

Adjusting AWE to account for re-classification of businesses

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1. Executive Summary

(1) A method is proposed to implement recommendation 3 of the review of the Average Earnings Index (AEI) and Average Weekly Earnings (AWE) (Weale, page 6). "*The AWE series should be linked across substantial employment reclassifications so that the effects of reclassifications themselves do not affect the estimated rate of growth of the average wage.*"

(2) In AWE, businesses are classified into industries, sector, and employment bands. Weale identified that re-classifications, especially where the firms change industries, can have a notable effect on the employment component of AWE. Given that AWE are used primarily as a measure of short term change in average earnings, Weale suggested that the growth in AWE should be adjusted whenever there were substantial disturbances caused by re-classification of firms.

(3) In brief, the proposal is to perform the following steps every month.

- a) The effect of all re-classifications, in aggregate, will be quantified by calculating monthly growth in AWE and comparing this with what the monthly growth would have been had the current month's register been available in the previous month. The difference in these growths shows the impact of register changes.
- b) These differences will then be compared with thresholds derived from the inherent variability of the series, to ascertain whether the impact of register changes is noticeable.
- c) Where so, the modified growth will be published in place of the originally estimated growth. The levels of AWE will also be adjusted.

(4) The effect of classification changes will be calculated only for the two top level published series: including bonuses and arrears and excluding bonuses and arrears. If register changes are found to have a substantial effect on *either* series, then the proposal is to adjust the growth, in that month, for every published AWE series. This guarantees coherence between every series of growths in AWE.

(5) If the recommended method is adopted then it is expected that adjustments to AWE growth will be rare – if the method had been used since the inception of AWE, then there would have been only one adjustment in six and a half years up to the end of 2008. The expected rarity of the adjustments is a consequence of accounting for the effect of class changes on only the top level series. It was decided to account for class changes on only the top level series after consulting users

2. Introduction

(6) The aim of the ONS is to consolidate the experimental short term earnings indicator AWE, and then submit the statistic to the UK Statistics Authority for consideration for approval to become a National Statistic. The review conducted by Martin Weale in 2008 made several recommendations for work that should be carried out by ONS in order to consolidate AWE. In particular, Weale proposed that the effect on AWE of re-classifications of firms on the Inter-departmental business register (IDBR) should be investigated by ONS, and a method for removing the effect of all substantial re-classifications be developed (Weale, recommendation 3, pages 6 and 45-46).

(7) This note is a report of the work carried out by ONS to implement Martin Weale's recommendation 3. The work has resulted in a proposal for a method to adjust growth in AWE whenever re-classifications to businesses on the IDBR have a substantial effect.

3. The proposal for adjusting growth in AWE

(8) This section contains the details of the proposal for adjusting the growth in AWE. The crucial parts of the proposal are highlighted in bold to distinguish them from the surrounding justifications.

3.1 How AWE are constructed

(9) Average earnings calculations make use of frozen variables stored on the IDBR. Average earnings are calculated by dividing an estimate of total pay by an estimate of total employment. Both the pay and employment estimators are ratio estimators, using the IDBR variable *frozen employment* as the auxiliary. Ratio estimates are calculated for each stratum and added to give the estimate for the total pay or employment. The strata are defined by two digit frozen SIC, together with public/private sector and employment band, both of which are derived from frozen variables on the IDBR. The main point is that the strata and auxiliary are based on frozen variables.

(10) The frozen variables on the IDBR including frozen SIC and frozen employment are so called because their values are typically constant for the whole year, though in exceptional cases the values will change. The IDBR also contains *current* versions of these variables that can change as soon as new and pertinent information is processed by the ONS. After the sample selection in December each year, changes to current SIC and current employment that have accumulated during the year are applied to the frozen variables before the sample selection in January. Some changes to frozen variables occur at other times in the year, if the change is determined to be significant according to a set of rules – those rules are given in appendix A.

(11) The source for AWE is the monthly wages and salaries survey (MWSS). The total number of changes to frozen SIC, employment band and sector for firms in the MWSS sample in the past eight years have been calculated, and are shown in table 3.1.1. The reader can see that the majority of changes occur in January (more precisely, the changes occur between December and January, but they affect first the January estimates), however it is possible that substantial changes may occur in any other month. Therefore, **the proposal is to test for the effect of re-classifications every month.**

	Total Number Of Classification Changes
Jan	5337
Feb	54
Mar	90
Apr	56
May	112
Jun	102
Jul	70
Aug	354
Sep	104
Oct	83
Nov	71
Dec	17

Table 3.1.1 – The total number of changes to register variables for firms in the MWSS sample between Jan. 2001 and Dec. 2008. The table shows that, while most changes occur in January, many can occur in other months.

(12) Outliers are identified in AWE as firms returning a highly unusual value of average pay excluding bonuses, average pay including bonuses or employment. They are treated by reducing their weight in the estimate. How this is accomplished is not relevant to this report, but it is relevant that the identification and treatment of a single outlier can make a large difference to the estimates for a stratum, and occasionally a noticeable difference to AWE for the whole economy.

3.2 The effect of register changes

(13) Changes to frozen register variables for a firm can have an effect on AWE whether or not the firm is part of the sample for MWSS. However, the effect is most easily understood by considering a change to one variable for just one firm in the sample, where the firm has employment of 20 or more. Suppose that the frozen SIC for one business changes from SIC W to SIC Z. Ignoring for the sake of simplicity employment band and sector, in other words defining strata by SIC alone, the effects on the ratio estimators for both pay and employment are as follows.

(14) Firstly, the population and sample in stratum W are denuded by one business, affecting the population and sample register employment – and consequently the weight applied to all units remaining in the stratum. There is a similar effect after the inclusion of the firm in stratum Z, affecting the weight for all units in that stratum.

(15) Secondly, outliers in both strata need to be recalculated, because firms are judged outliers in relation to others in their stratum, which has changed – this may greatly change the weights for some firms in either stratum.

(16) Lastly, the mean pay or mean employment for either stratum may still change substantially if the firm was atypical but not an outlier.

(17) It is, therefore, proposed to **account for the effect of re-classifications on the weights, outliers, pay and employment.**

(18) Changes of classification for firms of employment 20 or more (from now on called *large* firms) not in the sample can affect both the weights and the outliers, though not the mean pay or employment. For this reason changes to the classifications for these non-sampled firms usually have a smaller effect than changes for sampled firms. However, **the effect of re-classifications to both sampled and non-sampled are included in the proposed method.** When non-sampled businesses of less than 20 employment (from now on called *small* firms) are re-classified the effect is more complicated. The reason for the complication is that the estimates of pay for the small businesses are influenced by re-classifications for small firms and re-classifications for all other firms in the same industry and sector. The complications are not described here, but **the proposed method accounts both for re-classification of small firms and re-classifications in the large firms affecting the small firms.**

(19) There is one aspect of the change in frozen variables that was not considered by Weale - changes to frozen employment that are not explicitly accounted for by changes to employment band. Practical work, not reported in this note, has shown that accounting for changes to frozen employment increases, slightly, the effect on AWE of changes to the frozen register. Since the changes to frozen employment are very much in the spirit of Weale's recommendation, and since accounting for those changes makes adjustments to AWE a little more likely, and is therefore conservative, **the proposed method accounts for changes in frozen register employment.**

(20) **The proposal is to calculate the effect on AWE of all re-classifications in aggregate,** we propose not to attempt to isolate the effect of re-classifications for individual firms. The reasons for this are as follows.

(21) It is a seductive idea that growth in AWE may be affected by the re-classification of a handful of influential businesses. When implementing Weale's recommendation 3 it would certainly ease the job of the compilers of AWE if that were the case, *and* those firms were easily identifiable.

(22) It has proved practically impossible to disentangle the effect of reclassifications of individual firms. Two attempts were made to quantify the effect of individual re-classifications: the first was an attempt to develop an automatic method; the second was a careful manual investigation of the causes for potentially substantial changes. The first attempt, which is described in more detail in appendix B, failed because the simplifying assumptions that were made (in order that the method be useful) were found to exclude important cases. The second attempt was unsuccessful because almost all substantial changes are caused by an aggregate of many hundreds of changes to firms, and only exceptionally will the isolated effect of any one firm be substantial.

3.3 The recommended method

(23) To recap, the proposal is to perform the following steps every month.

- a) The effect of all re-classifications, in aggregate, will be quantified by calculating monthly growth in AWE and comparing this with what the monthly growth would have been had the current month's register been available in the previous month. The difference in these growths shows the impact of register changes.
- b) These differences will then be compared with a threshold derived from the inherent variability of the series, to ascertain whether the impact of register changes is noticeable.
- c) Where so, the modified growth will be published in place of the originally estimated growth. The levels of AWE will also be adjusted ..

(24) It is assumed that register changes are either corrections to previous misclassifications, or represent real changes in business activity that are applied to the register sometime after they occur. Under this assumption the current month's register is a better representation of reporting units in the economy last month than last month's register was. For this reason **the proposed method calculates, each month, the effect on last month's AWE of using the current month's IDBR.** If information on the date of a real classification change is available, the series will be revised back to this date. Otherwise the revision will take place when the change is identified on the business register.

(25) The inherent variability of growth in AWE is quantified by calculating estimates of standard errors for growth, using a method developed by John Wood (Wood, 2006). The estimates of standard error are themselves both volatile and susceptible to the effects of register changes. Also, it is a complicated and potentially time consuming process to calculate them. For these reasons it is **proposed to calculate standard errors once a year, and estimate the inherent variability of growth in AWE by taking a median of the standard error estimates over 12 months**. The median is proposed because it is not dominated by the effect of register changes in January, which inflate estimates of standard error. Using the median standard error thus makes it more likely to identify substantial changes to AWE, especially in months other than January. The threshold for the year January to December will be fixed at one median standard error for monthly growths over the same period the year earlier. The choice of *one* median requires some discussion. The reader may think that a more natural choice for the threshold would be two medians, corresponding roughly to the effect being significant at the 95% level. However, it is felt that a growth difference of two standard errors would be noticeable, and it is necessary to be more conservative by choosing a smaller threshold.

(26) AWE consists of several different series, for example series including and excluding bonuses, and series for different groups of industries. Register changes could have a substantial effect on one series but a small impact on another series to which the first contributes. Using modified growth for the former but unmodified growth for the latter would introduce an incoherence. In order to maintain coherence between the different series, **the proposal is to adjust the growth of all published series simultaneously**, whenever the effect of re-classifications is larger than the thresholds for the top level series either including or excluding bonuses.

(27) In summary, and more precisely, it is proposed to calculate the effect of re-classifications on the growth in both top level AWE series, S, which are the series including bonuses and arrears and excluding bonuses and arrears. The growth will be calculated between months t and t-1 using the following approach. Firstly, the following estimates will be calculated: the estimated level of the series at t-1, using the register as at time t-1, $W_{S,t-1,t-1}$; the estimated level of the series at t-1, using the register as at time t, $W_{S,t-1,t}$; and similarly for $W_{S,t,t}$; and the difference between the monthly growths $\Delta_{S,t,t-1} = (W_{S,t,t}/W_{S,t-1,t-1}) - (W_{S,t,t}/W_{S,t-1,t})$. Secondly, the threshold, $\sigma_{S,t,t-1}$, for the monthly growth $W_{S,t,t}/W_{S,t-1,t-1}$, is determined. This is calculated once a year as a median of 12 months of standard errors of monthly growth.

(28) An adjustment to growths in AWE is triggered if $|\Delta_{S,t,t-1}| > \sigma_{S,t,t-1}$, for either the series including or excluding bonuses. In the case the growths are modified, then every published series, S, will be modified, with the growth in the series S between t-1 and t given by $W_{S,t,t}/W_{S,t-1,t}$, when not modified the growth will be $W_{S,t,t}/W_{S,t-1,t-1}$.

(29) Finally, adopting the proposed method will result in an incoherence between the value series and the series of growths, for intervals including a month in which growth has been adjusted. This incoherence can only be removed by revising the value series; given the small number of adjustment occasions, the value series will therefore be revised for consistency. Historic values may as a result be less plausible, as they will not measure the actual value at the time, but a hypothetical value with consistent classifications.

4. Results

(30) Calculations using the proposed method, over the interval January, 2002 to September 2008, show that there would have been just one adjustment to AWE growths in that interval. The changes to the IDBR between December 2002 and January 2003 trigger an adjustment because of their substantial effect on the whole economy series excluding bonuses and arrears, this is shown graphically in figure 4.1. The effects of re-classifications on the whole economy series including bonuses and arrears have, over the interval examined, been much smaller than sampling variation, this is shown in figure 4.2. The effects of re-classifications are of approximately the same size in both series, however the inherent variability of the series including bonuses and arrears is about twice as large as that for the series excluding bonuses and arrears.

(31) The adjustment in December 2002 is triggered due to the combined effect of 891 changes of classification. Some of these changes have a positive effect, in the sense that they increase the adjusted AWE in Dec. 2002 over the unadjusted AWE, and some changes have a negative effect (see also

paragraph 32). Since the aggregate effect of all changes in classification is positive, a further investigation of the firms with the largest positive effect might help. The firms having a large positive effect can be identified using the method outlined in appendix B (though as noted in paragraph 22, this method should be used with an awareness of its weakness). There are about a dozen of these firms in Dec. 2002, all of their contributions are due to changes in size-band. A similar investigative process could be carried out whenever there is an adjustment to AWE.

(32) There are two further points the reader should note. Firstly, the estimates of standard errors for growth have been calculated using the method devised by John Wood (*Wood, 2006*); there is a possibility of further development work on the variance of movements in AWE. Secondly, due to time constraints, it was not possible to calculate standard errors for months before January, 2004. For all earlier periods we have, therefore, used the threshold adopted in 2005. Revisions to the thresholds that take place, after new standard errors are calculated, may mean that a different number of adjustments are triggered, however we anticipate that the revised number of adjustments will remain small.

(33) One interesting point that is prominent in figures 1 and 2 is that the difference in growth between AWE and the modified AWE in January tends to be positive. For both series the difference is positive in each January except for January 2007. This means that the estimate of average pay in December, based on January's updated IDBR, tends to be larger than the ordinary estimate of pay in December. It is tempting to speculate on possible reasons for this, however the issue is not relevant to this work so the phenomenon has not been investigated.

(34) The single adjustment to each published growth series triggered by the classification changes in December 2002 is illustrated for two top level series in figures 4.3 and 4.4. Those graphs show AWE, referenced to take the value 100 in December, 2001, together with the adjusted AWE, whose growth is identical to AWE except between December 2002 and January 2003.

**Difference in monthly growth (p.p.)
AWE – modified AWE
Whole Economy. Excluding bonuses and arrears.**

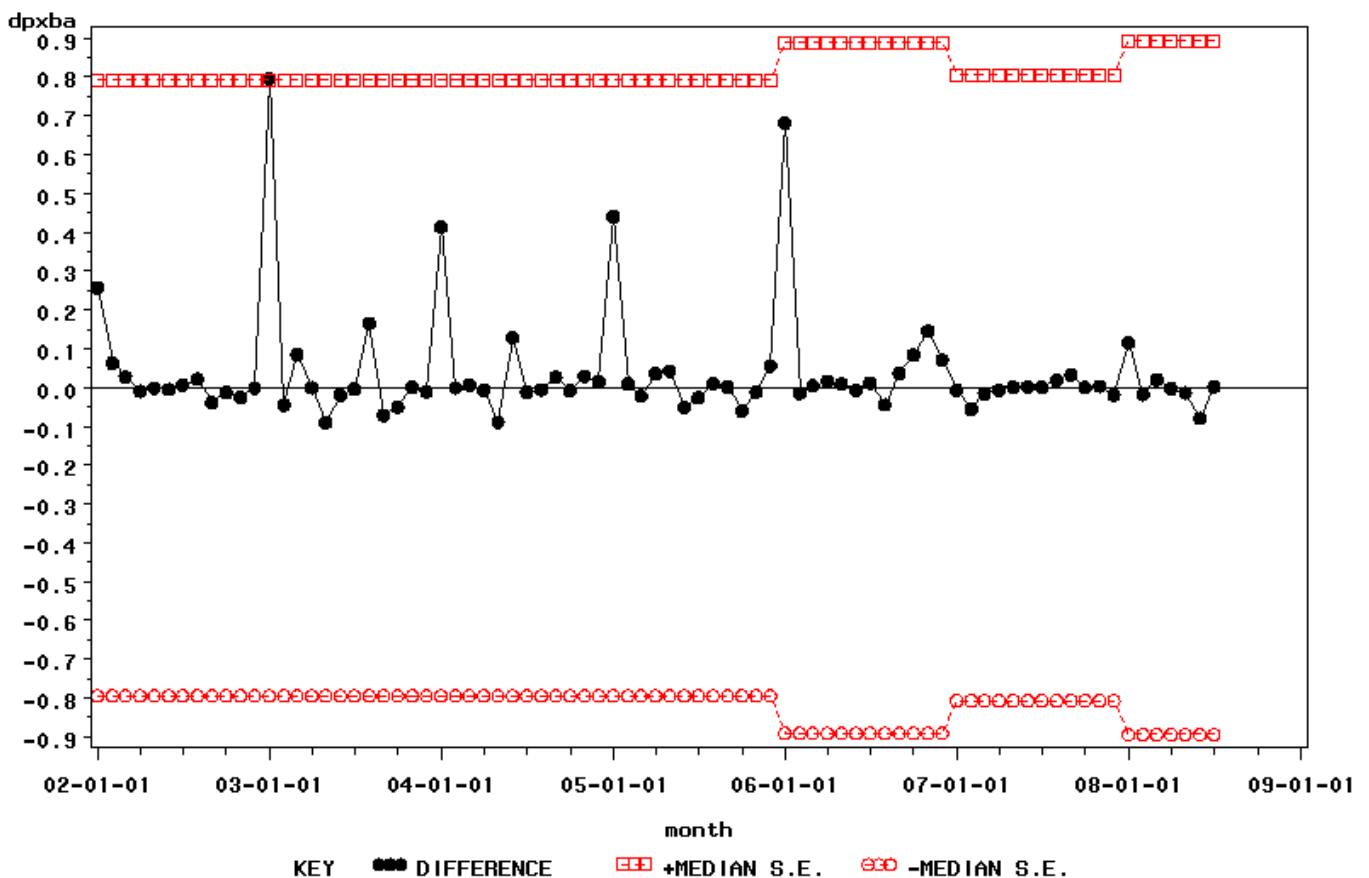


Figure 4.1 – Showing, in black and labelled *difference*, the difference in growth, in percentage points, between AWE and AWE based on the subsequent month's IDBR, excluding bonuses and arrears. The threshold for the difference is shown in red, labelled *+median* and *-median*. It shows clearly the one adjustment triggered in January 2003 because the difference is just larger than the threshold.

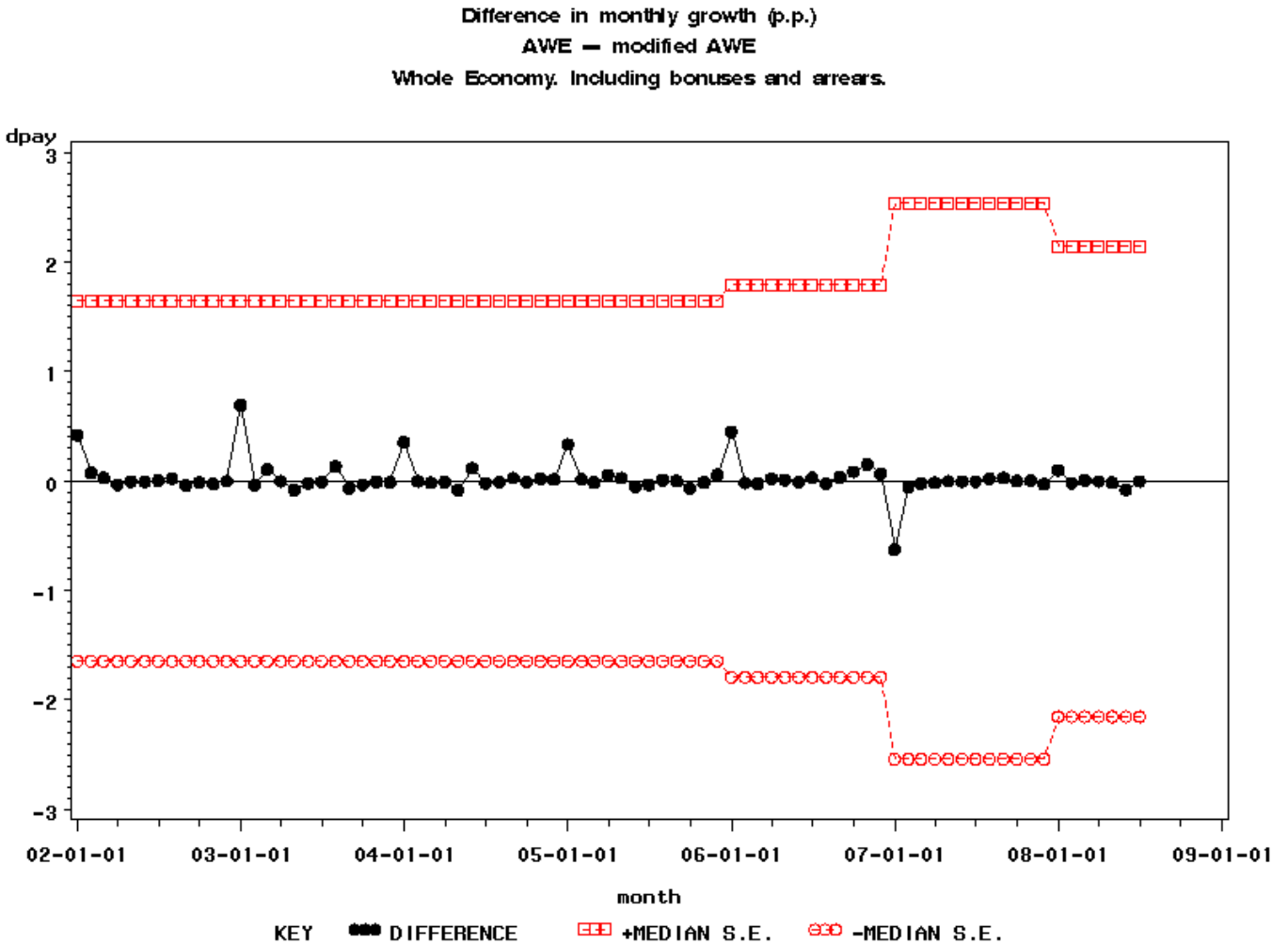


Figure 4.2 – Showing, in black and labelled *difference*, the difference in growth, in percentage points, between AWE and AWE based on the subsequent month's IDBR, including bonuses and arrears. The threshold for the difference is shown in red, labelled *+median* and *-median*. It shows that the difference has not been large enough to be distinguishable from the natural variability in the series.

Normalised levels for series: Whole Economy
Excluding bonuses and arrears.

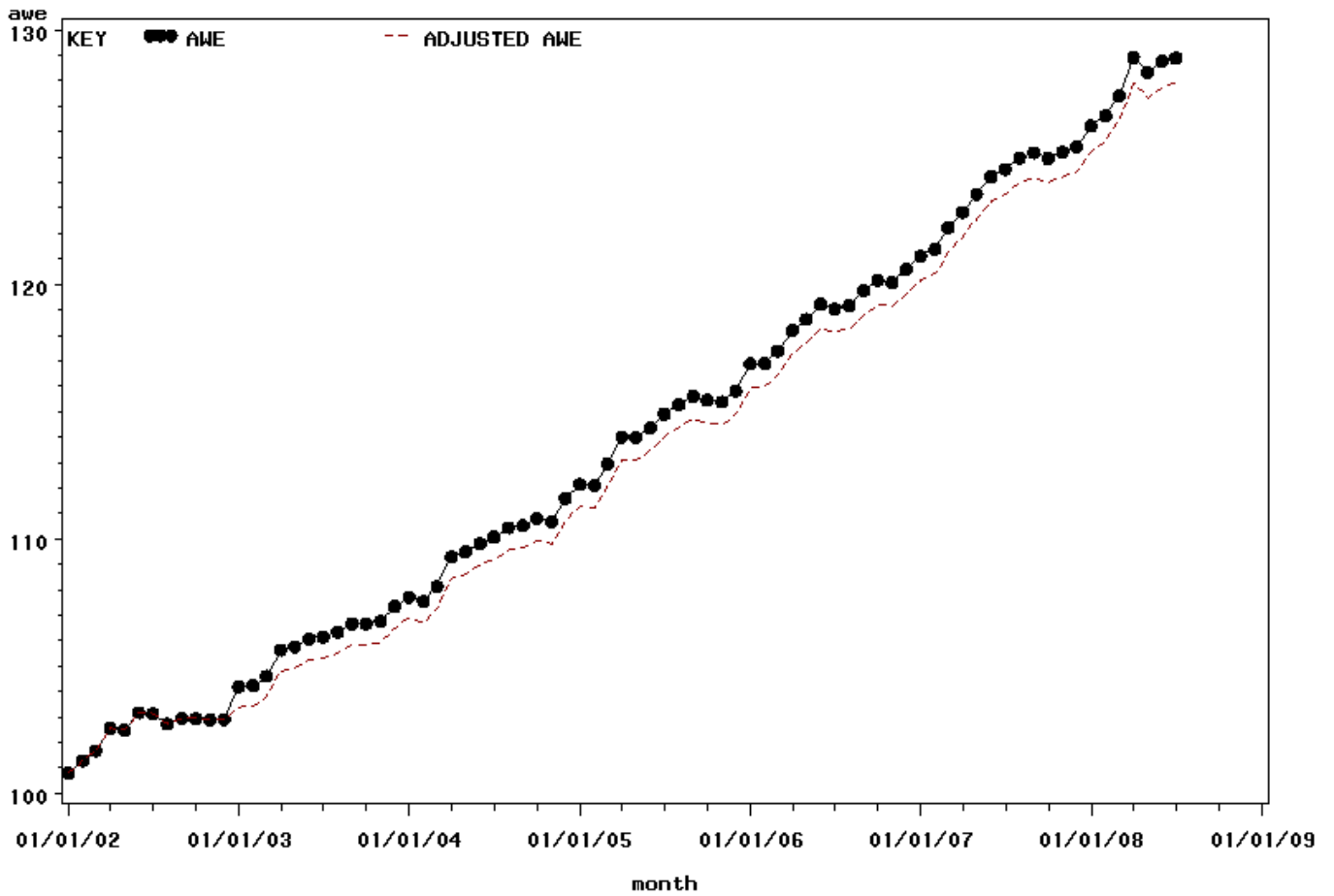


Figure 4.3 – Showing, in black and labelled *AWE*, the level of AWE excluding bonuses and arrears, referenced to be 100 in December 2001. The additional level, shown in red and labelled *adjusted AWE*, is a series carried forward from December 2001, using adjusted growths. The reader can clearly see the effect of the single adjustment to growth.

Normalised levels for series: Private Sector
Including bonuses and arrears.

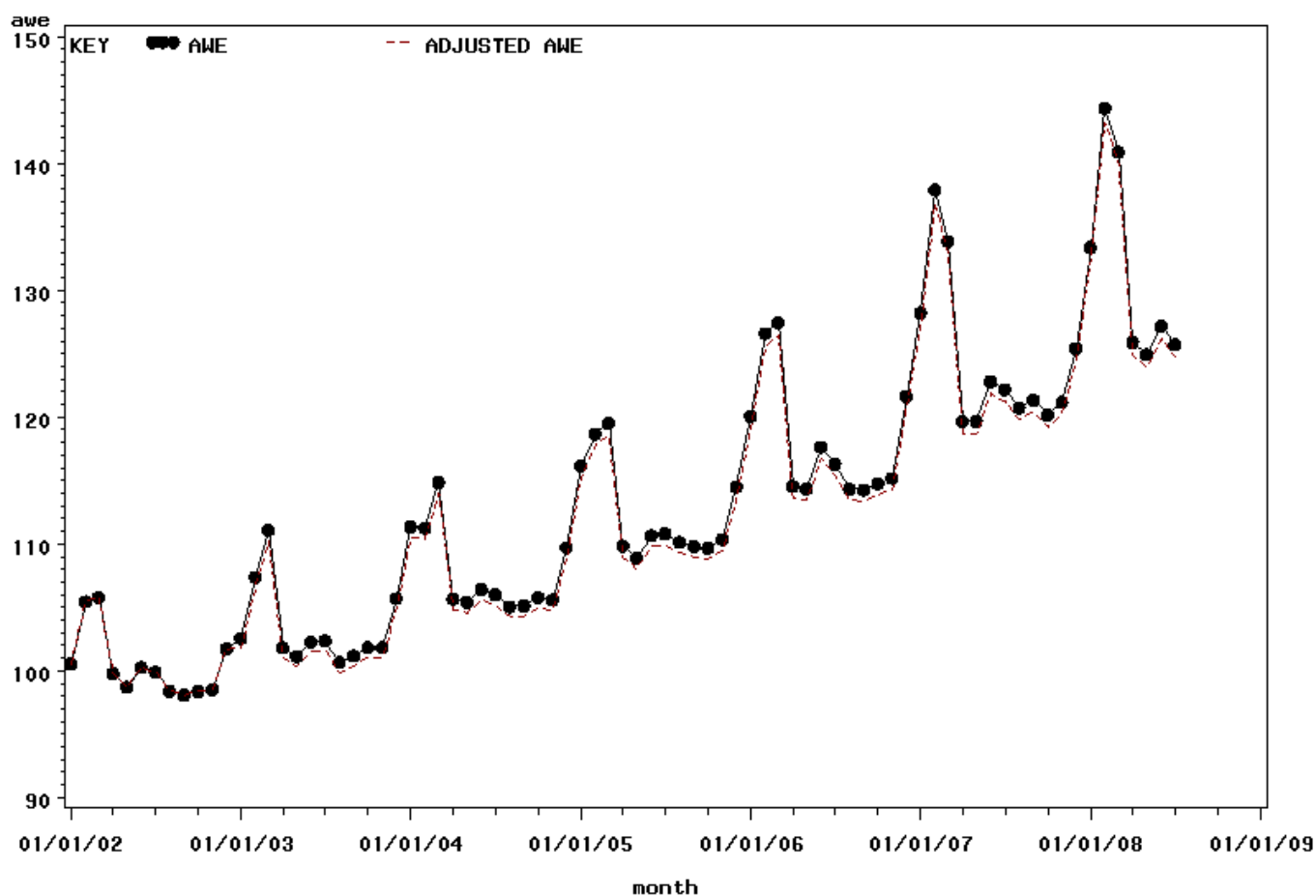


Figure 4.4 – Showing, in black and labelled *AWE*, the level of AWE including bonuses and arrears, referenced to be 100 in December 2001. The additional level, shown in red and labelled *adjusted AWE*, is a series carried forward from December 2001, using adjusted growths. The effect of the single adjustment to growth in January 2003 is not as obvious as for the series excluding bonuses.

5. Recommendations

(35) The recommendations justified above, in section 3, are listed here for convenience, with paragraph numbers in parenthesis. It is recommended to:

1. test for the effect of re-classifications in every month (11)
2. account for the effect of re-classifications on the weights, outliers, pay and employment (17)
3. account for the effect of re-classifications to both sampled and non-sampled firms (18)
4. account for re-classifications in the large firms affecting the small firms (19)
5. account for changes in frozen register employment (20)
6. calculate the effect on AWE of all re-classifications in aggregate (21)
7. calculate, each month, the effect on last month's AWE of using the current month's IDBR (24)
8. calculate standard errors once a year, and estimate the inherent variability of growth in AWE by taking a median of the standard error estimates over 12 months (25)
9. adjust the growth of all published series simultaneously (26)

10. adjust the series of values to be consistent with the growths (29)

6. Conclusions

(36) We believe the proposal for a method to adjust AWE to account for substantial changes to the IDBR is sufficient to meet recommendation 3 in Weale's review of the AEI and AWE. The method is straightforward and should be easy for users to understand. It should not add much to the burden of calculating AWE each month, or to the time it takes to calculate those statistics. The calculation of standard errors for AWE is a more complicated and time consuming task, but this should be done only once every 12 months.

7. References

1. Weale, M. R., 2008 "The Average Earnings Index and Average Weekly Earnings"
www.statistics.gov.uk/downloads/theme_labour/Wealefinalreport.pdf
2. Wood, J., 2006 "Estimating the Variance of Movements in Average Weekly Earnings", ONS internal report.

Appendix A – Changes to frozen variables

The content of frozen variables on the IDBR can change at any time if one or more of the following conditions are met.

- 1) A 2 digit SIC change (sector change) to the reporting unit SIC where the employment is 1000+.
- 2) Any change to a unit that brings it into scope of the standard universe will change the frozen values automatically. These are changes to 20+ employment, single source cases (normally Business Register Survey part 2, error free unproven births).
- 3) Any other change is regarded as exceptional and would be made according to a set of guidelines.

Appendix B - Effect of the reclassification of a single firm

Changes in the classification of firms will affect the value of stratum unit weights and outlier weights. This appendix sets out a method for approximating the effect of the reclassification for a single firm.

B1. Outline

The reclassification of a single firm affects the unit weights, outlier weights, and the small business adjustment. In this note, the effect on the unit weights will be approximated, but the effect on the outliers and small business adjustment will not. The effect on outliers is potentially very large in some strata for the series including bonuses. For this reason the approximations calculated can only be used as a guide, and a full re-calculation of AWE should be used to verify the calculations. The reason for leaving out the effect on outliers is to:

- (1) enable the approximation to be calculated rapidly, in a couple of seconds, so aiding the statistician in charge
- (2) ensure that the approximation remains valid after any change to the method for calculating outliers.

The effect of the reclassification on the value of the small business adjustment will be large whenever the effect of the outliers is large.

The rest of this note contains the calculations of the effect on the unit weights, and gives an approximation for the effect of a reclassification.

B2. Notation

The following simplified notation for AWE will be used. Note that the stratum is the cell identified by sector, industry, and employment band.

j is the identifier of the firm that is reclassified

f is the stratum before reclassification

g is the stratum after reclassification

Note that in the rest of the definitions it is assumed that the firm j is actually reclassified, that is it is assumed $g \neq f$. All of the values refer to the current period.

S_h is the sample for stratum h

U_h is the register population for stratum h

$y_{h,i}$ is the returned pay for unit i in stratum h

$x_{h,i}$ is the returned employment for unit i in stratum h

$z_{h,i}$ is the register employment for unit i in stratum h

y_j is the pay for the firm that is reclassified, $y_j = y_{g,j}$

z_j is the register employment for the firm that is reclassified, $z_j = z_{g,j}$

Z_h is the population register employment in stratum h , after reclassification $Z_h = \sum_{i \in U_h} z_{h,i}$

T_h is the sample register employment in stratum h , after reclassification $T_h = \sum_{i \in S_h} z_{h,i}$

Y_h is the sample total of pay in stratum h , after reclassification $Y_h = \sum_{i \in S_h} y_{h,i}$

γ_g is the unit weight for firms in stratum g after reclassification, $\gamma_g = \frac{Z_g}{T_g}$

γ_g^* is the unit weight for firms in stratum g before reclassification, $\gamma_g^* = \frac{Z_g - z_j}{T_g - z_j}$

γ_f is the unit weight for firms in stratum f after reclassification, $\gamma_f = \frac{Z_f}{T_f}$

γ_f^* is the unit weight for firms in stratum f before reclassification, $\gamma_f^* = \frac{Z_f + z_j}{T_f + z_j}$

E is the estimate of population employment after reclassification, $E = \sum_h \sum_{i \in S_h} \gamma_h x_{h,i}$

E^* is the estimate of population employment before reclassification, $E^* = \sum_h \sum_{i \in S_h} \gamma_h^* x_{h,i}$

R is AWE with the reclassification, and R_j is AWE without the reclassification of firm j .

B3. Reclassification of one unit in the sample

The difference the reclassification makes to AWE is given by,

$$R - R_j = \frac{1}{EE^*} \left(E^* \sum_h \sum_{i \in S_h} \gamma_h y_{h,i} - E \sum_h \sum_{i \in S_h} \gamma_h^* y_{h,i} \right). \quad (1)$$

Thus the effect will be positive when the reclassification of the firm has increased AWE, and negative when the reclassification has reduced AWE, and the units of the effect are pounds sterling per week.

The calculation proceeds in a similar way to that in the construction of the leverage measure for AWE. It is assumed that the employment total is not changed by the reclassification, which means that the weights in only two strata are affected. That is, after assuming $E \approx E^*$ all of the terms in (1) cancel except those in strata f and g , and it follows that

$$\begin{aligned} R - R_j &= \frac{1}{E} \left(\sum_{i \in S_f} [\gamma_f - \gamma_f^*] y_{f,i} + \sum_{i \in S_g} [\gamma_g - \gamma_g^*] y_{g,i} + [\gamma_g^* - \gamma_f^*] y_j \right), \\ &= \frac{1}{E} \left([\gamma_f - \gamma_f^*] Y_f + [\gamma_g - \gamma_g^*] Y_g + [\gamma_g^* - \gamma_f^*] y_j \right). \quad (2) \end{aligned}$$

Note that the third term in the sum (2) arises because the firm j is not included in the sums $\sum_{i \in S_f}$ but is included in the sums $\sum_{i \in S_g}$.

It is proposed to use the formula (2) to calculate the approximate effect of reclassifying firm j . The totals E , Z_h , Y_h , and T_h , are independent of j , and can be calculated from AWE data in one pass. Afterwards, the firm level effects $R - R_j$, for each firm in the sample, can be calculated in one more pass through the data. For one month's worth of data, these calculations can be completed in less than two seconds using SAS.

B3.1 When a firm is in the same stratum in both months

When there has been no reclassification for firm j , that is when $g = f$, it should be noted that the definitions for γ_f^* and γ_g^* given above are not valid. When there is no reclassification

$\gamma_f = \gamma_g = \gamma_f^* = \gamma_g^*$, and the value of equation (2) is zero.

B3.2 Connection with the measure of leverage for AWE

It is interesting to calculate what happens when using the same extra approximations that were used in the measure of leverage for AWE, namely $\gamma_g^* \approx \frac{Z_g}{T_g - z_j}$ and $\gamma_f^* \approx \frac{Z_f}{T_f + z_j}$. In that case we have

$\gamma_f - \gamma_f^* \approx \gamma_f^* \frac{z_j}{T_f}$, and $\gamma_g - \gamma_g^* \approx -\gamma_g^* \frac{z_j}{T_g}$. It follows that the measure of the effect of the reclassification,

$$R - R_j \approx \frac{1}{E} \gamma_g^* \left(y_j - \frac{Y_g}{T_g} z_j \right) - \frac{1}{E} \gamma_f^* \left(y_j - \frac{Y_f}{T_f} z_j \right),$$

is approximately equal to the difference between the leverage for unit j , in the current period, as it is in stratum g and the leverage for the same unit in the current period as it would have been in stratum f .