

Measuring low pay: Measures and precision

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Summary

Official estimates of the low paid calculated from the Annual Survey of Hours and Earnings (ASHE) are based on a derived hourly rate of pay obtained by dividing total earnings by hours worked. This in contrast to the supporting Labour Force Survey (LFS) estimates which are based on a stated rate. Since 2004 the ASHE has also included a question on a stated rate of pay and this provides the opportunity to produce ASHE estimates on the same methodology as the LFS. This investigation shows that the measure of hourly rate used can explain much of the difference between the ASHE and LFS estimates of low pay and supports the use of the current methodology. The paper also demonstrates how precision affects the estimates due to the yes/no nature of the estimate.

Introduction

The Annual Survey of Hours and Earnings (ASHE)¹ is the main source of information on earnings in the UK. It is used to generate the official estimates of the low paid. The ONS measures the numbers of low paid as the percentage of jobs paid below the National Minimum Wage (NMW)². This estimate is based on comparing individuals' hourly earnings with the appropriate NMW rate³. The National Statistics on low pay are therefore calculated from ASHE by comparing the **derived** hourly rate with the NMW: earnings for the period divided by hours worked.

Since 2004 ASHE has also collected a **stated** rate of pay, for those workers who are paid an hourly rate. ONS currently uses this hourly rate for the validation of the derived rate, which is believed to be the more accurate and appropriate measure.

In 2006 the authors were asked to review the hourly pay variables. This investigation studied differences between the stated and derived rates, and the results are reported here. These show that, while a large part of the difference can be explained, there is still a significant amount of unexplained differential.

The review shows that methodology counts. An alternative measure of the low paid is available from the Labour Force Survey (LFS)⁴. As the ASHE only holds a limited range of personal characteristics the LFS is still used to give supporting estimates of the number of low paid when these are required by ethnicity, skill, etc. Hence the LFS methodology continues to be used. Since the inclusion of a new question on the hourly rate of second jobs in 2004 the LFS methodology has recently been improved (see Ormerod (2006)). Differences between ASHE and LFS estimates of the number of low paid have always been put down to differences in data collection. Our results show that much of the differences may be explained by different methodologies.

Also, as a by-product of the investigation, it became clear that small changes in the precision of the estimates can affect the estimated low pay disproportionately. This is due to the nature of 'low pay' as a yes/no condition.

Overall, the paper shows that, while the use of the ASHE figure as the best estimate of low pay is not under question, it is apparent that careful interpretation of figures is necessary. There is a case for considering how the specific value is arrived at, making some allowance for margins of error.

Hourly rate measures

In ASHE **derived** hourly pay is obtained by dividing gross pay excluding shift premium by the number of basic hours worked. Gross pay is derived by summing basic pay, shift premium pay, other pay and incentive pay. The derived hourly pay is therefore defined as the sum of basic pay, other pay and incentive pay, divided by the number of basic hours worked. This is illustrated in figure 1.

Figure 1: Calculation of derived hourly rate

$\text{Derived hourly rate of pay} = \frac{\text{Gross pay excluding overtime} - \text{Shift premium pay}}{\text{Basic hours}}$
<p>Where</p> $\text{Gross pay excluding overtime} = \text{Basic pay} + \text{Shift premium pay} + \text{Other pay} + \text{Incentive pay}$
<p>Therefore</p> $\text{Derived hourly rate of pay} = \frac{\text{Basic pay} + \cancel{\text{Shift premium pay}} + \text{Other pay} + \text{Incentive pay} - \cancel{\text{Shift premium pay}}}{\text{Basic hours}}$

From 2004 respondents were also asked for a **stated** hourly rate. On the ASHE survey a routing question is provided to filter responses to the stated hourly rate question. Respondents are asked:

“Was the employee’s basic pay calculated by multiplying the number of hours they worked by an hourly rate of pay?”

If the answer to this question is “No” respondents are not routed to the basic pay question. If the response is “Yes” respondents are then asked:

“What was the employee’s hourly rate of pay?”

The stated hourly rate question is therefore defined as an hourly rate of basic pay and it can be assumed from the wording that this should not include other pay or incentive pay. If an employee does not receive any other or incentive payments then it can be assumed that the derived rate should equal the stated rate. However, if an employee does receive either incentive or other payments (or both) then we would not expect the derived rate to be equal to the stated rate. There is therefore a second hourly rate which can be derived which is comparable to the stated rate. The **basic-derived** hourly rate of pay is basic pay divided by hours worked.

This investigation is complicated by the fact that the basic pay question changed in 2005. In 2004 there was an inconsistency in the basic pay question title and guidance. Whilst the question asked for basic pay the guidance suggested that other pay should also be included. In 2005 this was changed and the question wording and guidance were consistent. To try to resolve this issue in the dataset the basic pay variables were examined to identify records that may have included other payments. Where this was found to be likely the other pay variable was imputed. The basic pay variable remained unchanged and therefore for 2004 basic pay either includes basic pay or basic pay and other pay. As it is impossible to identify which records have this issue analysis was carried out for 2004 and 2005 records in the same way.

There is a fourth measure of hourly pay which can be compared to the measure used to examine low pay in the LFS. The LFS methodology uses the stated rate if it is provided; otherwise an hourly rate is imputed using a nearest neighbour model where the derived rate of pay has the most influence. This imputation is applied in order to overcome problems with the LFS derived rate (see Ormerod 2006). As the ASHE does not suffer the same problems the records with a missing stated rate can more simply be filled using the derived rate; this is known as the **combined** hourly rate, and is the closest approximation in ASHE to the LFS rate.

Differences between stated and derived rates in ASHE

Aggregate level

Table 1 shows the values of various summary statistics for the stated, derived and basic-derived hourly pay variables. The 10th, 25th, 50th, 75th and 90th percentile values are shown along with the mean. ASHE results are published for the mean and median although emphasis is placed on the median as it is less influenced by outliers.

As only half the dataset holds a stated rate and individuals are more likely to have a stated rate if they are in the lower part of the earnings distribution, summary statistics are not expected to be comparable.

The value of all percentile points for the derived rate are higher than the percentile points for the stated rate (column a compared with column d). This is expected as high earners are less likely to have a stated hourly rate. Except for the value of the 10th percentile the other summary statistics for the basic-derived rate of pay (column g) are higher than the derived. The additional components in the derived rate make a difference mainly at the top end of the distribution. The mean rate for the derived is higher than for the basic-derived for this reason. The pattern is similar for records involved in the low pay estimates (columns b, e and h).

The percentile points for the stated rate are almost identical to the percentile point values for the stated where the derived is also present (columns b and c). Only a small number of records have a stated rate but do not have a derived rate. Records with a stated rate but no derived rate are therefore lower than those with both variables. For records with a derived rate the percentile points are lower if the stated rate is also present (columns e and f). This again shows that the records with a stated rate are less likely to be high earners.

Table 1: Summary statistics for stated, derived and basic-derived hourly pay, 2004-2005

		Stated ^a	Stated ^a	Stated ^a	Derived	Derived	Derived	Basic-derived	Basic-derived	Basic-derived
		All records	Hours and low pay weight	Hours and low pay weight ^b Derived present ^c	All records	Hours and low pay weight	Hours and low pay weight ^b Stated present ^d	All records	Hours and low pay weight ^b	Hours and low pay weight ^b Stated present ^d
		a	b	c	d	e	f	g	h	i
		£	£	£	£	£	£	£	£	£
2004	10%	4.60	4.63	4.63	4.94	5.00	4.69	4.88	4.99	4.65
	25%	5.21	5.21	5.25	5.25	6.01	6.16	5.35	5.92	6.01
	50%	6.49	6.49	6.59	6.59	8.45	8.63	6.91	8.22	8.42
	75%	9.27	9.27	9.51	9.51	12.83	13.08	9.92	12.60	12.83
	90%	14.36	14.36	14.47	14.47	19.11	19.35	14.91	18.73	18.97
Mean	11.03	11.03	11.31	11.31	10.89	11.08	8.89	10.66	10.84	
2005	10%	4.88	4.90	4.90	5.18	5.25	4.95	5.10	5.15	4.90
	25%	5.39	5.39	5.40	5.40	6.29	6.40	5.50	6.10	6.21
	50%	6.50	6.50	6.53	6.53	8.76	8.94	6.92	8.41	8.58
	75%	9.05	9.05	9.24	9.24	13.39	13.61	9.69	12.87	13.12
	90%	13.62	13.62	14.00	14.00	20.03	20.26	14.14	19.16	19.37
Mean	12.78	12.78	13.15	13.15	11.75	11.62	8.72	10.92	11.10	

Notes:

- a Following amendments for factor error
- b For records with a positive value for basic hours and low pay weight
- c For records where a derived rate of pay is also present
- d For records where a stated rate of pay is also present

Individual level

Figure 2 shows the difference between the stated and the two different derived rates in £1 bands for records having both a stated and derived variables. Both variables were rounded to the nearest penny before comparison to avoid negligible differences affecting the analysis. **Table 2** summarises the number and percentage of record involved.

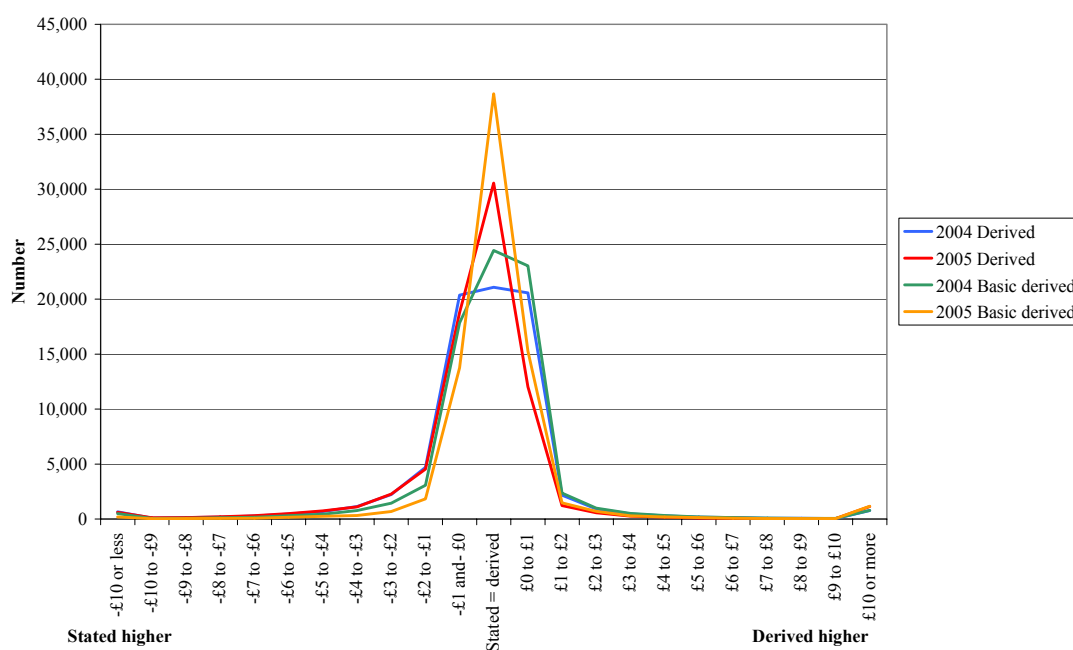


Table2: Number and percentage of records with differences between the stated and derived rates, 2004-2005

	Stated and derived				Stated and basic-derived			
	2004 <i>Number</i>	2004 <i>%</i>	2005 <i>Number</i>	2005 <i>%</i>	2004 <i>Number</i>	2004 <i>%</i>	2005 <i>Number</i>	2005 <i>%</i>
Derived higher	30,968	40	29,337	39	24,841	32	17,452	23
Stated higher	25,798	33	15,726	21	28,567	37	19,490	26
Variables equal	21,081	27	30,555	40	24,420	31	38,676	51
Total records	77,847	100	75,618	100	77,828	100	75,618	100

The number of records that can be compared for the stated and derived rate is relatively constant across the years with 78,000 in 2004 and 76,000 in 2005. In 2004 21,000 records or 27 per cent of the records that can be compared have a stated rate equal to the derived rate. This is greater in 2005 with 40 per cent or 31,000 records. For the records showing a difference the derived rate is more likely to be higher than the stated rate. In 2004 40 per cent of the records that can be compared have a higher derived rate, for 2005 this value is 39 per cent. This is expected as the derived rate will include other and incentive payments if these are received but the stated rate will not.

Can we explain the differences between the stated and derived rate?

As expected from the definition, when comparing the stated and basic-derived rate of pay more are equal, 31 per cent in 2004 and 51 per cent in 2005. This compares with 27 per cent in 2004 and 40 per cent in 2005 for the stated and derived rate. In both years the derived value tends to be higher than the stated and the basic-derived lower, but with substantial variation. This suggests that the reasons for the differences vary over individuals.

It is useful to break down Table 2 by the components of basic pay to try to identify any systematic effects. **Table 3** shows the presence or absence of incentive and/or other payments by whether the stated and derived rate are equal or not.

Table 3: Presence of incentive and / or other payments by differences between stated and derived hourly rate, 2004-2005

	2004 Number	2004 %	2005 Number	2005 %
Stated = Derived	21,081	27.11	30,555	40.29
121		0.58	326	1.07
Without incentive or other pay	20,960	99.42	30,229	98.93
Stated ≠ Derived	56,766	72.89	45,063	59.71
With incentive and/or other pay	10,752	18.95	17,590	38.96
Without incentive or other pay	46,014	81.05	27,473	61.04
Stated = Basic-derived	3,401	6.00	8,246	18.30
With incentive and/or other pay	3,401	6.00	8,246	18.30
Without incentive or other pay	0	0.00	0	0.00
Stated ≠ Basic-derived	53,346	93.98	36,817	81.70
With incentive and/or other pay	7,332	12.92	9,334	20.71
Without incentive or other pay	46,014	81.06	27,473	60.97
Basic-derived can not be calculated ^a	19	0.03	0	0.00

Notes:

a The basic-derived can not be calculated, despite the fact that the derived can as these records do not have basic pay information but have incentive and / or other payments

As expected, for records where the stated rate is equal to the derived rate almost all of these records do not have incentive or other payments. Only a small number of records with incentive and/or other payments do not follow the guidance on the form and include incentive and/or other payments in their stated hourly rate.

For records where the stated rate does not equal the derived rate (57,000 in 2004 and 45,000 in 2005) the majority (46,000 and 27,000 respectively) do not have incentive or other payments. These records therefore have an error in their stated or derived rate that can't be explained by the difference in definition between the stated and derived rate. The remaining 11,000 records in 2004 and 18,000 cent in 2005 are not expected to have an equal derived and stated rate.

These records would be expected to have an equal stated and basic-derived rate. However, of the 11,000 records in 2004 that are expected to have an equal stated and basic-derived rate only 3,400 are actually equal, the other 7,400 have differences that can not be explained by the difference in definition between the stated and derived. Of the 18,000 records in 2005 that are expected to have an equal stated and basic-derived rate only 8,000 are actually equal, the other 9,000 have differences that can not be explained by the difference in definition between the stated and derived. **Table 4** summarises the errors.

There are a small number of cases where basic pay is missing but one or more of the other components involved in the derived rate are present. In this case the derived rate is calculated but the basic-derived rate cannot be calculated. As individuals should not have a basic pay of zero it is recommended that derived rates for these individuals be recorded as missing.

If numbers are not exactly equal, there may be rounding or calculation errors. Table 5 breaks down the problematic totals in Table 4 into those which might be due to rounding error.

Table 4: Difference between stated and derived rate that can be explained by definitional differences and rounding, 2004-2005

Stated and derived	2004 Number	2004 Percentage	2005 Number	2005 Percentage
Records	77,847	100.00	75,618	100.00
Equal	21,081	27.08	30,555	40.41
Equal despite definition	121	0.16	326	0.43
Not equal	56,766	72.92	45,063	59.59
Not equal due to definition	3,401	5.99	8,246	18.30
Not equal not due to definition	53,346	93.98	36,817	81.70
Within £1	38,838	72.80	26,199	71.16
Outside £1 bands	14,508	27.20	10,618	28.84

Individual records were examined in detail to look at other possible reasons for the differences a very small number of records showed differences due to providing a stated rate with components included twice or incorrect components included. However, the number of these was not significant. It is recommended that further investigation be carried out, by contacting respondents, to investigate these differences, especially where they are large.

Of the remaining 53,000 records in 2004 and 37,000 records in 2005 which can not be explained by the definitional differences 73 per cent in 2004 and 71 per cent in 2005 have a derived rate within £1 of the stated rate. The remaining 27 per cent in 2004 and 29 per cent in 2005 have larger differences. It should be possible to allow a tolerance where the difference lies within an acceptable band, for example £1. However, as the hourly rate of pay is used to create low pay estimates this is not strictly the case. If the stated rate for an individual in 2005 is £13 and the derived £13.50 then the difference between these may not be enough to warrant further investigation. If the stated rate is £4.50 and the derived rate is £5.00 then this becomes significant despite the fact that the difference is the same. The NMW for adults aged 22 or over in 2005 was £4.75,

therefore this record has one variable showing the individuals as being paid less than the NMW and one variable showing the individual is paid above the NMW. The effect on the low pay estimates is investigated in the next section.

Further investigation has been carried out on the individual records to look at the differences between the stated and derived rate where these cannot be explained. The results of this have been inconclusive as it is difficult to make inferences only from observed responses. For example, it is thought that employers following inappropriate advice about using a 52-week year to calculate wages (see below) may be responsible for some of the low estimates for derived rates. A counter-factual calculation suggest that this is plausible for a small number of employees. However, given the small numbers, this may just be coincidence. In summary, it is unlikely that the unexplained differences can be resolved retrospectively.

Effect on low pay estimates

The ASHE methodology for low pay involves creating weighted tables of the number of individuals above and below the NMW. This estimate is based on the derived hourly rate. It is possible to apply the same methodology to create estimates based on the stated, basic-derived and combined rate. **Table 5** shows these estimates for 2004 to 2006. The LFS estimates are included for comparison purposes.

Figure 3 illustrates the pattern for individuals aged 18 and over. Estimates based on the basic-derived hourly rate of pay are higher than the estimates based on the derived rate as the hourly rate measure is lower (see figure 1). Estimates based on the stated rate are lower than estimates based on the derived rate for two possible reasons. Employers may be reluctant to write down a stated rate that is below the NMW. There may also be some employers who believe they are paying below the NMW when this is not actually the case. The situation can arise where the employer calculates an hourly rate by dividing an annual salary by 52 (weeks) and then by 7 (days). However there are 52.2 weeks in a year and the hourly rate is therefore less than intended.

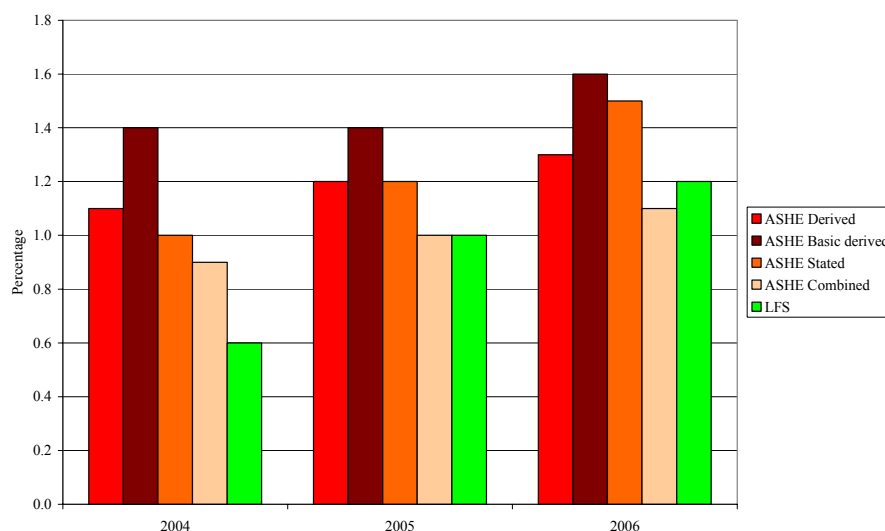
Table 5: Estimates of the number of jobs paid below the NMW using various hourly pay measures, 2004-2006

	16+ <i>Jobs</i> <i>Thousands</i>	16+ <i>Jobs</i> <i>below</i> <i>NMW</i> <i>Thousands</i>	16+ <i>Jobs</i> <i>below</i> <i>NMW</i> <i>%</i>	18+ <i>Jobs</i> <i>Thousands</i>	18+ <i>Jobs</i> <i>below</i> <i>NMW</i> <i>Thousands</i>	18+ <i>Jobs</i> <i>below</i> <i>NMW</i> <i>%</i>
2004						
ASHE Derived	-	-	-	24,518	276	1.1
ASHE Basic-derived	-	-	-	24,519	343	1.4
ASHE Stated ¹	-	-	-	11,221	117	1.0
ASHE Combined ¹	-	-	-	24,520	227	0.9
LFS ²	-	-	-	24,226	147	0.6
2005						
ASHE Derived	25,246	308	1.2	24,753	289	1.2
ASHE Basic-derived	25,246	376	1.5	24,753	355	1.4
ASHE Stated ¹	10,982	136	1.2	10,579	129	1.2
ASHE Combined ¹	25,247	256	1.0	24,752	239	1.0
LFS ²	25,124	250	1.0	24,527	244	1.0
2006						
ASHE Derived	25,309	337	1.3	24,964	322	1.3
ASHE Basic-derived	25,308	405	1.6	24,964	390	1.6
ASHE Stated ¹	10,602	160	1.5	10,319	153	1.5
ASHE Combined ¹	25,309	285	1.1	24,964	271	1.1
LFS ²	25,146	307	1.2	24,574	302	1.2

Notes:

- Not applicable as 16-17 year rate not introduced
- 1 Some basic validation carried out on stated rate where factor errors were obvious
- 2 Revised LFS methodology devised in 2005 based on calendar quarters

Figure 3: Estimates of the percentage of jobs paid below the NMW using various hourly pay measures for individuals aged 18 and over, 2004-2006



The ASHE combined measure is closer to the LFS measure, even in 2004 when the stated rate was subject to a number of problems. In 2005 the difference is negligible. Note that the combined measure is always below the stated measure, implying that, amongst the low paid, the stated rate is generally higher than the derived rate when only the latter is present.

This is consistent with Ormerod and Ritchie (2007a), who found the same result in the LFS data. They also showed that the level of low paid estimated in the LFS varies depending upon how close the NMW is to certain 'focal points', due to rounding in the derived rate; it is rare for the LFS stated rate to be below the NMW. Something similar may be at work here, although Ormerod and Ritchie (2007a) note that there is no evidence that the ASHE data is being rounded. The employee may have a stated rate at or above the NMW, but the actual hourly rate paid in the survey week may simply resolve itself into a different amount.

Ormerod and Ritchie (2007b) showed that part of the difference between the LFS and ASHE estimates can be a timing issue, as the proportion of low paid varies continually throughout the year. Alongside this and the rounding argument of Ormerod and Ritchie (2007a), it seems, then, that another source of the differences in estimates of the low paid has been identified.

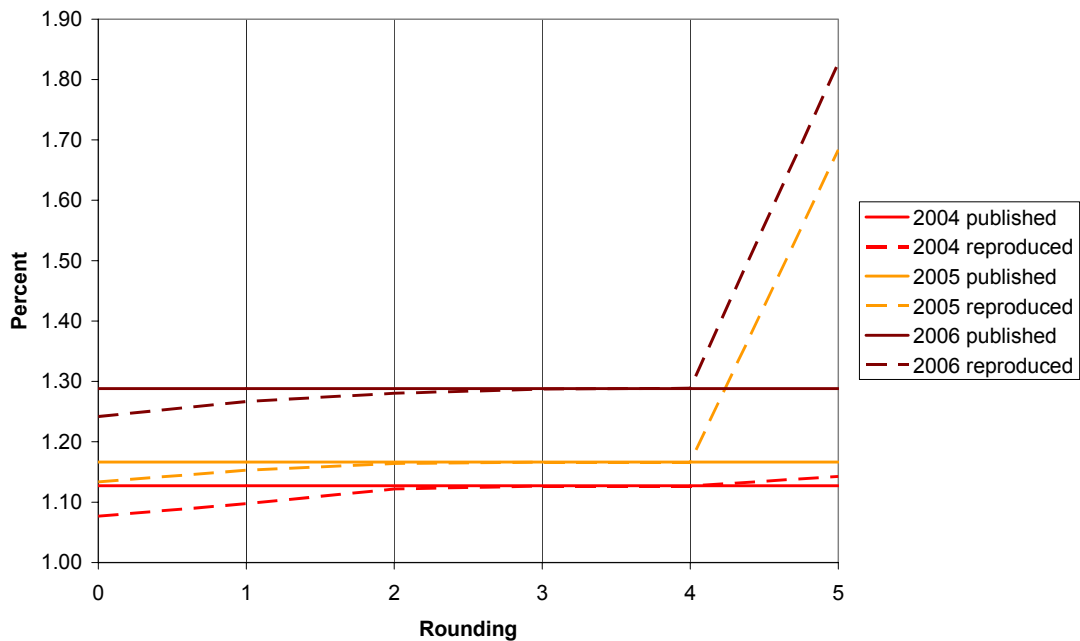
Precision affects estimates

One final concern reflects the mathematical reality of calculating complex estimates based upon a simple yes/no answer such as the number of people earning below the NMW. As noted above, stated rates may be on the NMW, but actual rates might be resolved differently. Although the overall impact on earnings on some variation around the minimum wage is negligible, the impact on the minimum wage is not, as the low pay calculation only sees one side of the variation.

For example, if two employees have a stated rate of £5.05 per hour, both are being paid the 2006 NMW and the number of low paid is zero. If inaccuracies in calculations by employers lead to these wages being derived as £5.03 and £5.07 per hour, the mean earnings are unchanged. However, the number of low paid has now increased by one, while the number at *or* below the NMW has fallen.

Generally, more variation leads to higher estimates of the low paid. However, sources are not the only source of error. In trying to reproduce the official ASHE numbers of low paid, the authors realised that the precision used in the estimates had a noticeable impact on the number of low paid. **Figure 4** shows the impact of rounding.

Figure 4: Proportion of low paid, with rounding to different decimal places at intermediate stages in the calculation of estimates, 2004-2006



The estimated percentage of low paid increases as the ‘precision’ of estimates is increased. This is because numbers just below the NMW cut-off are less likely to be rounded up to the NMW. The decision to round at four decimal places in intermediate calculations was taken as this seemed to indicate a point of some stability.

It was also observed that even the transfer of data between statistical packages caused small, but noticeable changes in the low pay estimates. This is still being investigated.

The sensitivity of the results to small changes in the data or calculation is exacerbated by the fact that the low pay estimates are based upon small numbers of observations, and then need to be weighted up to give population estimates. Hence moving a small number of observations from one side of the NMW cut-off point to the other makes a large difference.

These problems beset any attempt to do such a complex calculation as the population estimate of low paid from a sample. There is no suggestion that the ASHE estimate does not remain the best estimate of the number of low paid. However, it should be clear that this estimate is sensitive, and consideration might need to be given as to whether to introduce ‘margins of error’ around the NMW to stabilise the estimates.

Conclusion

This work supports the use of the derived rate of pay in the ASHE low pay estimates. The derived hourly rate is the most accurate measure of pay per hour. However when the information on total hours and total earnings comes from household surveys the derived rate is inaccurate. In this case the stated rate should be used. The ASHE and LFS low pay estimates are therefore based on a different measure of hourly pay.

ASHE estimates produced on the same basis as the LFS estimates are very similar. This suggests that the estimates can be partially reconciled on the basis of the methodology used. Previously users of low pay estimates assumed that differences mainly arose from the differences in the sources. This analysis suggests that this is not the case. Other investigations have also showed that ASHE and LFS data are more similar than previously thought.

Additional validation, based on the relationship between the stated and derived hourly rate, have also been identified. These are important for the accuracy of the estimates because small differences have a big impact, due to the way that the estimates are created.

Endnotes

- 1 The ASHE is a one per cent sample of employees on the Pay As You Earn (PAYE) register. Employers are surveyed, requesting information about hours and earnings of their employees. Since the ASHE replaced the New Earnings Survey (NES) in 2004 it is considered the most reliable source of information on earnings including those of low earners. The NES sample was extended to improve the coverage of the low paid and imputation and weighting was applied to ensure the sample was representative of the population. For more information on ASHE see:
<http://www.statistics.gov.uk/STATBASE/Source.asp?vlnk=1319&More=Y>
- 2 It should be noted that although low pay estimates attempt to measure the number of jobs that are paid below the NMW, the estimates cannot be used as a measure of non-compliance with the legislation. This is because it is not possible to discern from data sources on earnings whether an individual is eligible for the minimum wage. For example, it is not possible to identify people such as apprentices and those undergoing training, who are exempt from the minimum wage or are entitled to lower rates. If employees receive free accommodation, employers are entitled to offset hourly rates to reflect this.

- 3 The National Minimum Wage (NMW) was introduced in the UK in 1999. The Low Pay Commission (LPC) makes recommendation to the government on the level of the NMW. There are three NMW rates:
- The Adult Rate for workers aged 22 and over.
 - The Development Rate for workers aged 18 - 21 inclusive.
The Development Rate can also apply to workers aged 22 and above during their first 6 months in a new job with a new employer and who are receiving accredited training.
 - The 16 - 17 year old rate.

The NMW rates at April (1999-2007) are:

	Youth (Aged 16-17)	Development (Aged 18-21)	Adult (Aged 22 and over)
1999		3.00	3.60
2000		3.00	3.60
2001		3.20	3.70
2002		3.50	4.10
2003		3.60	4.20
2004		3.80	4.50
2005	3.00	4.10	4.85
2006	3.00	4.25	5.05
2007	3.30	4.45	5.35

The NMW is updated in October of each year. ONS official estimates measure the rate at April due to the data source being available at this time.

- 4 The Labour Force Survey (LFS) is a survey of households living at private addresses in Great Britain. It is the main source for information on the labour market in the UK. It is a random household survey of approximately 57,000 households every three months. As well as private households, the survey includes people living in student residence halls and NHS accommodation. For more information on the LFS see:
<http://www.statistics.gov.uk/STATBASE/Source.asp?vlnk=358>

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