National Institute of Economic and Social Research

AN INVESTIGATION INTO THE EXTENT OF NON-COMPLIANCE WITH THE NATIONAL MINIMUM WAGE[1]

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Final Report to the Low Pay Commission

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Abstract

Non-compliance with the National Minimum Wage (NMW) Act directly undermines the objectives of the policy and is hence of keen policy interest. Evidence, to date, on the extent of non-compliance in the UK has been generally anecdotal and/or qualitative. In this report, we confront directly methodological issues in relation to the measurement of non-compliance to produce analysis on the nature, evolution and distribution of non-compliance with the NMW in the UK. We also construct local area measures of non-compliance in order to estimate econometric models of non-compliance that show the relationship between non-compliance and the bite of the NMW as well as some indicators of the economic cycle. The results show that non-compliance increased over time according to LFS estimates, but was broadly stable over time according to ASHE estimates. Non-compliance was generally higher for younger workers than adult workers. Adjusting non-compliance estimates for the possible reporting of earnings at rounded rates can have a large impact on non-compliance estimates, as can adjustments relating to apprentices for workers eligible for the Youth Development Rate and the 16-17 Year Old Rate. Models of non-compliance indicate that non-compliance fell during the recent economic downturn according to ASHE estimates, but increased according to LFS estimates.

Executive Summary

Introduction and Overview

Non-compliance with the National Minimum Wage (NMW) Act directly undermines the objectives of the policy. Much of the evidence about non-compliance to date has been generally anecdotal and/or qualitative (for example Ram, 2004). In this report, we confront directly the methodological and data issues that, to date, have hindered quantitative analysis. We are mainly concerned with issues of measurement. The biggest challenges in assessing the extent of non-compliance with the NMW relate to whether pay can be accurately measured in national surveys and whether key exemptions in NMW policy are adequately captured in these national datasets.

The Low Pay Commission (LPC) notes that 'achieving and maintaining a high level of compliance requires widespread awareness and understanding of the wage arrangements, and also enforcement'. Furthermore, one of the guiding principles of the NMW regime has been one of simplicity, helping make it easy to understand, implement and enforce. To this end, evidence to the LPC indicated that whilst the regulations are seen as simple enough, there were requests for better guidance.

Data sources and measurement issues

In line with most other analysis of worker pay related to the NMW, we use the Labour Force Survey (LFS) April 2000 – March 2012 and the Annual Survey of Hours and Earnings (ASHE) 2000 - 2011 to construct our estimates of non-compliance. Issues relating to measuring levels of pay in these national surveys have been considered widely and are relatively well-understood (Ormerod & Ritchie, 2007; and Hicks, Conn, & Johnson, 2009).

ASHE is the National Statistic source for estimates of the number of jobs paying below the NMW. However, ASHE does not collect data on all the characteristics of the low paid (e.g. ASHE does not include any data about qualifications of workers); hence estimates from the LFS are important when looking at some groups of workers affected by the NMW.

Our analysis of LFS data uses the approach developed by (Skinner, Stuttard, Beissel-Durrant, & Jenkins, 2002) in which missing values on the new hourly rate variable are replaced by imputed values.

A further complication with pay measurement at levels close to the NMW is highlighted by (Ormerod & Ritchie, 2007) who identify that when the NMW is close to a round number many employees report pay at the nearest round number rather than the NMW. This round number may be above or below the NMW. For issues relating to non-compliance, this only becomes important for reporting of pay at a round number below the NMW. Here, error in reporting may lead to higher estimates of non-compliance. To deal with this problem we present adjusted non-compliance estimates based on a NMW rate rounded down to the nearest 10 pence.

Some workers can be paid below the NMW for legitimate reasons:

- Bonuses and commissions count for pay for NMW purposes such that the basic hourly pay (i.e. excluding extras) may have been lawfully below the NMW. Until October 2009 tips could also count for pay for NMW purposes, but from October 2009 onwards tips can no longer be included.
- NMW workers receiving accommodation from their employer can be legitimately paid below the NMW via the accommodation offset.
- Individuals on apprenticeships were exempt from the NMW until October 2010 (if they were under 19; or 19 and over and in the first year of apprenticeship) but have been entitled to the Apprentice Rate of the NMW since then.

The extent to which workers qualifying for these exemptions can be identified in ASHE and LFS is limited. Our analysis suggests that taking bonuses; commissions and tips; and the accommodation offset into account when assessing non-compliance is largely trivial in terms of their impact on estimates of non-compliance rates. However, consideration of apprentices, particularly for workers eligible for the 16-17 Year Old Rate or the Youth Development Rate makes some difference to estimates

of non-compliance. Adjusting non-compliance estimates for rounding also makes a difference to estimates of non-compliance.

Baseline estimates of non-compliance rates

Using LFS data that has been adjusted using the Skinner et al. multiple imputation approach, we calculate baseline estimates of non-compliance based on the main job of each worker. The ASHE data require no such adjustments to hourly pay. Baseline estimates from each source can then be compared. We plot these estimates of non-compliance over time from both data sources at an aggregate level and by some key worker characteristics: gender, firm size[2], sector and region.

According to the LFS the baseline non-compliance rate was relatively stable at around 0.5% between 2000 and 2004 after which it increased year-on-year, with the exception of 2010, reaching 2.1% in the first quarter of 2012.

Baseline non-compliance is typically higher for younger workers than adult workers. The differences are clear according to ASHE data, but the volatility of the estimates according to the LFS data (due to modest sample sizes, particularly for workers eligible for the 16-17 Year Old Rate) make the patterns less clear cut.

The ASHE estimates of adult baseline non-compliance are relatively stable for most of the period, typically just below 1%, whilst the LFS baseline estimates show a different picture with the non-compliance rate increasing from 0.4% in 2000 to 2.0% in 2012. Baseline non-compliance rates for 16-17 Year Old Rate and Youth Development Rate workers are also stable for much of the period, according to ASHE estimates, but both increase between 2009 and 2011. The LFS baseline estimates of non-compliance for 16-17 Year Old Rate and Youth Development Rate workers also show an upward trend, albeit with some volatility in the estimates.

Baseline non-compliance rates also varied by other worker characteristics; they were higher for women than for men; lowest in London (ASHE estimates, but not LFS

[2] The LFS records the size of the workplace rather than the firm. Workplace is an imperfect measure of firm size, because in many instances the firm will be substantially larger than the workplace. ASHE includes an identifier that indicates the number of employees in the reporting unit where the respondent works. In the vast majority of cases, the reporting unit is equivalent to the enterprise. However, in some cases, typically larger firms, the firm may be made up of several reporting units.

estimates); higher in Distribution, Hotels and Restaurants; and in Other Services; and highest in firms/workplaces with fewer than 25 employees.

The bite of the NMW (the ratio of the NMW to median earnings) increases over time for each age group. The bite was lower for adult workers followed by 16-17 year old workers and then those eligible for the Youth Development Rate. In general, non-compliance rates for adult workers were higher when the bite of the adult NMW was also higher.

Adjusted estimates of non-compliance rates

For adult workers the largest adjustment to non-compliance rates was related to reporting of earnings at focal points in the earnings distribution. Thus if the NMW rate was assumed to be rounded down to the nearest 10 pence, then non-compliance rates would be, on average, 0.6 percentage points lower according to LFS estimates and 0.2 percentage points lower according to ASHE estimates.

For 16-17 Year Old Rate and Youth Development Rate workers the treatment of apprentices also made a big difference to non-compliance estimates. In the case of 16-17 year-olds, reducing non-compliance rates by as much as 2.5 percentage points in 2011, but in other years, reductions of around 0.5 percentage points were typical. For Youth Development Rate workers the adjustments were more stable over time, reducing non-compliance estimates on average by around one percentage point. These adjustments can only be identified with LFS data and, given the relatively small number of workers eligible for the 16-17 Year Old Rate and the Youth Development Rate, are often not very precisely determined.

For adult workers, the non-compliance rates estimated from ASHE and LFS are in general not hugely different in the period up to 2005 when NMW rates were set in multiples of 10 pence. Following this, the ASHE estimates remain broadly constant over time with a rate of 0.6% in 2011, whilst the LFS estimates increase, even after the rounding adjustment up to 1.2% in 2011.

Taking all the adjustments into account, the average non-compliance rate from 2002-2011 according to ASHE was 0.8% for adults; 2.6% for workers on the Youth

Development Rate; and 4.3% for 16-17 Year Old Rate workers (2005-2011). The equivalent figures from the LFS were 1.0% (adults), 1.4% (Youth Development Rate) and 1.3% (16-17 Year Old Rate). The estimates for adults are similar, but the adjustments made to the LFS estimates for 16-17 Year Old Rate and Youth Development Rate workers make them much lower than the ASHE estimates.

Models of non-compliance

Our models of non-compliance reflect the differences between the two data sources in non-compliance estimates. Analysis based on ASHE suggests non-compliance rates were negatively associated with indicators of the downturn (e.g. negatively associated with local area unemployment and positively associated with GDP growth). According to analysis based on the LFS, the evidence shows a relationship in the opposite direction although the impacts are weaker (non-compliance rates were not associated with local area unemployment and negatively associated with GDP growth).

For both data sources, non-compliance was generally positively associated with the bite of the NMW.

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Abbreviations

ASHE	Annual Survey of Hours and Earnings
LFS	Labour Force Survey
NIESR	National Institute of Economic and Social Research
NMW	National Minimum Wage
ONS	Office for National Statistics

1 Introduction and overview

Non-compliance with the National Minimum Wage (NMW) Act directly undermines the objectives of the policy and is hence of keen policy interest. However, evidence to date has been generally anecdotal and/or qualitative (for example Ram, 2004). In this report, we confront directly the methodological and data issues that, to date, have hindered quantitative analysis.

The importance of compliance with the NMW is highlighted in the Low Pay Commission (LPC) 2012 report (LPC, 2012). The report also notes that 'achieving and maintaining a high level of compliance requires widespread awareness and understanding of the wage arrangements, and also enforcement'. Here, the cut in advertising expenditure from 2010 onwards may influence NMW awareness and hence non-compliance rates.

One of the guiding principles of the NMW regime has been one of simplicity, helping make it easy to understand, implement and enforce. To this end, evidence to the LPC indicated that whilst the regulations are seen as simple enough, there were some requests for better guidance. The complexity and lack of understanding of the legislation may lead to greater non-compliance, but also relevant is the nature of the impact of the NMW. It is well understood (LPC, 2012) that the NMW has more of an impact on particular sectors of the economy and on particular groups of workers. This is related to the type of work these workers do, the kind of payments they receive or other aspects of their work arrangements. However, in this report we are mainly concerned with issues of measurement. The biggest challenges in assessing the extent of non-compliance with the NMW relate to whether pay can be accurately measured in national surveys and whether key exemptions in NMW policy are adequately captured in these national datasets.

Much of the focus of the report is on identifying these measurement issues and then making a range of assumptions that allow us to derive alternative measures of non-

compliance with the NMW. Our attempts to assess the extent of non-compliance are limited by the available data and we acknowledge that some biases may remain in all our estimates of non-compliance. This means that the results presented are not definitive, but we believe the analysis provides relevant and useful evidence on the nature, evolution and distribution of non-compliance with the NMW in the UK.

Many biases in estimates of the level of non-compliance with the NMW could be argued to be stable over time. Hence considering changes over time in non-compliance should lead to unbiased estimates. However, we acknowledge a particular form of measurement error in the reporting of pay at levels close to the NMW whereby there appears to be a degree of rounding in the reporting of hourly pay levels (see Ormerod & Ritchie, 2007 for more details) which may lead to some inconsistencies over time. One of the assumptions we incorporate into our analysis allows for the reporting of pay at round numbers in years where the level of the NMW is not a round number. Furthermore, as the number of apprentices increased over time it is possible that the bias associated with under recording of apprenticeships in the data may be increasing over time. However, our analysis does not indicate an increase over time in the adjustment of non-compliance rates that is related to apprenticeships.

We present a range of estimates of non-compliance with the NMW based on the methodology used in Ashenfelter & Smith (1979) and further developed in Grenier (1982) and Chang & Ehrlich (1985) using a number of different assumptions about the measurement of pay outlined in Sections 2.1 and 2.2. This is applied to data from the Annual Survey of Hours and Earnings (ASHE) and the Labour Force Survey (LFS), which offer the most reliable measures of hourly pay in the UK.

As well as presenting a variety of estimates of non-compliance rates, we also apply the methodology to construct local area measures of non-compliance, which we use for econometric estimations to attempt to answer the following key policy questions:

- Have successive increases in the NMW affected the extent of non-compliance in the economy?

- Has non-compliance been exacerbated by the recession?
- Does the extent of non-compliance vary by firm size?
- Is the level of non-compliance different across broadly defined low paying sectors?
- Is non-compliance higher where the 'non-complying market wage' is closer to the NMW (Ashenfelter & Smith, 1979) or where this is further from the NMW (Grenier, 1982), (Chang & Ehrlich, 1985)? Here we use the bite of the NMW as a proxy for the 'non-complying market wage'. The bite of the NMW is defined as the NMW divided by the median hourly wage in the cell.

The remainder of the report is structured as follows. Data sources and methodological issues are discussed in detail in the following section. Section 3 lays out the research methods used. Section 4 presents estimates of non-compliance by key worker characteristics and Section 5 shows the results from our econometric estimates. Section 6 concludes.

2 Data sources and measurement issues

Obtaining an accurate estimate of those unlawfully paid below the NMW depends on being able to identify the correct hourly pay for workers, and on being able to exclude those paid below the NMW for legitimate reasons.

In line with most other analysis of worker pay related to the NMW, we use the Labour Force Survey (LFS) April 1999 – March 2012 and the Annual Survey of Hours and Earnings (ASHE) 1999-2011 to construct our estimates. They are both official data sources and may not effectively cover the non-compliant population; for example coverage of the informal sector of the economy may be limited in both surveys. In the LFS individuals may not report information about informal jobs which may not be compliant with the NMW legislation; and because ASHE data is provided by employers, they may not report jobs which are not compliant with NMW legislation. As such, estimates of the percentage of workers paid below the NMW from official data sources are likely to be lower than the real extent of non-compliance with the NMW across the whole economy.

A further issue to note is that non-compliance rates are expressed as the percentage of the whole working population. However, many millions of workers have earnings well in excess of the NMW and these workers would need to see a substantial fall in earnings in order to be non-compliant with the NMW. This means that changes in non-compliance rates will be dampened by the large numbers of workers for whom non-compliance is never a real concern.

Issues relating to measuring levels of pay in the LFS and ASHE have been considered widely and are relatively well-understood (Ormerod & Ritchie, 2007; and Hicks, Conn, & Johnson, 2009). Below we consider the key measurement issues and identify how exemptions are identified in the data.

We aggregate the four quarters of LFS data with the same NMW and these are referred to as NMW years, e.g. NMW year 2002 is 2001 Q4 to 2002 Q3.

2.1 Measuring pay

ASHE is the National Statistic source for estimates of the number of jobs paying below the NMW. However, ASHE does not collect data on all the characteristics of the low paid (e.g. ASHE does not include any data about qualifications of workers); hence estimates from the LFS are important when looking at some groups of workers affected by the NMW.

When the NMW was introduced in 1999, neither data source was ideal in identifying workers paid below the NMW. ASHE was largely sampled from PAYE records and hence many low paying workers, particularly part-time workers, were not included in the survey. The LFS also had problems in correctly identifying hourly pay rates for some employees.

Since 1999, the coverage of ASHE has improved and weights have been developed to allow the number of low paid workers to be estimated more accurately. In the LFS, questions were introduced to identify workers that were paid hourly and then these workers were asked to report their hourly rate. This too improved estimates of the number of low paid workers. However, for workers who were not paid hourly, problems remain with the derivation of hourly pay.

An approach was developed by (Skinner, Stuttard, Beissel-Durrant, & Jenkins, 2002) in which missing values on the new hourly rate variable are replaced by imputed values. This leads to substantially reduced estimates of low pay proportions based on the LFS because at the bottom of the earnings distribution these imputed values are on average higher than derived figures of hourly earnings. The authors report that these new estimates of hourly pay are more accurate and estimates of low pay from the LFS using them are more in line with ASHE estimates. The analysis presented in this report is based on data where this imputation method has been applied to the LFS data.

A further complication with pay measurement at levels close to the NMW is highlighted by (Ormerod & Ritchie, 2007) who identify that when the NMW is close to a round number many employees report pay at the nearest round number rather

than the NMW. This round number may be above or below the NMW. For issues relating to non-compliance, this only becomes important for reporting of pay at a round number below the NMW. Here, error in reporting may lead to higher estimates of non-compliance.

2.2 NMW exemptions

Some workers can be paid below the NMW for legitimate reasons:

- Until October 2009 bonuses, commissions and tips could count as pay for NMW purposes such that the basic hourly pay (i.e. excluding extras) may have been lawfully below the NMW. From October 2009 onwards bonuses and commission can still count as pay for NMW purposes, but tips no longer can.
- NMW workers receiving accommodation from their employer can be legitimately paid below the NMW via the accommodation offset.
- Apprentices defined under the Master and Servant Act were exempt from the NMW until October 2010; as were those on a specified government apprenticeship scheme. Since then apprentices under the age of 19 and those aged 19 and over in the first 12 months of their apprenticeship are entitled to the Apprentice NMW.

The extent to which workers qualifying for these exemptions can be identified in ASHE and LFS is limited. In relation to bonuses, commissions and tips; in ASHE hourly pay including and excluding incentive pay can be identified[3]. However, the LFS identifies those in receipt of such extras, but not the amount they receive, thereby not allowing precise identification of whether these are sufficient to bring reported pay for those below the NMW to a level above the NMW. Similarly, the LFS asks

[3] In practice including incentive pay makes almost no difference to estimates of non-compliance. In line with the data used by the LPC and the ONS, the ASHE estimates presented throughout the report include incentive pay.

whether individual's gross pay includes piecework payments, but does not report how much of the pay is on this basis.

The accommodation offset is not reported in ASHE. In the LFS it is possible to identify whether accommodation goes with the job of anyone in the respondent's household, but not the value of the accommodation.

Apprenticeship status is not reported in ASHE, and only partially reported in the LFS. The LFS asks respondents if they are doing a recognised apprenticeship. However, there may be other apprenticeship types that are eligible for the NMW exemption, but are not recorded as recognised apprenticeships in the LFS. Hence the number of apprentices that would qualify for the exemption is likely to be underestimated. The LFS also includes questions about the receipt of work related training which will be related to apprenticeships. However, this is probably too broad an indicator of apprenticeships, but along with the recognised apprenticeship indicator discussed above allows us to examine broader definitions about which workers may be exempt from the NMW.

3 Research methods

The data limitations described above mean that it will not be possible to provide an accurate estimate of the level of non-compliance with the NMW. However, we do not believe these limitations preclude making a best attempt to extract relevant information on non-compliance from the survey data.

3.1 Adjusting pay estimates in the LFS

Before undertaking any analysis of LFS data, we applied the fractional imputation methodology of (Skinner, Stuttard, Beissel-Durrant, & Jenkins, 2002) to the LFS data. This uses personal characteristics (including stated and/or derived hourly pay rates) in a model that predicts an hourly rate for each worker. This allows the ranking of workers in terms of their similarity to each other. Then, workers without a stated hourly rate receive the stated hourly pay rates from the five workers directly above and five workers directly below them in the ranking.

Thus workers without a stated hourly pay rate receive a donated stated hourly pay rate from 10 workers who are close to them in terms of predicted derived hourly wages. The fraction of these 10 hourly pay rates is then used to compute the number of jobs below the NMW, such that if two of the ten rates were below the NMW rate then this counts as 0.2 of a job below the NMW. This is the methodology used by the Office of National Statistics (ONS) to determine the number of jobs paid below the NMW (see Box 1 in (Hicks, Conn, & Johnson, 2009) for more detail).

In an additional step, we take the average of these 10 rates and calculate a new hourly pay rate for each individual. This allows us to obtain a single wage distribution utilising the information contained in both the pay variables[4]. We use the new wage

[4] Note that for cases with a valid stated hourly rate the new rate will be equal to the stated hourly rate. Those cases with a valid derived hourly pay rate, but not a valid stated hourly rate will be assigned a new pay rate.

distribution to calculate the relevant median wages[5] that are required to determine the bite of the NMW for each key worker characteristic.

3.2 Baseline and alternative estimates of non-compliance

Using this modified data we calculate baseline estimates of non-compliance based on LFS data (Section 4.1). These estimates are based on the main job of each worker. The ASHE data require no such adjustments to hourly pay and the baseline estimates from each source can be compared. We plot these estimates of non-compliance over time in section 4.2 using both data sources; both in aggregate and by some key worker characteristics: gender, firm size[6], sector and region.

We then calculate alternative estimates of non-compliance based on differing treatment of the biasing factors highlighted in Section 2.2.

For both data sources we address the bias from pay being reported in terms of rounded hourly rates by rounding down the NMW rates to the nearest 10p. This means, for example, that for the adult NMW of £5.93 per hour that applied from October 2010 to September 2011; our alternative measure of non-compliance would consider only those workers paid below £5.90 per hour. In this example, the estimate of non-compliance is reduced by 0.3 percentage points according to ASHE estimates and by 0.4 percentage points according to LFS estimates.

For the LFS data we also consider data adjustments in relation to the NMW exemptions discussed in Section 2.2. As noted, the survey allows only partial identification of some of these biases. To assess the extent to which biases affect the estimates of non-compliance we construct different non-compliance measures using

[5] Alternative specifications of the median wage using the original variables hourpay and hrrate produce very similar results. In 2008q2 the new pay variable produces a median wage for adults of £9.82 (Bite of NMW 0.56), the hourpay variable on its own £10.04 (Bite 0.55) and a combination of hrrate and hourpay £10.00 (Bite 0.55).

[6] The LFS records the size of the workplace rather than the firm. Workplace is an imperfect measure of firm size, because in many instances the firm will be substantially larger than the workplace. ASHE includes an identifier that indicates the number of employees in the reporting unit where the respondent works. In the vast majority of cases, the reporting unit is equivalent to the enterprise. However, in some cases, typically larger firms, the firm may be made up of several reporting units.

a range of assumptions. For the accommodation offset the baseline estimate assumes the accommodation offset has no impact on non-compliance. Our alternative assumption in this case is that anybody who earned below the NMW and reported in the LFS that accommodation goes with the job of anyone in their household would not be considered as having pay that was not compliant with the NMW. Similar assumptions are made in relation to bonuses, tips and commission and apprentices. In the case of apprentices we consider responses to LFS questions about whether the worker was doing a recognised apprenticeship; or whether they received work related training or education in the week, four weeks or 13 weeks prior to their interview.

The aim of this approach is to assess which possible biases have a large impact on the non-compliance estimates.

3.3 Models of non-compliance

Finally, using non-compliance rates across local areas we estimate regression models of non-compliance to assess which factors are important determinants of non-compliance in the UK.

The cell size for each of these local areas is an important consideration as this will affect the sampling variability of the measure of non-compliance and therefore the extent to which we can recover a true impact of changes in non-compliance. The large sample size means this is relatively straight forward using ASHE data, whilst for the LFS we will need to combine quarterly data to give us annual observations.

We construct measures of non-compliance for 136 county/unitary authority units[7] covering a period of 11 upratings (1 October 2001 - 1 October 2010) in order to analyse these measures of non-compliance econometrically.

$$NC_{it} = \varphi X_{it} + f_t + r_i + \varepsilon_{it} \qquad (1)$$

[7] (Dickens, Riley, & Wilkinson, 2009) derived 135 areas for Great Britain and we have added Northern Ireland to the LFS analysis as an additional area to cover most of the United Kingdom.

$$NC_{it} = \varphi X_{it} + r_i + \varepsilon_{it} \qquad (2)$$

The dependent variable (*NC*) in equations 1 and 2 is the measure of non-compliance in area *i* in year *t* where the non-compliance rate is the proportion of workers paid below the legislated NMW. Local area fixed effects are captured by *r* for each area *i.* Time dummies are captured by NMW year dummies *f* in equation 1, whilst these are excluded in equation 2, where variations in time are captured by annual UK real GDP growth and local area unemployment rates (encapsulated in the vector of regressors *X*).

The main factors we explore are presented below:

- **Trends over time.** We test for the extent to which compliance has improved or worsened since the introduction of the NMW by introducing year dummies *f* to account for changes over time. This also allows us to assess whether non-compliance changed following the cut in awareness-raising expenditure from 2010 onwards.
- **Impact of the recession.** We test for whether compliance levels suffer during recessionary periods, by including controls for annual UK real GDP growth and more locally defined measures of the economic cycle (local area unemployment rates) within the vector of regressors *X.*
- **Bite of the NMW.** Theoretical models disagree on whether the incentive to not comply is higher where the 'non-complying market wage' is closer to the NMW, (Ashenfelter & Smith, 1979) and (Chang & Ehrlich, 1985), or where this is further from the NMW (Grenier, 1982). We seek to address this question by including the bite of the NMW (defined as the NMW/median hourly wage in the cell) within our independent variables.
- **Firm size.** The incentive to comply may be lower for smaller firms, perhaps because of a lower probability of enforcement checks. By including the share of employment by firm size in each local area, we allow this factor to affect the level of non-compliance in the local area.
- **Low paying sectors.** In line with the above, we will also include the share of employment in low paying sectors, and in each low-paying sector separately, in each area to explore how the size of given sectors might affect the level of non-compliance in the given area.
- **Other factors.** We explore whether non-compliance is related to factors such as gender, proportion of part-time workers, proportion of workers not on

permanent contracts, proportion of non-UK born workers, proportion of non-UK nationals, proportion of workers with no qualifications, proportion of ethnic minority workers.

We estimate these models using different non-compliance measures to see how robust the models are to these different specifications. The rationale behind this is that the more a result is robust to the variation in the measurement of non-compliance the less we need to be concerned about the underlying data limitations.

4 Estimates of non-compliance rates

This section presents estimates of the non-compliance rate for the overall population and certain key worker characteristics using the LFS and ASHE. Our LFS estimates are based on the main job of each worker and most of the estimates are presented only for those entitled to the adult rate of the NMW.

Section 4.1 describes our baseline estimates of non-compliance where we consider a strict definition of the non-compliance rate that includes all jobs paid below the exact value of the NMW as a proportion of all jobs. We do not adjust for rounding errors, or take into account any of the possible biases[8] in the data. In Section 4.2, we consider the impact of rounding errors and possible biases on our baseline estimates of the non-compliance rate.

We also present data on the bite of the NMW[9] estimated using the LFS and ASHE data respectively. The estimates provide some evidence for the results found by Ashenfelter & Smith (1979) that the non-compliance rate was positively related to the 'non-complying market wage'. This will be further explored in Section 5 using econometric models for local areas.

4.1 Baseline estimates of non-compliance

4.1.1 Overview of non-compliance

Figure 1 below shows the baseline non-compliance rate as well as number of jobs with an hourly wage lower than the NMW for each second quarter of LFS data[10], based on the method described in section 3.1 on page 16.

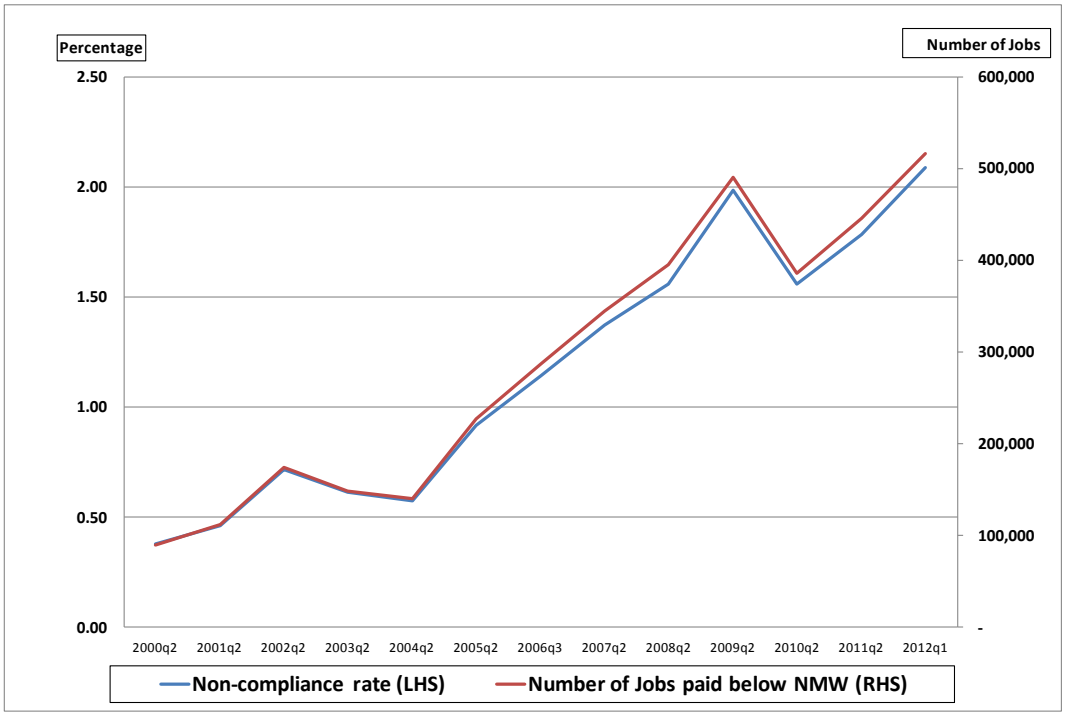
[8] As discussed in section 2.2

[9] Defined as: Bite of the NMW = NMW rate/relevant median wage

[10] Except 2006 where we have had to use q3 rather than q2 due to missing income weights in the LFS data. The second quarter is also the closest match to the ASHE data.

The non-compliance rate was relatively stable between 2000 and 2004 after which it increases year-on-year, with the exception of 2010, reaching 2.1% (516,000 jobs) in the first quarter of 2012[11].

Figure 1: LFS baseline non-compliance rate and number of jobs, all workers in main jobs



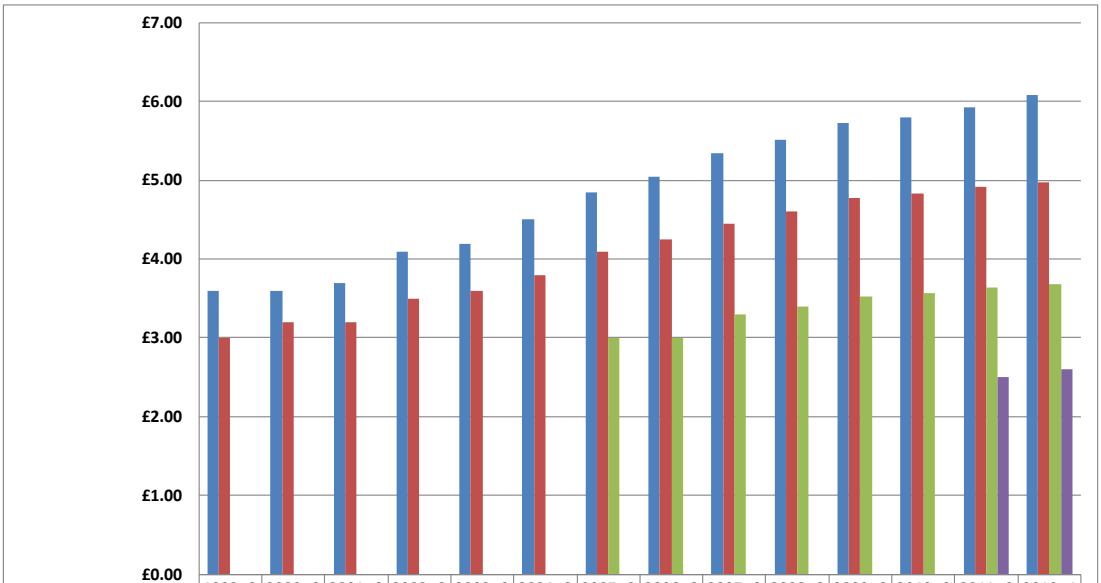
Note: Estimates are calculated from data for the second quarter of each year, with the exception of 2006q2 (due to missing data) and 2012q2 (not available at time of calculation).

There are four different rates of the NMW relating to different groups of workers[12]. Three groups are based on age (16-17 year olds, development and adult) and one for those doing an apprenticeship. Figure 2 shows the NMW rates applicable for each group.

[11] This is the latest quarter of LFS data we have available.

[12] The Apprentice Rate applied to apprentices under 19 or 19 or over and in the first year of their apprenticeship from 1 October 2010. Before this date, apprentices were exempt from the NMW. The 16-17 Year Old Rate (which came into force in October 2004) applies to all workers aged 16-17 not doing an apprenticeship. The Youth Development Rate applied to all workers aged 18-21 before 1 October 2010 and to all workers aged 18-20 thereafter not doing an apprenticeship. The Adult rate applied to all those aged 22 and over before 1 October 2010 and to all workers aged 21 and over thereafter (and not in the first year of an apprenticeship).

Figure 2: Official NMW rates in each quarter of analysis



	1999q2	2000q2	2001q2	2002q2	2003q2	2004q2	2005q2	2006q3	2007q2	2008q2	2009q2	2010q2	2011q2	2012q1
Adult rate	£3.60	£3.60	£3.70	£4.10	£4.20	£4.50	£4.85	£5.05	£5.35	£5.52	£5.73	£5.80	£5.93	£6.08
Development rate	£3.00	£3.20	£3.20	£3.50	£3.60	£3.80	£4.10	£4.25	£4.45	£4.60	£4.77	£4.83	£4.92	£4.98
16-17 year olds rate							£3.00	£3.00	£3.30	£3.40	£3.53	£3.57	£3.64	£3.68
Apprentice rate													£2.50	£2.60

We will first consider baseline non-compliance rates for the different age-related groups. Due to the difficulty in correctly identifying apprentices, we will deal with them separately in section 4.2 along with other reasons why an individual may be legitimately paid below the NMW. Having discussed baseline non-compliance by age group we then focus on the characteristics of adult workers only[13].

4.1.2 NMW age groups[14]

Figure 3 and Figure 5 show estimates of baseline non-compliance from the LFS and ASHE respectively. Baseline non-compliance is typically higher for younger workers

[13] This is because sample sizes are too small to allow any disaggregation of compliance rates by worker characteristics for workers eligible for the 16-17 Year Old Rate and Youth Development Rate.

[14] The age-related groups are based on NMW entitlement. This means that when those aged 21 became entitled to the Adult rate of the NMW rather than the Youth Development Rate on 1st October 2010 they moved over to the Adult rate group. Therefore, 21 year olds are included in the Youth Development Rate group before this date and in the Adult rate group afterwards.

than adult workers. The differences are clear according to ASHE data, but the volatility of the estimates according to the LFS data (due to modest sample sizes, particularly for workers eligible for the 16-17 Year Old Rate) make the patterns less clear cut.

The ASHE estimates of adult baseline non-compliance (Figure 5) are relatively stable for most of the period, typically just below 1%, whilst the LFS estimates (Figure 3) show a different picture with the baseline non-compliance rate increasing from 0.4% in 2000 to 2.0% in 2012. In Section 4.2 we explore the extent to which rounding and the exemptions discussed above change these estimates.

Baseline non-compliance rates for 16-17 Year Old Rate and Youth Development Rate workers are also stable for much of the period, according to ASHE estimates, but both increase between 2009 and 2011. This may be related to the recession or to the reduction in awareness-raising activities. The LFS estimates of baseline non-compliance for 16-17 Year Old Rate and Youth Development Rate workers also show an upward trend, albeit with some volatility in the estimates, from 2007 for Youth Development Rate workers and from the introduction of the 16-17 Year Old Rate for these workers.

The relationship between recession and non-compliance will be explored through econometric analysis (Section 5). However, sample sizes mean that this analysis can only be carried out for adult workers, so it will not be possible to say whether increases in non-compliance for Youth Development Rate and 16-17 Year Old Rate workers is related to the recession.

Figure 4 and Figure 6 show the bites of the NMW for each of the age groups for the LFS and ASHE respectively. This is defined as the ratio of the NMW to median earnings for each age group. The patterns are similar for each dataset, with an upward trend in the bite of the NMW for each age group and the lowest bite being for adult workers followed by 16-17 Year Old Rate workers and then those eligible for the Youth Development Rate.

For adult workers the bite increased from 50% in 2001 to 60% in 2012; and for development rate workers from 69% in 2001 to 81% in 2012 (LFS estimates). The positive correlation in baseline non-compliance rates (Figure 3) and bites (Figure 4) shown by the LFS (both have an upward trend) suggest that baseline non-compliance may be higher where the NMW is closer to the market wage, in line with the

proposition of Ashenfelter & Smith (1979). However, the ASHE data (at least for adult workers) does not show the same raw correlation (baseline non-compliance is relatively stable, Figure 5, whilst the bite, Figure 6 increased over time). The relationship between non-compliance and the bite of the NMW for adult workers will be explored further in our econometric analysis (see Section 5).

Figure 3: LFS Baseline non-compliance rates by NMW Age bands

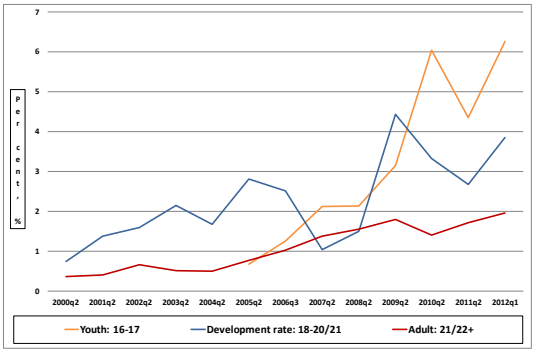


Figure 4: LFS Bite of the NMW by the three NMW age bands

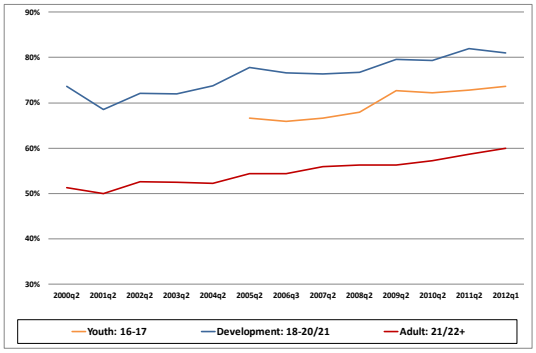
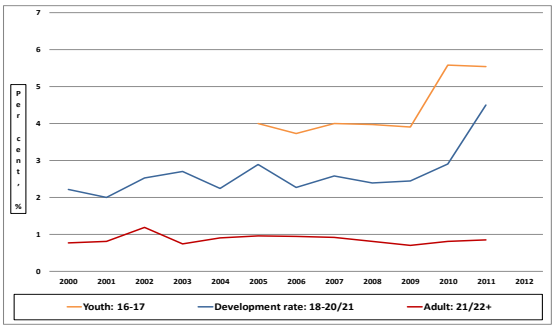
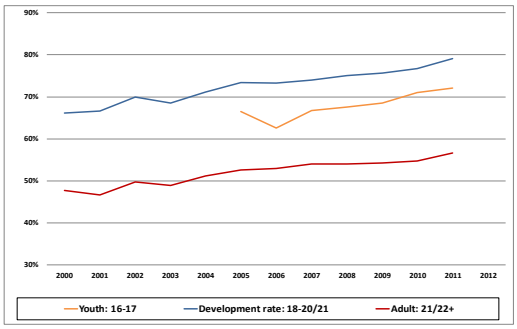


Figure 5: ASHE Baseline non-compliance rates by NMW Age bands



Note: ASHE data are only available up to 2011. 2012 is only included as a placeholder to make the chart easier to compare with the one in Figure 3 above.

Figure 6: ASHE Bite of the NMW by the three NMW Age bands.



Note: ASHE data are only available up to 2011. 2012 is only included as a placeholder to make the chart easier to compare with the one in Figure 4 above.

4.1.3 Gender

Next we consider how baseline non-compliance and the bite of the adult NMW vary by gender. Here the patterns across the two datasets are similar. Baseline non-compliance is higher for women than for men (Figure 7 and Figure 9) and the bite of the NMW is also higher for women than men (Figure 8 and Figure 10). The bite for men and women increases over time and ASHE baseline non-compliance estimates are relatively stable over time, whilst LFS estimates show an upward trend in line with the overall figures.

Figure 7: LFS Adult baseline non-compliance rates by gender

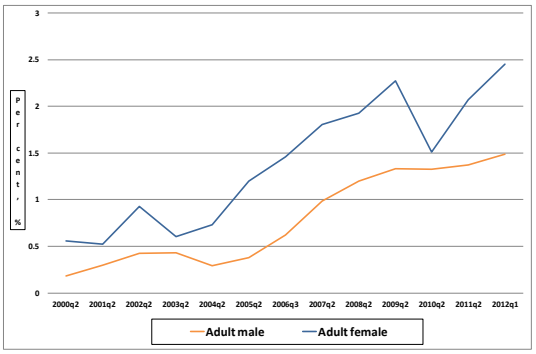


Figure 8: LFS Adult bite of the NMW by gender

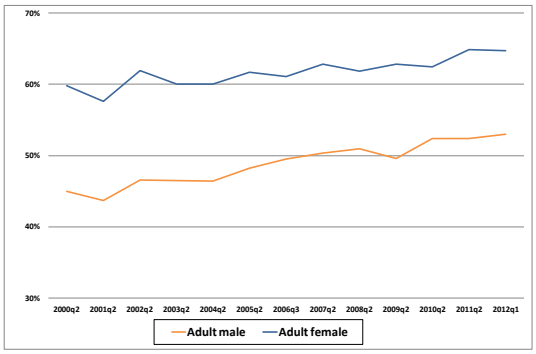


Figure 9: ASHE Adult baseline non-compliance rates by gender

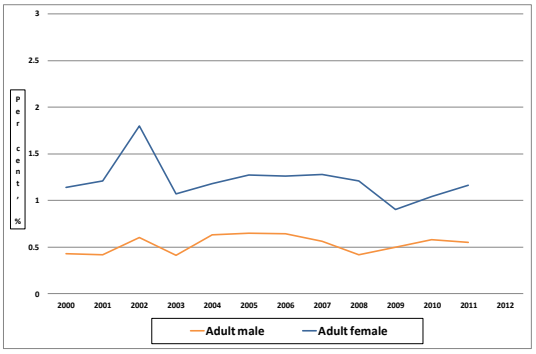
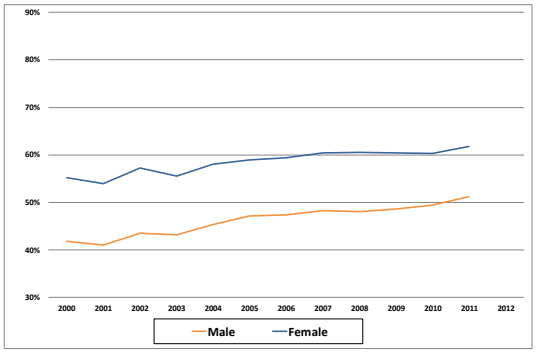


Figure 10 ASHE Adult bite of the NMW by gender



Note: Unweighted sample sizes from the LFS range from 5,086 to 8,539 respondents for men; from 5,766 to 9,718 respondents for women. For ASHE estimates the unweighted sample sizes range from 61,754 to 62,744 (men); and 80,849 to 86,144 (women).

4.1.4 Regions

Figures 11 and 12 present the baseline non-compliance rate and bite of the NMW for the countries and regions of the United Kingdom estimated using the LFS. The picture is not as clear as for some of the other characteristics due to smaller sample sizes in many regions leading to estimates that are more volatile. Baseline non-compliance tends to be high in Northern Ireland, whilst the bite is lowest in London followed by the South East and East of England.

ASHE estimates of baseline non-compliance (only covering Great Britain) shown in Figure 13 are more stable for all regions, reflecting the larger sample sizes upon which these estimates are based. Here, baseline non-compliance is lowest in London, whilst, in general, rates for other regions are similar. The ASHE estimates of the bite of the adult NMW (Figure 14) show a similar pattern to the LFS estimates with the lowest bite in London followed by the South East.

Figure 11: LFS Adult baseline non-compliance rates by country and region of the United Kingdom

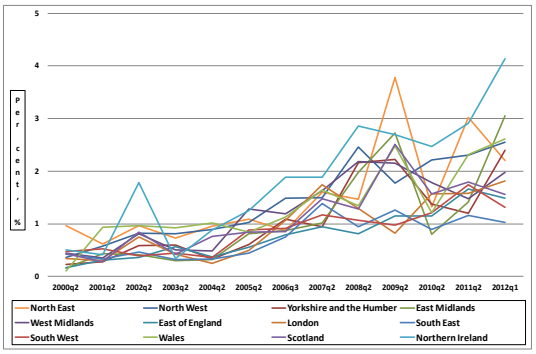


Figure 12: LFS Adult bite of the NMW by country and region of the United Kingdom

Figure 13: ASHE Adult baseline non-compliance rates by country and region of Great Britain

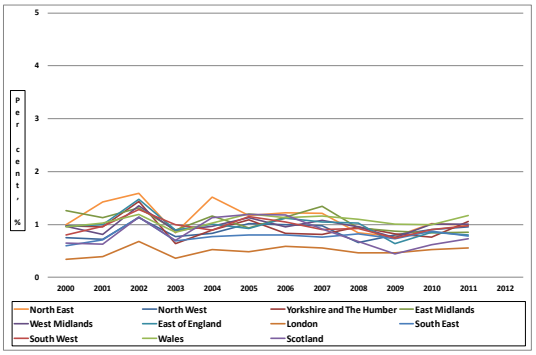
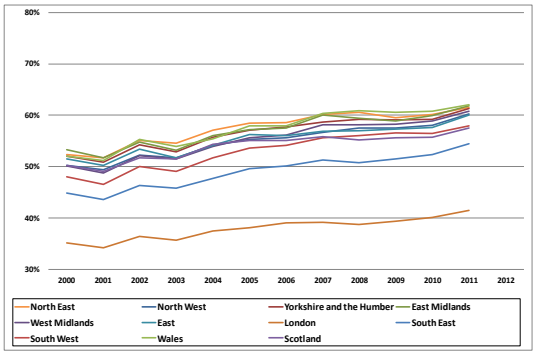


Figure 14: ASHE Adult bite of the NMW by country and region of Great Britain



Note: Unweighted sample sizes from the LFS range from 254 in Northern Ireland in 2011 to 2,635 South East in 1999. For ASHE estimates the unweighted sample sizes range from 4,925 in the North East in 2008 to 25,036 in London in 2011.

4.1.5 Industry

Figure 15 and Figure 17 present estimates of the baseline non-compliance rate of the NMW for six main industrial sectors[15] from the LFS and ASHE respectively. Both show baseline non-compliance was highest in Distribution, Hotels and Restaurants followed by Other Services. According to LFS estimates the baseline non-compliance rate was considerably higher in Distribution, Hotels and Restaurants than other sectors (in 2012 it was 5.2% compared with 3.1% in Other Services and less than 1.5% in all other sectors), whilst differences according to ASHE were much smaller.

[15] The sectors are based on SIC92 for LFS and SIC 2003 for ASHE. Due to small sample sizes in the LFS, we combined four sectors into the production sector. The Production sector is a combination of Agriculture and Fishing, Energy and Water, Manufacturing and Construction. Workplaces outside the UK were excluded from the analysis at the start.

The high baseline non-compliance rate recorded by the LFS may be partly explained by many workers (waiters, hotel porters, etc.) in this sector receiving tips in addition to their hourly pay and the potential measurement error introduced by the incorrect inclusion/exclusion of such payments from the hourly pay reported in the LFS may lead to an overestimate of the extent of non-compliance.

The pattern for the bite of the NMW is also similar for ASHE (Figure 18) and LFS (Figure 16). According to both sources the bite was highest in Distribution, Hotels and Restaurants followed by Other services. Note this is the same ordering as for the rates of baseline non-compliance.

According to LFS data there was a sharp fall in the bite of the NMW for the Transport and Communication sector after 2008. However, no such fall was evident in the ASHE data. This may be related to a change in the industrial classification system as the LFS moved from using SIC 2003 to SIC 2007.[16]

[16] Transport, storage and communication (Section I in SIC 2003) maps to transport and storage (Section H in SIC 2007) and information and communication (Section J in SIC 2007). Some of the activities included in information and communication in SIC 2007 were classified under a number of Sections in SIC 2003 including Manufacturing; Transport, storage and communications; Real estate, renting and business activities; and Other community, social and personal service activities.

Figure 15: LFS Adult baseline non-compliance rates by industry sectors in the United Kingdom

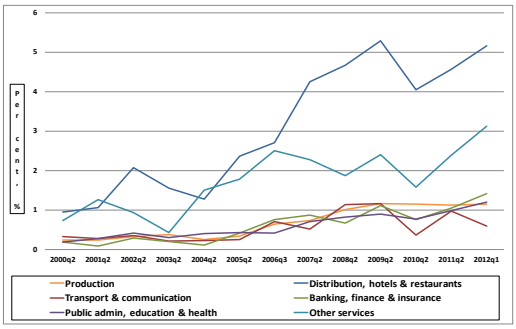


Figure 16: LFS Adult bite of the NMW by industry sectors in the United Kingdom

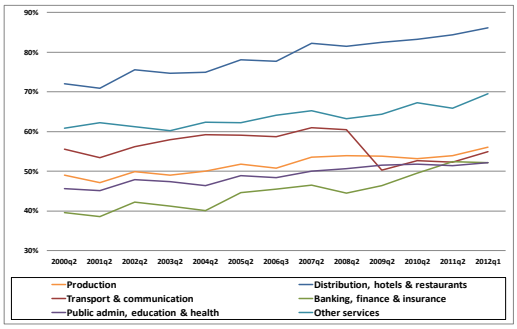


Figure 17: ASHE Adult baseline non-compliance rates by industry sectors in Great Britain

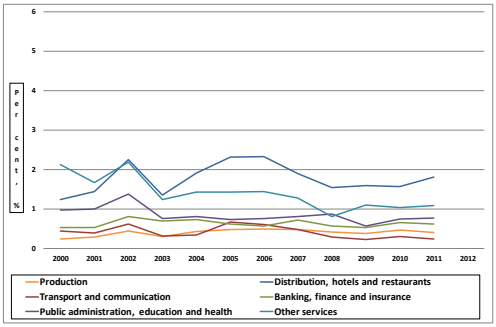
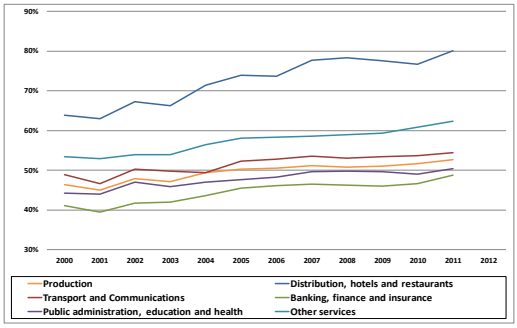


Figure 18: ASHE Adult bite of the NMW by industry sectors in Great Britain



Note: Unweighted sample sizes from the LFS range from 425 in Other services in 2011 to 5,884 in Public administration, Education and Health in 1999. For ASHE estimates the unweighted sample sizes range from 4,624 in Other services in 2001 to 60,894 in Public administration, Education and Health in 2011.

4.1.6 Firm size

Figure 19 and Figure 20 below show the estimates for different firm sizes using the LFS. Due to changes in the LFS variables, we show one definition for the whole sample and another for the years from 2001 onwards.

The first definition only divides firms into two categories, those with fewer than 25 employees and those with 25 or more employees. The second definition allows us to define three categories within the 25 or more employees' category (25-49, 50-499 and 500+ employees).

The Figures again show both series have upward trends and that smaller firms have higher rates of baseline non-compliance as well as a higher bite. Furthermore, it is worth noting that across all years considered, whilst roughly one-third of adult

employees worked in firms with less than 25 employees, roughly three-fifths of adult employees with earnings below the NMW were working in firms with less than 25 employees.

Figure 21 shows the estimates of the non-compliance rates by firm size for ASHE data. Here we consider size bands of less than 25 employees, 25-49, 50-249, 250-499 and 500+ employees. Baseline non-compliance rates are similar for all size bands above 25 employees, particularly from 2003 onwards. However, baseline non-compliance rates were consistently higher in very small firms (with less than 25 employees).

Figure 22 show the estimates of the bite of the adult NMW by firm size. Similar to the LFS estimates we see a general upward trend with the bite highest among employees of very small firms (less than 25 employees).

Figure 19: LFS Adult baseline non-compliance rates by firm size in the United Kingdom

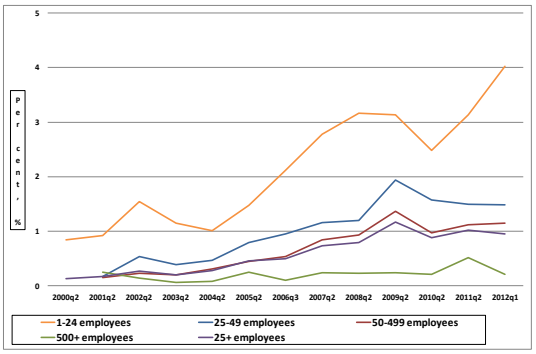


Figure 20: LFS Adult bite of the NMW by firm size in the United Kingdom

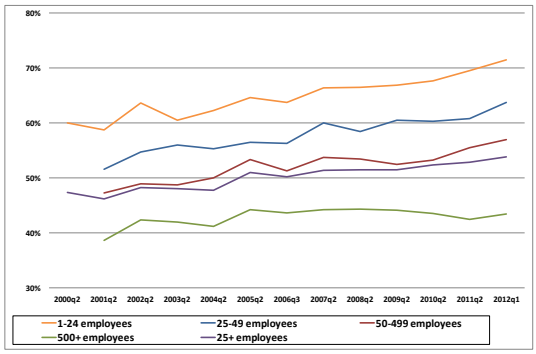


Figure 21: ASHE Adult baseline non-compliance rates by firm size in Great Britain

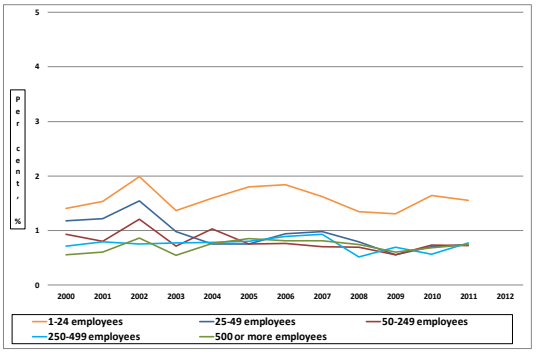
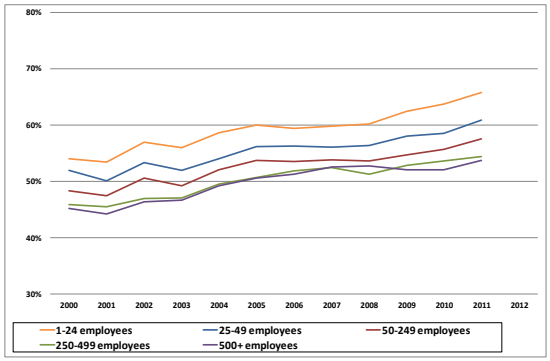


Figure 22: ASHE Adult bite of the NMW by firm size in Great Britain



Note: Unweighted sample sizes from the LFS range from 1,446 for workplaces with 25-49 employees in 2011 to 12,338 for workplaces with 25 or more employees in 1999. For ASHE estimates the unweighted sample sizes range from 6,395 for workplaces with 25-49 employees in 2008 to 105,579 for workplaces with 500 or more employees in 2011.

4.2 Rounding and other biases in measuring non-compliance

As discussed earlier, it is possible that the baseline non-compliance estimates presented in the previous section will have overstated the actual non-compliance rates. This can be due to rounding errors or because tips, bonuses, the accommodation offset or apprenticeships have not been fully taken into account in the assessment of earnings. The biases are legitimate reasons for an employer to pay an employee below the relevant NMW. However, it is difficult to correctly identify these legitimate occurrences of underpayment due to data limitations. We attempt to solve this problem by making some assumptions about the data that we have available.

In this section we present the impact that rounding and the other biases have on our baseline estimates of non-compliance. ASHE data is considered more precise than LFS data and we expect that rounding will have less of an impact on ASHE estimates than LFS estimates. In addition, ASHE does not have information to allow the identification of some of the biases, so the analysis focuses mainly on LFS data.

The results presented below should be treated with caution due to small sample sizes. This is especially important when looking at the impacts on the non-compliance rates for 16-17 Year Old Rate and Youth Development Rate workers.

The LFS allows us to identify some of those that are legitimately paid below the NMW. However, small sample sizes made it necessary to consider the extent of the biases over the whole NMW year[17] rather than individual quarters. Due to the difficulty in precisely defining the exclusions we used some simple assumptions to identify workers that may have been legitimately paid below the NMW. Our assumptions are detailed in Table 1 below.

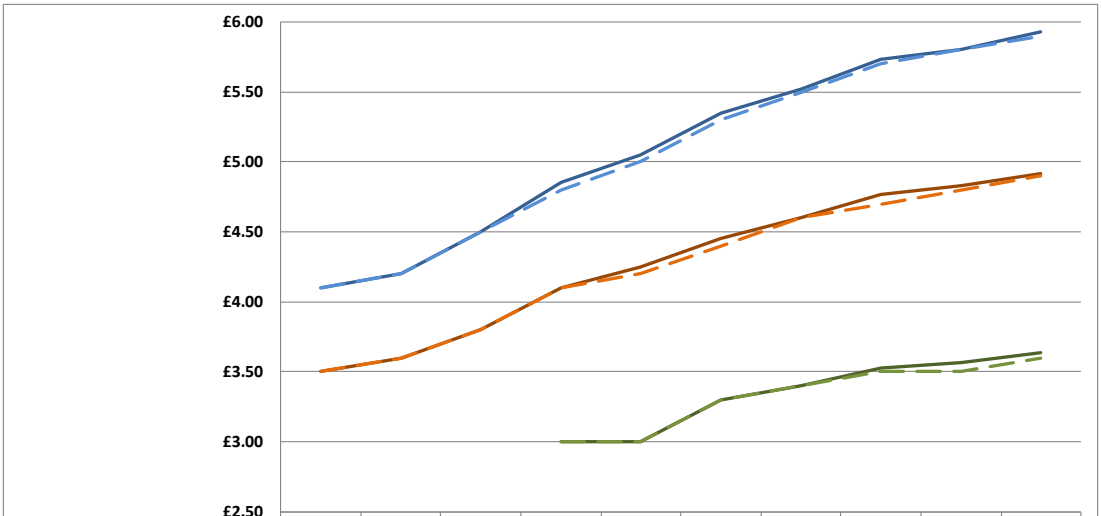
[17] NMW year = October to September, or LFS quarter 4 to quarter 3 of the following year

Table 1: Assumptions for identifying NMW exclusions

Exclusion	Identification Assumption	Dataset
Rounding	All those paid below the rounded value of the relevant NMW. The NMW was rounded down to the nearest 10p, e.g. £5.93 rounded down to £5.90. See Figure 23 below.	LFS and ASHE
Accommodation Offset	Included all those paid below the rounded NMW and who had lived in accommodation provided free by their employer.	LFS
Tips	Included all those paid below the rounded NMW and received tips in addition to their basic pay.	LFS
Bonuses	Included all those paid below the rounded NMW and received a bonus in addition to their basic pay.	LFS
Apprentices – Assumption 1	Included all those paid below the rounded NMW and doing a recognised apprenticeship.	LFS
Apprentices – Assumption 2	Included all those paid below the rounded NMW and doing a recognised apprenticeship or had done work related training or education in the last week.	LFS
Apprentices – Assumption 3	Included all those paid below the rounded NMW and doing a recognised apprenticeship or had done work related training or education in the last 4 weeks.	LFS
Apprentices – Assumption 4	Included all those paid below the rounded NMW and doing a recognised apprenticeship or had done work related training or education in the last 13 weeks.	LFS

Figure 23 shows the actual and rounded NMW rates, highlighting, that our definition of rounding is only relevant from 2005 onwards for workers on the Adult rate and the Youth Development Rate; and from 2009 onwards for workers on the 16-17 Year Old Rate.

Figure 23: Actual and Rounded NMW rates



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Adult rate	4.1	4.2	4.5	4.85	5.05	5.35	5.52	5.73	5.8	5.93
Adult rate rounded	4.1	4.2	4.5	4.8	5	5.3	5.5	5.7	5.8	5.9
Development rate	3.5	3.6	3.8	4.1	4.25	4.45	4.6	4.77	4.83	4.92
Development rate rounded	3.5	3.6	3.8	4.1	4.2	4.4	4.6	4.7	4.8	4.9
Youth rate				3	3	3.3	3.4	3.53	3.57	3.64
Youth rate rounded				3	3	3.3	3.4	3.5	3.5	3.6

4.2.1 The impact of rounding and other biases on LFS estimates

Figures 24-26 show the impact of rounding and the other assumptions shown in Table 1 for each of the NMW age groups. In respect of the assumptions to identify those doing apprenticeships the figures show the impact of assumption 1 and the additional impact from assumption 4 only. It is difficult to identify apprentices from the LFS. Official figures indicate there were 457,200 apprenticeship starts in 2010/11 with 131,700 under the age of 19; and 143,400 aged 19-24 (Department for Business Innovation and Skills, 2012). The LFS identifies roughly 140,000 employees on recognised apprenticeships in April to June 2010, whilst almost 1.9 million employees received training in the last week and 7 million employees received some training in the previous 13 weeks.

Considering data from the LFS for the NMW age bands: roughly 36,000 employees aged 16-17 were on recognised apprenticeships; and a further 45,000 employees received training in the previous week; and an additional 21,000 received training in the previous 13 weeks. For employees aged 18-20 the corresponding figures are: 61,000 (recognised apprenticeships); 162,000 (training in the last week); and a further 154,000 (training in the previous 13 weeks). For adult rate workers there were just 40,000 employees on recognised apprenticeships, but 1.6 million employees of this age received training in the last week and a further 5 million employees received training in the previous 13 weeks.

Based on the total number of apprentices in the UK; for 16-17 year-olds identifying employees recorded in the LFS as being in receipt of training in the previous 13 weeks may therefore be a reasonable approximation of being an apprentice. For 18-20 year-olds the same assumption may slightly overstate the number of apprentices, whilst an assumption based on receipt of training in the previous four weeks may understate the number of apprentices. For employees aged 22 or more, the number of people in receipt of training has no correspondence to the number of apprentices. However, our results indicate that any adjustment to non-compliance rates for adult workers in relation to apprentices have a small impact (and apprentice surveys also suggest little non-compliance among adult apprentices).

Across all age groups adjustments relating to the accommodation offset, tips and bonuses were small; at most reducing the non-compliance estimates by 0.1 percentage points. Adjustments relating to rounding and apprenticeships were typically larger.

16-17 Year Old Rate

Figure 24 shows the adjustments to the baseline estimates of the non-compliance rate for those entitled to the 16-17 year olds rate of the NMW. The baseline estimates range from 1.1% in 2005 and 2006 to 4.9% in 2011. Applying all the adjustments to the non-compliance estimates reduces non-compliance rates to 0.5% in 2005; 0.4% in 2006 and 2.0% in 2011.

The largest adjustment was in 2011. In this year, the NMW rate was £3.64 per hour and the baseline non-compliance estimate was 4.9%. Our rounding adjustment assumes that anyone paid between £3.60 and £3.63 per hour (in reality most of these workers were paid £3.60 per hour) was legitimately paid at least the NMW,

but a rounding error meant hourly earnings were misreported in the LFS. In 2011 this adjustment had a modest impact on the non-compliance estimate, reducing it by 0.3 percentage points. The assumptions about apprenticeships had a much larger impact. Applying assumption 1 alone, so that anyone recorded in the LFS as doing a recognised apprenticeship and earning below the 16-17 Year Old Rate, but more than the Apprentice Rate were compliant with the NMW reduces the estimate of non-compliance by 1.9 percentage points. Applying assumption 4, so that anyone earning below the 16-17 Year Old Rate but more than the Apprentice Rate and in receipt of work related education or training in the last 13 weeks, but not recorded as on a recognised apprenticeship was compliant with the NMW reduces the non-compliance estimate by an additional 0.6 percentage points making the 'revised' non-compliance estimate 2.0% in 2011.

The impact of the adjustment varies considerably over time. The rounding adjustment has a bigger effect in 2009 and 2010 than 2011. In 2010, the 16-17 Year Old Rate was £3.57 so the rounding assumption reduced the 16-17 Year Old Rate by seven pence, compared with adjustments of three pence in 2009 and four pence in 2011. Furthermore, in 2009 and 2010, the rounding adjustment moved the 16-17 Year Old Rate to £3.50, a multiple of 50 pence, which the analysis of Fry and Ritchie (2013) indicates attract a higher degree of rounding than other multiples of 10 pence.

The apprenticeship adjustments also vary over time. This may be partly related to the increase in the number of apprentices over time, but also reflects the small sample size for which estimates for 16-17 year-olds are based. For those on recognised apprenticeships and earning below the 16-17 Year Old Rate, the adjustment was 0.3 percentage points in 2010 and 1.9 percentage points in 2011. For those in receipt of work related education or training in the last 13 weeks and earning below the 16-17 Year Old Rate , the adjustment was less than 0.1 percentage points in 2005 and 0.6 percentage points in 2011.

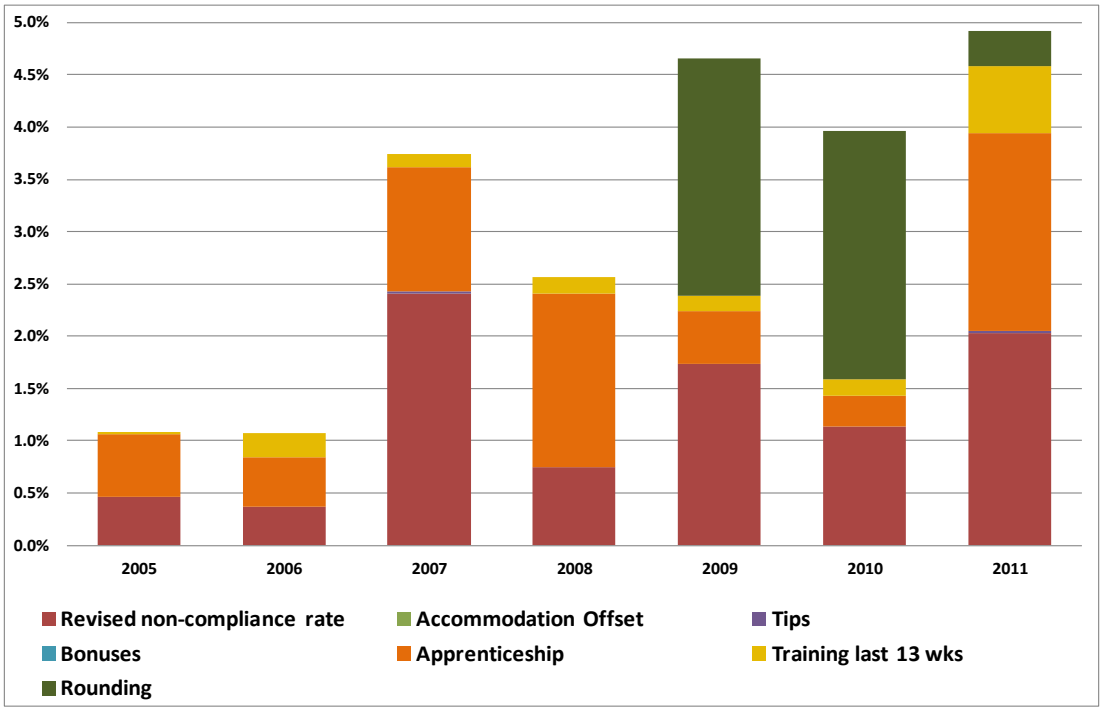
It is very difficult to determine the cause of these variations, but it is important to recall that these results are based on a relatively small sample of respondents.

A further consideration to recall here is that the adjustments are based on assumptions, and that it is possible that some young workers in receipt of work related education or training in the last 13 weeks are not apprentices so the

adjustments made may be too general and reduce non-compliance estimates by too much. The 'revised' non-compliance rate in Figure 24 provides a guide for a lower bound estimate of non-compliance with the NMW, whilst the baseline estimates can be thought of as an upper bound, at least in terms of estimates from official data, which does not take into account the possibility of non-compliance in the informal economy.

These revised estimates now indicate that non-compliance for workers aged 16-17 also varied over time. They were lowest at around 0.5% in 2005 and 2006 and highest in 2007 at 2.4% with an average over the whole period of 1.3%.

Figure 24 16-17 Year Old Rate: Adjustments to the non-compliance rate, 2005-2011



Source: *Labour Force Survey*

Note: Unweighted sample sizes range from 623 to 1,100.

Youth Development Rate

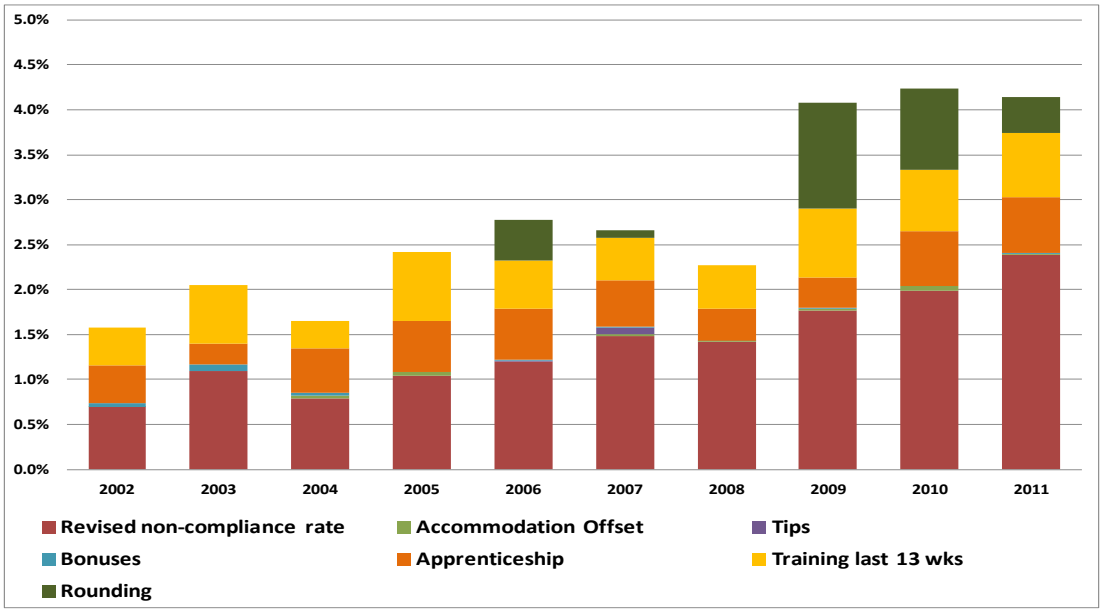
Figure 25 shows the adjustments to the baseline estimates of the non-compliance rate for those entitled to the Youth Development Rate of the NMW. The impact of the two apprenticeship assumptions appears more stable over time. Assumption 1 reduces the baseline non-compliance rate by 0.5 percentage points on average over the period, with the smallest adjustment of 0.2 percentage points and the biggest at 0.6 percentage points. Similarly, applying assumption 4 leads to an additional 0.6

percentage point reduction on average. Here the smallest adjustment was 0.3 percentage points and the biggest 0.8 percentage points.

Rounding has a similar impact on average (0.5 percentage points) but there is a lot more variation in the size of the impact between particular years. In 2007 the impact is close to zero. In this year the Youth Development Rate was £4.45 and we would expect that much of the rounding error would be an over-reporting of hourly earnings to £4.50 per hour. In 2009 the rounding adjustment is 1.2 percentage points. Here the Youth Development Rate was £4.77, so our rounding adjustment was seven pence (the largest adjustment considered) and it was also just above a multiple of 25 pence which Fry and Ritchie (2013) highlight as a focal point for the reporting of rounded hourly rates.

The cumulative effect of the adjustments is a more stable non-compliance rate, particularly between 2002 and 2008. Here, the 'revised' non-compliance rate ranged from 0.7% in 2002 to 1.5% in 2007 compared with baseline estimates of 1.6% (2002) and 2.7% (2007). From 2009 onwards the revised non-compliance rate drifted upwards to 1.8% in 2009, 2.0% in 2010 and 2.4% in 2011. This pattern was similar to the baseline estimates from ASHE, but markedly different to the baseline LFS estimates for 2009-2011 which were fairly stable at 4.1% (2009 and 2011) and 4.2% (2010).

Figure 25 Youth Development Rate: Adjustments to the non-compliance rate, 2002-2011



Source: ***Labour Force Survey***

Note: Unweighted sample sizes range from 1,524 to 3,658.

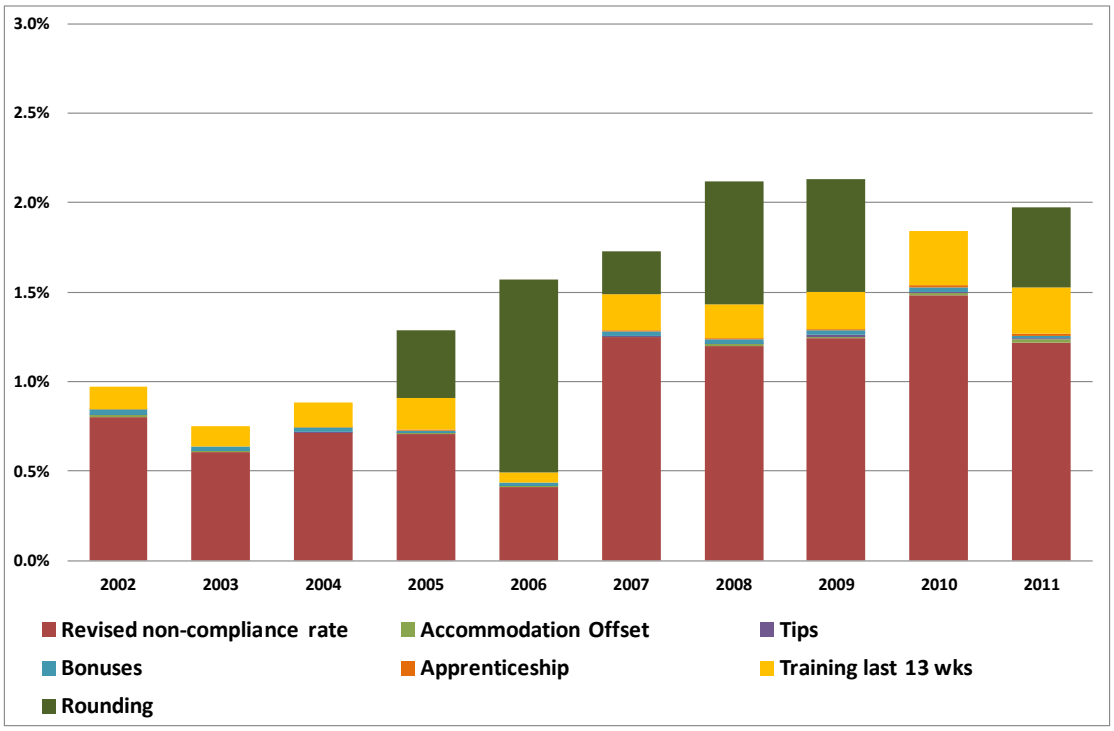
Adult rate

Figure 26 shows the adjustments to the baseline estimates of the non-compliance rate for those entitled to the adult rate of the NMW. The impact of the apprenticeship adjustments is relatively small. There were few adults on recognised apprenticeship schemes earning below the adult NMW and typically only 0.1% to 0.2% of adults were earning below the adult NMW and in receipt of work-related education or training in the last 13 weeks.

The impact of the rounding adjustments was much more important for adult workers. Rounding reduces the baseline non-compliance rate by 0.6 percentage points on average in the years where the adult rate is not a round number. Again, there was variation in its impact over the period. In 2006 rounding reduces the non-compliance rate by 1.2 percentage points to 0.4%. The adult rate in 2006 was £5.05 and the large adjustment reflects the relatively large proportion of adult workers who reported that they earned £5.00 per hour. The smallest adjustment was 0.2 percentage points in 2007 when the adult NMW was £5.35 per hour.

The cumulative effect of the biases reduces non-compliance rates in all years, notably less in those years with round NMW rates. This means that the revised non-compliance rate was relatively stable at around 0.7% between 2002 and 2005, in line with the ASHE estimates, and also stable from 2007 onwards, but at a slightly higher level of around 1.2%. Hence the adjustments change the non-compliance profile over time from one of a steady increase from 2004 onwards in the baseline estimates, to what looks more like a step jump in the non-compliance rate from 2007 onwards in the revised estimates.

Figure 26 Adult Rate: Adjustments to the non-compliance rates, 2002-2011



Source: ***Labour Force Survey***

Note: Unweighted sample sizes range from 43,809 to 60,635.

4.2.2 Comparisons with estimates from ASHE

Figures 27 to 29 show alternative estimates of non-compliance rates for 16-17 Year Old Rate, Youth Development Rate and adult rate workers according to ASHE data. Here we just apply the rounding adjustment.

For all groups the rounding adjustment is relatively modest. For 16-17 Year Old Rate workers (Figure 27) the rounding adjustment reduced the non-compliance rate by between 0.2 percentage points in 2011 and 0.4 percentage points in 2009.

For Youth Development Rate workers (Figure 28) the rounding adjustment reduced the non-compliance rate by between 0.2 percentage points in 2010 and 0.6 percentage points in 2011.

For adult rate workers (Figure 29) the rounding adjustment reduced the non-compliance rate by around 0.2 percentage points in all years.

Figure 27: ASHE Non-compliance rates for 16-17 Year Old Rate workers

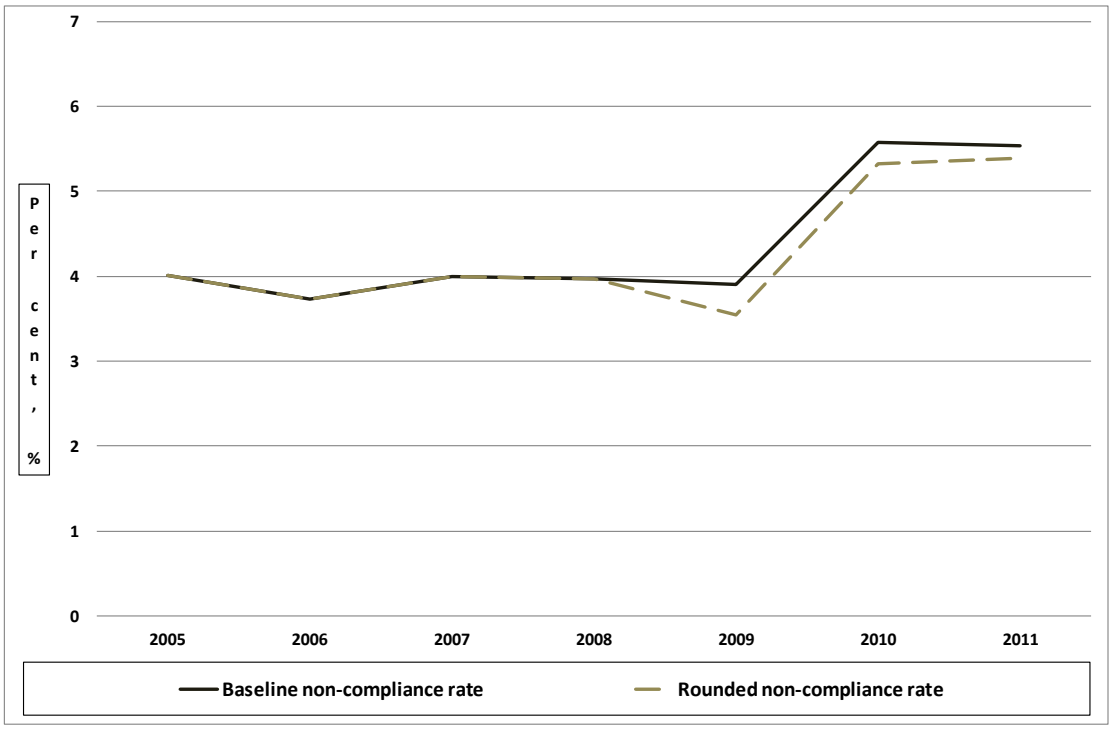


Figure 28: ASHE Non-compliance rates for Youth Development Rate workers

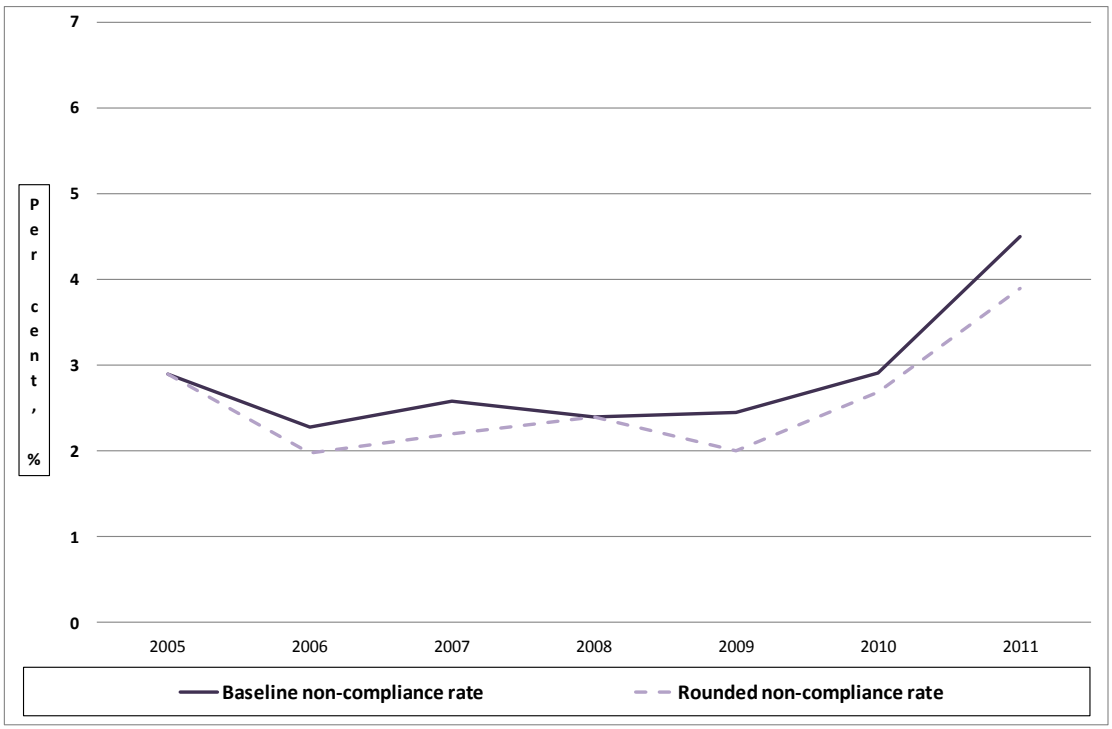
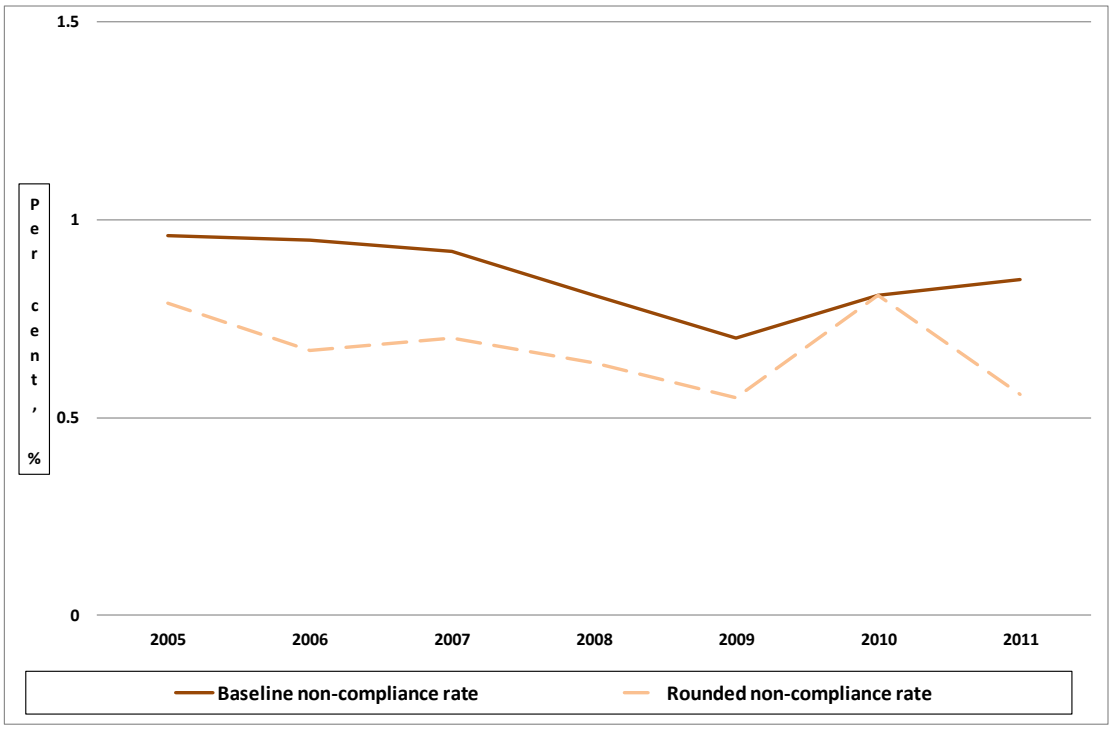


Figure 29: ASHE Non-compliance rates for Adult rate workers



Rounding has a much smaller impact on ASHE estimates than LFS estimates. This is most probably because ASHE data is reported by employers, and often comes from their payroll data, so measurement error of this type is less likely. On the other hand, LFS data is reported by the worker and as such is much more likely to be susceptible to mis-measurement.

5 Models of non-compliance

The literature on non-compliance with a minimum wage is sparse. Ashenfelter & Smith (1979) were the first to consider the issue of compliance with a statutory minimum wage. Prior to this, the economic literature did not consider the impacts of the law on wages rates as most assumed full compliance with the law by employers. Ashenfelter and Smith used employer and employee survey data to establish the 'quantitative significance' of non-compliance. They also developed a theoretical framework to consider the issue of non-compliance. Using a simple one-period optimization framework for a profit-maximising firm, they found that non-compliance would be higher the larger the market wage relative to the minimum wage and the larger the elasticity of the demand for labour.

Grenier (1982) in a response to Ashenfelter and Smith developed the theoretical framework, but applied a different assumption about the penalty structure for non-compliance. Grenier reached the opposite conclusion to Ashenfelter and Smith, that non-compliance would be higher the closer the market wage is to the minimum wage.

A third paper in the series by Chang & Ehrlich (1985) provided a further development to the theoretical framework. They addressed the perceived failings of the earlier papers by modelling the penalty for non-compliance as a factor that increases the marginal cost of labour and therefore acts as a ‘disincentive’ on the firm to employ labour. This allowed the model to capture both the evasion of the minimum wage law (paying lower wages) and the avoidance of the law (change in employment) aspects of the decision of non-compliance. They find that if the penalty for non-compliance is effective as a deterrent then the incentive for non-compliance is higher the larger the gap between the minimum wage and the market wage. If the gap between the minimum wage and market wage increases then there is also an increase in the incentive to not comply if the elasticity of the demand for labour is higher (in absolute value).

Our econometric analysis is set in the spirit of the theoretical framework of these papers, but takes a reduced form approach. We estimate models at a local area level to test whether non-compliance is affected by the size of the gap between the minimum wage and the market wage. The market wage in the absence of a minimum wage is not observable, so we use the bite of the minimum wage in a local area as a proxy, where the bite is defined as the ratio of the NMW and median hourly earnings; the Kaitz index.

We also explore the relationship between non-compliance and other job and worker characteristics e.g. firm size, gender and industry. Our descriptive analysis in Section 4.1 showed some variation in non-compliance estimates by these characteristics, but also, in general, that groups of workers who had high non-compliance rates were those where the bite of the NMW was highest. This analysis therefore seeks to determine whether it is the bite of the NMW that is associated with non-compliance once we control for these other characteristics and whether non-compliance is higher for certain types of worker once we control for the bite of the NMW.

We also explore the relationship between non-compliance with the NMW and general economic conditions to see if non-compliance increased during the recent economic downturn. Here we look at national GDP growth to identify impacts relating to the economic cycle that are common to all areas and local area unemployment to identify impacts relating to the local economic cycle.

The models to be estimated are described in equations 1 and 2 in Section 3.3. We estimate separate models using LFS and ASHE data for adults. The sample sizes for workers on the 16-17 Year Old Rate and the Youth Development Rate are insufficient to allow local area non-compliance measures to be estimated. We also estimate separate models using our baseline estimates of non-compliance as well as estimates of non-compliance that are adjusted for possible rounding errors. In these latter models we use the rounded NMW rate to give us an adjusted measure of the bite.

In Table 2 and Table 3 we present the results from four models for each data source; two for the baseline estimates and two for the rounded estimates of non-compliance. Using the first specification (Models 1 and 2) changes over time are

captured by year dummies, whilst in the second specification (Models 3 and 4) we replace the year dummies with the annual growth rate of UK GDP.

5.1 LFS models

Our LFS analysis uses annual observations based on the NMW year[18] (October to September) from October 2001 onwards. We estimated Ordinary Least Squares (OLS) models using data weighted by the size of each local area (Table 2).

The results show that the bite of the NMW (as measured using the Kaitz index) is positively related to the non-compliance rate. This result holds for all four models and is consistent with the theoretical predictions of Ashenfelter & Smith (1979) and Chang & Ehrlich (1985). The estimated coefficient is larger in the models where the baseline estimate of non-compliance was used, but in all cases the estimated coefficients are strongly significant.

The coefficients on the year dummies (relative to 2007), in models 1 and 2, show little evidence of any change in non-compliance relating to the period of economic downturn. For the model using the baseline non-compliance estimates, non-compliance was higher from October 2005 onwards than before October 2005. This change is well in advance of the big fall in GDP in minimum wage year October 2008 to September 2009. For the model using the rounded non-compliance estimates, non-compliance was significantly higher from October 2006 onwards than before October 2006; one year later than the unadjusted figures reflecting the big rounding adjustment associated with the October 2005 adult NMW rate. Again this is well before the economic downturn so it is not clear from these estimates that the change in non-compliance that occurred at around this time is related to the economic cycle. Gross valued added in Wholesale and Retail Trade (one of the sectors with an above average proportion of minimum wage workers) fell slightly in 2005 before recovering in 2006 and 2007 and falling again in 2008 and 2009,

[18] Note NMW year 2002 corresponds to October 2001 to September 2002 and the same pattern applies to all subsequent years.

highlighting that the start of economic downturn varied by industry. However, the magnitude of the fall in 2005 is not likely to be large enough to explain the change in non-compliance rates in this period.

In both models the local area unemployment rate was not associated with non-compliance rates suggesting that the local area economic cycle was not strongly related to non-compliance. The other variables in the model indicate that non-compliance was higher in smaller firms (those with less than 25 employees); in areas where the proportion of workers in part-time employment was high; and in geographic areas where the proportion of workers in Retail was high and where the proportion of workers in Social Care was low[19]. This result needs to be considered in the context of findings discussed in Hussein (2011) who argues that low pay and non-compliance with the NMW in Social Care is higher than portrayed from analysis of LFS and ASHE data. Using data from the Minimum Data Set for Social Care (NMDS-SC) she finds that the LFS and ASHE under-represent both the size of the social care sector and the extent of low pay in the sector. However, Bessa et al. (2013) analysing the same data found estimates of the proportion of workers paid below the NMW broadly in line with those from ASHE, but note that these estimates are likely to be a lower bound as no account was taken of paid or unpaid travel time.

In models 3 and 4, we replace the year dummies with an indicator of the annual change in UK GDP. In both models the coefficient is negative and significant, indicating that when GDP growth was low, non-compliance was high. In these models the local area unemployment rate was positive, but not significant in the model using baseline non-compliance estimates and weakly significant when we use rounded non-compliance estimates. Overall, in contrast to the results of models 1 and 2, the above suggests that non-compliance is associated with the economic cycle and the recent downturn may have led to increased non-compliance.

[19] When we included a variable that measured the share of employment in all low paying sectors, it was not significant in any model specification based on both LFS and ASHE data.

The size of the coefficient on GDP growth is much higher (four times higher) in the model with the baseline non-compliance estimate than rounded estimates. To put the estimates in perspective, between October 2007 and September 2011, on average, annual GDP fell by 0.4% per annum in the UK, compared with average growth of 3.0% in the preceding six years. If GDP growth had remained at 3.0% between October 2007 and September 2011 then baseline non-compliance rates would have been roughly 0.3 percentage points lower and the rounded rates 0.075 percentage points lower. This indicates that, at least for the rounded estimates, the association between GDP growth and non-compliance was small.

In these models the association between non-compliance and firm size remains, and non-compliance was more negatively related to the employment share in Social Care. The other associations identified in models 1 and 2 were less evident.

Table 2: Estimates of non-compliance rates, LFS models

	Model 1	Model 2	Model 3	Model 4
Bite of the NMW				
Kaitz index	6.472***		11.774***	
	(0.822)		(0.726)	
Kaitz index - rounded NMW		4.499***		6.055***
		(0.732)		(0.680)
Minimum Wage Year (Reference year 2007)				
2002	-0.602***	-0.376***		
	(0.137)	(0.124)		
2003	-0.728***	-0.534***		
	(0.140)	(0.126)		
2004	-0.658***	-0.430***		
	(0.137)	(0.123)		
2005	-0.389***	-0.522***		
	(0.135)	(0.123)		
2006	0.037	-0.996***		
	(0.134)	(0.122)		
2008	0.583***	0.072		
	(0.134)	(0.122)		
2009	0.165	-0.203		
	(0.193)	(0.175)		
2010	-0.168	0.153		
	(0.233)	(0.212)		
2011	-0.194	-0.309		
	(0.238)	(0.216)		
Unemployment and GDP				
Local area unemployment rate	-0.028	1.576	2.503	2.762*
	(1.755)	(1.555)	(1.840)	(1.662)
UK annual GDP growth			-0.086***	-0.022**
			(0.009)	(0.009)
Employment Shares				
Proportion in small workplaces (<25)	1.686**	1.593***	1.430**	1.675***
	(0.663)	(0.587)	(0.715)	(0.646)
Proportion female	0.359	0.215	0.145	0.125
	(0.954)	(0.845)	(1.034)	(0.934)
Proportion in part-time employment	1.634*	1.834**	0.418	1.562*
	(0.867)	(0.768)	(0.930)	(0.841)
Proportion in temporary employment	-0.555	-0.022	-3.737**	-0.63
	(1.426)	(1.263)	(1.517)	(1.370)
Proportion in Agriculture and Food processing	1.907	2.121	-1.157	1.73
	(1.769)	(1.567)	(1.895)	(1.713)
Proportion in Textiles	1.578	0.35	0.251	-0.635
	(1.164)	(1.031)	(1.055)	(0.953)
Proportion in Retail	3.634***	2.613**	0.945	2.295*

	(1.334)	(1.182)	(1.300)	(1.177)
Proportion in Hospitality and Security	2.029	1.032	-0.397	0.512
	(1.823)	(1.615)	(1.861)	(1.683)
Proportion in Cleaning	-2.456	-1.718	-1.008	-2.832**
	(1.495)	(1.324)	(1.553)	(1.401)
Proportion in Social Care	-3.368*	-3.237*	-5.186**	-4.942***
	(1.956)	(1.732)	(2.107)	(1.904)
Proportion in Other low-paying sectors	-0.282	0.105	-3.388**	-0.074
	(1.652)	(1.463)	(1.719)	(1.555)
Constant	-3.734***	-2.530***	-5.298***	-3.051***
	(0.583)	(0.518)	(0.609)	(0.553)
Area dummies	Yes	Yes	Yes	Yes
Area weights	Yes	Yes	Yes	Yes
Adjusted R-squared	0.547	0.475	0.466	0.357
Number of Observations	1360	1360	1360	1360

Standard errors reported in brackets. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level.

5.2 ASHE models

The ASHE estimates (Table 3) are based on the same general specification as the LFS estimates.

In all but one of the models (models 1-3) we find a positive association between the bite of the NMW and the non-compliance rate, in line with the LFS results. However in model 4, which estimates the rounded non-compliance rate with GDP growth included in the control variables, the opposite is true.

In contrast to the LFS based models, the post 2007 year dummies are generally negative, indicating that non-compliance went down during the period of the economic downturn (models 1 and 2). The same relationship is evident when we include GDP growth rather than the year dummies (models 3 and 4). The coefficient on GDP growth is positive and statistically significant in both the model for the baseline estimate and for the rounded estimate of non-compliance, so that as GDP growth fell between October 2007 and September 2011 non-compliance fell.

Given the difference in results between estimates based on LFS data and estimates based on ASHE data, it is not possible to make strong conclusions about how non-compliance with the NMW has changed during the recent economic downturn.

This is further confused when considering our measure of the local area economic cycle. In both sets of estimates the local area unemployment rate is not statistically significant in three out of the four model specifications. However, the one significant estimate based on LFS data indicates non-compliance was higher when local area unemployment was higher (although the estimated coefficient was only statistically significant at the 10% level); whereas the one significant estimate based on ASHE data indicates completely the opposite (here the estimated coefficient was statistically significant at the 5% level). In both cases the significant findings in relation to the local area unemployment rate are found in models where the rounded non-compliance rate is the dependent variable.

Our prior was that non-compliance would have gone up during the recent economic downturn, broadly in line with the estimates obtained from LFS data. We do not

have a strong hypothesis as to why, according to our estimates based on ASHE data, non-compliance is negatively related to the economic cycle. There is more cleaning of ASHE data than LFS data, particularly relating to pay at or below the NMW, so it is possible that ASHE data is more accurate. However, ASHE is less likely to capture jobs in the informal economy, whilst because the LFS is self-reported some of these jobs may be recorded in the LFS and not in ASHE. This may mean that although the reported data may be more accurate in ASHE, it may also miss out on some jobs that are not compliant with the NMW legislation.

The other variables in the model indicate that non-compliance was higher in smaller firms (those with less than 25 employees) a result in line with the LFS estimates. However, the ASHE estimates also indicate higher non-compliance when the proportion of female employees was high (models 3 and 4 only), whilst none of the other coefficients were statistically significant at conventional levels.

Table 3: Estimates of non-compliance rates, ASHE models

	Model 1	Model 2	Model 3	Model 4
Bite of the NMW				
Kaitz index	4.347***		1.764***	
	(-0.946)		(-0.614)	
Kaitz index - rounded NMW		3.257***		-1.406**
		(-0.897)		(-0.63)
Minimum Wage Year (Reference year 2007)				
2002	0.479***	0.645***		
	(-0.084)	(-0.077)		
2003	0.083	0.229***		
	(-0.069)	(-0.062)		
2004	0.139**	0.314***		
	(-0.058)	(-0.052)		
2005	0.086*	0.123***		
	(-0.048)	(-0.045)		
2006	0.077*	-0.003		
	(-0.046)	(-0.043)		
2008	-0.103**	-0.071*		
	(-0.046)	(-0.043)		
2009	-0.219***	-0.158***		
	(-0.048)	(-0.045)		
2010	-0.132***	0.072		
	(-0.051)	(-0.048)		
2011	-0.188***	-0.250***		
	(-0.056)	(-0.053)		
Unemployment and GDP				
Local area unemployment rate	-1.145	-1.113	-2.680***	-0.758
	(-1.021)	(-0.963)	(-0.831)	(-0.824)
UK annual GDP growth			0.022***	0.018***
			(-0.005)	(-0.005)
Employment Shares				
Proportion in firms with 25-49 employees	1.09	0.497	3.281**	2.650*
	(-1.628)	-1.534	(-1.642)	(-1.608)
Proportion in firms with 50-249 employees	0.5	0.446	-0.722	-1.261
	(-1.345)	-1.268	(-1.356)	(-1.327)
Proportion in firms with 250-499 employees	1.093	1.212	-1.063	-1.191
	(-1.396)	-1.315	(-1.378)	(-1.348)
Proportion in firms with 500+ employees	0.116	0.194	-2.608***	-3.236***
	(-0.916)	-0.863	(-0.800)	(-0.781)
Proportion female	1.399*	1.085	2.737***	2.933***
	(-0.836)	-0.788	(-0.824)	(-0.807)
Proportion in part-time employment	0.466	0.264	0.205	-0.063
	(-0.829)	-0.781	(-0.821)	(-0.804)
Proportion in temporary employment	1.465	1.427	1.765*	1.131

	(-0.952)	-0.897	(-0.95)	(-0.930)
Proportion in Agriculture and food processing	0.762	0.246	1.728	1.248
	(-1.735)	-1.634	(-1.765)	(-1.728)
Proportion in Textiles	0.033	0.564	1.123	3.194
	(-3.714)	-3.499	(-3.776)	(-3.693)
Proportion in Retail	-0.618	-1.045	-0.369	-0.168
	(-0.916)	-0.862	(-0.895)	(-0.878)
Proportion in Hospitality and Security	1.81	2.258*	0.066	0.121
	(-1.324)	-1.248	(-1.299)	(-1.274)
Proportion in Cleaning	-1.04	-1.021	-0.719	-1.740
	(-1.735)	-1.635	(-1.768)	(-1.729)
Proportion in Social Care	0.796	1.176	-0.057	-0.134
	(-1.116)	-1.052	(-1.134)	(-1.110)
Proportion in Other low-paying sectors	0.444	2.176	-2.344	-0.084
	(-2.814)	-2.652	(-2.843)	(-2.786)
Constant	-2.446**	-1.879**	0.443	2.392***
	(-0.997)	-0.939	(-0.840)	(-0.825)
Area dummies	Yes	Yes	Yes	Yes
Adjusted R-squared	0.377	0.410	0.346	0.331
Number of Observations	1350	1350	1350	1350

Standard errors reported in brackets. * indicates significance at 10%, ** indicates significance at 5%, *** indicates significance at 1% level.

6 Conclusions

In general, non-compliance rates were found to be higher for younger workers than for those on adult rates. For adult workers the baseline estimate of non-compliance according to the Labour Force Survey increased over time from 0.4% in 2000 quarter 2 to 1.7% in 2011 quarter 2; whilst the estimate of non-compliance according to the Annual Survey of Hours and Earnings remained at around 0.8% over the same period.

Non-compliance rates also varied by other adult worker characteristics. They were higher for women than for men; lowest in London (ASHE estimates, but not LFS estimates); higher in Distribution Hotels and Restaurants and in Other Services; and highest in firms/workplaces with less than 25 employees. In general, non-compliance rates for adult workers were higher when the bite of the adult NMW was also higher.

There are some potential biases in the measurement of non-compliance rates. However, in general these can only be partially identified using LFS data and there is little information in ASHE to identify any of these biases. For adult workers the largest identifiable bias was related to reporting of earnings at focal points in the earnings distribution. Thus if we assumed the NMW, when it was set at a rate that was not a multiple of 10 pence, was actually at the nearest value below the actual rate that was a multiple of 10 pence, then non-compliance rates would be, on average, 0.6 percentage points lower according to LFS estimates and 0.2 percentage points lower according to ASHE estimates.

For 16-17 Year Old Rate and Youth Development Rate workers the treatment of apprentices also makes a big difference to non-compliance estimates. These can only be identified with LFS data and, given the relatively small number of workers eligible for the 16-17 Year Old Rate and Youth Development Rate, are often not very precisely determined. Our revised estimates indicate that non-compliance for workers on the 16-17 Year Old Rate was on average 1.3% between 2005 and 2011. It was at its lowest in 2005 and 2006 at around 0.5% and highest in 2007 at 2.4%. For workers on the Youth Development Rate our revised estimate of non-compliance

was on average 1.4% between 2002 and 2011. It was lowest in 2002 at 0.7% and peaked in 2011 at 2.4%.

For adult workers, the non-compliance rates estimated from ASHE and LFS are in general not hugely different in the period up to October 2005 when NMW rates were set in multiples of 10 pence. Over this period non-compliance rates were typically just below one per cent (ASHE estimates ranged from 0.7% - 1.1% and LFS estimates ranged from 0.4% - 0.8%). Following this, the ASHE estimates remain broadly constant over time, ranging from 0.6% to 0.9% after the rounding adjustment, whilst the revised LFS estimates increased, averaging 1.2% from October 2006 onwards.

Our models of non-compliance reflect differences between the two sources. Analysis based on ASHE suggests non-compliance rates were negatively associated with indicators of the downturn (e.g. negatively associated with local area unemployment and positively associated with UK GDP growth). According to analysis based on the LFS, the evidence shows a relationship in the opposite direction although the impacts are weaker (non-compliance rates were not associated with local area unemployment and negatively associated with GDP growth).

For both data sources, non-compliance was generally positively associated with the bite of the NMW.

7 Bibliography

Ashenfelter, O., & Smith, R. S. (1979). Compliance with the Minimum Wage Law. *Journal of Political Economy , 87* (2), 333-350.

Bessa, I., Forde, C., Moore, S. and Stuart, M. (2013). *The National Minimum Wage, Earnings and Hours in the Domiciliary Care Sector.* Research Report for the Low Pay Commission. February. (Leeds University Business School.)

Chang, Y.-M., & Ehrlich, I. (1985). On the Economics of Compliance with the Minimum Wage Law. *Journal of Political Economy , 93* (1), 84-91.

Department for Business innovation and Skills (2012) Post-16 Education and Skills: Leaner Participation, Outcomes and Level of Highest Qualification held, Quarterly Statistical First Release, DS/SFR13 January 2012.

Dickens, R., Riley, R. and Wilkinson, D. (2009). *The employment and hours of work effects of the National Minimum Wage.* Low Pay Commission Report.

Fry, S., and Ritchie, F. (2013). Behavioural aspects of the National Minimum Wage: Measuring and interpreting behaviour in the low-wage labour market. Low Pay Commission Report.

Grenier, G. (1982). On Compliance with the Minimum Wage Law. *Journal of Political Economy , 90* (1), 184-87.

Hicks, S., Conn, S., & Johnson, J. (2009). Characterictics of those paid below the National Minimum Wage. *Economic & Labour Market review , 3* (1), 67-73.

Hussein, S. (2011). Estimating Probabilities and Numbers of Direct Care Workers Paid Under the National Minimum Wage in the UK: A Bayesian Approach. *Social Care Workforce Periodical.* 16. December.

LPC. (2012). *National Minimum Wage.* Low Pay Commission Report.

Ormerod, C., & Ritchie, F. (2007). Issues in the measurement of low pay. *Economic & Labour Market Review , 1* (6), 37-45.

Skinner, C., Stuttard, N., Beissel-Durrant, G., & Jenkins, J. (2002). The Measurement of Low Pay in the UK Labour Force Survey. *Oxford Bulletin of Economics and Statistics, 64* (s1), 653-676.

Appendix

The charts in the appendix include revised non-compliance rates by key characteristics for adults. This takes into account adjustments for the accommodation offset, tips, bonuses, apprenticeships and training receipt in the previous 13 weeks. In all charts, the non-compliance rate reported is the revised non-compliance rate reported in Figure26.

Figure A1: LFS Adult revised non-compliance rates by gender in the UK, 2002-2011

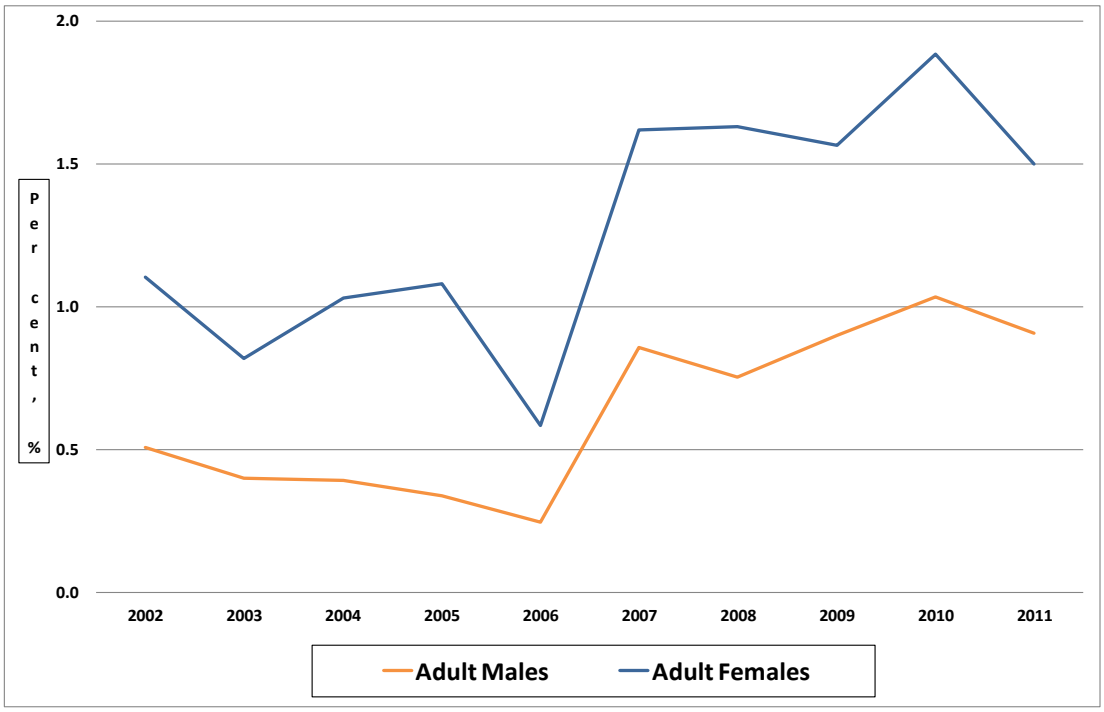


Figure A2: LFS Adult revised non-compliance rates by country and region of the UK, 2002-2011

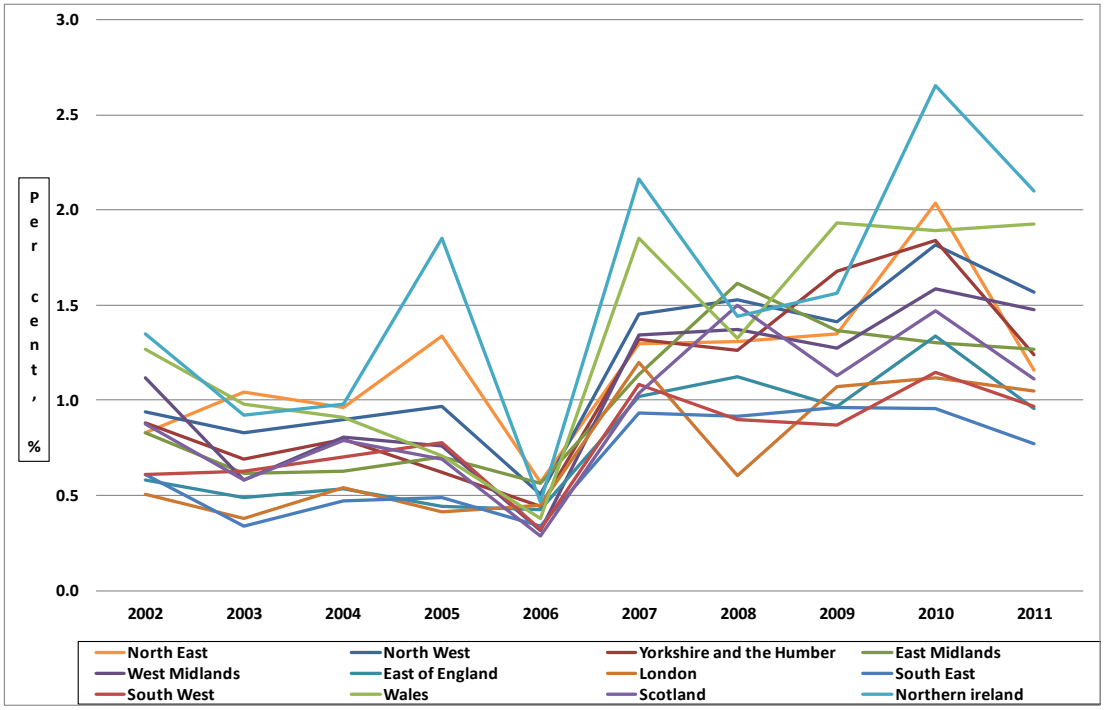


Figure A3: LFS Adult revised non-compliance rates by industry sectors in the UK, 2002-2011

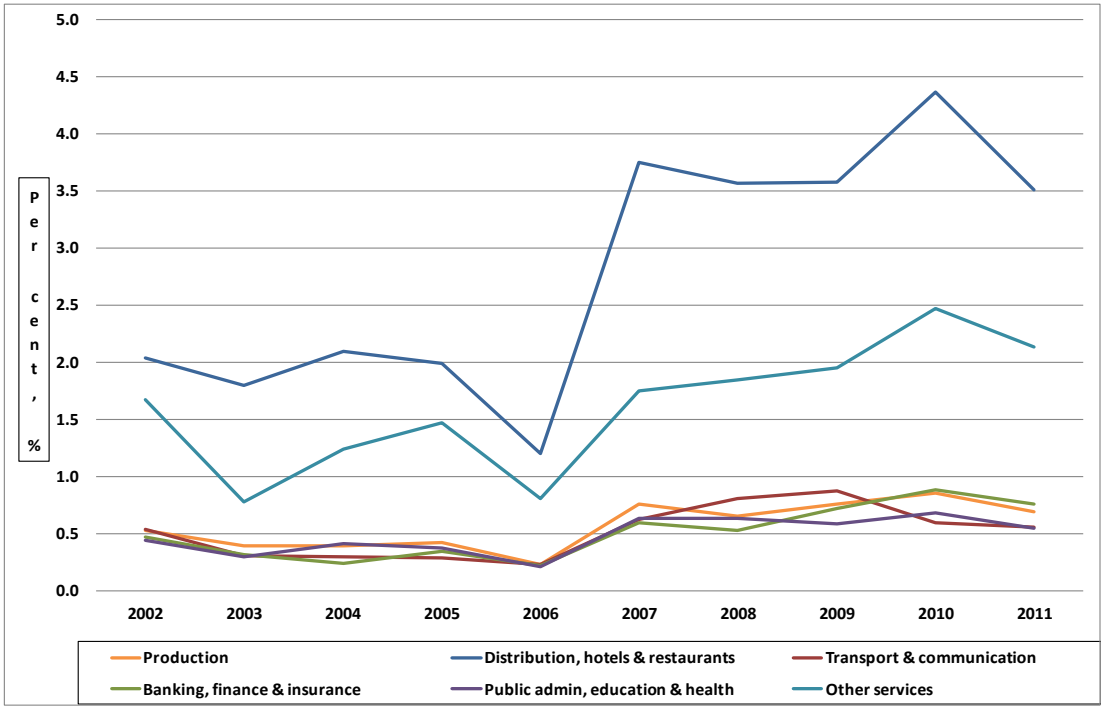


Figure A4: LFS Adult revised non-compliance rates by firm size in the UK, 2002-2011