The Substitution Rate between Low Pay Workers and the National Minimum Wage

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This report has been commissioned by the Low Pay Commission.

February 2013

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Acknowledgements

The authors would like to thank Tim Butcher, James Brennan and Yi Zhang for their comments and support throughout this project. Comments from the participants of the Low Pay Commission research workshop greatly improved the presentation and content of this report.

This work was based on data from the Quarterly Labour Force Survey and the Annual Survey of Hours and Earnings, produced by the Office for National Statistics (ONS) and supplied by the Secure Data Service at the UK Data Archive. The data are Crown Copyright and reproduced with the permission of the controller of HMSO and Queen's Printer for Scotland. The use of the data in this work does not imply the endorsement of ONS or the Secure Data Service at the UK Data Archive in relation to the interpretation or analysis of the data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

Executive Summary

This project studies the effect of the National Minimum Wage (NMW) on the workforce composition, in terms of distinct age groups with similar qualifications, within the low paying sectors of the economy. We are interested in the degree of substitutability between labour inputs (young and old employees) in the production process. Within each sector, we consider the relative difference between the average wage of two age groups, and relate it to the relative size of the different groups.

We expect that an analysis of the "optimal" level of the minimum wage rates for the different groups depends on the elasticity of substitution between the two groups of workers, assuming that the two are neither perfect substitutes nor perfect complements in production. In the extreme case, if old and young workers are perfect substitutes, firms are expected to substitute away from the more expensive type of worker towards the cheaper kind. Alternatively, if both types are treated as complements, substitution between types of workers will not take place and most of the effect of the NMW will be akin to a scale effect on the reduction of the aggregate level of employment of old and young relative to the rest of the labour force.

The first Low Pay Commission report suggests that the effective design of the alternative NMW rates was based on the comparison of the average productivity of low skill workers, which implies that the different age applicable NMW rates reflects differences in workers' productivity at various ages, but once this is accounted for, different (age-wise) types of employees are assumed to be perfect substitutes. While differences in productivity at different ages are indeed necessary to understand the effect of the NMW on the relative employment of the age groups, existing evidence on the degree of substitution between age groups is limited.

We use data drawn from the quarterly UK Labour Force Surveys (LFS) from 1997 to 2010 and the Annual Survey of Hours and Earnings (ASHE) from 1997 to 2011. The Labour Force Survey is a quarterly sample survey of households, providing information on the UK labour market, while ASHE is based on a one per cent sample of employees taken from the HM Revenue & Customs (HMRC) PAYE register. The repeated cross sectional nature of either database allows us to create a 'pseudo' panel of average observations from each one. The analysis is performed on employees only. We assign individuals into distinct categories (cells) over time using three distinct criteria. Firstly, we classify them according to their occupational group using definitions of low-pay and major occupational groups according to the Standard Occupation Classification frameworks of 1990 and 2000. Secondly, we use standard statistical (formerly known as Government Office Region) geographical classifications. Finally, respondents are classified according to their ages following the age bands defined by the existing NMW rates i.e. 16-17, 18-20, 21, 22-54 and 55+ year old.

The empirical approach leads to straightforward estimates of the elasticity of substitution between young and old employees by relating the effect of changes in relative average wages on relative employment size for each group of young workers relative to old ones. Moreover, we can assess the impact, if any, of the NMW and its regular (almost annual) upratings on relative wages, size of employment and sectoral costs of labour.

We find the following:

- Average wages in the low paying sectors of the economy have been rising steadily since the beginning of our estimation sample but not markedly more than the NMW during the same period. This *prima facie* observation would suggest that firms' motivation for wage increases stems less from workers' productivity increases and more from legal obligations. Arguably, firms may choose to pay (just) above the current NMW rate for both psychological and logistical reasons.
- The ratio of employment across age groups over time has remained stable for all groups i.e. there have not been any significant adjustments in the labour force composition in neither direction over our sample period. An exception to this seems to the employment of the very young (16-17), which followed a short-lived upwards trend from 2004 until 2008 when a significant downward adjustment was apparent. Since the onset of the 2008 recession, firms had adjusted to reduced demand by shedding workforce, in particular young employees, to minimise firm-specific capital losses and compensation costs. The stability of employment ratios across age groups over time, in conjunction with both the introduction and yearly uprating of the NMW rate(s), suggests that the potential adverse employment effects of the NMW are small.
- We find evidence that both the introduction and regular upratings of the NMW have a significant effect on determining observed changes in average wages for age groups older than 16-17 years of age. However, our results show that the effects of the NMW and its upratings on the sectoral cost of labour are rather weak across the two data sources that we use, and therefore we conclude that, if any, the influence of the NMW has to be small and limited to the very young (16-17 year olds) or the 21 year olds.
- We find no evidence that the NMW or its increases have an effect on relative employment size of young and old age groups.

- When modelling the effect of changes in the relative average wage on the relative size of employment the implied elasticities are positive but statistically significant only for the 21 year old group. We estimate the elasticity of substitution, in this case, to be around 0.35, which would imply significant complementarity (or at least argue against perfect substitution) between the 21 year old and the older age group.

Overall, we conclude that the NMW has a significant, consistent and small effect on the changes of the relative average wage within occupation, region and year but it has no effect on the labour force age composition. This is consistent with the proposition that young workers are complements to old workers in the production process.

1. Introduction

The objective of this project is to study the effect of the National Minimum Wage (NMW) on the allocation of labour between age groups with similar qualifications within occupational groups/sectors (i.e. keeping technology fixed). We are interested in the degree of substitutability between labour inputs (young and old employees) in the production process, and by extension in the effect of the NMW on sectors' adaptability to changing demographics and consequently labour market composition. We consider the within occupational sector age wage differential, i.e. the difference between the average wage of two age groups, and relate it to the relative size of the input labour for the different groups.

The introduction of the NMW as well as its yearly uprating and the definition of two additional group specific minimum wage rates (the 16-17 Year Olds Rate and the Apprentice Rate) provide exogenous variability which allows us to instrument the relative group size of the labour input or the relative size of the cost of labour to the firm so as to obtain sensible estimates of the elasticity of substitution between the two types of labour.

We expect that an analysis of the "optimal" level of the minimum wage rates for the different groups depends on the value of this parameter (the elasticity of substitution), assuming that the two kinds of labour inputs are neither perfect substitutes nor perfect complements in the production function. In the extreme case, if the technology is such that the old and young workers are perfect substitutes, everything else equal, firms will be expected to substitute away from the more expensive type of labour (per unit of efficient labour) towards the cheaper kind. Alternatively, if the technology treats both types of labour as complements, substitution between types will not take place and most of the effect of the NMW will be akin to a scale effect in the reduction of the aggregate level of employment of old and young relative to the rest of the labour force. We expect that in practice the value of the elasticity of substitution implies a scenario in between these two extremes.

The first LPC report suggests that the effective design of the alternative NMW rates was based on the comparison of the average productivity of low skill workers. In this case, the difference in NMW rates reflects differences in the marginal product between workers of different ages, but once this is accounted for, the types of labour are assumed to be perfect substitutes. We suggest that this assumption requires further study at least at the sectoral level and possibly at the firm level. Furthermore, while the differences in productivity at different ages are indeed necessary to understand the effect of the NMW on the relative employment of the age groups, the evidence on the degree of substitution between age groups is limited.

Our project is based on the expression of the within sector old/young wage differential in equilibrium, where the parameter corresponding to the ratio of labour inputs at different ages is directly related to the elasticity of substitution between the two types of labour (in the Constant Elasticity of Substitution case for example). This specification has many advantages - it is simple; it can be derived and extended to many different groups as shown for example in a different context by Card (2001) or Borjas (2003). We extend this specification to apply directly to well defined low-paying sectors where the technology is assumed identical between firms. The estimation exercise is based on data drawn from the Quarterly Labour Force Survey (LFS)for the period from 1997 to 2010 and the Annual Survey of Hours and Earnings (ASHE) for the period from 1997 to 2011.

This report is organised as follows: Section 2 provides a brief review of the recent literature. Section 3 presents our model and empirical strategy, while the next section (4) describes the construction of both datasets, the ratios of interest and discusses the resulting data and measures. Section 5 presents our estimates of both the reduced form and structural equations. The final section concludes.

2. Literature Review

Changing demographics and social considerations over the last decades have altered the labour force composition in most, if not all, OECD member countries including the UK. On one hand, the ageing population puts a strain on typical pay-as-you-earn social security systems, forcing policy makers to promote increased labour force participation of older workers by increasing pensionable age, linking it to life expectancy[1]. On the other hand, increasing rates of youth unemployment requires measures to control a widening living standards gap and to mitigate the negative effects of prolonged unemployment experienced early on in a typical working life. The design of early retirement schemes as a means for boosting youth employment, was put forward in the past (mainly in the 1970s and the next decade). The argument for the positive effects of such schemes on the youth employment was based on the assumption of substantial substitutability between young and older workers (Kalwij et al, 2009).

A widely accepted premise is that higher similarities in terms of skills between different age groups would tend to increase the substitutability of said groups in the production process. The degree to which workers of different ages substitute or complement each other in production has been debated since the early 1960s (see Hamermesh, 1993, chapter 3). Different authors have measured the elasticity of substitution between young and older workers and have found that it varies considerably (see Hamermesh, 2001, for a summary of main conclusions). The literature we review below does come to a consensus value for this elasticity of substitution while the imperfect substitutability of heterogeneous labour inputs is a broadly accepted "fact" in the field.

2.1 The Elasticity of Substitution between Age Groups

The earlier literature discusses the substitutability between age groups in the production process but more recent contributions have a widened focus, assessing substitution elasticity among different workers based on gender, experience, skills/education and more recently, ethnic origin. Hamermesh (1993, chapter 3: pp. 108-127) provides an extensive review of the early literature with discussion, the main findings being that skills and technological advancement are complementary, the same as capital and skills. Moreover, the elasticity of demand for homogeneous labour is greater than zero but less than one and the elasticity of complementarity between natives and migrants is rather low. Recently Card and Lemieux (2001) investigate the reasons behind the widening of the wage gap

[1] http://www.oecd.org/daf/financialmarketsinsuranceandpensions/privatepensions/50560110.pdf

among young men of differing skill level. The authors use data on the college-high school wage gap for five year birth cohorts over the period 1959 – 1996 in the U.S., 1974 – 1996 in the U.K. and 1980 – 1995 in Canada, to estimate a two-step model, where at first they obtain estimates of the partial elasticity of substitution and other parameters of interest, which are subsequently used in the estimation of the aggregate supplies of the two labour inputs included in the production function in the second step. They relax the assumption of perfect substitutability of labour inputs by assuming a CES production function, which is an aggregate of two CES components of High School and College educated workers. They measure the elasticity of substitution between younger (25 – 35) and older (46 – 60) workers to be between 3.7 and 6.2 across countries, subject to model specification (for the U.K.: 3.8 – 4.2).

Wasmer (2001) studies wage inequality in the U.S and France. He uses data from the March Current Population Survey from 1964 to 2000 for the US and the Formation et Qualifications Professionnelles: 1970, 1977, 1985 and 1993 for France. In his modelling framework, he relaxes the implicit assumption made by previous studies of disaggregated labour markets. This approach translates to a labour market where individual workers of all skills and/or characteristics, compete for the same vacancies. The author measures the elasticity of substitution between young and highly educated and old and low educated workers to be 0.5.

2.2 Minimum Wages and the Employment of the Young

A possible way of assessing the demand for young workers is through the effect of minimum wages on employment since properly enforced minimum wage legislation implies the exogeneity of the wage to the labour market and thus, the effect of such an intervention can provide evidence on the young workers' elasticity of demand. Based on this idea, a substantial number of studies have investigated the effects of minimum wages on the employment of the young. It is beyond our scope to review the literature on the elasticity of employment of the young; however, the interested reader can look at Neumark and Wascher (2007) for an exhaustive review of this literature. Notably, the reported minimum wage effect on employment has been declining in recent years. Card and Krueger (1995) *op cit* Neumark and Wascher (2007) argue that early studies suffered from "publication bias", while Neumark and Wascher (1998) *op cit* Neumark and Wascher (2007) attribute this pattern of reported estimates to model misspecifications and/or "parameter instability" and provide reasons for the latter. It suffices to say that early estimates of (statistically) significant employment effects of minimum wages do not withstand close scrutiny and have not been consistent over time.

2.3 Minimum Wages and the Elasticity of Substitution between Age Groups

The effect of minimum wages on the substitution between young and old workers, to the best of our knowledge, has received very limited attention in the literature. The UK Low Pay Commission (LPC) annual reports (Low Pay Commission, 2005) present some initial assessments of possible substitution between workers of different ages. Looking at changes in the employment share of young workers relative to the population share of that age group, the LPC suggests that in 2002 – 2003 there has, indeed, been a small substitution effect towards older workers (22 – 24 year olds) but the employment of the 25 – 34 group has fallen. In subsequent years, however, commissioned empirical studies fail to find any evidence of substitution between age groups.

In this study we are interested in the effect of the minimum wage on the "labour–labour" substitution and not on the elasticity of demand of young workers *per se* – even though, part of the elasticity of demand arises from substitution possibilities between labour types and more widely other inputs. The labour–labour substitution issue has been primarily examined in the context of labour with differing skills. There is an argument that higher minimum wages induce firms to hire more skilled workers, and thus low skilled workers are adversely affected (Connolly, 2002). We mention a few studies whose results are suggestive of the existence of significant substitution effects between workers of different age groups.

Neumark and Wascher (2004) study the minimum wage effect on employment in 17 OECD countries and find consistently negative effects. The authors note that these effects are particularly strong in countries where youth "sub – minimum" rates are not in operation, a result they see being consistent with the hypothesis of higher substitution towards younger workers in such instances. This may also be driving some of the results of negative effects on the employment of the young in the UK reported by Stewart (2004).

Hyslop and Stillman (2007) explored the 2001 minimum wage reform in New Zealand and present estimates on the employment of three distinct age groups, namely 16 – 17, 18 – 19 and 20 – 21 year olds. This dual reform firstly, lowered the eligible age for the adult minimum wage from 20 to 18 years, increasing the minimum wage for 18 and 19 year olds by 69%, and secondly raised the youth minimum wage to 80% of the adult minimum, increasing the minimum wage for 16 and 17 year olds by 41% over a two-year period. The authors report that in 2001, the employment rate of the 16 – 17 group increased by 2.2 percentage points and that of the 20 – 21 group by 4.2 percentage points. For the 18 – 19 group, however, the reported 0.7 percentage point increase is statistically insignificant. These results suggest that the employment of the 18 – 19 year olds, for whom the minimum wage increased the most, fell relative to both of the other age groups and the employment of the 16 – 17 year olds (with the next largest minimum wage increase) fell relative to the 20 – 21 group. These results are thus in line with our theoretical expectation. Indeed an increase in the employment of the 20 – 21 year olds can be rationalised as the reaction of employers substituting towards this age group because of the increased minimum wage of the other two age groups.

Similar studies have been conducted for other countries too (see Dolado et al., 1996, for France and/or Pereira, 2003, for Portugal) with similar estimates of the elasticity of the demand for 'young' labour. The conclusion that employers substitute towards different age groups when the wages of another increase can be reached in almost all (with the exception of some studies that raise serious econometric specification/modelling or data quality concerns, see for example Karageorgiou, 2004, for Greece and/or Bazen and Skourias, 1997, for France).

3. Model and Empirical Strategy

In this section we present a simple model which will justify the empirical methodology we pursue later on. Besides the different types of labour (young, middle aged, and older workers), the production function involves other inputs, which we will simply collect within an aggregate called capital, K. We assume further that the production function depends on young and old labour through a labour aggregate, L_{13} L_2 which we allow to depend on the size of middle aged labour utilised.

We therefore assume that the production function takes the form:

$$Q = F(K, L_2, L_{13}) \tag{1}$$

where the young/old aggregate is defined as a CES aggregate and satisfies

$$L_{13}^{\rho} = \theta L_1^{\rho} + L_3^{\rho} \tag{2}$$

with $-\infty \le \rho \le 1$. The elasticity of substitution σ is such that $\rho = 1 - \frac{1}{\rho}$.

The optimality conditions for L_1 and L_3 are:

$$p \frac{\partial F}{\partial L_{13}} \frac{\partial L_{13}}{\partial L_1} = \lambda w_1 \tag{3}$$

$$p \frac{\partial F}{\partial L_{13}} \frac{\partial L_{13}}{\partial L_3} = \lambda w_3 \tag{4}$$

where we leave $\frac{\partial F}{\partial L_{13}}$ unspecified and we can deduce from our previous specification the following

$$\frac{\partial L_{13}}{\partial L_1} = \theta L_1^{\rho-1} \left[\theta L_1^{\rho} + L_3^{\rho}\right]^{\frac{1}{\rho}-1} \tag{5}$$

$$\frac{\partial L_{13}}{\partial L_3} = L_3^{\rho-1} \left[\theta L_1^{\rho} + L_3^{\rho}\right]^{\frac{1}{\rho}-1}. \tag{6}$$

Hence, the optimality condition (relative wage equals marginal rate of substitution) becomes (expressed in logs):

$$\begin{aligned} \ln \frac{w_{ft1}}{w_{ft3}} &= \ln \theta_{ft} + (\rho - 1) \ln \frac{L_{ft1}}{L_{ft3}} \\ &= \ln \theta_{ft} - \frac{1}{\sigma} \ln \frac{L_{ft1}}{L_{ft3}}. \end{aligned} \tag{7}$$

Where we allow the relative marginal productivity, measured by θ, to depend on the firm/sector and the time period. The right hand side of equation (7) describes the (logarithm) of the marginal rate of substitution between the two kinds of labour. This specification is simple, it suggests that the within firm log wage young/old differential depends on the (logarithm of the) relative utilisation of the two inputs. This relationship holds under more general conditions. Clearly it holds if the labour and products markets are competitive; however it will hold as well when the product market is not competitive, or when the labour markets are not competitive in some instances. In this latter case the imperfection on the labour markets amounts to a wage "mark down" which is proportional between labour input groups and is independent of the relative size of the input groups (as would be the case with constant elasticity of labour supplies). This relative robustness to market structure is a further advantage of this approach. The approach is identical to the CES model used in other context, but with similar objectives, by Card (2001) and Borjas (2003). The parameter of the (logarithm of the) relative utilisation of the two inputs identifies directly the elasticity of substitution (within the young/old aggregate).

The parameter ρ measures here the substitution between young and old workers keeping the size of the young/old aggregate constant. This is the quantity of interest (given the assumption concerning the technology we make) to determine the role that technological choices can play to evaluate the effect of an intervention designed to substitute between the labour of distinct generations of workers. The specification remains straightforward since it is (apparently) linear in the parameters of interest. Of course the empirical difficulty is that the arguments on the right hand side are likely to be determined endogenously.

We base our empirical work on the relationship (7) expressed instead as a relationship between $\ln \frac{L_{ft1}}{L_{ft3}}$ and $\ln \frac{w_{ft1}}{w_{ft3}}$ or between $\ln \frac{L_{ft1}}{L_{ft3}}$ and $\ln \frac{w_{ft1} L_{ft1}}{w_{ft3} L_{ft3}}$. Furthermore to deal with firm/sector specific effect we specify the model in terms of first differences, hence we consider the two specifications:

$$\Delta \ln \frac{L_{ft1}}{L_{ft3}} = \ln \theta'_{ft} - \sigma \Delta \ln \frac{w_{ft1}}{w_{ft3}}, \qquad (8)$$

and

$$\Delta \ln \frac{L_{ft1}}{L_{ft3}} = \ln \theta''_{ft} + \frac{1}{\rho} \Delta \ln \frac{w_{ft1} L_{ft1}}{w_{ft3} L_{ft3}}. \qquad (9)$$

Given the restrictions on the technology, σ must be positive. In particular, values for 1/ρ between 0 and 1 are not consistent with a positive value for σ. The quantities $\ln \theta'_{ft}$ and $\ln \theta''_{ft}$ are related to the relative marginal productivities and depend in general on the firm/sector and time period. These allow for some changes in the technology which used the two kinds of labour. To complete this specification, we assume that the change from one period to the next of the wage differentials or of the relative wage bills depends on the proportion of workers in firm/sector *f* measured in period t-1 who are paid a wage between the minimum wage in effect at time t-1 and the minimum wage that will apply at time t. We denote these quantities $\text{Prop}\left[\underline{w}_{t-1,k}, \underline{w}_{t,k}; t-1\right]$ with k=1 (young workers) or 3 (older workers). Since the minimum wage for young workers and older workers take different values, we measure two distinct proportions. Clearly in the absence of demand side reactions these proportions are directly correlated to the increase in total cost (measured by the wage bill) or the increase in the average/marginal costs (measured by the average wage) which follow the introduction or the regular uprating of the minimum wage.

$$\Delta \ln \frac{w_{ft1}}{w_{ft3}} = \gamma_{0t} + \gamma_1 \text{Prop}\left[\underline{w}_{t-1,1}, \underline{w}_{t,1}; t-1\right] + \gamma_3 \text{Prop}\left[\underline{w}_{t-1,3}, \underline{w}_{t,3}; t-1\right], \qquad (8')$$

$$\Delta \ln \frac{w_{ft1} L_{ft1}}{w_{ft3} L_{ft3}} = \delta_{0t} + \delta_1 \text{Prop}\left[\underline{w}_{t-1,1}, \underline{w}_{t,1}; t-1\right] + \delta_3 \text{Prop}\left[\underline{w}_{t-1,3}, \underline{w}_{t,3}; t-1\right], \qquad (9')$$

these two equations play the role of the reduced form which determine the wage differentials and the relative wage bills in response to a change to the national minimum wage. Finally equations (8) and (8') on the one hand and (9) and (9') on the other hand imply that the reduced form equation for the change in the relative employment sizes take the same general form :

$$\Delta \ln \frac{L_{ft1}}{L_{ft3}} = \beta_{0t} + \beta_1 \text{Prop}\left[\underline{w}_{t-1,1}, \underline{w}_{t,1}; t-1\right] + \beta_3 \text{Prop}\left[\underline{w}_{t-1,3}, \underline{w}_{t,3}; t-1\right]. \qquad (10)$$

Finally note that when the two inputs are complements in production, i.e. whenever σ=0 or ρ=-∞, the reduced form (8) and (9) suggest that the relative employment size is determined independently from the relative wages or the relative wage bills. Hence we can possibly observe a case where the relative wage and the relative wage bill depends on the changes to the NMW, while the reduced form for the relative employment size does not respond on the change to the NMW.

4. Data

The empirical analysis uses data drawn from the quarterly UK Labour Force Surveys (LFS) from 1997 to 2010 and the Annual Survey of Hours and Earnings (ASHE) from 1997 to 2011. The LFS surveys the active population whether in work or not, while ASHE surveys 1% of the population. ASHE compensates for the limited information it holds (in comparison to the LFS) on respondents' personal characteristics by the quality of data on wages and earnings. The high quality of ASHE's wage and earnings data is attributed to its data sources: tax returns. The repeated cross section nature of either database allows us to create a 'pseudo' panel of average observations from each one. We assign respondents to groups defined by occupation, region and age, and then take an average of each cell, thereby creating a 'representative employee' of each group.

We proceed to discuss some features pertinent to each of the two datasets before we present further descriptive statistics of the datasets and the estimation samples.

4.1 The LFS sample

As already mentioned, the LFS is a quarterly survey. The approach we follow here is to merge the four quarters of any calendar year into an annual dataset. Since 1997, respondents have been asked to state their wages in waves 1 and 5 i.e. the first and last quarter they would be surveyed. For every annual dataset, we keep only those individuals with reported wage information and thus no individual will be sampled twice in any one year – the fifth time an individual is interviewed cannot, by construction, be in the same calendar year as his/her previous interviews. The analysis is performed on employees only. In pure counts, the pooled LFS dataset comprises 1,077,693 observations with 536,517 males (49.78%) and 541,176 females (50.22%) over the 14 years.

The annual datasets are subsequently collapsed to yearly data averaged over occupational group, region and age bands, and then appended to each other to create a pseudo-panel of approximately 25,244 (mean) observations.

Wage information is recorded in the LFS derived variable HOURPAY. We have experimented with constructing our own measures of the hourly wage rate as a comparison exercise. We measure hourly pay in four different ways: (1) we divide gross weekly pay by 187.5 (37.5 hours per day times 5 days), which we take to be the 'usual' average weekly hours of work, (2) we divide gross weekly pay by 165, which has been suggested in the literature (see Hamermesh, 1993) as a more realistic number of the weekly working hours, (3) we divide gross weekly earnings by the reported actual hours of work in the reference week, and (4) we divide gross weekly pay by the reported usual hours of work in the reference week. The last two measures are highly correlated with variable HOURPAY, measure (4) even more so than measure (3), while the first two deviate considerably from HOURPAY. In the analysis we use the native LFS measure (HOURPAY) since our own constructed measures, (3) and (4), are almost equivalent, in mean and range.

4.2 The ASHE sample

The ASHE dataset collects information on about 1% of employees in the UK directly from employers and thus compensates for its drawback of limited information on respondents' demographic characteristics (compared to the LFS) by the increased accuracy of data on earnings, wages, hours of work etc. It is worth noting that the introduction of two discontinuities in the ASHE by the inclusion of 'supplementary information' in year 2004 and the 'special arrangements' in year 2006, have resulted in extra strata being included in those years. Since we are neither interested in preserving the panel nature of the annual datasets, nor utilise any of the special arrangements introduced in 2006 but wish to remain able to use the supplementary information from 2004 onwards, we include the new stratum in year 2004 and exclude the new stratum in year 2006. This means that we maintain a steady number of individuals in the yearly data without any informational loss. The resulting pooled ASHE dataset amounts to 2,319,808 individual observations with 1,178,219 males (50.79%) and 1,141,589 females (49.21%) over the 15 years – as with the LFS, this is not the estimation sample.

In a similar approach to the LFS pseudo-panel construction, we collapse individual yearly data into averages across occupations, regions and age bands and sequentially append them. The resulting pseudo-panel has approximately 14,863 (mean) observations. Wage records of ASHE are considered to be more reliable than those of the LFS since in the former the information is collected directly from the employers. The variable recording hourly compensation in ASHE is HE (Hourly Earnings).

4.3 Variable description

We classify individuals into distinct categories using definitions of low-pay and major occupational groups according to the Standard Occupation Classification frameworks of 1990 and 2000 (see Table A1 in the Appendix for corresponding SOC90 and SOC2000 codes). From 2002, 'Sales' was subsumed into the 'Retail' category and for consistency it is applied to the beginning of the sample as well. The resulting categories are: Managers and Administrators, Professionals, Assistant professional and technical occupations, Clerical and secretarial, Personal and protective, Plant and machine operatives, Other (non-low pay), Retail (including Sales), Hospitality, Social Care, Food processing, Leisure, travel and sport, Cleaning, Agriculture, Security, Childcare, Textiles and clothing, Hairdressing and Office work. See Table 1 for counts in the two datasets.

Table 1 Absolute Frequency by Occupational Group.

	LFS		ASHE	
	n	%	*n*	%
MANAGERS AND ADMIN	150,556	14.26	293,506	12.65
PROFESSIONALS	123,950	11.74	258,158	11.12
ASS. PROF. AND TECHNICAL	131,659	12.47	300,920	12.97
CLERICAL AND SECRETARIAL	144,098	13.65	363,571	15.67
CRAFT AND RELATED	82,798	7.84	158,682	6.84
PERSONAL AND PROTECTIVE	42,651	4.04	83,176	3.58
PLANT AND MACHINE OPERATIVES	78,719	7.45	161,722	6.97
OTHER (NON LOW PAY)	38,542	3.65	129,962	5.60
(LOW PAY OCCUPATIONS)				
RETAIL	98,579	9.33	234,157	10.09
HOSPITALITY	43,559	4.12	80,519	3.47
SOCIAL CARE	26,251	2.48	55,397	2.38
FOOD PROCESSING	10,025	0.94	22,112	0.95
LEISURE, TRAVEL AND SPORT	4,868	0.46	11,791	0.50
CLEANING	32,221	3.05	71,373	3.07
AGRICULTURE	3,746	0.35	7,487	0.32
SECURITY	8,230	0.77	18,254	0.78
CHILDCARE	15,467	1.46	28,130	1.21
TEXTILES AND CLOTHING	4,068	0.38	8,362	0.36
HAIRDRESSING	2,037	0.19	1,497	0.06
OFFICE WORK	13,621	1.29	31,032	1.33
TOTAL	1,055,645	100	2,319,808	100

For consistency and ease of comparison between datasets we adopt a broad regional classification for both the ASHE and LFS samples. The regional classification is thus: North East, North West, Yorkshire and the Humber, East midlands, West midlands, East of England, London, South East, South West, Wales, Scotland, Northern Ireland and Outside the UK (LFS sample only). Table 2 summarises this information across datasets.

Table 2 Absolute Frequencies by Region

	LFS		ASHE	
	n	%	*n*	%
NORTH EAST	44,519	4.23	97,265	4.19
NORTH WEST	117,370	11.16	261,615	11.28
YORKSHIRE AND HUMBER	93,885	8.93	205,391	8.86
EAST MIDLANDS	74,705	7.10	167,826	7.24
WEST MIDLANDS	93,479	8.89	214,860	9.26
EAST OF ENGLAND	93,498	8.89	212,099	9.15
LONDON	122,455	11.64	329,773	14.22
SOUTH EAST	142,599	13.56	314,036	13.54
SOUTH WEST	89,470	8.51	198,065	8.54
WALES	47,139	4.48	104,532	4.51
SCOTLAND	96,411	9.17	213,741	9.22
NORTHERN IRELAND	35,679	3.39		n/a†
OUTSIDE THE UK	544	0.05		n/a‡
TOTAL	1,051,753	100.00	2,319,203	100.00

†Not Available; Northern Ireland data is owned by the Department for Trade and Investment (www.detini.gov.uk) and is not included in ASHE.
‡ Data for employees outside the UK not available due to ASHE's sampling design.

We further create five age bands, namely 16 to 17 year olds, 18 to 20 year olds, 21 year olds, 22 to 54 year olds and 55+ year olds, who we also regard as the 'old' workers (Table 3). This classification is based on the National Minimum Wage Rates' groups i.e. the Adult rate (for those 22+; 21+ from 1 October 2010), the Development rate (for those 18-21; 18-20 from 1 October 2010) and the 16-17 Year Olds rate. Individuals on the Apprenticeship rate (from 1 October 2010) could be identified in the LFS sample but not in the ASHE sample. Our LFS dataset only extends to the first quarter of 2010 and as such we cannot identify those on apprenticeship rates.

Table 3 Absolute Frequencies by Age Group

	LFS		ASHE	
	n	%	*n*	%
VERY YOUNG (16-17)	25,082	2.33	28,549	1.23
YOUNG (18-20)	49,736	4.62	91,081	3.93
21 YEAR OLD	16,844	1.56	35,153	1.52
MIDDLE AGED (22-54)	833,365	77.33	1,834,827	79.09
OLD (55+)	152,666	14.17	330,198	14.23
TOTAL	1,077,693	100.00	2,319,808	100.00

4.4 Ratios

The main variables of interest in this analysis take the form of log ratios of magnitudes between age groups. Specifically, we require the ratios of the average wage and labour cost between young and old employees, as well as the ratios of their relative size. We have already mentioned that we distribute workers to cells according to their occupation, region of work and age group. To that end, consider a set of workers of a specific occupation c, $c = 1, \dots, C$; in region r, $r = 1, \dots, R$; in age band i, $i = 1, \dots, I$; who are observed in year t, $t = 1, \dots, T$. The measure of the ratio of the number of young relative to old workers for each resulting group therefore is:

$$l_{crt}^{i/o} = \frac{L_{crt}^{i}}{L_{crt}^{o}}$$

where L_{crt}^{i} and L_{crt}^{o} give the number of young and old employees, respectively, in cell (c, r, t). In our models, the labour measure L_{crt}^{i} alternates for the four age groups (excluding, of course, the 55+ group). We define the ratio of the average wage as:

$$w_{crt}^{i/o} = \frac{w_{crt}^{i}}{w_{crt}^{o}}$$

where w_{crt}^{i} is given by either

$$w_{crt}^{i} = \frac{1}{n_i}\sum w_{crt}^{i}$$

or

$$w_{crt}^{i} = \frac{\sum\left(w_{crt}^{i} \times h_{crt}^{i}\right)}{\sum h_{crt}^{i}}$$

and h_{crt}^{i} is the usual weekly hours worked. These two measures could then be understood as an average individual hourly wage and an average hourly wage respectively.

Similarly, we construct the ratio of labour cost, the relative wage bill, for each age group relative to older workers as:

$$\mathbb{w}_{crt}^{i/o} = \frac{\mathbb{w}_{crt}^{i}}{\mathbb{w}_{crt}^{o}}$$

where $\mathbb{w}_{crt}^{i}$ is defined in three different ways, namely:

(a) $\mathbb{w}_{crt}^{i} = w_{crt}^{i} \times L_{crt}^{i}$

or (b) $\mathbb{w}_{crt}^{i} = w_{crt}^{i} \times \sum h_{crt}^{i}$

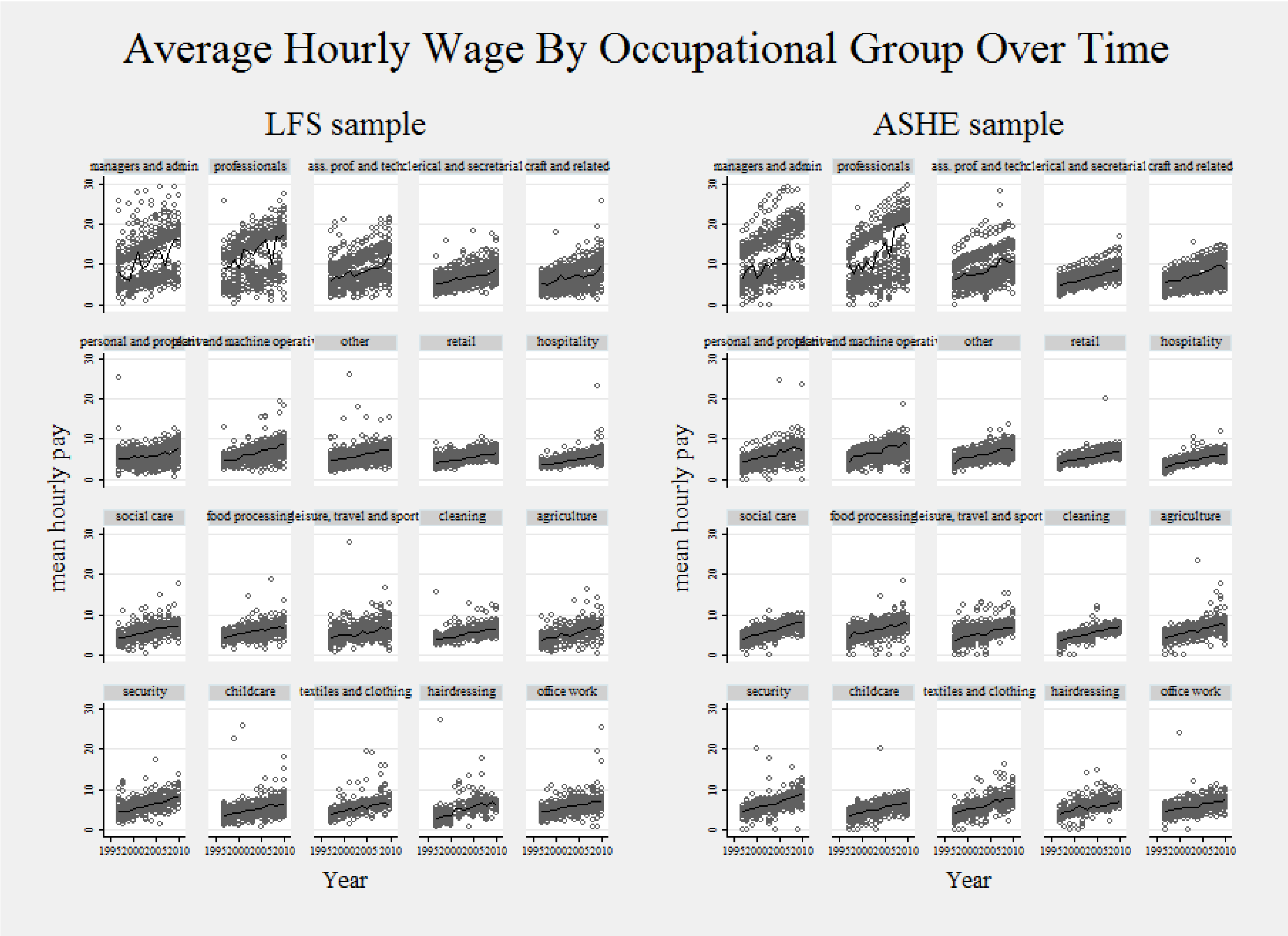
or (c) $\mathbb{w}_{crt}^{i} = \sum w_{crt}^{i} \times h_{crt}^{i}$

Note that all measures are means over individuals in each (crt) cell and therefore we withhold explicit mean notation. All averages are weighted by the original dataset sampling weights.

4.5 Data Description

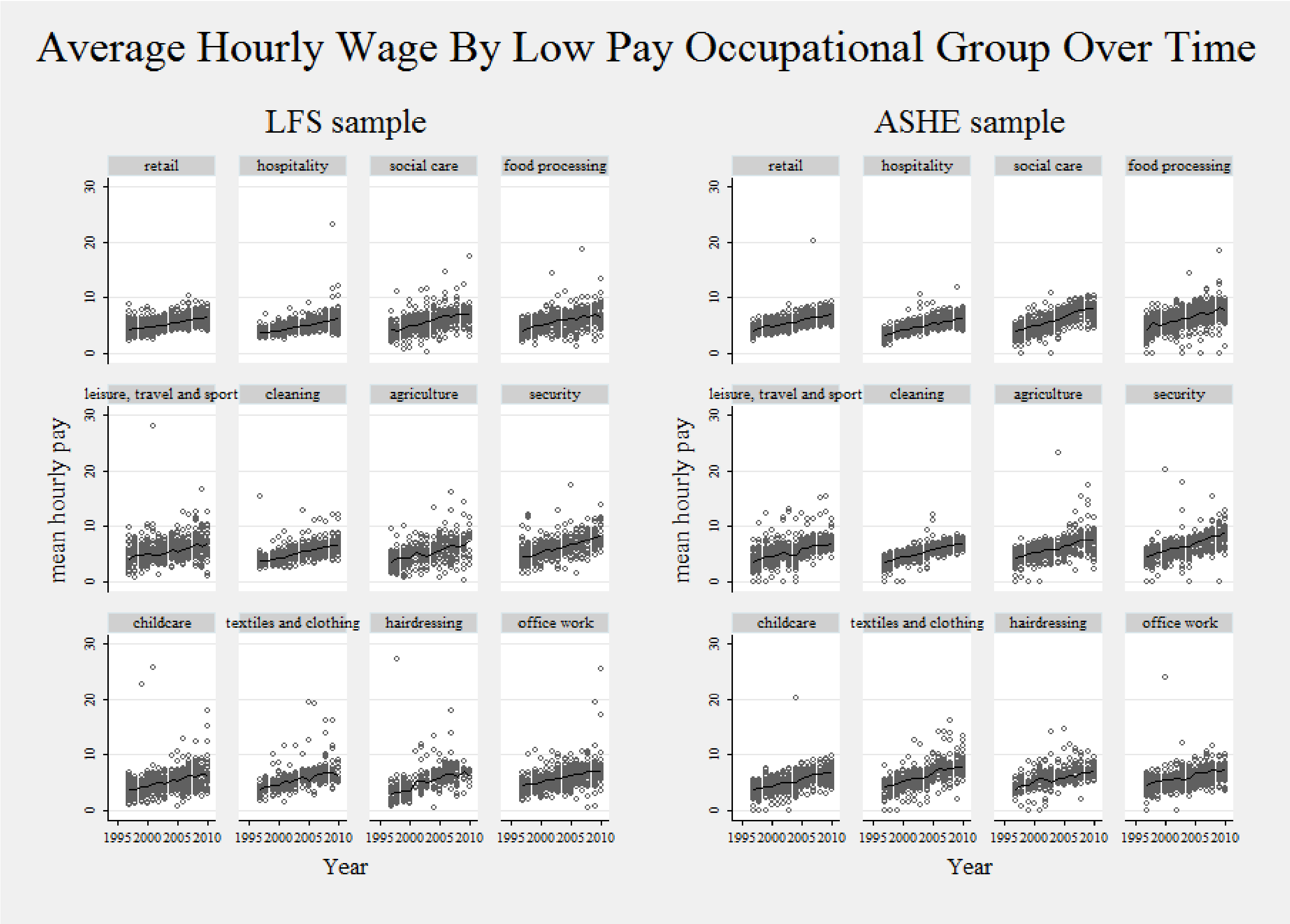
We begin by looking at the behaviour of average wages over time for each occupational group. We notice a small and steady increase present in both the LFS and ASHE samples – this may be clearer in the LFS sample, which also exhibits greater variation (than ASHE), particularly for the non-low paying occupations (Figure 1). Notice here the reduced variation in hourly earnings in occupational groups such as Retail, Hospitality and/or Cleaning (more so in the ASHE sample). This observation suggests the evenness of compensation in such sectors, which undoubtedly follows the standardisation of practice, the transferability of (low) skills and hence the higher supply of labour in these occupations. As already mentioned, the self-reported nature of the LFS wage measure may translate into increased measurement error, whereas the more reliable ASHE record provides us with a more accurate description of the wage adjustment. The behaviour of hourly compensation for managers and professionals is also noteworthy, both the LFS and ASHE samples suggest a steady increase for managerial and professional wages, despite erratic data.

Figure 1 Average Hourly Wage by Occupation Over Time.



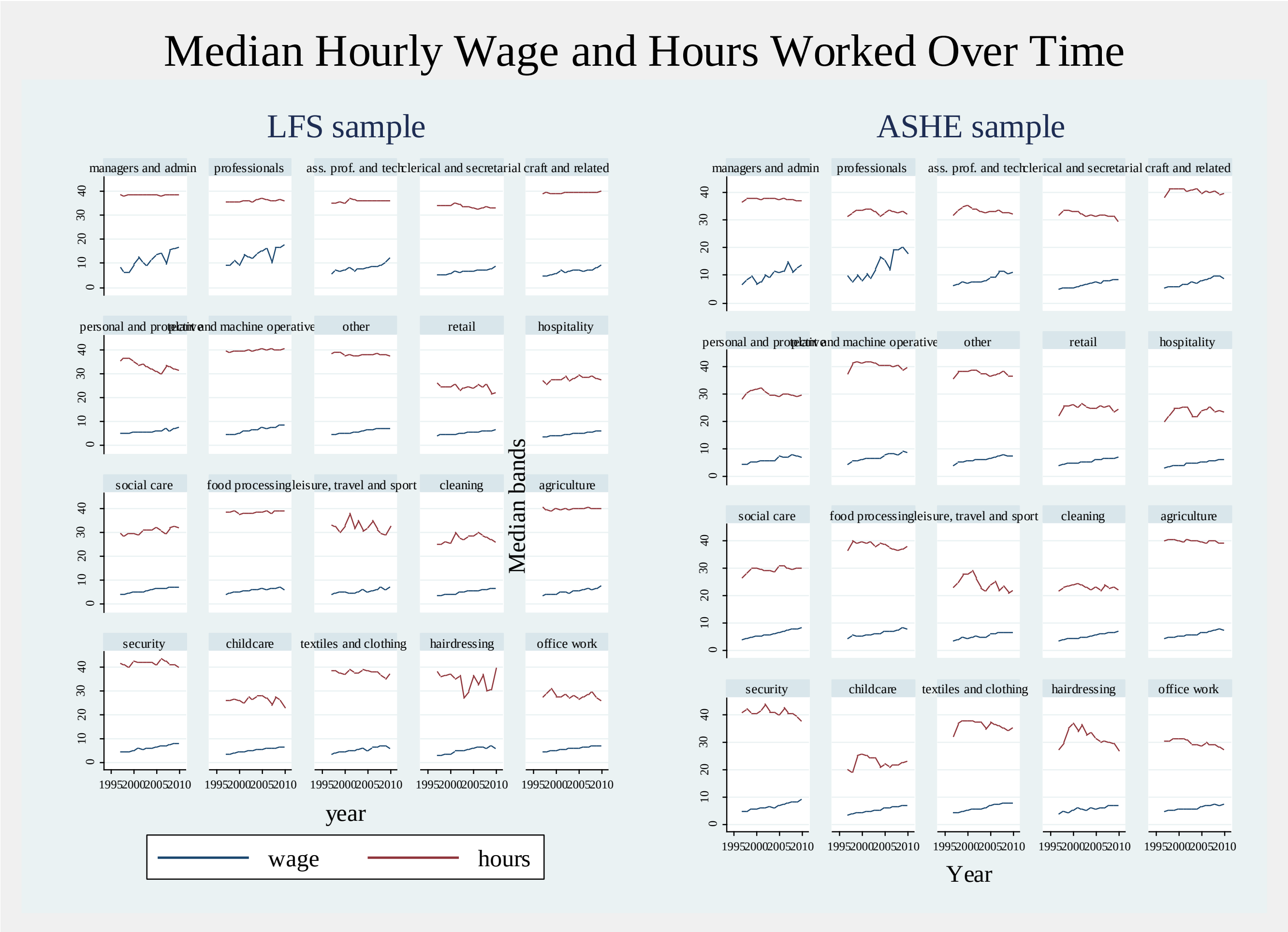
In Figure 2 we present the average hourly earnings by low paying occupation. We notice that for most occupational groups, average hourly wages followed the uprating of the NMW over the years and in particular in more recent periods, the average wage exceeds the national minimum wage. An interesting feature of the two samples is that although Hairdressing appears to pay below the national minimum according to LFS data, the same cannot be observed in the ASHE data, where the average is consistently above the legal minimum.

Figure 2 Average Hourly Earnings by Low Paying Occupation Over Time.



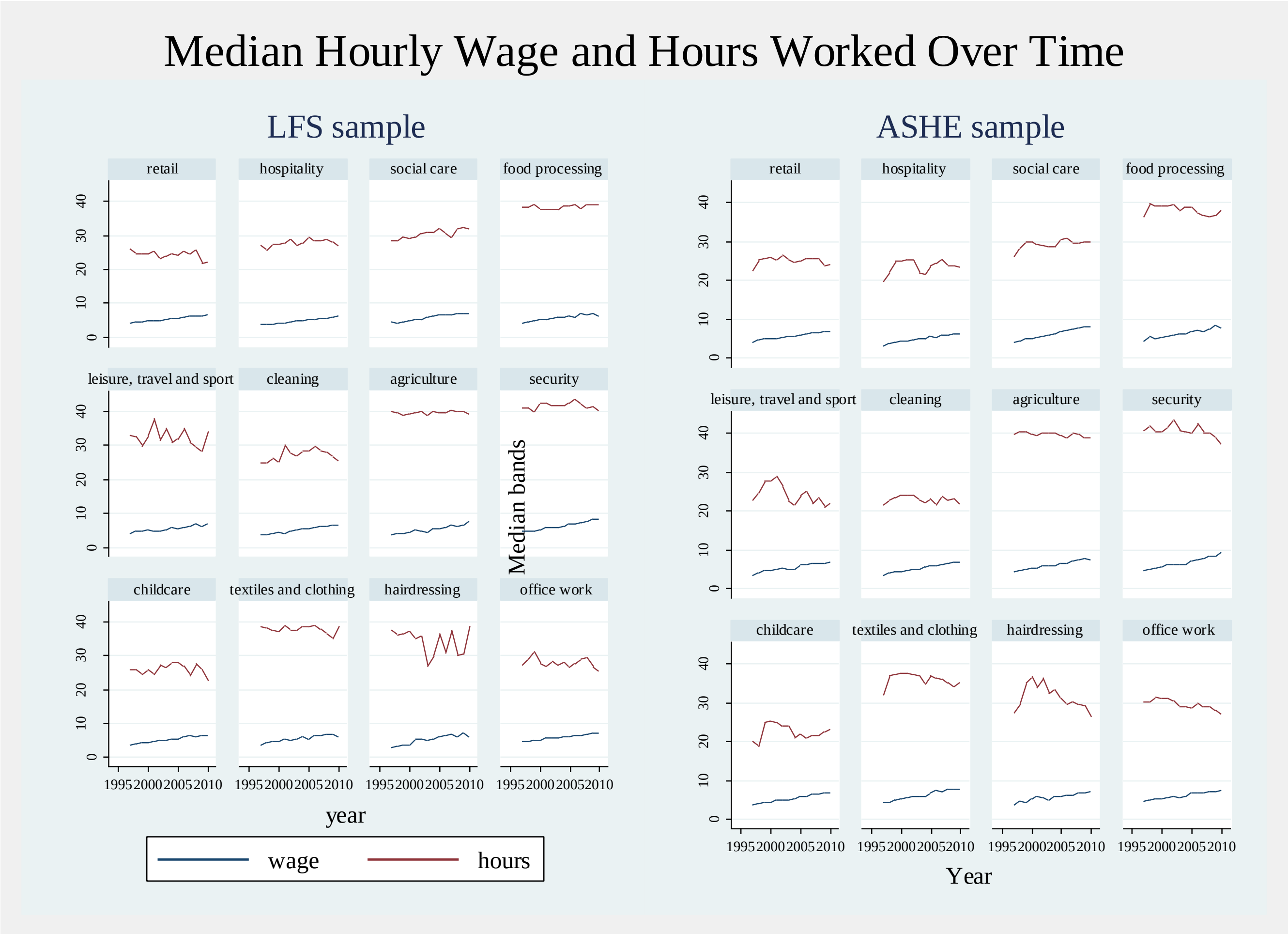
We now turn our attention to the hourly wage in relation to working hours. Figure 3 presents median usual hours worked and average hourly wages. Some interesting observations emerge. Firstly, both the LFS and ASHE samples convey a similar picture. For non-low paying occupational groups, the typical hours of work reported remain relatively steady over the sample period. For the low paying sectors of the economy, however, we notice a somewhat more volatile behaviour. Notice that in Retail, Hospitality, Cleaning and Childcare the median hours reported are considerably below other occupational groups – this is probably due to a higher proportion of non-full time employees in the sector. The same pattern is also observed among those in Office Work, which again is attributed to the impact of flexible working arrangements among those employed in the sector. The idiosyncratic features of the specific occupation allows more people to take up employment under a flexible working hours contract (such as job-share, working from home etc.).

Figure 3 Median (Usual) Hours Worked and Average Hourly Wages by Occupation



In order to see the evolution of wages and number of working hours more clearly, we have reproduced the information of Figure3 on Figure 4(below) but restricted the samples to those earning less than £20 per hour. Focusing on the low-paying sectors, we see that working hours have remained relatively stable but hourly wages have indeed increased over time. Yearly adjustments in working hours in certain sectors possibly reflect employers' responses to changing market conditions. It is likely that employers adjust hours instead of employment, especially in low skill occupations.

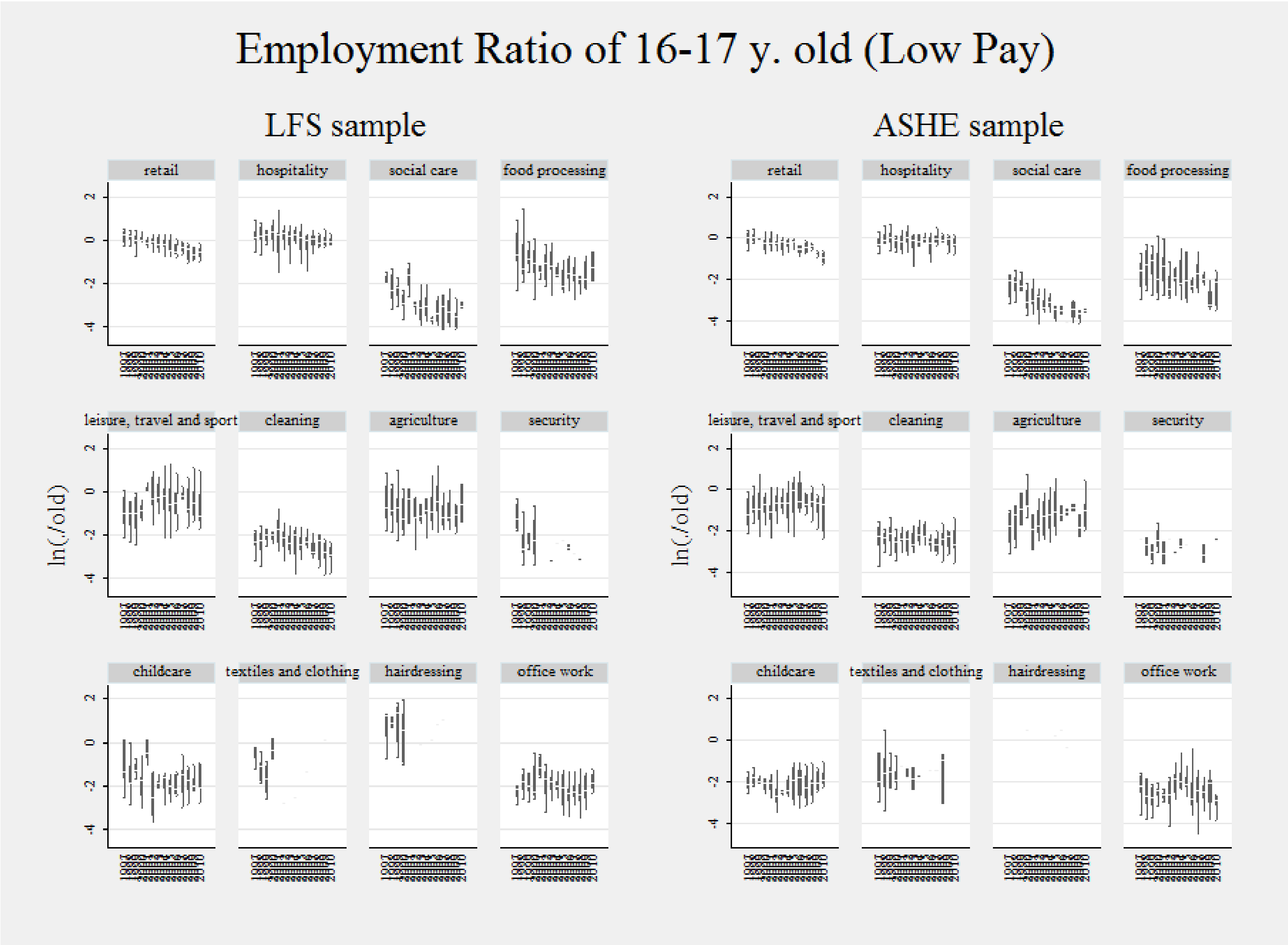
Figure 4 Median (Usual) Hours Worked and Average Hourly Wages by Occupation (<£20/h)



Given that our interest is in the substitutability of young and old employees, it is useful to consider the numbers of employment of such age groups over time. Of course, we do not expect to see any noticeable differences in the high-skills, high-pay occupational groups and therefore focus our attention to low-paying occupations. For indicative purposes, Figure 5 compares employment numbers of 16 to 17 year olds to old (+55 years old) employees in low-paying sectors where possible differences are expected to be more pronounced. We discuss each age category in turn below.

Looking at both LFS and ASHE results, we notice that many low-paying sectors have, over time, adjusted the age-wise composition of their workforce towards old employees, particularly since around 2008. This is not surprising. The financial crisis and the following contraction of economic activity has resulted in many old workers entering the low skill and low pay job market. Furthermore the demographic evolution of the population has resulted in larger sizes for the older cohorts relative to the young ones. Looking at the Retail sector, both datasets suggest the increased participation of old workers at the expense of the very young. We also notice increasing employment of old workers compared to very young ones in sectors such as Social Care and Office Work (according to ASHE but not LFS). In sectors that traditionally employ older workers this observation hints us not so much to the fact that there has been a compositional change due to cost or inter-occupational labour mobility but more to the fact that the prevailing state of the economy and the austerity measures adopted in recent years have, plausibly, considerably lowered old workers' reservation wages.

Figure 5 Average Employment of 16 – 17 year olds in Low Pay Occupations

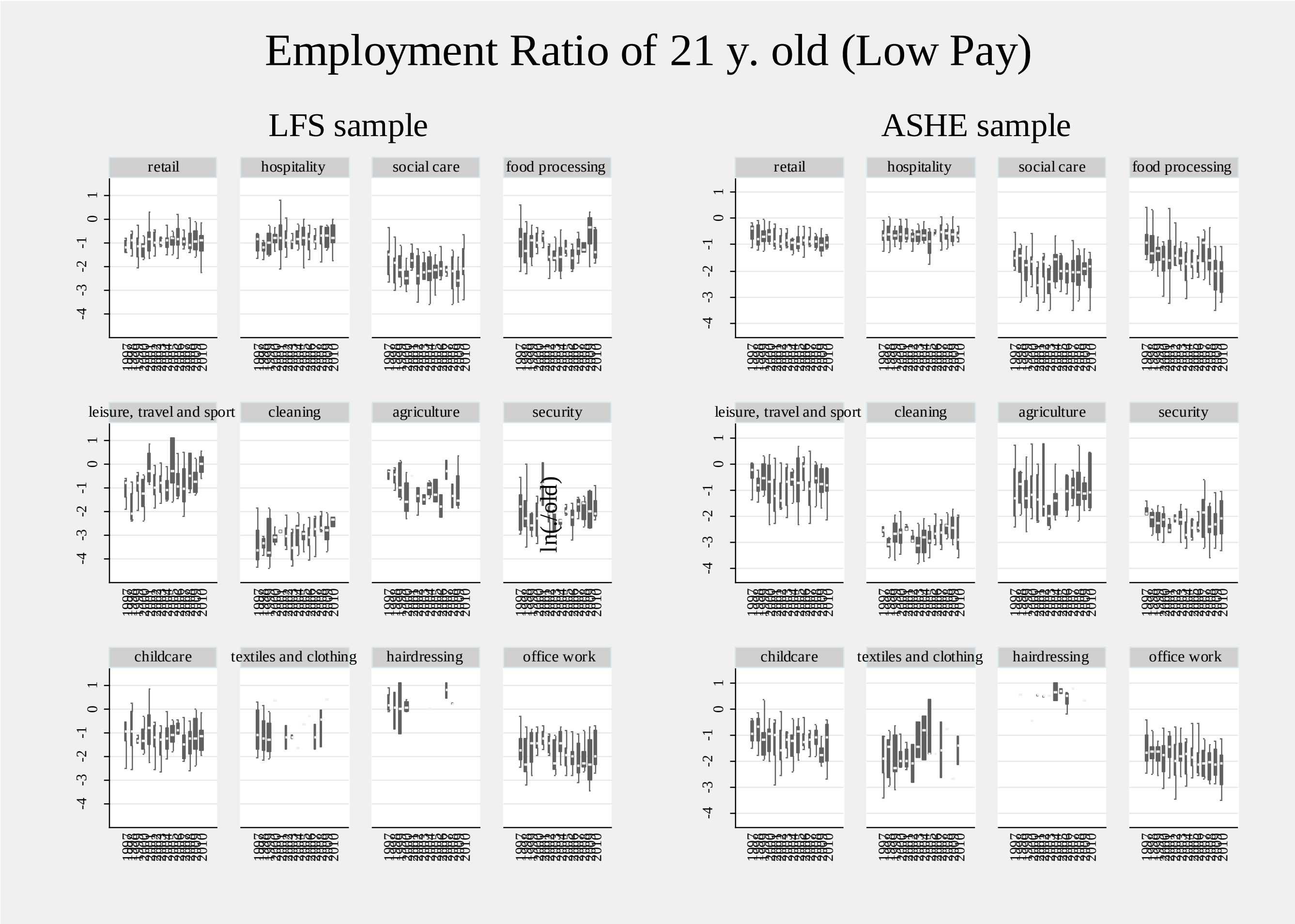


Among the 18 - 20 year old workers, we notice a slightly different picture (Figure 6). Participation in agriculture remains relatively stable over time, whereas we observe the increased participation of young workers in the Leisure, Travel and Sport sector (according to LFS). The latter sector is expected to attract and utilise younger workers owing to the nature of the job more than anything else. Other low-paying sectors exhibit the composition patterns as expected, with security for instance employing more old workers and hospitality more young people.

Figure 6 Average Employment of 18 - 20 year olds in Low Pay Occupations

For the 21 year old group (Figure 7), the most noticeable feature when using the LFS data is the increasing number of young (21) relative to old workers in the leisure, travel and sport sector and the textile and clothing until around the mid 2000's. We do not observe this pattern from the ASHE data. In other low-paying sectors, the employment ratio of 21 year old to old (55+) appears stationary but variable in certain sectors.

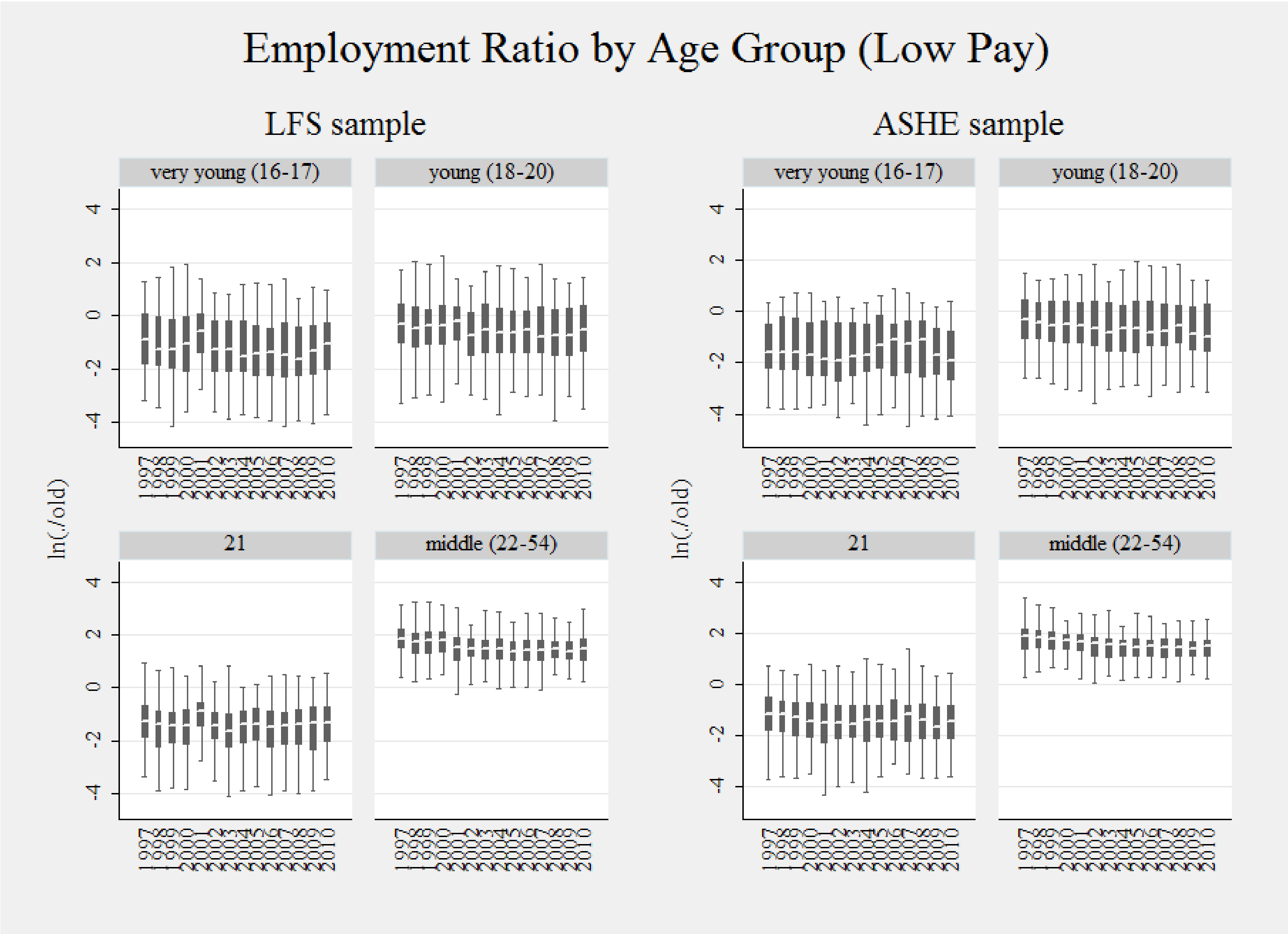
Figure 7 Average Employment of 21 year olds in Low Pay Occupations



Looking at the ratio of employment across age groups over time (Figure 8), we notice that it has remained stable for all groups i.e. there have not been any significant adjustments in the labour force composition in neither direction over our sample period. An exception to this seems to the employment of the very young (16-17) based on the ASHE data, which follows a short-lived upwards trend from 2004 up until 2008 when a significant downward adjustment is apparent. Quite plausibly, firms after the 2008 recession decided to adjust to the reduced demand by shedding workforce, in particular young employees to minimise firm-specific capital losses and compensation costs.

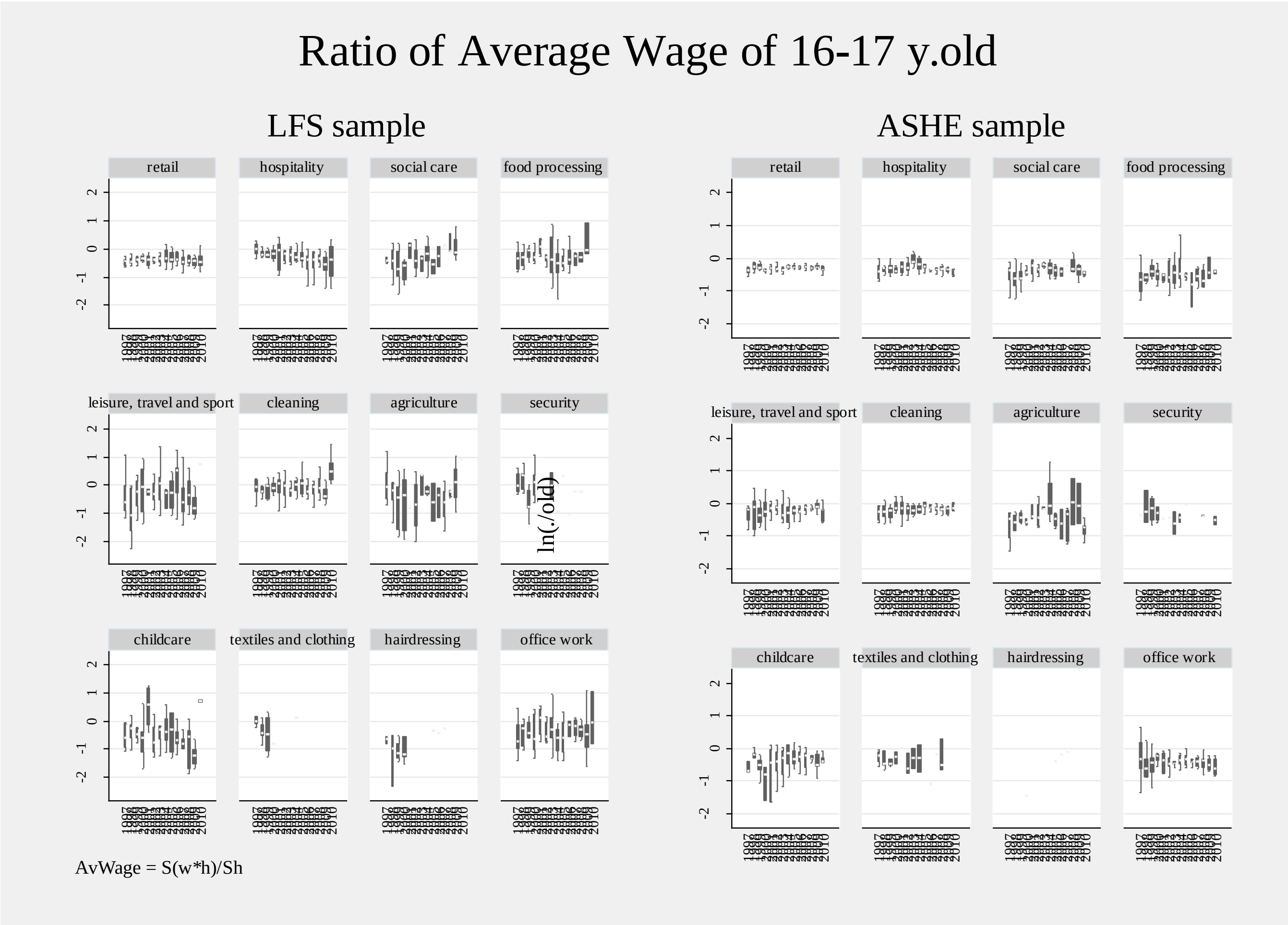
The stability of employment ratios across age groups over time, in conjunction with both the introduction and yearly uprating of the NMW rate(s), suggests that potential adverse employment effects of the NMW are small.

Figure 8 Average Employment by Age Group (Low Pay Occupations)



We now consider the evolution of average wages across age groups and occupations. Again, we focus on the low-paying sectors of the economy. Figure 9 presents the ratio of average wage between young (16 – 17 year olds) and old employees. Firstly, notice the higher variability in the LFS sample relative to the evidence drawn from the ASHE data. We are inclined to put greater faith in the ASHE wage data since the latter is collected directly from the employers' records rather than being self-reported, and thus subject to larger measurement error. Despite the general tendency of a stable ratio for the wages of the young relative to the old, we observe a steady increase in the young's hourly compensation in Childcare since around 2001 and a somewhat significant increase around the introduction of the 16-17 year olds' rate in 2004. More moderate increases in the median wages of 16-17 year olds are observed for other low-paying sectors, with the exception of agriculture, where the increase is quite substantial (seen more clearly in the ASHE data) but is dominated by the variability.

Figure 9 Relative Wage over time and sector, 16-17 year olds.



Figures 10 and 11 present the evolution of the average wages for the 18-20 year olds and for 21 year olds respectively, relative to the average wage of older workers. The results for the 18-20 year olds are very similar to those of the 16-17 year olds. However, for the 21 year olds, we observe a distinct increase in the average wage of the young both at the NMW introduction point but also at each subsequent uprating in the next few years in sectors such as Security and Office Work. In other sectors, such as Retail, the relative average wages remains very stable over time.

Figure 10 Ratio of Average Wage of 18-20 year olds

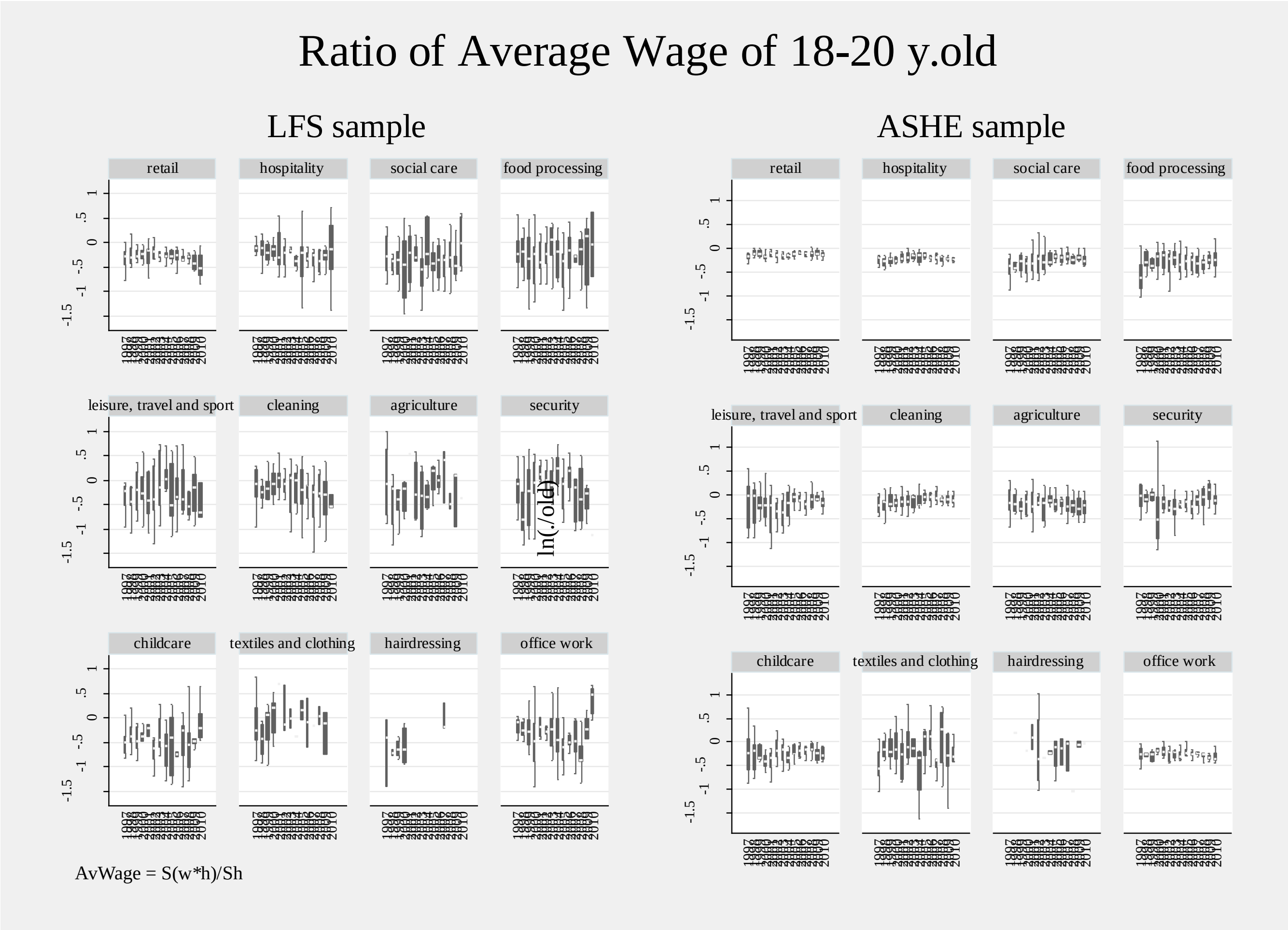


Figure 11 Relative Wage over time and sector, 21 year olds

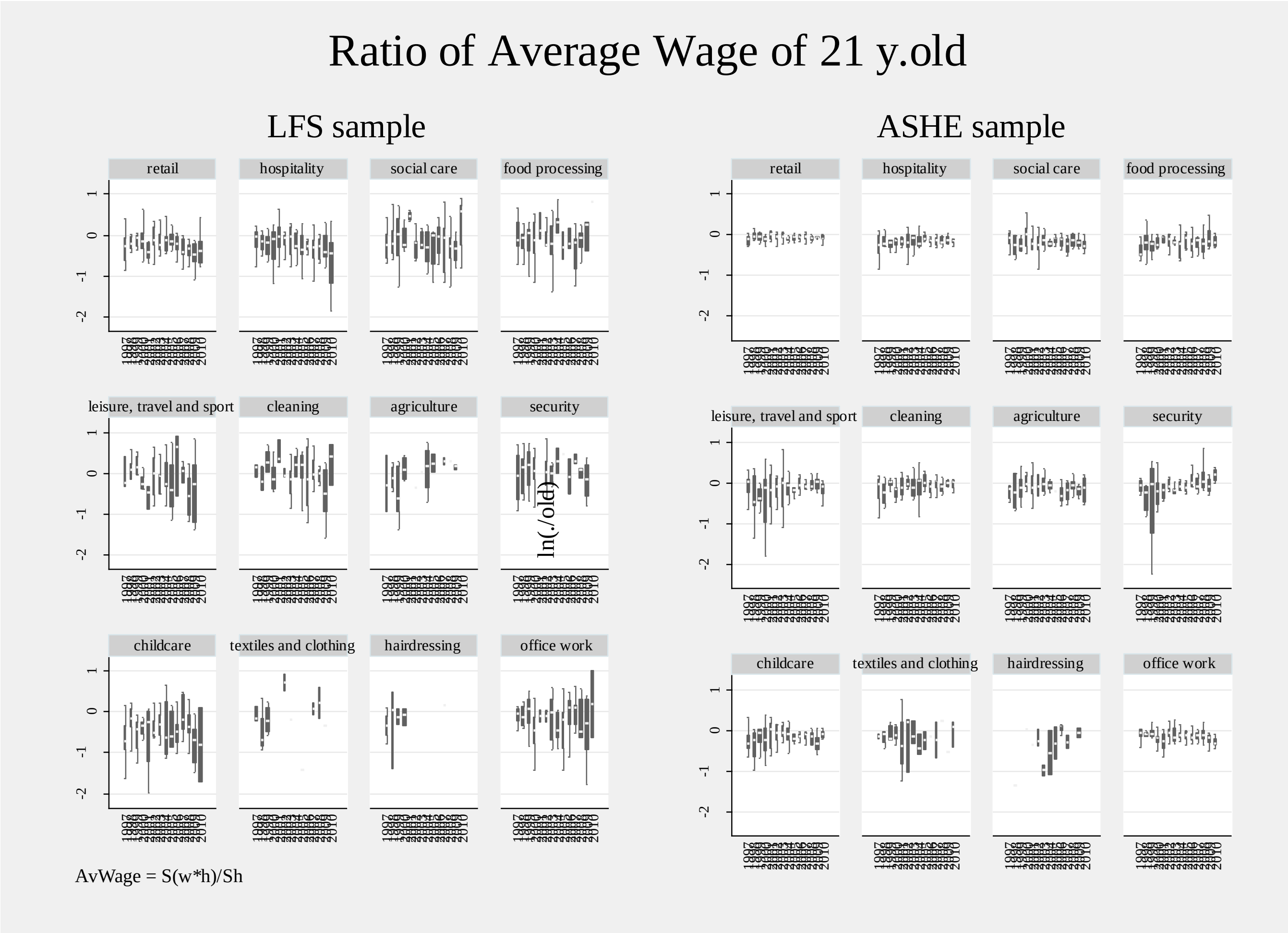
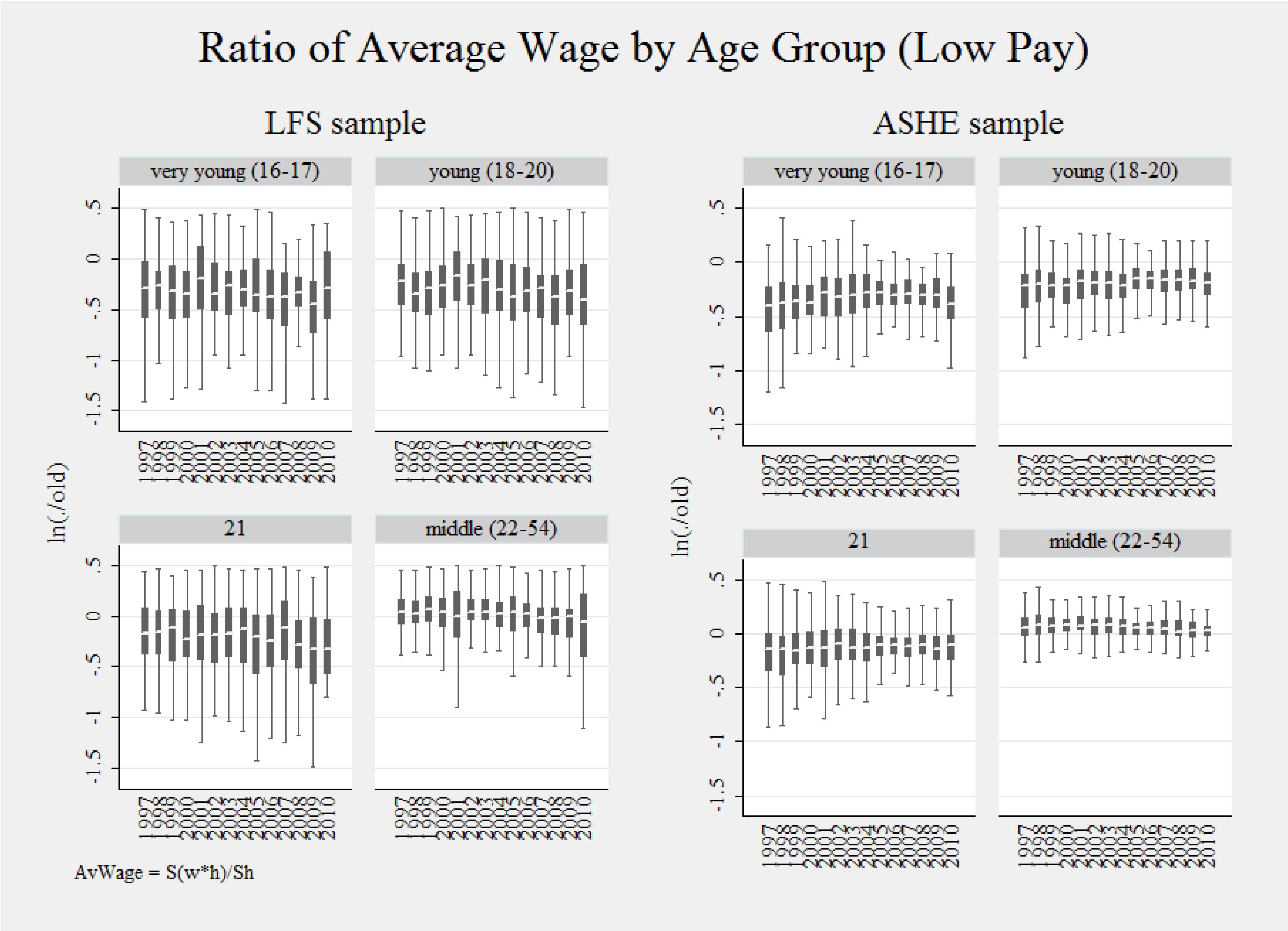


Figure 12 presents a summary of the evolution of the ratio of the average wage for each age group relative to old workers regardless of employment sector. The ratio of average wages exhibits greater variability for the young age groups i.e. 16 - 17, 18 - 20 and 21 year olds in the LFS than ASHE. However, for the 16 – 17 year olds, an increase in the relative wages can be traced out in both data sources.

Figure 12 Relative Wage over time, by Age Group (Low Pay Occupation)



Turning to the relative cost of labour as we measure through the ratios of the wage bill between young and old workers across low-paying sectors (figure 13), we notice that in sectors such as Food processing, Social Care and Office work, the wage bill of the old workers has increased relatively to that of the young. In contrast, in sectors such as Textiles and Clothing and Hairdressing, the opposite is true. Retail has managed to keep the relative cost of labour steady over time.

Figure 13 Relative Wage Bill (Low Pay)

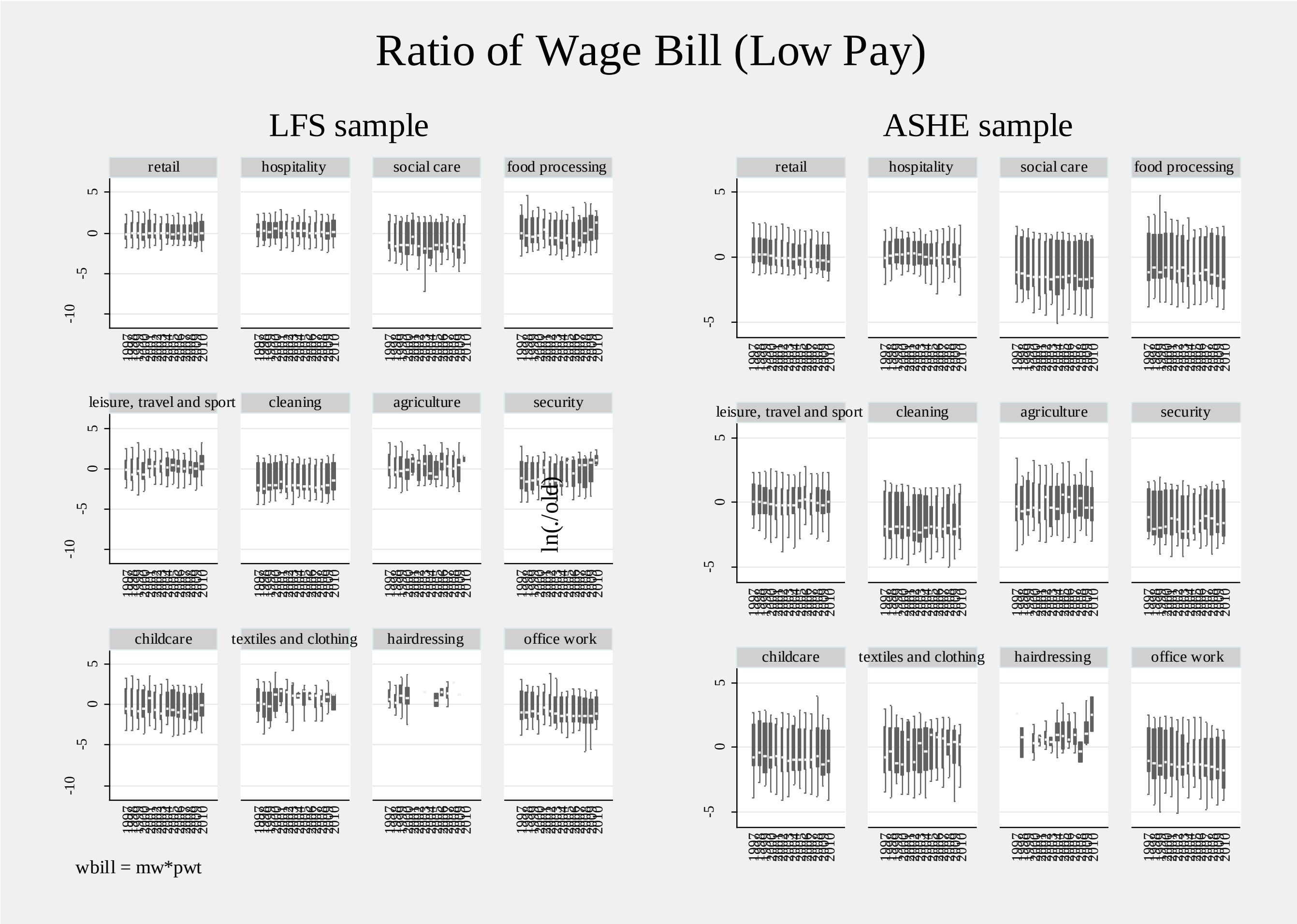
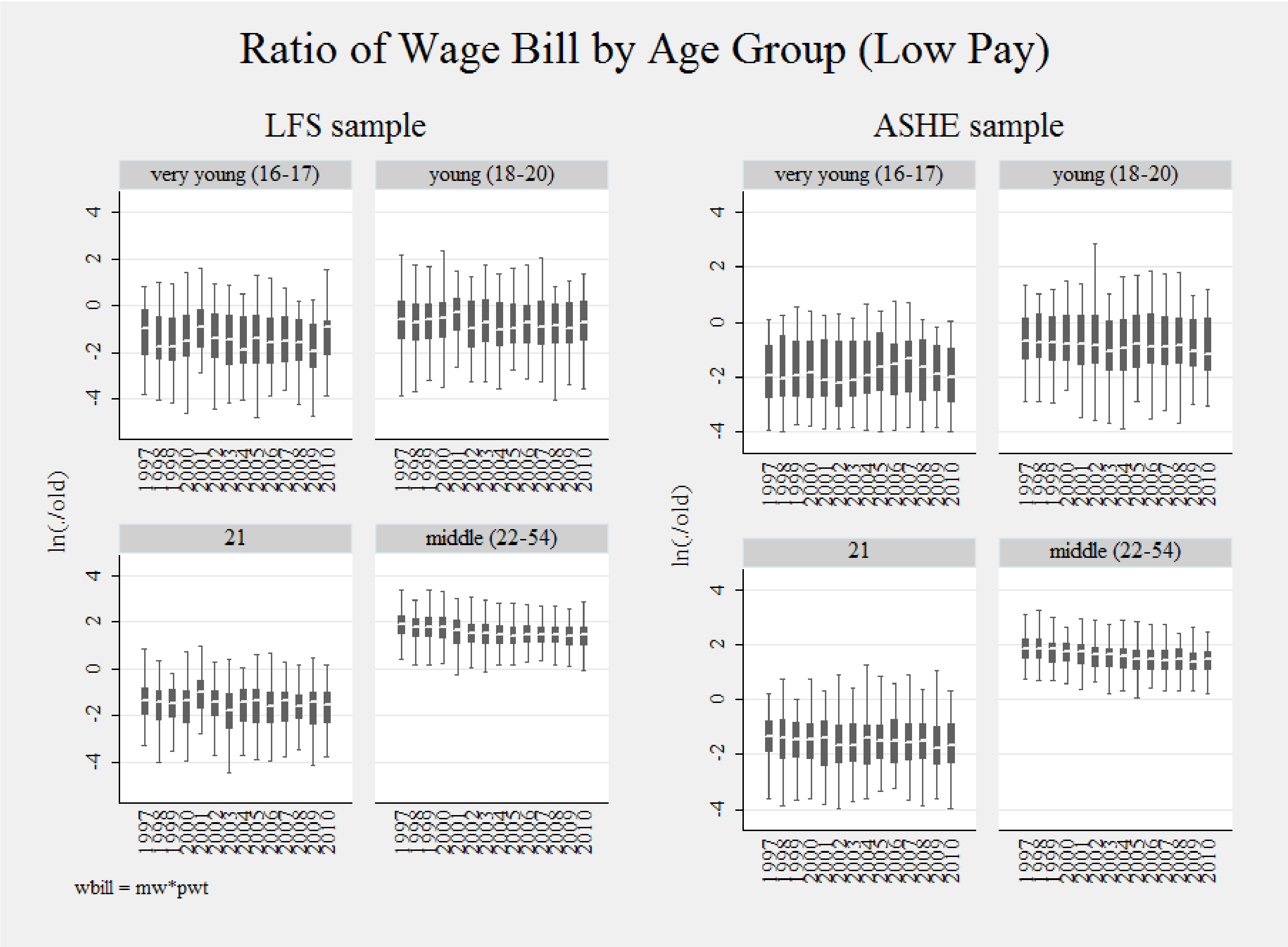


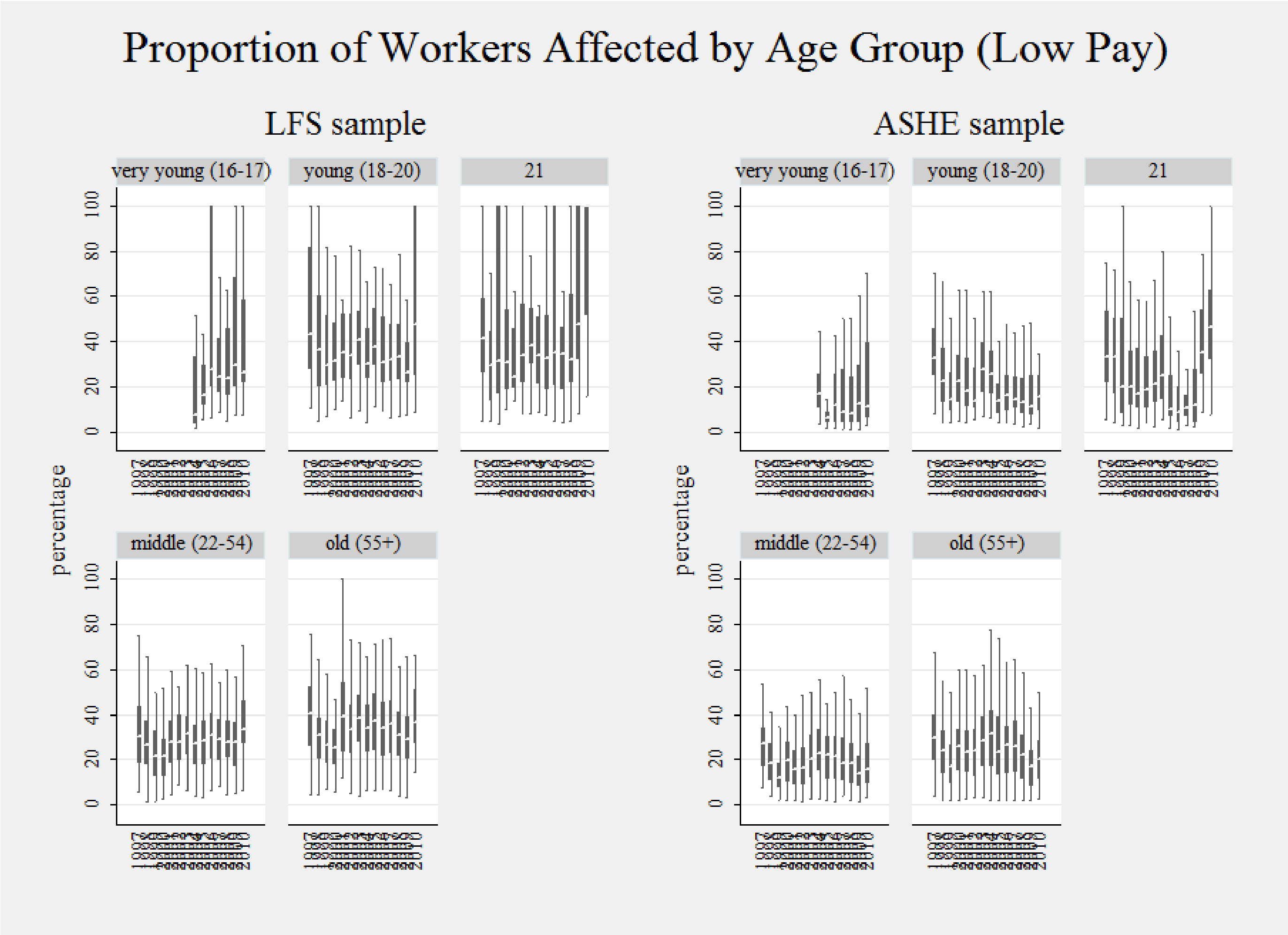
Figure 14 presents relative costs by age group. As illustrated in the figure, costs for the very young (16-17 year olds) have increased since the introduction of the NMW for that age category (the adjustment starting from just before). The rest of the age groups exhibit a rather steady evolution over time.

Figure 14 Relative Wage Bill by Age Group (Low Pay)



Finally, we look at the proportion of workers who would be affected by both the introduction and the yearly up ratings of the NMW. Figure 15 presents these proportions (in percentage) based on both the LFS and ASHE samples across age groups. It shows that the proportion of affected workers declined in 1997 and 1998, when the NMW was not in operation, indicates employers' adjustment to the impeding introduction of the NMW. Had we pooled these years together the proportion of workers earning below £3.60 would have been considerably higher. As before, LFS figures are to be read with caution given the limitations discussed earlier on the self-reported hourly wage. Bearing that in mind, both datasets paint a similar picture, with ASHE being more conservative in the reported proportions. Following an initial 'shock', we notice that proportions affected by the next uprating steadily decline or remain relatively stable. As expected, there is a noticeable big 'jump' in the proportion affected in 2009, since the adult rate would be extended to the 21 year olds (as opposed to them being under the Development rate) in the year after. That represents an £1.10 increase in the minimum wage for that age group from 2010 onwards.

Figure 15 Proportion of Workers Affected by Age Group (Low Pay)



5. Policy Questions and Empirical Findings

5.1 The policy question and the analysis of the reduced form evidence.

The question which is of primary interest to policy makers concerns the effect of the introduction and the uprating of the NMW on the composition of the workforce. This amounts to deciding whether the different age related NMW rates have a significant effect on the number of young workers relative to the number of older workers and whether they had a significant effect on the relative wage rate and the relative wage bill. Given the structural economic model we described earlier, the policy question can be expressed in terms of the reduced form equations which relate the outcomes of interest - the change in the logarithm of the relative wage, wage bills and group size, to the exogenous variables - the proportion of young and old workers affected by the future introduction or uprating of the NMW.

Recent theoretical and applied developments in empirical economics (as they are discussed for example in Angrist and Pischke, 2009) argue that for the effects of economic policy to be rationalised in terms of the theoretical model we discussed earlier, the effect of the exogenous variables must be statistically significant across all reduced form equations. In this context, this means that a policy will have effects we can understand and discuss in terms of our model, if its effects are significant enough to allow for the estimation of the structural form parameters. Hence, to answer the policy question above we are first interested in the how well changes in the labour force composition from one period to the next can be explained by the proportion of the population of workers affected by the change in the NMW.

In practical terms, this means that we will conclude that the policy has had sizeable effects on the outcome of interest if the test statistics summarising the explanatory power of the proportion affected by the change in the NMW take large enough values. In our case, the F-statistics for the test of the hypothesis that the instruments can be excluded from the reduced form equations is required to take values greater than 10, say, at least (Stock and Watson, 2011, in their textbook give this rule of thumb. See Angrist and Pischke, 2009 for discussions in an empirical applied context and a theoretical justification). We demand further that the effects of the proportion affected by the change in the NMWare sufficiently significant for the reduced forms of all outcomes. Hence we require more than the simple significance of a given variable in a reduced form equation - we demand that the significance is "strong" enough in all reduced form equations of interest. Finally, although we expect data produced from ASHE to be of higher quality than the data produced from the LFS our conclusion will be strengthened if the inferences drawn from both data sources agree.

Obviously, in practice this criterion is stringent, and the empirical literature produces examples of policies which do not satisfy it. However the issue here is whether the NMW has an effect on labour force composition and we may require a positive conclusion to pass stringent requirements, since such a conclusion would call for a redesign of the NMW rates. The received wisdom from the research commissioned by the Low Pay Commission is that the UK NMW has had little detectable effect on many labour market outcomes; hence we demand strong evidence to reverse the accepted (on the basis of documented research) view.

In Table 4 and 5 we present the estimation results for the reduced form of the relative wage equation. Each table considers alternative sectoral measure of the average wage; in Table 4 we consider the average individual hourly wage within a particular occupation, region and period, while in table 5 we consider instead the group average wage as described in the data section.

Each table shows the parameter estimates for the wage of each age group relative to the wage of older workers. We report a F-statistic of the null hypothesis that the explanatory variables do not explain the relative wages. We report as well the evidence based on the relative quantities for middle aged workers. This should serve as a gauge to assess the relative strength of our results for the younger age groups. In principle we would expect the younger age groups to exhibit stronger reactions to a change in the minimum wage since their share in total employment is smaller.

In Table 4, we observe that the proportion of a particular age group receiving a wage between the current NMW and NMW in the next period has a positive effect on the change in the log ratio of hourly wages over the two periods. This is true regardless of whether the data originates from the LFS or ASHE. Similarly the effect of the proportion of older workers receiving a wage between the current NMW and NMW in the next period has a significant negative effect on the change in log ratio of hourly wages over the two periods. However, for the relative wage of the 21 year old this effect is insignificant. Again this is true for both data sources. Overall the parameters estimated using the LFS are substantially larger in absolute value than the parameters estimated using ASHE. The F-statistics suggest that the proportions of young and older workers with a wage inside the interval defined by NMW in two successive periods contribute significantly to the explanation of the observed change of the relative wages. This is clearly so (F-statistics>15) for all age groups older than 17. Based on these estimates, the introduction and the regular uprating of the NMW explains around 10% of the variability of the relative average wage over time between occupations and regions.

Table 4 Change in Log Ratio of Hourly Wages (relative to old workers) (var: lravihw)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	0.165**	0.300**	0.260**	0.177**
	(0.060)	(0.052)	(0.048)	(0.024)
(lag of) prop. of old workers affected by the next uprating	-0.166	-0.116**	-0.080	-0.219**
	(0.135)	(0.037)	(0.071)	(0.026)
R^2	0.124	0.103	0.134	0.086
N	160	711	347	1175
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	4.041	24.28	24.63	39.73
Prob $>F$	0.024	0.000	0.000	0.000
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	0.000	7.501	3.049	3.283
Prob $>F$	0.993	0.007	0.085	0.072
ASHE				
(lag of) proportion of workers affected by the next uprating	0.081**	0.105**	0.168**	0.050**
	(0.022)	(0.014)	(0.023)	(0.010)
(lag of) prop. of old workers affected by the next uprating	-0.048	-0.026**	-0.001	-0.051**
	(0.038)	(0.011)	(0.021)	(0.009)
R^2	0.220	0.098	0.143	0.051
N	168	874	511	1376
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	9.808	26.59	27.75	14.97
Prob $>F$	0.000	0.000	0.000	0.000
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	0.462	24.00	23.70	0.022
Prob $>F$	0.500	0.000	0.000	0.882

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

Table 5, based on a distinct measure of the wage averaged over occupations, regions and periods, shows comparable results in terms of magnitude and significance. The F-statistics however take consistently smaller values, which indicate that the proportions affected by the uprating of the NMW explain a smaller proportion of the variance of the change in the relative wages over time and across occupations. Excluding the younger age group, based on this particular measure of the average wage the introduction and the regular uprating of the NMW explains less than 5% of the variability of the relative average wage over time between occupations and regions.

Table 5 Change in Log Ratio of Hourly Wages (relative to old workers) (var: lravhw)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	0.142	0.337**	0.228**	0.129**
	(0.133)	(0.096)	(0.069)	(0.042)
(lag of) prop. of old workers affected by the next uprating	-0.125	-0.207**	-0.442**	-0.194**
	(0.152)	(0.091)	(0.119)	(0.041)
R^2	0.0987	0.0834	0.173	0.0402
N	100	423	204	942
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	1.129	7.475	18.13	11.23
Prob $>F$	0.341	0.000	0.000	0.000
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	0.007	1.183	1.884	3.888
Prob $>F$	0.936	0.280	0.178	0.0511
ASHE				
(lag of) proportion of workers affected by the next uprating	0.060**	0.073**	0.105**	0.035**
	(0.022)	(0.014)	(0.018)	(0.006)
(lag of) prop. of old workers affected by the next uprating	-0.032	-0.016*	0.001	-0.037**
	(0.035)	(0.009)	(0.018)	(0.007)
R^2	0.132	0.0718	0.115	0.0433
N	168	874	511	1376
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	6.670	13.83	17.54	16.74
Prob $>F$	0.003	0.000	0.000	0.000
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	0.322	13.47	14.15	0.406
Prob $>F$	0.573	0.000	0.000	0.525

Standard errors in parentheses
* $p< 0.10$, ** $p< 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

Tables 6 to 8 report the same analysis applied to the changes of the (occupation, region) relative wage bills. Table 6 considers the measure of the group wage bill calculated by the formula: $\mathbb{w}_{crt}^{i} = w_{crt}^{i} \times L_{crt}^{i}$ (see Section 4.4). Both data sources broadly produce the same pattern of significance, a larger than average proportion of a younger group paid at an hourly wage between the current NMW and next period's NMW is associated with a larger change in the relative wage bill, while a larger than average proportion of older workers paid at an hourly wage between the current NMW and next period's NMW is associated with a smaller change in the relative wage bill. The F-statistics which characterise the "strength" of the association are larger when we use the LFS than when we use the ASHE. If we take a F-statistic larger than 10as our threshold for a credible association, then the association is potentially weak for the relative wage bill of the 21 year old (for both data sources) and for the middle aged workers when using ASHE. Overall the introduction and the year on year uprating of the minimum wage explains about 5% of the overall variance of the relative wage bill when based on this particular measure of the wage bill.

Table 6 Change in Log Ratio of Wage Bill (relative to old workers) (var: lrwbill1)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	0.138**	0.279**	0.246**	0.100**
	(0.061)	(0.053)	(0.076)	(0.030)
(lag of) prop. of old workers affected by the next uprating	-0.410**	-0.0765	0.113	-0.164**
	(0.104)	(0.053)	(0.102)	(0.028)
R^2	0.217	0.079	0.128	0.038
N	160	711	347	1175
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	10.30	14.17	5.253	16.81
Prob $>F$	0.000	0.000	0.008	0.000
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	5.067	8.867	6.084	5.151
Prob $>F$	0.029	0.004	0.016	0.025
ASHE				
(lag of) proportion of workers affected by the next uprating	0.070	0.109**	0.201**	0.051**
	(0.057)	(0.029)	(0.053)	(0.019)
(lag of) prop. of old workers affected by the next uprating	0.192	-0.010	0.062	-0.047**
	(0.116)	(0.025)	(0.046)	(0.017)
R^2	0.211	0.0593	0.0672	0.0387
N	168	874	511	1376
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	1.621	7.125	7.486	4.113
Prob $>F$	0.207	0.001	0.001	0.019
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	3.242	6.870	11.89	0.134
Prob $>F$	0.077	0.010	0.001	0.715

Standard errors in parentheses
* $p< 0.10$, ** $p< 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

Table 7 presents similar evidence based on an alternative measure of the wage bill, namely, $\mathbb{w}^i_{crt} = w^i_{crt} \times \sum h^i_{crt}$, see Section 4.4. The estimates exhibit a similar pattern to the one observed in Table 6: an increase in the number of young workers increases the wage bill consistently for both data sources, while a similar increase for older workers in general has a negative effect on the relative wage bill when the effect is significant. Again the parameter estimated based on the LFS appear larger than the parameter estimated based on the ASHE. The evidence from the LFS suggests that the proportions do not explain any of the changes in the relative wage bill. The evidence based on ASHE suggests a different conclusion. In that case the F-statistics are large enough to suggest an association, but it is only for the 18-20 year old that the association would appear significant "enough" (based our rule of thumb that the F-statistics should be larger than or equal to 15). Based on the LFS evidence the proportions affected by the change in the NMW explain less than 1% of the variance of the relative age bills for the various age groups.

Table 7 Change in Log Ratio of Wage Bill (relative to old workers) (var: lrwbill2)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	0.215	0.163	0.157	0.090*
	(0.142)	(0.100)	(0.096)	(0.052)
(lag of) prop. of old workers affected by the next uprating	-0.016	-0.027	0.042	-0.097*
	(0.352)	(0.100)	(0.153)	(0.053)
R^2	0.0709	0.0166	0.107	0.0169
N	107	492	249	1019
$F(H_0: \beta_1 = \beta_2 = 0)$	1.175	1.395	1.347	1.993
Prob $>F$	0.327	0.253	0.270	0.141
$F(H_0: \beta_1 + \beta_2 = 0)$	0.255	0.867	1.139	0.023
Prob $>F$	0.618	0.355	0.292	0.879
ASHE				
(lag of) proportion of workers affected by the next uprating	0.027	0.113**	0.259**	0.060**
	(0.074)	(0.031)	(0.056)	(0.018)
(lag of) prop. of old workers affected by the next uprating	0.248	-0.014	0.075	-0.057**
	(0.186)	(0.028)	(0.045)	(0.017)
R^2	0.151	0.057	0.080	0.036
N	168	874	511	1376
$F(H_0: \beta_1 = \beta_2 = 0)$	0.904	6.866	10.98	6.371
Prob $>F$	0.411	0.001	0.000	0.002
$F(H_0: \beta_1 + \beta_2 = 0)$	1.736	5.691	18.01	0.0647
Prob $>F$	0.193	0.019	0.000	0.800

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

Table 8 reports the evidence based on our third measure of the wage bill by occupation and region, $\mathbb{w}_{crt}^{i} = \sum\left(w_{crt}^{i} \times h_{crt}^{i}\right)$, that is the sum of individual earnings for a particular (occupational, regional) group at time t, see Section 4.4. The pattern we report on Table 6 and 7 applies here as well. The effect of the proportion of workers affected by the increase in the NMW is positive and significant in the regression of the change in the logarithm of the relative wage bill on the proportions. The evidence based on the LFS suggests that when the statistic is significant the effect of the proportion of older workers affected by an increase in the NMW is negative. Based on the ASHE the evidence is less conclusive, since the effect of the proportion of older workers affected by a change in the NMW can be significantly positive for younger workers, insignificant for the 18 to 20 year old group, and significantly negative for middle aged workers. Based on this measure of the wage bill these reduced form models explain about less than 5% of the variance of the changes in the relative wage bill, and consequently the F-statistics are all relatively small (i.e. less than 10).

Considering the middle-aged group, we observe that an equal increase in the proportions affected by the next increase in the NMW for the middle aged and older workers cancels out almost exactly, leaving the relative wage unchanged. This pattern is present in the previous tables as well. Hence, in terms of the effect of the uprating of the NMW differs among the younger age groups it differs because the up-rating of the NMW for the young has a larger effect on the relative wage bill or the relative wages of the young than it has on the relative quantities of the middle aged. We test in each case the null hypotheses that the sum of the effects of the proportion affected by the uprating of the NMW in the younger and older group is equal to zero. Almost systematically among the middle aged and the very young workers, we are able to accept this null hypothesis that the effect is of equal absolute size but opposite signs. For the very young, the null hypothesis is rejected when we consider the relative employment size. For the 18-20 year old and for the 21 year old the evidence is more mixed. We reject the null hypothesis for the reduced form of the relative wages, while for the relative wage bill the decision depends on the measurement used. Finally in the case of the relative employment size we accept the null hypothesis for the 18-20 year old age group, but we reject the hypothesis for the 21 year old. The middle aged group can be seen as a base line where the effect of the uprating on the all relative quantities is almost exactly balanced (the change in the relative quantities in response to a larger than average proportion of middle aged workers in t-1 affected by the up-rating in period t is equal to the opposite of the change in the relative quantities in response to a larger than average proportion of older workers in t-1 affected by the uprating in period t). This is not the case for the other age groups, where overall we observe a larger response to the proportions for the particular younger age group than to the proportions calculated for the older age group. This suggests that the differential uprating of the ager related NMW rates affect more directly the outcome of the younger age groups.

Table 8 Change in Log Ratio of Wage Bill (relative to old workers) (var: lrwbill3)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	0.328*	0.410**	0.272**	0.139**
	(0.182)	(0.146)	(0.104)	(0.065)
(lag of) prop. of old workers affected by the next uprating	0.042	-0.284*	-0.229	-0.186**
	(0.365)	(0.147)	(0.181)	(0.060)
R^2	0.080	0.049	0.117	0.022
N	100	423	204	942
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	1.640	4.885	4.018	4.840
Prob $>F$	0.216	0.010	0.026	0.010
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	0.824	0.458	0.044	0.710
Prob $>F$	0.373	0.501	0.835	0.401
ASHE				
(lag of) proportion of workers affected by the next uprating	0.006	0.078**	0.204**	0.044**
	(0.074)	(0.030)	(0.054)	(0.016)
(lag of) prop. of old workers affected by the next uprating	0.264	-0.001	0.090**	-0.042**
	(0.177)	(0.026)	(0.043)	(0.015)
R^2	0.148	0.039	0.065	0.034
N	168	874	511	1376
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	1.121	3.419	8.182	4.568
Prob $>F$	0.333	0.036	0.001	0.012
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	1.748	3.540	15.45	0.012
Prob $>F$	0.192	0.062	0.000	0.912

Standard errors in parentheses
* $p< 0.10$, ** $p< 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

Finally, Table 9 reports the findings concerning the relative employment size. Strikingly here the significant estimates are the exception rather than the rule. If we consider first the middle aged group we observe none of the parameter estimates are significant, and consequently the F-statistics are very small (less than 1). For the other age groups this pattern seems to repeat itself although not in such an extreme way. The potential exception is the very young workers where the reduced form regression explains about 5% (LFS) and 10% (ASHE) of the variation in the changes of the relative employment size. For all other age groups the reduced form equation explains less than 1.5% of the variance in the changes of the relative employment size.

Table 9 Change in Log Ratio of Employment Size (relative to old workers) (var: lrl)

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
(lag of) proportion of workers affected by the next uprating	-0.005	0.083*	0.057	-0.003
	(0.048)	(0.048)	(0.050)	(0.029)
(lag of) prop. of old workers affected by the next uprating	-0.255**	0.003	0.174**	-0.023
	(0.088)	(0.042)	(0.086)	(0.024)
R^2	0.086	0.017	0.103	0.010
N	171	745	362	1195
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	4.248	1.572	2.324	0.697
Prob $>F$	0.0196	0.212	0.105	0.500
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	5.813	2.162	4.563	0.997
Prob $>F$	0.019	0.144	0.036	0.320
ASHE				
(lag of) proportion of workers affected by the next uprating	0.007	0.021	0.096**	-0.000
	(0.046)	(0.029)	(0.039)	(0.014)
(lag of) prop. of old workers affected by the next uprating	0.236**	0.0163	0.048	0.005
	(0.090)	(0.023)	(0.045)	(0.013)
R^2	0.199	0.039	0.025	0.035
N	169	881	529	1376
$F(\mathrm{H_0}: \beta_1 = \beta_2 = 0)$	3.879	0.562	3.492	0.171
Prob $>F$	0.0265	0.572	0.0343	0.843
$F(\mathrm{H_0}: \beta_1 + \beta_2 = 0)$	4.453	1.108	5.743	0.290
Prob $>F$	0.040	0.295	0.018	0.591

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service

5.2 What can be learned about the technology?

Tables 10 to 13 present the estimation results of the structural equations (8) and(9), based on the information drawn from the LFS (Tables 10 and 12) and the ASHE (Tables 11 and 13). Our analysis in the previous section suggests that, if anything, the introduction and uprating of the NMW has had a significant effect on the determination of wages and wage bills, while the NMW had no systematic effect on the evolution of relative employment (i.e. in terms of the employment size of younger workers age groups relative to the employment size of older workers). Hence one of the usual requirements for the application of Instrumental Variables methodology is apparently not satisfied - the candidate instruments should be significant in the reduced form equations for all endogenous variables whether they are on the RHS or the LHS of the structural equation of interest (see Angrist and Pischke, 2009, for a discussion). However in our particular case, if two inputs are complements in production, i.e. whenever σ=0 or ρ=-∞, the reduced form equations (8) and (9) suggest that the relative employment size should be determined independently from the relative wages or the relative wage bills.

Each Table presents the results based on one particular data source for one specification. We report the structural estimated parameter for the effect of a change in the relative wage on the relative employment size (for a given young age group relative to the older age group). The specification always controls for year dummies although these estimated parameters are not presented. We report furthermore the overidentification test statistics, which assess whether the exclusion of one of our two instruments from the structural equation is supported by the data. When more instruments than endogenous variables are available, a test of overidentifying restrictions is possible. The test assumes that one instrument is valid and then tests for the validity of all other instruments i.e. whether the instruments are uncorrelated with the error term in the second stage. The applied J test statistic operates under the null hypothesis $H_o\colon E[z_i u_i] = 0$ and converges in distribution to $\chi^2(p-K)$. We accept this hypothesis in almost all cases (and in particular when the data is obtained from the ASHE).

Table 10 presents the structural parameter estimates for equation (8), from the Instrumental Variables (IV) estimation, separately for our two measures of the hourly wage based on the LFS: The top of the table reports the results when the average of the individual hourly wages is used, while the bottom half of the table reports the results when the overall average hourly wage (the wage bill divided by the total number of hours for the particular occupation, region or year group) is used. Given our model specification, multiplying the coefficient estimates on the difference of the log ratio of average wages between young and old workers by -1, provides a measure of the elasticity of substitution, $\sigma \geq 0$. The estimated values are quite distinct whether we consider one wage measure or the other. With the average individual wage, the implied elasticity of substitution is all negative and significantly so only among the 18-20 age group. With the overall average wage, the implied elasticities are all positive but only significantly so for the 21 year old. In this case we would conclude that the elasticity of substitution is about 0.35, which would argue in favour of some significant complementarity (or at least argue against perfect substitution) between the 21 year old and the older age group.

Table 10 IV Estimates, Structural Equation (equation 8), LFS Low Pay Occupations

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
D.lravihw	0.511	0.292**	0.095	0.117
	(0.391)	(0.143)	(0.179)	(0.112)
Constant	-0.098	0.061	0.088	0.023
	(0.174)	(0.089)	(0.114)	(0.044)
N	160	711	347	1175
R^2	-0.593	-0.094	0.087	-0.016
J-statistics	1.612	1.206	4.243	1.310
Prob >*J*	0.204	0.272	0.0394	0.252
D.lravhw	-0.039	-0.040	-0.346**	-0.102
	(0.313)	(0.148)	(0.149)	(0.143)
Constant	0.079	-0.084	0.230	0.023
	(0.073)	(0.116)	(0.191)	(0.044)
N	100	423	204	942
R^2	0.123	0.025	-0.114	0.021
J-statistics	1.296	3.341	1.193	1.545
Prob >*J*	0.255	0.068	0.275	0.214

Standard errors in parentheses
* $p< 0.10$, ** $p< 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service
Regressions include year dummies

Table 11 produces the comparable estimation results when the evidence is taken from the ASHE. None of the estimated values obtained here are significantly different from 0. The point estimates are negative (which we can take as an improvement over the evidence based on the LFS) in all cases except for the 21 year old. We consider 0 as an estimate of the elasticity of substitution which the data does not reject, and we conclude the evidence presented in Table 11 is consistent with complementarity between younger age groups and older age groups. We observe that in Table 10 and 11 the estimates obtained for the middle aged group relative to the older worker are consistently insignificantly different from zero, which would again suggest complementarity. This is the conclusion the analysis of the reduced form would have suggested, that is, the NMW has a significant, consistent and small effect on the changes of the relative average wage within occupation, region and year but it has no effect on the labour force age composition. This is consistent with the young age groups being complement to the older age group.

Table 11 IV Estimates, Structural Equation (equation 8), ASHE Low Pay Occupations

	16-17 year old	18-20 year old	21 year old	22-54 year old
D.lravihw	-0.793	-0.038	0.247	-0.061
	(0.614)	(0.248)	(0.225)	(0.266)
Constant	-0.351**	0.029	-0.119	0.064**
	(0.110)	(0.048)	(0.085)	(0.019)
N	168	874	511	1376
R^2	-0.091	0.039	0.003	0.036
J-statistics	3.587	0.646	2.565	0.181
Prob >*J*	0.058	0.422	0.109	0.670
D.lravhw	-1.056	-0.050	0.429	-0.092
	(0.889)	(0.360)	(0.357)	(0.371)
Constant	-0.371**	0.029	-0.119	0.065**
	(0.115)	(0.048)	(0.086)	(0.019)
N	168	874	511	1376
R^2	-0.114	0.040	0.009	0.036
J-statistics	3.498	0.652	2.376	0.168
Prob >*J*	0.061	0.419	0.123	0.682

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: ASHE data supplied by the Secure Data Service
Regressions include year dummies

Table 12 presents estimates based on equation (9) for the data constructed from the LFS. We produce 3 different estimated values for $1/\rho=\sigma/(\sigma-1)$ based on alternative measures of the wage bill for a particular occupation, region and year. The parameter estimates are significantly positive when we use the first measure of the wage bill, but negative in almost all other cases and insignificant in all cases. The positive values obtained in the former case are only consistent with negative values for σ which are not admissible (σ must be positive, values of $1/\rho$ between 0 and 1 are not consistent with a positive value for σ). Hence based on these estimates we tentatively conclude that the data is consistent with substantial complementarity in production between the young age group and older workers.

Table 12 IV Estimates, Structural Equation (equation 9), LFS Low Pay Occupations

	16-17 year old	18-20 year old	21 year old	22-54 year old
LFS				
D.lrwbill1	0.445**	0.339**	0.277**	0.193
	(0.121)	(0.099)	(0.128)	(0.126)
Constant	-0.029	0.047	0.064	0.017
	(0.066)	(0.051)	(0.085)	(0.035)
N	160	711	347	1175
R^2	0.620	0.560	0.538	0.342
J-statistics	1.157	1.936	4.699	1.264
Prob >*J*	0.282	0.164	0.030	0.261
D.lrwbill2	-0.134	0.089	-0.119	-0.116
	(0.262)	(0.283)	(0.376)	(0.286)
Constant	0.091	-0.013	0.091	0.045
	(0.067)	(0.098)	(0.129)	(0.044)
N	107	492	249	1019
R^2	-0.257	0.156	-0.193	-0.242
J-statistics	0.766	8.062	3.649	1.711
Prob >*J*	0.381	0.004	0.056	0.191
D.lrwbill3	-0.150	-0.042	-0.278	-0.118
	(0.154)	(0.124)	(0.222)	(0.163)
Constant	0.121	-0.087	0.285	0.022
	(0.078)	(0.117)	(0.209)	(0.053)
N	100	423	204	942
R^2	-0.196	-0.052	-0.679	-0.231
J-statistics	0.899	3.070	2.484	1.163
Prob >*J*	0.343	0.080	0.115	0.281

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: Labour Force Survey data and ASHE data supplied by the Secure Data Service
Regressions include year dummies

Table 13 presents the comparable evidence when the ASHE is used to construct the dataset. Here we observe that the first measure of the wage bill produces estimated values which are quite comparable to the estimated values we obtain for the other measure of the wage bill. In the case of the 18-20 year old and the 21 year old age group the parameter estimates are not consistent with the model we propose (i.e. $1/\rho$ takes its values between 0 and 1 which is not consistent with a positive value for σ). The evidence for the middle aged group suggests that there is substantial complementarity in production between middle aged workers and older workers. For very young workers the point estimates are all smaller than 1 but in all cases within one standard deviation of 1. This corresponds to the case where young workers and older workers are perfect substitutes. This result is however based on a small number of occupation, region and year groups and would be subject to all caveats associated with the use of small samples.

Table 13 IV Estimates, Structural Equation (equation 9), ASHE Low Pay Occupations

	16-17 year old	18-20 year old	21 year old	22-54 year old
D.lrwbill1	0.851**	-0.009	0.273**	-0.054
	(0.162)	(0.250)	(0.133)	(0.289)
Constant	-0.037	0.029	-0.088	0.067**
	(0.059)	(0.049)	(0.062)	(0.028)
N	168	874	511	1376
R^2	0.841	0.022	0.471	-0.070
J-statistics	18.67	0.679	2.983	0.180
Prob >*J*	0.000	0.410	0.0841	0.671
D.lrwbill2	0.978*	-0.016	0.210*	-0.047
	(0.544)	(0.240)	(0.117)	(0.239)
Constant	0.040	0.028	-0.098	0.066**
	(0.221)	(0.048)	(0.067)	(0.025)
N	168	874	511	1376
R^2	-0.061	0.008	0.345	-0.054
J-statistics	0.540	0.661	2.453	0.177
Prob >*J*	0.463	0.416	0.117	0.674
D.lrwbill3	0.937**	0.007	0.279**	-0.067
	(0.469)	(0.345)	(0.132)	(0.331)
Constant	0.039	0.028	-0.090	0.068**
	(0.200)	(0.048)	(0.063)	(0.030)
N	168	874	511	1376
R^2	0.148	0.053	0.437	-0.093
J-statistics	0.137	0.710	2.168	0.166
Prob >*J*	0.712	0.399	0.141	0.683

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$
Source: ASHE data supplied by the Secure Data Service
Regressions include year dummies

Conclusions

We analyse data from 1997 to 2010 drawn from the LFS and the ASHE with a view to characterising the effect of the different NMW age based rates and their uprating on the relative wages and the age related employment structure among the low-paying occupations. Our analysis suggests that, if anything, the introduction and uprating of the NMW has had a significant effect on the determination of wages and wage bills, while the NMW has no systematic effect on the evolution of relative employment (i.e. in terms of the employment size of younger workers age groups relative to the employment size of older workers).

The evidence points in the direction of substantial, if not perfect, complementarity between the young age groups (18-20 year old and 21 year old) and the older workers (more than 55 year old). This in turn suggests that the differences of the NMW between the age groups may not matter much when it comes to determining the labour force composition, i.e. it does not have any effect on the distribution of work among the age groups. In that sense the current structure of the minimum wage appears innocuous. However, the evidence we report shows that the regular upratings of the NMW has an effect on the relative wages between younger and older age groups, but it remains small. In this sense there is a small but significant effect from the uprating of the NMW.

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Appendix

Table A1: Definitions of Low-Paying Occupations, by SOC2000 and SOC1990 Codes

Low-Paying Occupation	SOC 2000(2)	SOC 1990(3, 4)
Retail	1234, 5496, 711, 7125, 721, 925	178, 720, 721, 722, 730, 731, 732, 790, 791, 792, 954, 959
Hospitality	5434, 9222-9225	620, 621, 622, 951, 952, 953
Social care	6115	644
Employment Agencies	n/a	n/a
Food Processing	5431-5433, 8111	580, 581, 582, 800, 801, 802, 809
Leisure, travel and sport	6211, 6213, 6219, 9226, 9229	630, 699, 875, 999
Cleaning	6231, 9132, 923	670, 671, 956, 957, 958
Agriculture	5119, 9111, 9119	900, 902, 903
Security	9241, 9245, 9249	615, 619, 955
Childcare	6121-6123, 9243, 9244	650, 651, 659
Textiles and clothing	5414, 5419, 8113, 8137	553, 556, 559
Hairdressing	622	660, 661
Office work	4141, 4216, 9219	460, 461, 462

Notes:

(1) n/a is not applicable
(2) Low-paying occupation definitions (SOC 2000) provided by the UK Low Pay Commission. Low Pay Commission report 2010, Appendix 4: Review of the Low-paying sectors, Table A4.1, p. 243.
(3) Adapted from data from the Office for National Statistics licensed under the Open Government Licence v.1.0: OOSS User Guide 2000: 22, Occupational Information Unit, Office for National Statistics.
(4) Some relationships were adapted from: Elias, P., and Purcell, K. (2004) "SOC(HE) A classification of occupations for studying the graduate labour market", *Researching Graduate Careers Seven Years On; Research Paper No. 6*, Warwick Institute for Employment Research, Table A3, p. 40.