability of union membership/coverage and hours in the absence of union membership/coverage. If there are variables that are relevant and omitted from the propensity score then they would undermine the CIA and the selection on observed variables strategy.[53] We use a relatively large number of variables to control for observable characteristics and some of these variables are also likely correlated with some unobserved variables, which can lessen the biases arising from CIA violation.

The variables we include in the propensity score are selected by drawing from the previous literature on union status determination and union differentials as well as theoretical considerations and demographics, all of which are dummies useless otherwise stated: Female, age (3 dummies, 25-34; 35-49; and 50-59), NVQ (3 dummies, NVQ5; NVQ4; NVQ1-3), White, Married, occupation (9 dummies), permanent, tenure

[53] For example, we have compared the estimates with and without the variable firmsize, we find that without it the estimates are larger than with it.

(5 dummies), region (12 dummies), firmsize (5 dummies), uniondensity (continuous).

However, the functional form of the variables in the propensity score needs to be determined as well. The objective is to find a specification for the propensity score that induces balance. The conventional approach is trial and error. However, this can be very time consuming and tedious, and importantly, it might not necessarily reduce the amount of covariate imbalance since it is not guaranteed (Iacus, King and Porro 2012). We deal with this problem by including a large number of interaction terms between the variables and the union/coverage dummies.

There are many ways to define the counterfactual using the propensity score. In this study we use nearest neighbour that involves taking each treated individual (member/covered) and identifying the untreated individual (non-member/not-treated) with the most similar propensity score. The matches were made with replacement so that in some cases, a non-treated individual provides the closest match for a number of treated individuals, whereupon they feature in the comparison group more than once[54].

4.5 Results and Discussion

In this section, we present estimates of the union hours effects), the category of the effect (Membership/Coverage effects), the sub-samples used in the estimation (Union/non-union/covered/not-covered), as well as gender (All/Men/Women). Since there are so many tables, for the ease of reading, in our discussions, we only present the graphs, while attaching the detailed tables in Appendix 1.

4.5.1 Union membership effects on weekly total usual hours.

Figure 4.8 below, corresponding to the estimates in table 4.2 and 4.4 - 4.8. We plotted the estimates by year so that the changes in the effect over time can be shown. It reports the estimated union membership effects on the weekly total usual hours by OLS and PSM.

[54] Dehijia and Wahba (1999) find that allowing the untreated to be used more than once improves the performance of the match.

There are two types of membership effects reported, one is the membership effects among the not-covered subsample (U-NC/NU-NC), and the other the membership effects among the covered subsample (U-C/NU-C). These estimates suggest that union members on average work more than their non-union counterparts. (approximately 1 to 2.5 hours per week among the not-covered, 2 to 6 hours among the covered). The results also suggest that the membership effects are declining overtime (see figure 4.8). This may reflect the declining coverage and influence of trade unions. Across methods, the estimates are more or less in line with one another, apart from the estimates by PSM, where the size of the estimates are smaller and the declining trend seems much flatter than those of other three methods, especially among the covered workers.

If we go on to decompose the estimates by gender, we will see that among the not-covered workers, the membership effects are around zero for men and the estimates are mostly not statistically significant (see table 4.3), however, for women the membership effects are strongly statistically significant and they fall in time from approximately 5 hours to 2.5 hours. As for the covered workers, the membership effects for men are around 1.5 hours and fairly significant and consistent in time. For women, the membership effects are falling from approximately 5 hours to 1.5 hours.

Table 4.5 and table 4.8 presents the PSM analysis. These are run on identical samples to those used in the parametric estimates in other tables. The sample sizes shown are smaller than those appearing in other tables, because in the process of matching members to their nearest neighbours, PSM leaves many non-members out of the estimation sample, i.e. off the common support. Fortunately, this group tends to be small ranging between 5% -7% in most cases. This means common support is not a problem. When comes to the difference between the PSM estimates, smaller in most cases, and those from other methods. People may argue that the difference in sample size and common support enforcement could be the reason, rather than that the parametric estimates are upwardly biased due to the linear functional form assumption. Of course, it is arguable that the parametric models are simply mis-specified and that results could be reconciled through the addition of appropriate interaction terms. In practice this may

require a great deal of trial and effort.

4.5.2 Union coverage effects on total usual hours

Similar with the membership effects, the coverage effects are also run over two subsamples – union workers and non-union workers. The coverage effects are largely negative as presented in figure 4.9 with the estimates reported in table 4.6 and 4.7, suggesting that covered workers work less on average than those that are not-covered. And the absolute values of the sizes of the effects are also decreasing in time. Among the non-union workers, the coverage effects fall from approximately 5 hours to half an hour. And for the union workers, the coverage effects rise from -1 to 1, indicating that before 2004, the covered workers on average were working less than the not-covered, but from 2005 onwards, the covered workers on average were working more than the not-covered, the size of the effects flat out at around one hour. Decomposing by gender, we see that the increase in the hours worked by union members were mainly because of female union workers. This echoes the documented increasing trend in female participation in the labour market.

4.5.3 The compound effects

The compound effects are estimated by comparing the hours of unionized, covered workers to the hours of non-unionized, not-covered workers. The estimates are presented in figure 4.10. Although we estimated the compound effects across both methods same as the previous analysis, but we only show the estimates by OLS as below due to the fact that the estimates vary very little across methods. We also compare the above estimates with those obtained from analysis include variable firm-size, which is considered very important in the wage differential literature. (see Andrews et al., 1998)

Two main interesting findings are that the compound effects are the balance of other effects. And firm size only matters in the effects against the non-union, not-covered workers. To be specific, the compound effects are significant and consistently falling between 1 and 2 hours. Amongst men, the compound effects are increasing from -1

hours to roughly 0 hours. As the estimates approach zero in time, they are becoming less significant, suggesting that the union effects are weakening among male workers. Amongst women, the union compound effects are fairly consistent and significant around 3 hours on average. After we control for firm size, the coverage effects among the non-union workers and the union effects among the not-covered workers both decreased by approximately 1 hour. Decomposing by gender, we see the decrease in effects only happens in women, this suggest that firm size is more important in explaining women`s hours in trade unions rather than men`s.

4.5.5 Tobit results on overtime hours.

In this section, we investigate the effects of union status on workers` probability of working overtime, and how many hours of overtime worked in the case of positive overtime. We report Tobit results on paid overtime hours as well as unpaid overtime hours, the estimates reported are the average marginal effects.

The Probit estimates represent the probability of working paid overtime hours. All of the equations include union dummy, age, female, education, marital status, ethnicity, sector, job type, tenure (Years working for the employer), region and union density as independent variables. The estimates reported in the second and fourth columns include a vector of dummy variables identifying nine major industry and two major occupation classifications, the third and fourth column also included the variable firm size.

Turning now to these results, there is strong evidence that union membership and coverage substantially increases the likelihood of working paid overtime. When evaluated against the non-union, not-covered workers, the union membership raises the probability of working paid overtime by 7.8 percentage points and union coverage raises the probability by 7.1 percent, which is higher when compared with the membership effects among covered workers (6.3 percent) and the coverage effects among union workers (4.4 percent). However, some of these effects are due to the fact that unions are disproportionately represented in industries and occupations, so that introducing the industry and occupation dummy variables in column 2 reduces the

positive effects, especially so among the covered/union workers (see 2nd columns in table 42-46). The estimates in columns 3 and 4 suggest that at least part of the effect of union membership/coverage on the probability of working paid overtime is due to firm size.

Other characteristics have much to offer on the big picture. As people get older, union workers are less likely to work paid overtime. Female union workers are 6 to 12 percent less likely to work paid overtime than their male counterparts. People with a degree (NVQ5) are 13 to 19 percent less likely to work paid overtime than people with A level or below. Married union workers are less likely to work paid overtime. White collar workers are 12 percent less likely to work paid overtime than blue workers.

However, the picture is not complete without the unpaid overtime, since these hours normally do not reflect willingness or preference. And it is reasonable to assume that people have an upper limit on their labour supply. Therefore, the more unpaid overtime, the less paid overtime will be chosen.

Probit estimates of the probability of working unpaid overtime hours. The independent variables included are exactly the same as those for paid overtime. The results show that the union workers are 2 to 3 percent less likely to work unpaid overtime hours than their non-union/not-covered counterparts, despite some mixed effects in subsample results. People with higher education levels are more likely to work unpaid overtime hours, people with a degree or higher can be as high as 33 percent more likely to work unpaid overtime. People working with their employer longer are more likely to work unpaid overtime, with the group “staying more than 5 years” the most likely (10 percent more likely) to work unpaid overtime than people “work less than 1 year”. After controlling for firm size, the bigger the company is, the more likely the worker to work unpaid overtime. White-collar are 17 to 23 percent more likely to work unpaid overtime time hours than blue-collar.

The Tobit results are presented table 4.9. The results suggest that union has a positive compound effect on the probability of working and actually working paid overtime

hours (3.5 to 5 hours), with membership effects ranging from 1.4 to 4.4 hours and coverage effects ranging from 1.2 to 2.9 hours depending on the subsamples. Decomposing by gender, the compound effects for men are at a range from 4.7 to 6.6 hours, with membership effects (1.3 to 4.9 hours) and coverage effects (1.2 to 4.5 hours). As for women, the compound effects are at a range from 1 to 3.4 hours, with membership effects (1 to 3 hours) and coverage effects (1 to 2 hours). However, the coverage effects for women are largely insignificant. After controlling for firm size, the size of the effect's decreases, especially for women, at a margin of half an hour.

The estimates confirm the pattern in our data concerning overtime hours. Controlling for industry, occupation, firm size reduces but does not eliminate the effects of union membership/coverage on probability of working overtime hours. Union membership/coverage appears to increase the prevalence of paid overtime, but decrease that of unpaid overtime. The results seem to suggest that white collar/people with higher education levels are more susceptible to unpaid overtime, willingly or not, which making the finding that they are less likely to work paid overtime subject to different interpretations, income effect or fatigue.

4.6 Conclusion

This paper has analysed the effects of trade unions on working hours, at two dimensions: weekly total usual hours, and overtime hours. As a whole, union workers work 1 to 1.7 hours more than their non-union/not-covered counterparts. And the effects are different between men and women, amongst men, union workers work roughly 1 hour less than the non-union/not-covered men, and the effects diminishes in time and becomes not significant from 2010 onwards. Amongst women union workers, the effects are significant and large and consistent in time at around 3 to 4 hours. If the effects are further decomposed into membership effects and coverage effects, we find that the membership effects generally positive, and are larger among the covered workers (2 to 6 hours) than those among the not-covered workers (1 to 2.5 hours). The coverage effects are negative, and are larger in size among the non-union workers (-4 to -5 hours)

than those among the union workers (-1 to -0.5 hours). We also analysed the effects of union on the prevalence of overtime hours. We find that union membership/coverage increase the prevalence of paid overtime by approximately 13.9 percent, but decrease the prevalence of unpaid overtime by 2.3 percent. After controlling for individual characteristics such as industry and occupation, and firm characteristics such as firm size, the effect decreases to 8.7 percent and 0.8 percent respectively, but still significant.

The results suggest that there is a positive correlation between union membership and hours of work. The possible reason that underline such relationship might be a queuing story (abowd & Farber 1982), where trade unions selects the "hard working" workers from the queue. Besides, the results also suggest a negative correlation between union coverage and hours of work. It is likely that this reflects the effects of free-riding (Bryson, 2008). Where non-union but covered workers free-rides the union`s voice on overtime hours.

We also find that unions do use overtime hours to stabilize working hours and highlight the value of their membership. Our results also suggest that unions work in a way to reduce the chance of their members being taken advantage by their employers to work more unpaid overtime, and increase the chance of more paid overtime.

The huge differences in our estimates between union members and union non-members, as well as covered and non-covered, suggest that the selection problem does exist in the process of unionization. Due to the lack of instruments, we used our model to estimate the union wage differential to gauge the level of bias in our results (table 4.3). Our estimates are closer to the lower bound when compared with literature (Andrews et al., 1998; Bryson, 2002; 2011), which also suggest the contentious endogeneity problem with unionisation. Therefore, the future work is to find appropriate instruments to reflect this selection bias.

Tables:

Table 4.1: Definition of variables used, sample means and standard deviations

Variable	Description	Union/Coverage Status							
		Union		Non-union		Covered		Not-covered	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
ttushr	Total usual hours worked in a week	39.396	*11.173*	37.705	*12.874*	38.317	*11.344*	38.336	*12.940*
overtime	Paid overtime hours worked in a week	7.068	*6.007*	6.703	*5.770*	6.907	*5.911*	6.836	*5.856*
NVQ5	NVQ level 5	0.307	*0.461*	0.265	*0.441*	0.297	*0.457*	0.269	*0.443*
NVQ4	NVQ level 4	0.165	*0.371*	0.106	*0.308*	0.150	*0.357*	0.112	*0.315*
NVQ1-3	NVQ level 1-3	0.528	*0.499*	0.629	*0.483*	0.553	*0.497*	0.619	*0.486*
age	Age of the respondent	42.669	*9.149*	40.766	*9.504*	42.278	*9.195*	40.891	*9.534*
female	=1 if female	0.525	*0.499*	0.498	*0.500*	0.534	*0.499*	0.490	*0.500*
married	=1 if married	0.669	*0.470*	0.608	*0.488*	0.662	*0.473*	0.609	*0.488*
white	=1 if white	0.944	*0.230*	0.928	*0.258*	0.945	*0.227*	0.925	*0.263*
tenure	Number of years with current employer	4.312	*1.409*	3.406	*1.508*	4.168	*1.456*	3.435	*1.519*
firmsize	Number of employees at workplace	2.910	*2.396*	2.231	*2.426*	2.997	*2.444*	2.150	*2.380*
permanent	1 if the job is permanent	0.966	*0.182*	0.948	*0.221*	0.955	*0.206*	0.954	*0.209*
uresmc	Usual residence region	6.369	*3.356*	6.488	*2.998*	6.433	*3.333*	6.452	*2.987*
uniondensity	% of regional labour force unionized	0.294	*0.061*	0.272	*0.057*	0.293	*0.060*	0.270	*0.056*
uniondensityin	% of industry`s labour force unionized	0.297	*0.074*	0.239	*0.096*	0.295	*0.076*	0.235	*0.096*
observations	Number of observations	173,086		296,845		195,205		274,726	

Note: All variables are available from 1996 to 2016; apart from Firmsize which is only available from 2002 onwards.

Table 4.2: Union effects on hours of work

Outcome	OLS					
	All		M		F	
U vs NU	-0.008		-1.617	***	2.353	***
	(0.030)		(0.035)		(0.040)	
C vs NC	-0.874	***	-1.609	***	0.775	***
	(0.036)		(0.043)		(0.049)	
NU-C vs NU-NC	-2.650	***	-2.288	***	-0.603	***
	(0.057)		(0.069)		(0.072)	
U-NC vs NU-NC	0.126		0.044		1.904	***
	(0.067)		(0.082)		(0.086)	
U-C vs NU-NC	0.015		-1.319	***	2.157	***
	(0.043)		(0.051)		(0.060)	
U-NC vs U-C	0.229	***	1.329	***	-0.311	***
	(0.064)		(0.080)		(0.085)	
NU-C vs U-C	-2.901	***	-1.093	***	-2.948	***
	(0.054)		(0.067)		(0.071)	

Note: U represents union, NU, non-union; C represents covered, NC, not covered. The results in this table are from the OLS estimation of hours. The * signifies the level of significance, * 90%, ** 95%, *** 99%. Standard errors are in the brackets.

Table 4.3: Union effects on wage

Outcome	OLS					
	All		M		F	
U vs NU	0.020	***	-0.012	***	0.079	***
	(0.002)		(0.003)		(0.003)	
C vs NC	-0.004		-0.025	***	0.048	***
	(0.002)		(0.003)		(0.003)	
NU-C vs NU-NC	-0.043	***	-0.037	***	0.010	**
	(0.004)		(0.005)		(0.005)	
U-NC vs NU-NC	-0.004		-0.021	***	0.070	***
	(0.005)		(0.007)		(0.006)	
U-C vs NU-NC	0.013	***	-0.024	***	0.089	***
	(0.003)		(0.004)		(0.004)	
U-NC vs U-C	-0.014	***	0.008		-0.028	***
	(0.004)		(0.005)		(0.005)	
NU-C vs U-C	-0.057	***	-0.012	***	-0.076	***
	(0.003)		(0.005)		(0.004)	

Note: U represents union, NU, non-union; C represents covered, NC, not covered. The results in this table are from the OLS estimations of wages. The * signifies the level of significance, * 90%, ** 95%, *** 99%. Standard errors are in the brackets.

Table 4.4: PSM Membership effects on total usual hrs (U-NC vs NU-NC)

Year	All	Bootstrap		Men	Bootstrap		Women	Bootstrap	
1996	2.301	*1.24*	*3.36*	0.410	*-0.74*	*1.56*	2.499	*0.54*	*4.45*
Obs.	*2830*			*1540*			*1288*		
1997	2.908	*1.78*	*4.03*	0.108	*-1.25*	*1.47*	3.638	*2.16*	*5.10*
Obs.	*2769*			*1430*			*1336*		
1998	1.934	*0.78*	*3.08*	0.501	*-0.88*	*1.88*	1.344	*-0.20*	*2.88*
Obs.	*2667*			*1424*			*1337*		
1999	2.151	*1.44*	*2.86*	0.279	*-0.47*	*1.02*	2.380	*1.38*	*3.37*
Obs.	*19144*			*10128*			*9016*		
2000	1.358	*0.67*	*2.03*	-0.298	*-1.02*	*0.42*	2.555	*1.41*	*3.69*
Obs.	*18330*			*9645*			*8685*		
2001	2.361	*1.74*	*2.97*	0.020	*-0.90*	*0.94*	3.322	*2.31*	*4.32*
Obs.	*18939*			*9816*			*9123*		
2002	1.408	*0.72*	*2.08*	0.023	*-0.72*	*0.77*	2.052	*0.91*	*3.19*
Obs.	*18284*			*9595*			*8689*		
2003	1.787	*1.11*	*2.46*	0.416	*-0.42*	*1.26*	2.640	*1.60*	*3.67*
Obs.	*17482*			*8998*			*8484*		
2004	1.049	*0.45*	*1.64*	-0.115	*-0.85*	*0.62*	1.262	*0.35*	*2.17*
Obs.	*17577*			*8981*			*8596*		
2005	0.554	*-0.09*	*1.19*	-0.468	*-1.21*	*0.27*	1.318	*0.36*	*2.26*
Obs.	*16686*			*8485*			*8201*		
2009	1.945	*1.18*	*2.7*	1.080	*-0.05*	*2.21*	1.848	*0.90*	*2.79*
Obs.	*14509*			*7246*			*7262*		
2010	1.358	*0.67*	*2.03*	-0.298	*-1.28*	*0.69*	1.714	*0.43*	*2.99*
Obs.	*18330*			*7021*			*7011*		
2011	1.616	*0.87*	*2.35*	0.133	*-1.00*	*1.26*	2.069	*1.05*	*3.08*
Obs.	*13871*			*6958*			*6913*		
2012	1.417	*0.67*	*2.16*	0.767	*-0.32*	*1.86*	2.348	*1.06*	*3.63*
Obs.	*13696*			*6775*			*6921*		
2013	1.764	*1.02*	*2.5*	0.402	*-0.94*	*1.74*	1.861	*0.76*	*2.95*
Obs.	*13904*			*6983*			*6920*		
2014	2.220	*1.37*	*3.06*	0.989	*0.00*	*1.97*	2.454	*1.28*	*3.62*
Obs.	*14242*			*7089*			*7152*		
2015	1.565	*0.84*	*2.28*	0.231	*-0.83*	*1.30*	2.361	*1.28*	*3.44*
Obs.	*13372*			*6678*			*6694*		
2016	2.192	*1.91*	*2.46*	0.136	*-0.21*	*0.48*	2.682	*2.30*	*3.06*
Obs.	*25811*			*12831*			*12980*		

Note: Bootstrap shows the 95% confidence interval for the bootstrapped estimates. The support loss is generally between 5%-7% of the sample. Standard errors are in parentheses. ***denotes statistically significant at 1-percent level of significance, ** at 5-percent, * at 10-percent. Age is a continuous variable, in this study we only used 25-50. Female is dummy, 1 for female, 0 for male. NVQ1_3 is the education group that is omitted. Married is marital status dummy, 1for married or cohabiting, 0 for otherwise. White is ethnicity dummy, 1 for white, 0 for otherwise. Private is the sector dummy, 1 for Private sector, 0 for Public sector. Permanent is the job permanency dummy, 1 for permanent, 0 for not. Tenure is the dummy for number of years the worker worked for the current employer, Tenure>5 more than 5 years is the group that is omitted. Uniondensitylo is the regional union density, Uniondensityin is the industry union density. Firmsize>500, more than 500 people at workplace is the omitted group. White collar is the occupation dummy, 1 for white collar, 0 for blue collar. All regressions have 12 regional dummies included, omitted due to lack of space. Column 2 and 4 also included 9 industry dummies as well.

Table 4.5: PSM Membership effects on total usual hrs (U-C vs NU-C)

Year	All	Bootstrap		Men	Bootstrap		Women	Bootstrap	
1996	2.554	*2.06*	*3.04*	1.100	*0.39*	*1.80*	4.037	*3.23*	*4.83*
Obs.	*12785*			*6392*			*6393*		
1997	2.251	*1.78*	*2.71*	0.730	*0.07*	*1.39*	3.894	*3.20*	*4.57*
Obs.	*13368*			*6605*			*6762*		
1998	2.390	*1.85*	*2.92*	0.359	*-0.31*	*1.03*	4.458	*3.74*	*5.17*
Obs.	*13165*			*6541*			*6623*		
1999	2.199	*1.72*	*2.67*	0.772	*0.15*	*1.38*	3.683	*3.00*	*4.36*
Obs.	*12871*			*6303*			*6569*		
2000	2.314	*1.83*	*2.78*	0.655	*-0.04*	*1.35*	3.745	*3.06*	*4.42*
Obs.	*12383*			*5977*			*6406*		
2001	2.374	*1.89*	*2.84*	0.499	*-0.09*	*1.09*	3.815	*3.12*	*4.51*
Obs.	*12432*			*5952*			*6480*		
2002	1.993	*1.54*	*2.44*	0.939	*0.36*	*1.51*	3.099	*2.44*	*3.75*
Obs.	*12157*			*5681*			*6476*		
2003	1.971	*1.47*	*2.47*	0.619	*-0.03*	*1.27*	3.177	*2.49*	*3.86*
Obs.	*11492*			*5374*			*6118*		
2004	2.126	*1.64*	*2.6*	1.102	*0.47*	*1.72*	2.827	*2.15*	*3.50*
Obs.	*11544*			*5278*			*6266*		
2005	2.074	*1.58*	*2.55*	0.944	*0.34*	*1.54*	3.290	*2.51*	*4.06*
Obs.	*10889*			*4999*			*5890*		
2009	1.680	*1.16*	*2.2*	0.701	*-0.02*	*1.42*	2.313	*1.58*	*3.04*
Obs.	*8468*			*3702*			*4767*		
2010	1.797	*1.24*	*2.34*	0.401	*-0.35*	*1.15*	2.753	*1.94*	*3.56*
Obs.	*7542*			*3347*			*4194*		
2011	2.104	*1.53*	*2.67*	0.899	*0.21*	*1.57*	3.095	*2.30*	*3.88*
Obs.	*7540*			*3243*			*4297*		
2012	1.904	*1.3*	*2.5*	0.835	*0.08*	*1.58*	2.715	*1.91*	*3.51*
Obs.	*6848*			*2985*			*3863*		
2013	1.710	*1.11*	*2.3*	0.635	*-0.19*	*1.46*	2.407	*1.61*	*3.20*
Obs.	*6943*			*3079*			*3864*		
2014	2.408	*1.79*	*3.02*	0.949	*0.21*	*1.68*	3.142	*2.30*	*3.97*
Obs.	*6337*			*2784*			*3552*		
2015	2.016	*1.37*	*2.65*	0.682	*-0.19*	*1.56*	2.656	*1.77*	*3.53*
Obs.	*6051*			*2646*			*3405*		
2016	1.559	*1.22*	*1.89*	1.561	*1.11*	*2.01*	2.098	*1.60*	*2.59*
Obs.	*10678*			*4704*			*5975*		

Note: Bootstrap shows the 95% confidence interval for the bootstrapped estimates. The support loss is generally between 5%-7% of the sample. Standard errors are in parentheses. ***denotes statistically significant at 1-percent level of significance, ** at 5-percent, * at 10-percent. Age is a continuous variable, in this study we only used 25-50. Female is dummy, 1 for female, 0 for male. NVQ1_3 is the education group that is omitted. Married is marital status dummy, 1for married or cohabiting, 0 for otherwise. White is ethnicity dummy, 1 for white, 0 for otherwise. Private is the sector dummy, 1 for Private sector, 0 for Public sector. Permanent is the job permanency dummy, 1 for permanent, 0 for not. Tenure is the dummy for number of years the worker worked for the current employer, Tenure>5 more than 5 years is the group that is omitted. Uniondensitylo is the regional union density, Uniondensityin is the industry union density. Firmsize>500, more than 500 people at workplace is the omitted group. White collar is the occupation dummy, 1 for white collar, 0 for blue collar. All regressions have 12 regional dummies included, omitted due to lack of space. Column 2 and 4 also included 9 industry dummies as well.

Table 4.6: PSM Coverage effects on total usual hours (NU-C vs NU-NC)

Year	All	Bootstrap		Men	Bootstrap		Women	Bootstrap	
1996	-2.296	*-3.02*	*-1.57*	-2.947	*-3.77*	*-2.11*	-1.553	*-2.74*	*-0.36*
Obs.	*5109*			*2333*			*2776*		
1997	-2.392	*-3.13*	*-1.65*	-3.090	*-3.99*	*-2.18*	-1.493	*-2.56*	*-0.42*
Obs.	*5222*			*2277*			*2945*		
1998	-2.295	*-3.09*	*-1.50*	-2.644	*-3.59*	*-1.69*	-2.014	*-3.21*	*-0.81*
Obs.	*5154*			*2376*			*2778*		
1999	-1.356	*-1.80*	*-0.90*	-2.688	*-3.29*	*-2.08*	-0.391	*-1.07*	*0.29*
Obs.	*20595*			*10544*			*10051*		
2000	-2.028	*-2.46*	*-1.58*	-2.857	*-3.46*	*-2.24*	-1.309	*-1.98*	*-0.63*
Obs.	*19726*			*10095*			*9631*		
2001	-1.371	*-1.81*	*-0.92*	-2.427	*-2.97*	*-1.87*	-0.619	*-1.24*	*0.00*
Obs.	*20304*			*10293*			*10105*		
2002	-1.357	*-1.79*	*-0.92*	-1.892	*-2.47*	*-1.30*	-1.139	*-1.74*	*-0.53*
Obs.	*19745*			*10013*			*9732*		
2003	-0.875	*-1.34*	*-0.40*	-1.846	*-2.53*	*-1.16*	-0.213	*-0.83*	*0.41*
Obs.	*18714*			*9377*			*9338*		
2004	-1.149	*-1.59*	*-0.70*	-2.259	*-2.85*	*-1.65*	-0.212	*-0.83*	*0.41*
Obs.	*18896*			*9421*			*9475*		
2005	-0.931	*-1.37*	*-0.48*	-1.820	*-2.43*	*-1.20*	-0.554	*-1.17*	*0.06*
Obs.	*17908*			*8988*			*8920*		
2009	-0.466	*-1.00*	*0.07*	-1.545	*-2.25*	*-0.83*	0.563	*-0.17*	*1.30*
Obs.	*15344*			*7661*			*7683*		
2010	-0.671	*-1.21*	*-0.12*	-1.425	*-2.26*	*-0.58*	-0.311	*-1.06*	*0.44*
Obs.	*14578*			*7390*			*7187*		
2011	-1.049	*-1.59*	*-0.50*	-2.042	*-2.70*	*-1.37*	-0.490	*-1.27*	*0.30*
Obs.	*14672*			*7373*			*7299*		
2012	-0.400	*-1.05*	*-0.25*	-1.589	*-2.36*	*-0.81*	-0.047	*-0.92*	*0.83*
Obs.	*14098*			*7091*			*7007*		
2013	-0.433	*-1.03*	*0.16*	-1.107	*-1.84*	*-0.36*	0.193	*-0.67*	*1.06*
Obs.	*14366*			*7294*			*7072*		
2014	-0.446	*-1.09*	*0.20*	-1.909	*-2.70*	*-1.11*	0.010	*-0.75*	*0.77*
Obs.	*14551*			*7317*			*7234*		
2015	-0.060	*-0.69*	*0.57*	-1.781	*-2.51*	*-1.04*	1.158	*0.35*	*1.95*
Obs.	*13731*			*6975*			*6756*		
2016	-0.575	*-0.82*	*-0.32*	-2.070	*-2.36*	*-1.78*	0.773	*0.41*	*1.13*
Obs.	*26322*			*13222*			*13100*		

Note: Bootstrap shows the 95% confidence interval for the bootstrapped estimates. The support loss is generally between 5%-7% of the sample. Standard errors are in parentheses. ***denotes statistically significant at 1-percent level of significance, ** at 5-percent, * at 10-percent. Age is a continuous variable, in this study we only used 25-50. Female is dummy, 1 for female, 0 for male. NVQ1_3 is the education group that is omitted. Married is marital status dummy, 1for married or cohabiting, 0 for otherwise. White is ethnicity dummy, 1 for white, 0 for otherwise. Private is the sector dummy, 1 for Private sector, 0 for Public sector. Permanent is the job permanency dummy, 1 for permanent, 0 for not. Tenure is the dummy for number of years the worker worked for the current employer, Tenure>5 more than 5 years is the group that is omitted. Uniondensitylo is the regional union density, Uniondensityin is the industry union density. Firmsize>500, more than 500 people at workplace is the omitted group. White collar is the occupation dummy, 1 for white collar, 0 for blue collar. All regressions have 12 regional dummies included, omitted due to lack of space. Column 2 and 4 also included 9 industry dummies as well.

Table 4.7: PSM Coverage effects on total usual hours (U-C vs U-NC)

Year	All	Bootstrap		Men	Bootstrap		Women	Bootstrap	
1996	-1.163	*-2.04*	*-0.28*	-2.180	*-3.23*	*-1.12*	-0.438	*-1.74*	*0.86*
Obs.	*10506*			*5598*			*4905*		
1997	-1.598	*-2.44*	*-0.74*	-1.805	*-2.89*	*-0.72*	-0.623	*-1.72*	*0.47*
Obs.	*10910*			*5758*			*5127*		
1998	-1.023	*-1.9*	*-0.14*	-1.938	*-3.01*	*-0.86*	0.495	*-0.75*	*1.74*
Obs.	*10771*			*5589*			*5182*		
1999	-0.806	*-1.33*	*-0.27*	-1.623	*-2.30*	*-0.93*	-0.360	*-1.13*	*0.41*
Obs.	*11420*			*5886*			*5534*		
2000	-0.728	*-1.29*	*-0.16*	-1.376	*-2.08*	*-0.66*	-0.019	*-0.86*	*0.83*
Obs.	*10987*			*5527*			*5460*		
2001	-1.405	*-1.99*	*-0.82*	-1.867	*-2.60*	*-1.12*	-0.683	*-1.54*	*0.17*
Obs.	*11068*			*5570*			*5498*		
2002	-0.307	*-0.91*	*0.3*	-1.104	*-1.83*	*-0.37*	0.964	*0.04*	*1.88*
Obs.	*10696*			*5263*			*5433*		
2003	-0.921	*-1.51*	*-0.32*	-1.666	*-2.42*	*-0.90*	-0.287	*-1.13*	*0.55*
Obs.	*10260*			*4995*			*5265*		
2004	-0.188	*-0.81*	*0.43*	-0.918	*-1.63*	*-0.20*	1.037	*0.26*	*1.81*
Obs.	*10225*			*4838*			*5387*		
2005	-0.107	*-0.7*	*0.48*	-1.133	*-1.85*	*-0.41*	0.586	*-0.26*	*1.43*
Obs.	*9667*			*4496*			*5171*		
2009	-0.456	*-1.13*	*0.22*	-2.330	*-3.34*	*-1.31*	0.559	*-0.35*	*1.47*
Obs.	*7634*			*3287*			*4347*		
2010	0.077	*-0.59*	*0.75*	-1.281	*-2.13*	*-0.43*	0.833	*-0.05*	*1.72*
Obs.	*6996*			*2978*			*4019*		
2011	-0.162	*-0.83*	*0.5*	-0.970	*-1.91*	*-0.02*	0.834	*0.01*	*1.65*
Obs.	*6738*			*2828*			*3910*		
2012	0.705	*-0.03*	*1.44*	-0.990	*-2.03*	*0.05*	1.214	*0.32*	*2.10*
Obs.	*6446*			*2668*			*3778*		
2013	-0.094	*-0.84*	*0.65*	-1.109	*-2.18*	*-0.03*	0.890	*0.02*	*1.75*
Obs.	*6480*			*2767*			*3713*		
2014	0.070	*-0.63*	*0.77*	-1.883	*-2.85*	*-0.91*	0.852	*-0.00*	*1.70*
Obs.	*6027*			*2557*			*3470*		
2015	0.495	*-0.14*	*1.13*	-0.723	*-1.68*	*0.23*	1.587	*0.71*	*2.46*
Obs.	*5692*			*2349*			*3343*		
2016	-0.159	*-0.51*	*0.19*	-0.876	*-1.32*	*-0.43*	0.285	*-0.25*	*0.83*
Obs.	*10167*			*4313*			*5854*		

Note: Bootstrap shows the 95% confidence interval for the bootstrapped estimates. The support loss is generally between 5%-7% of the sample. Standard errors are in parentheses. ***denotes statistically significant at 1-percent level of significance, ** at 5-percent, * at 10-percent. Age is a continuous variable, in this study we only used 25-50. Female is dummy, 1 for female, 0 for male. NVQ1_3 is the education group that is omitted. Married is marital status dummy, 1for married or cohabiting, 0 for otherwise. White is ethnicity dummy, 1 for white, 0 for otherwise. Private is the sector dummy, 1 for Private sector, 0 for Public sector. Permanent is the job permanency dummy, 1 for permanent, 0 for not. Tenure is the dummy for number of years the worker worked for the current employer, Tenure>5 more than 5 years is the group that is omitted. Uniondensitylo is the regional union density, Uniondensityin is the industry union density. Firmsize>500, more than 500 people at workplace is the omitted group. White collar is the occupation dummy, 1 for white collar, 0 for blue collar. All regressions have 12 regional dummies included, omitted due to lack of space. Column 2 and 4 also included 9 industry dummies as well.

Table 4.8: PSM Compound effects on total usual hours (U-C vs NU-NC)

Year	All	Bootstrap		Men	Bootstrap		Women	Bootstrap	
1996	0.059	*-0.78*	*0.89*	-1.732	*-2.41*	*-1.05*	2.010	*0.88*	*3.13*
Obs.	*11406*			*6142*			*5264*		
1997	-0.777	*-1.5*	*-0.04*	-2.727	*-3.48*	*-1.96*	0.952	*-0.42*	
Obs.	*11709*			*6244*			*5464*	*2.32*	
1998	0.218	*-0.63*	*1.06*	-2.113	*-2.90*	*-1.32*	2.322	*1.09*	*3.54*
Obs.	*11568*			*6135*			*5432*		
1999	0.561	*0.18*	*0.93*	-1.747	*-2.24*	*-1.24*	3.051	*2.41*	*3.68*
Obs.	*25637*			*13545*			*12091*		
2000	0.779	*0.39*	*1.16*	-1.344	*-1.80*	*-0.88*	2.670	*2.10*	*3.23*
Obs.	*24607*			*12924*			*11683*		
2001	0.821	*0.46*	*1.18*	-1.467	*-1.91*	*-1.02*	3.013	*2.41*	*3.60*
Obs.	*25126*			*12993*			*12134*		
2002	0.486	*0.09*	*0.87*	-1.281	*-1.71*	*-0.84*	2.272	*1.68*	*2.85*
Obs.	*24194*			*12538*			*11656*		
2003	1.179	*0.78*	*1.57*	-1.187	*-1.62*	*-0.74*	2.936	*2.37*	*3.49*
Obs.	*23157*			*11808*			*11349*		
2004	1.032	*0.66*	*1.39*	-1.245	*-1.67*	*-0.81*	2.998	*2.48*	*3.51*
Obs.	*23196*			*11655*			*11541*		
2005	0.962	*0.6*	*1.32*	-1.115	*-1.55*	*-0.67*	2.590	*1.98*	*3.19*
Obs.	*21888*			*10990*			*10897*		
2009	0.939	*0.51*	*1.36*	-0.998	*-1.52*	*-0.46*	2.615	*1.96*	*3.26*
Obs.	*18230*			*9001*			*9229*		
2010	1.138	*0.67*	*1.6*	-0.698	*-1.33*	*-0.05*	2.465	*1.80*	*3.12*
Obs.	*17066*			*8450*			*8616*		
2011	1.436	*0.95*	*1.91*	-0.364	*-0.95*	*0.23*	2.490	*1.69*	*3.28*
Obs.	*17121*			*8370*			*8751*		
2012	1.433	*0.94*	*1.92*	-0.441	*-1.12*	*0.24*	2.709	*2.00*	*3.41*
Obs.	*16417*			*8027*			*8390*		
2013	1.427	*0.89*	*1.95*	-0.387	*-1.05*	*0.28*	3.155	*2.43*	*3.87*
Obs.	*16628*			*8249*			*8379*		
2014	1.720	*1.18*	*2.25*	-0.373	*-1.10*	*0.36*	3.052	*2.27*	*3.83*
Obs.	*16408*			*8135*			*8273*		
2015	1.761	*1.22*	*2.29*	-0.623	*-1.30*	*0.05*	3.393	*2.62*	*4.15*
Obs.	*15412*			*7628*			*7784*		
2016	2.042	*1.8*	*2.28*	-0.263	*-0.56*	*0.03*	3.163	*2.81*	*3.51*
Obs.	*29439*			*14613*			*14826*		

Note: Bootstrap shows the 95% confidence interval for the bootstrapped estimates. The support loss is generally between 5%-7% of the sample. Standard errors are in parentheses. ***denotes statistically significant at 1-percent level of significance, ** at 5-percent, * at 10-percent. Age is a continuous variable, in this study we only used 25-50. Female is dummy, 1 for female, 0 for male. NVQ1_3 is the education group that is omitted. Married is marital status dummy, 1for married or cohabiting, 0 for otherwise. White is ethnicity dummy, 1 for white, 0 for otherwise. Private is the sector dummy, 1 for Private sector, 0 for Public sector. Permanent is the job permanency dummy, 1 for permanent, 0 for not. Tenure is the dummy for number of years the worker worked for the current employer, Tenure>5 more than 5 years is the group that is omitted. Uniondensitylo is the regional union density, Uniondensityin is the industry union density. Firmsize>500, more than 500 people at workplace is the omitted group. White collar is the occupation dummy, 1 for white collar, 0 for blue collar. All regressions have 12 regional dummies included, omitted due to lack of space. Column 2 and 4 also included 9 industry dummies as well.

Table 4.9: Tobit results on overtime

Outcome	Paid Overtime						Unpaid Overtime					
	All		**M**		**F**		**All**		**M**		**F**	
U vs NU	5.030	***	6.142	***	2.582	***	1.255	***	-0.707	***	3.158	***
	(0.039)		(0.053)		(0.051)		(0.036)		(0.054)		(0.046)	
C vs NC	3.238	***	4.241	***	1.710	***	-0.563	***	-2.047	***	0.834	***
	(0.052)		(0.072)		(0.067)		(0.047)		(0.071)		(0.060)	
NU-C vs NU-NC	2.933	***	4.555	***	1.887	***	0.624	***	0.744	***	0.990	***
	(0.079)		(0.123)		(0.088)		(0.069)		(0.111)		(0.078)	
U-NC vs NU-NC	4.002	***	5.469	***	2.485	***	2.678	***	1.554	***	3.777	***
	(0.097)		(0.147)		(0.110)		(0.082)		(0.134)		(0.092)	
U-C vs NU-NC	5.524	***	6.680	***	2.862	***	1.151	***	-0.962	***	3.303	***
	(0.042)		(0.057)		(0.056)		(0.039)		(0.058)		(0.050)	
U-NC vs U-C	-1.137	***	-1.324	***	-0.221	***	0.575	***	1.626	***	-0.277	***
	(0.087)		(0.119)		(0.112)		(0.079)		(0.131)		(0.099)	
NU-C vs U-C	-2.409	***	-1.975	***	-1.229	***	-1.017	***	0.781	***	-2.343	***
	(0.073)		(0.102)		(0.093)		(0.069)		(0.110)		(0.087)	

Note: U represents union, NU, non-union; C represents covered, NC, not covered. The results in this table are from the Tobit estimations of both paid and unpaid overtime hours. The * signifies the level of significance, * 90%, ** 95%, *** 99%. Standard errors are in the brackets.

Figures:

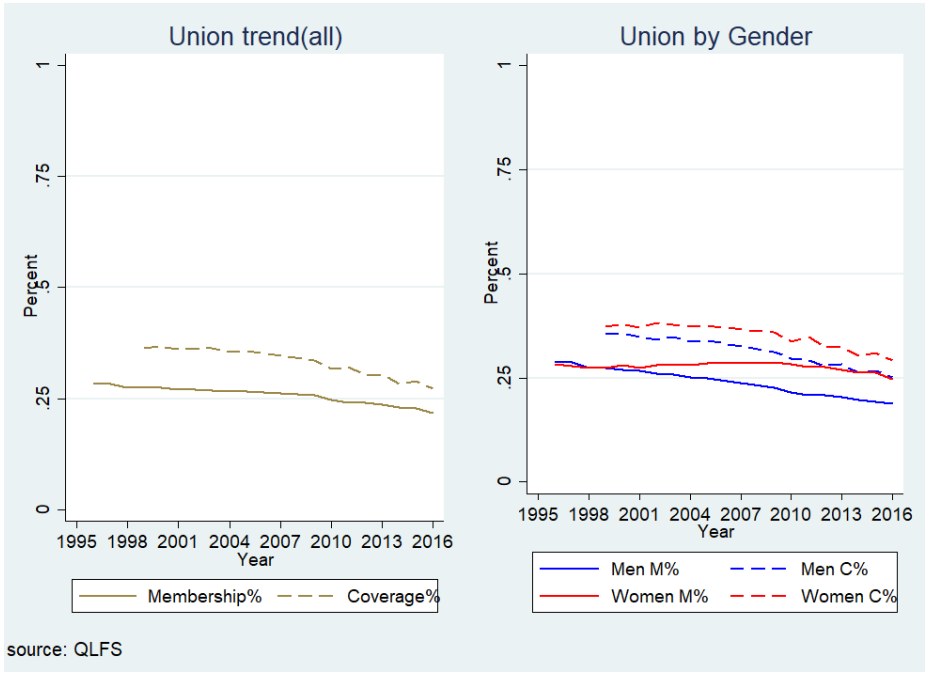

Figure 4.1: Union membership and coverage trend.

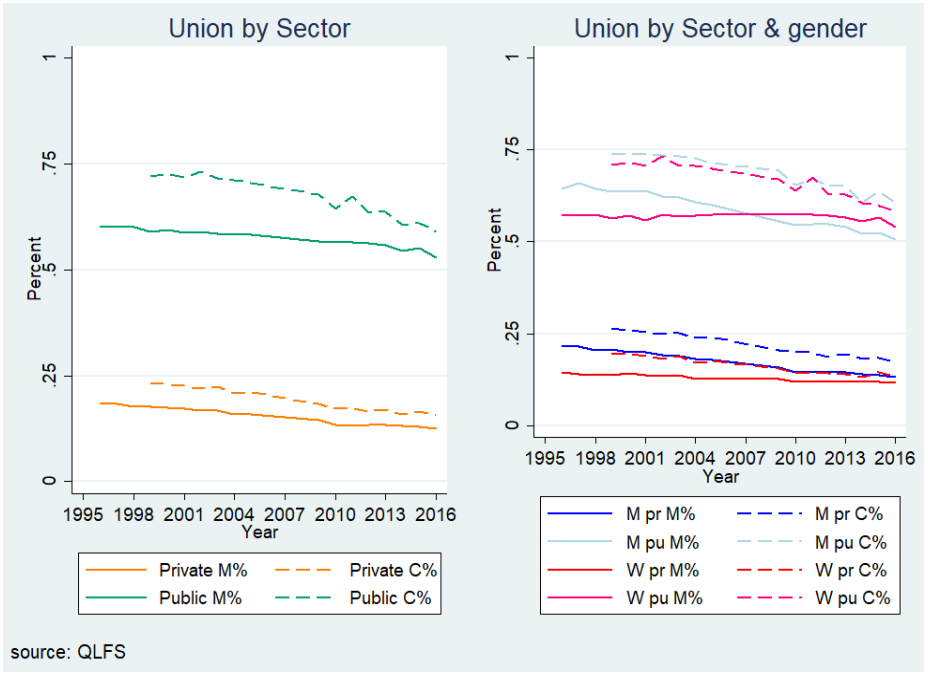

Figure 4.2: Union membership and coverage trend by sector.

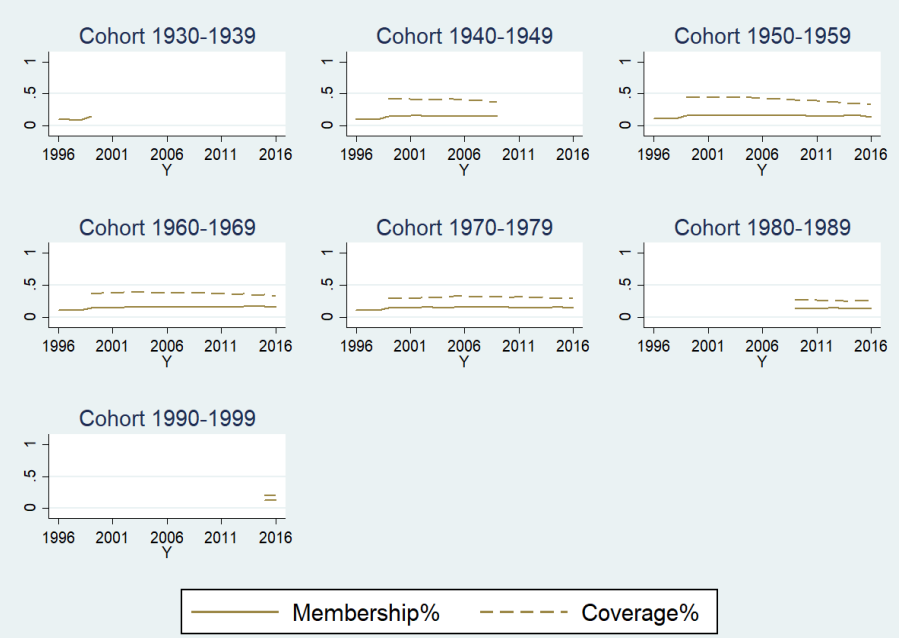

Figure 4.3: Union membership and coverage trend by cohort.

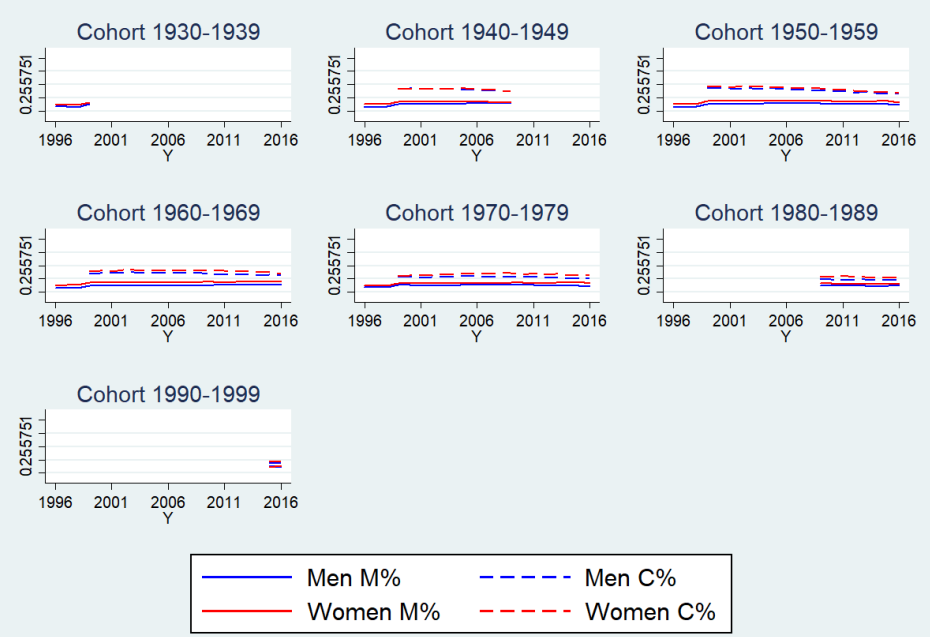

Figure 4.4: Union membership and coverage trend by cohort & gender.

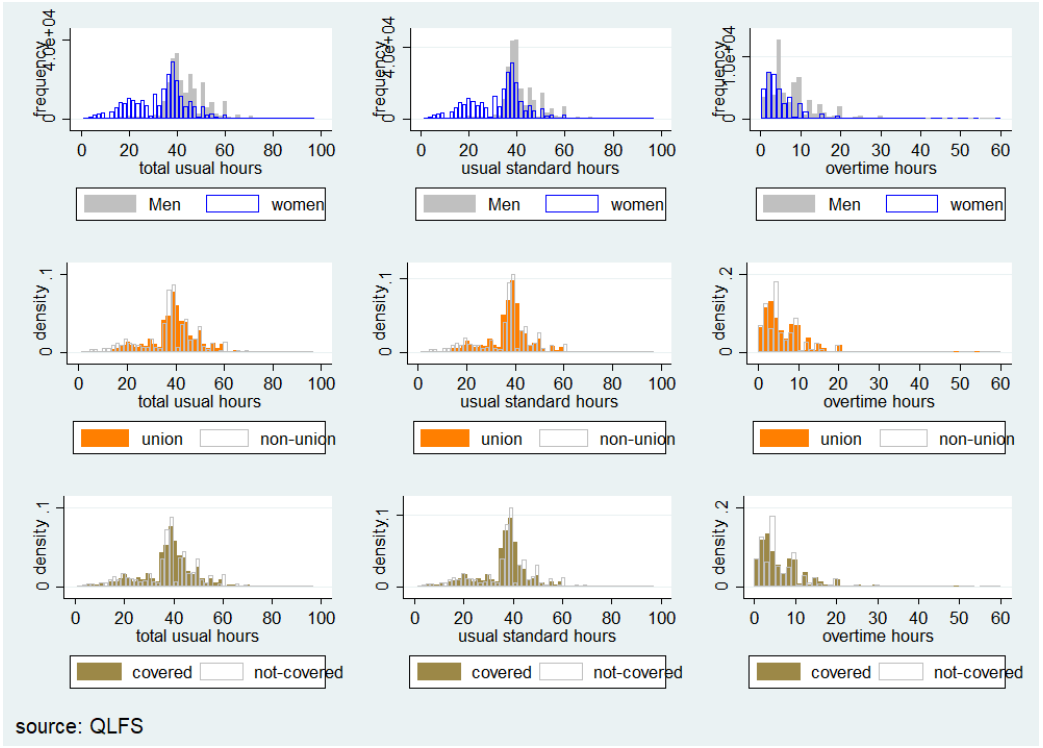

Figure 4.5: Hours distribution as per gender, union status and coverage

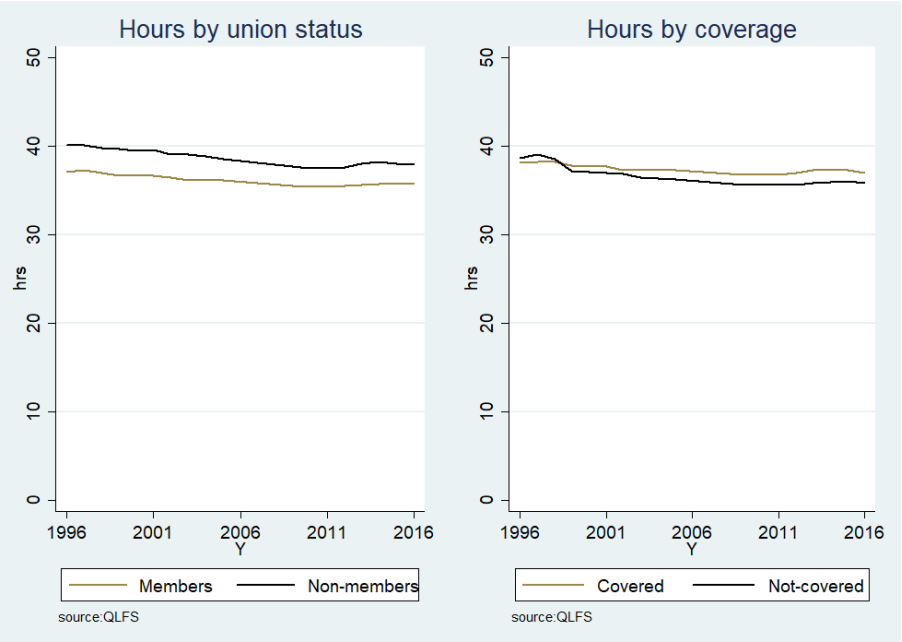

Figure 4.6: Hours' time series by union status

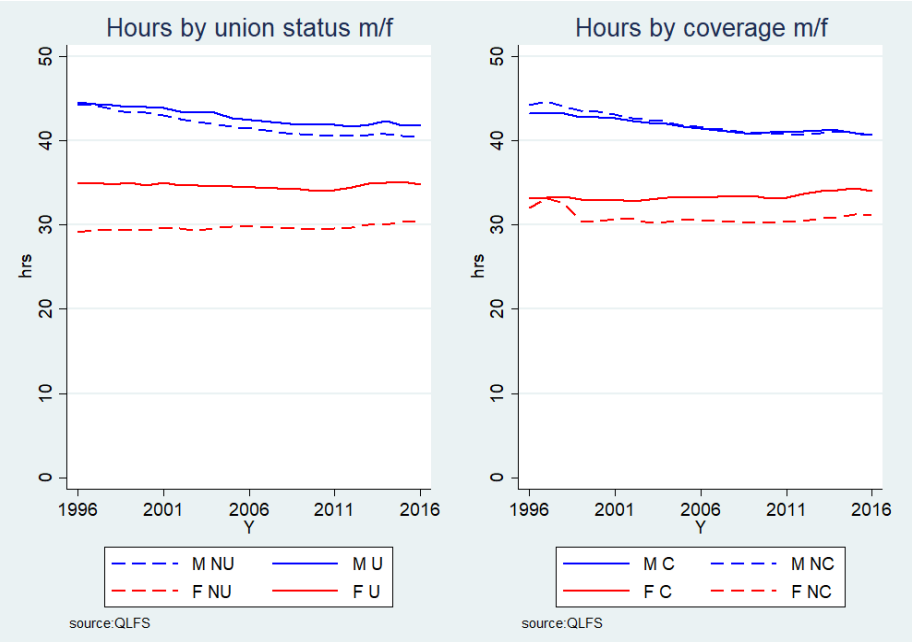

Figure 4.7: Hours` time series by union status and gender

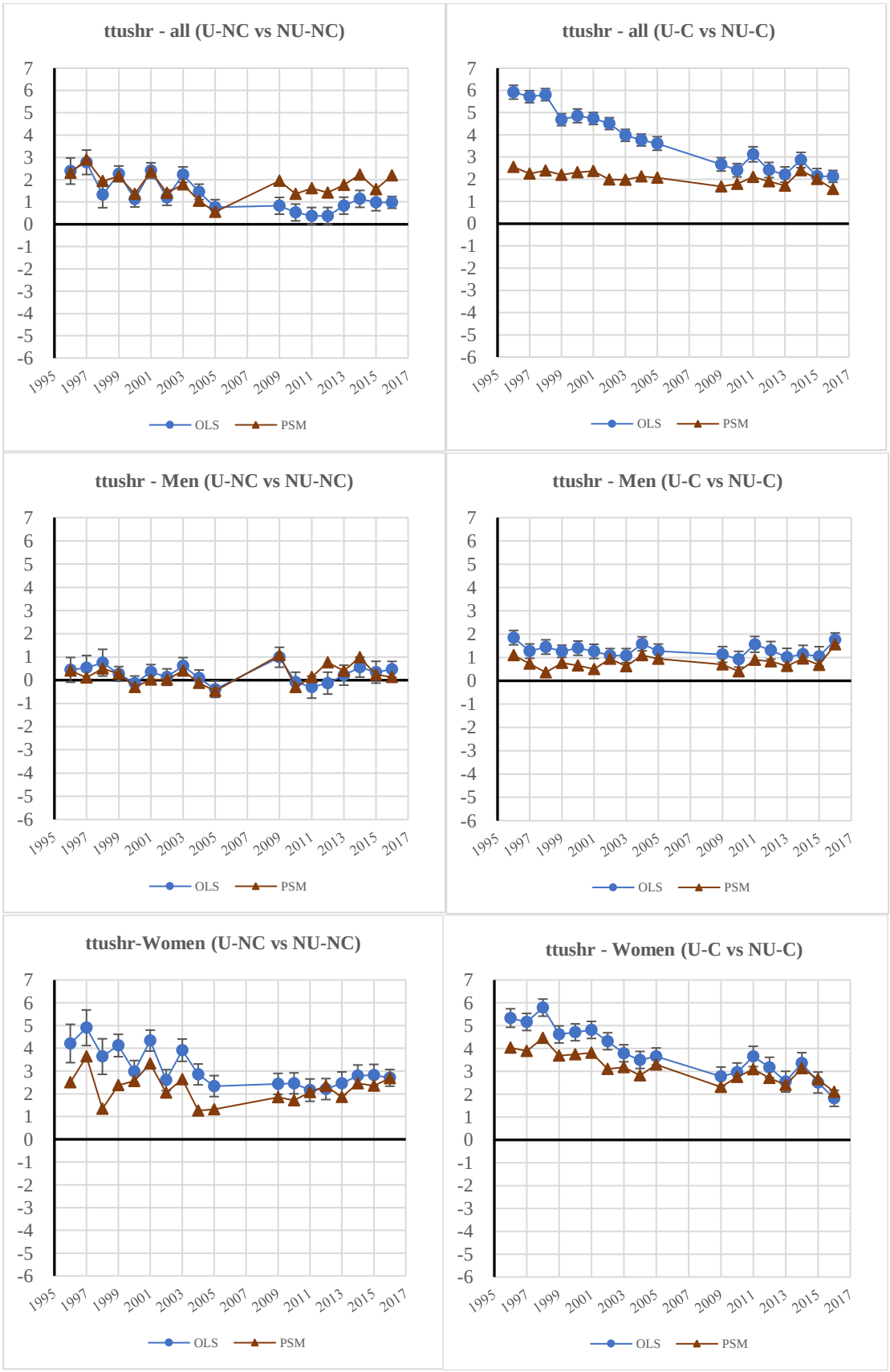

Figure 4.8: Membership effects on Weekly total usual hours.

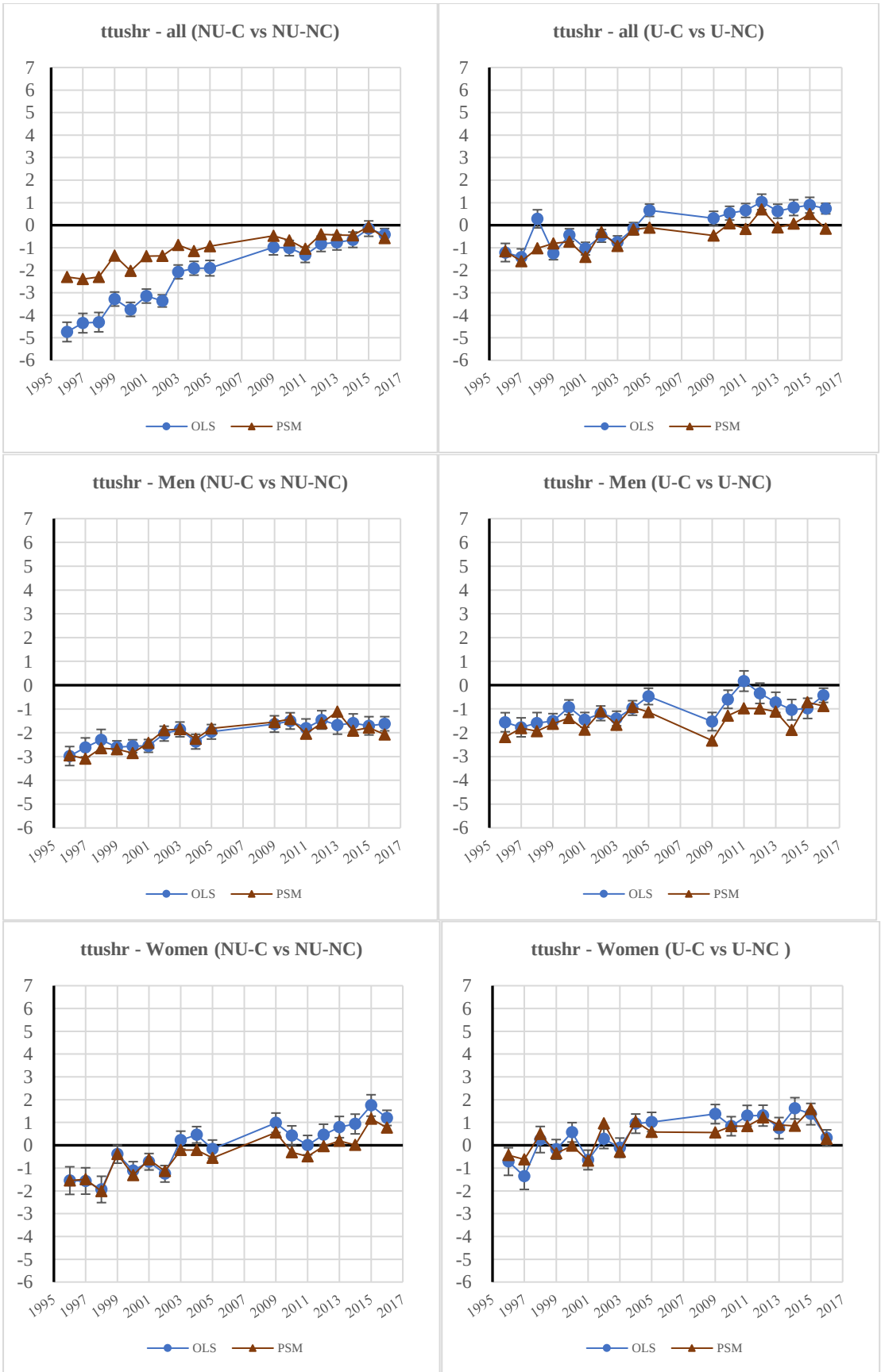

Figure 4.9: Coverage effects on Weekly total usual hours.

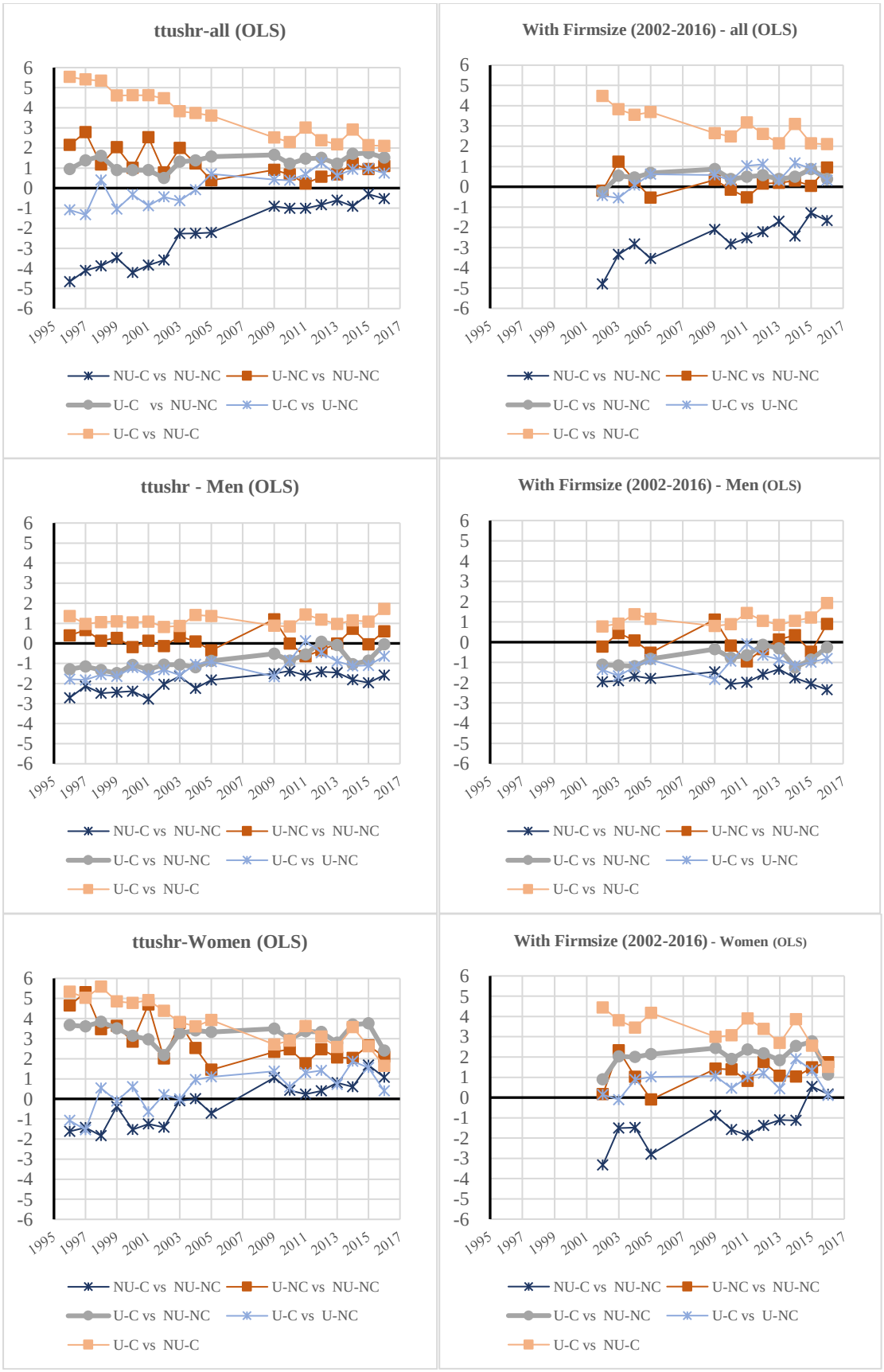

Figure 4.10: Union compound effects on Weekly total usual hours with OLS.

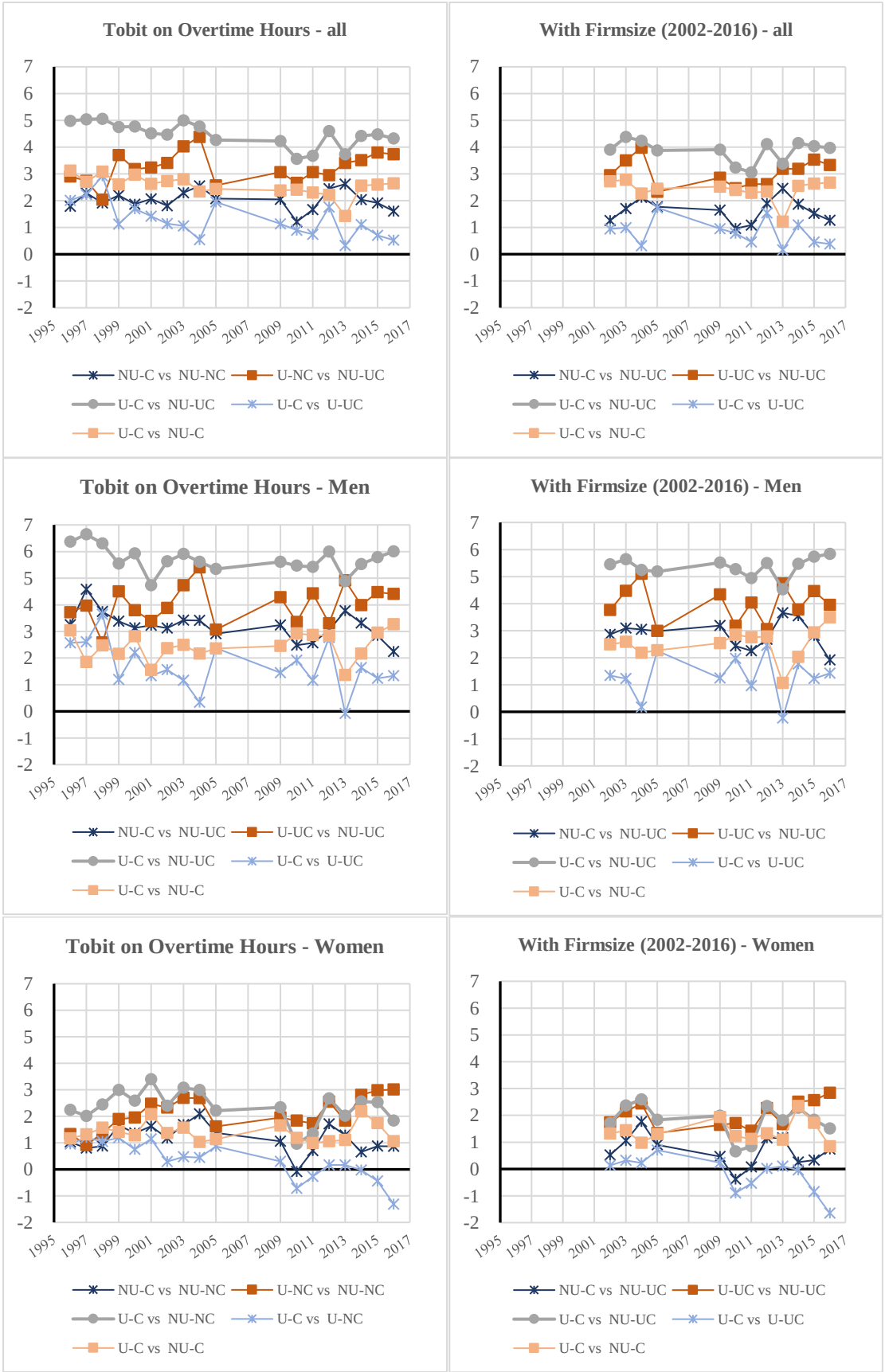

Figure 4.11: Tobit on paid overtime hours.

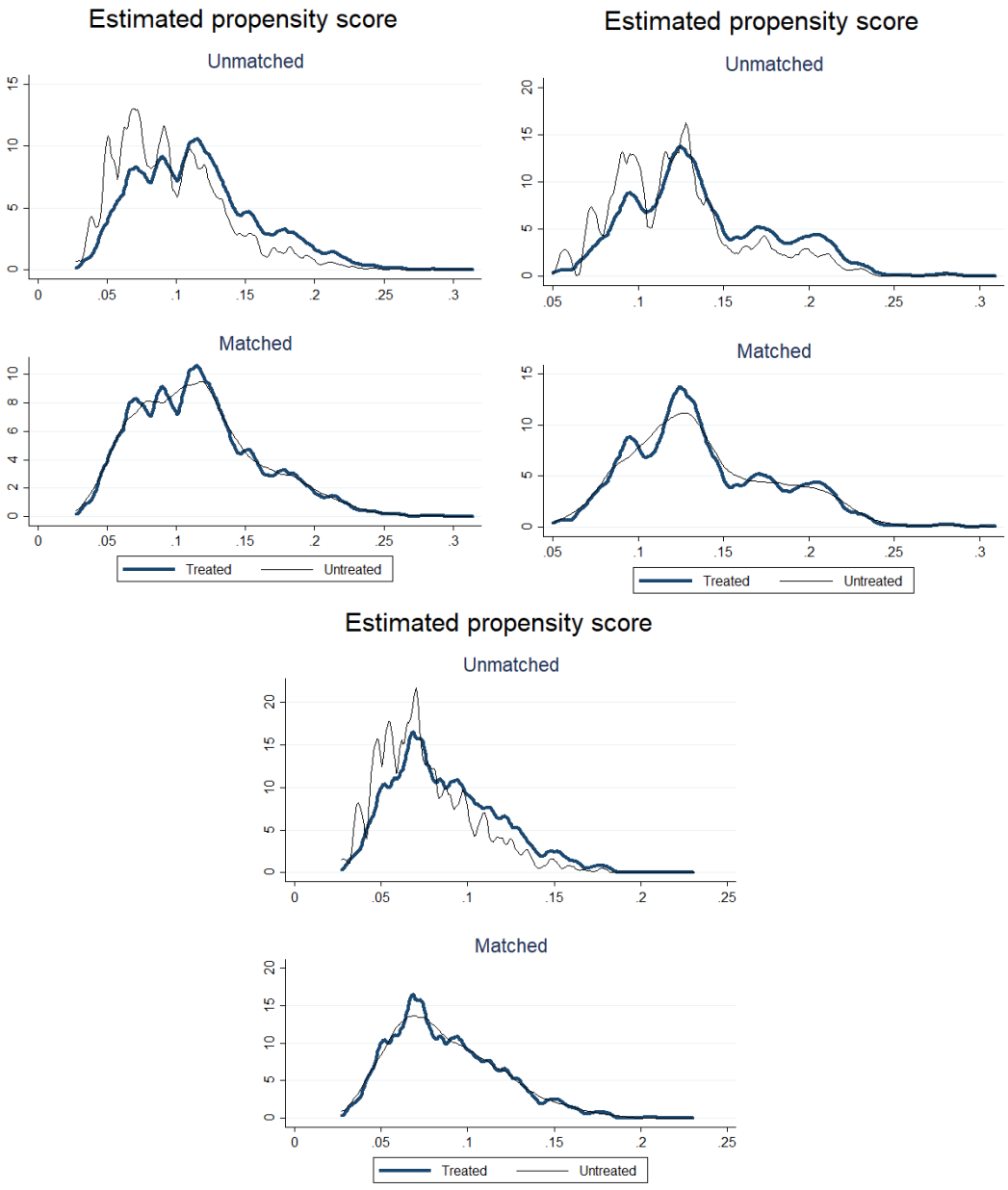

Figure 4.12 PSM matching performance (Men, Women, all)

Chapter 5

Concluding Remarks

In this thesis, I have addressed three separate yet related topics on the economics of labour supply. Chapter 2 surveys the labour supply behaviour in the UK at three different aspects: static labour supply, life-cycle labour supply and labour supply in trade unions. With the insight in the labour supply trends, we therefore are interested to find out how large are the labour supply responsiveness to changes in income to understand the driving forces behind such variations in labour supply. Therefore in Chapter 3 we seek to estimate married couples` labour supply responsiveness to exogeneous wage changes; this has important policy implications, since if we know the magnitude of the labour supply responsiveness of a particular subgroup of the population, we could work out the distortion effects on labour supply of any potential tax or benefit policy to mitigate loss and maximize the gain in welfare. In this particular chapter, we use instruments such as discontinuities on the tax and benefit profile as well as the reform induced changes to generate exogenous variations to recover our parameters in the analysis. However, our understanding towards the hours of work determination may be short-sighted if we only consider the individual focused supply side of labour, the institutional factors should also be accounted. Over the past decades, one of the most important institutional changes in the labour market has been the dramatic decrease in the influences of trade unions. Despite the decrease in coverage and influence, unions still play an important role in setting labour market properties, such as wage, hours and many other benefits. We therefore have spotted a literature gap – the impact of unionization on workers` hours of work. Hence, in Chapter 4 We explore and attempt to gauge the direction and magnitude of such effects.

There are some interesting and useful findings in my research. In Chapter 2, I find that

labour supply does vary over all the demographic characteristics. We investigated at both margins, hours and participation. There is also strong evidence for lifecycle labour supply, especially for women, who are much more likely to smooth their consumption (working) across the lifecycle. Moreover, our results suggest that Education interestingly affects men and women`s working hours very differently the positive effect on women are fairly significant, especially amongst the highly educated. Whereas, men`s working hours are hardly different on average across all education levels; Despite the fact that men are much more likely to work full time than women, the proportion of part-timers amongst men has increased dramatically over time; The historically persistent hours gap between single and married workers has been closed in the recent decade due to the steady increase in married women`s working hours; The best remunerated workers are most likely to work a standard full-time working week, those working longer or shorter hours than standard are significantly less well paid.

The effect of marital status on the lifecycle profiles can be understood by the division of labour within a family: it pushes up the lifecycle profiles of married men and lowers the lifecycle profiles of married women.

Both union membership and union coverage rates have been falling over time, though the fall in the rates of male workers are more pronounced. The patterns are consistent by education, sector, industry and occupation; The union premiums (wage and hours) are consistent in patterns, with membership premium decreases and coverage premium increases over time. This chapter set out to paint the picture of labour supply behaviors in the UK, it is descriptive in nature, therefore findings should be pushed further so that more meaningful in-depth insights could be gained.

My results in Chapter 3 indicate that women`s labour supply are more responsive than that of men at all margins, hours, participation and lifecycle. and wage changes have a larger effect on the decision to work, but a smaller effect on hours of work. Frisch elasticities suggest that women, rather than men, especially the ones with lower education are more prone to smooth their consumption across lifecycle due to child

bearing and rearing There are several limitations in our study, namely the lack of accurate measures for non-labour income/property income, without it, the parameter estimates are uninterpretable. Spouse income that we used as an equivalent measure, potentially downward biases our estimates. Furthermore, in our analysis, we treat the couples individually, such separability is too strong an assumption if we consider the collective decision making within families. Future work might consider other data sources which has available and well measured non-labour income, yet even better if they are panel data. And researchers can also consider to place the analysis within a family labour supply model, and compare and contrast the results.

Chapter 4 is the first evidence we know of in the UK which estimates the union effects on hours of work. We show that the size of the effects is largely between -6 and 6 hours depending on characteristics, such as gender, type of effects and groups of people. And the size of the effects is falling overtime. We also show that unions do alleviate firms` greed on workers in terms of unpaid overtime hours. The limitations are that the analysis are only preliminary explorations, and yet to unveil much of the mechanism of the transmission in this relationship. Further, the analysis can be improved with potential of finding good instruments to overcome the endogeneity issue. Future work might consider to jointly model hours of work and wage, which could shine more light on the transmission mechanism from unionization to hours, wage and income. Future work might also consider to model the interactions between paid and unpaid overtime hours, which may shed more light on more behavioral understandings on hours determination.

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