Seasonal adjustment of quarterly M4 excluding intermediate OFCs ($M4^{ex}$)

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The Monetary Policy Committee's (MPC) key measure of broad money is M4 excluding the deposits of intermediate other financial corporations (IOFCs), denoted as $M4^{ex}$ in this article. The published seasonally adjusted measure rose strongly in 2010 Q2 but, as noted in the August 2010 Inflation Report, this apparent pickup in money growth should be interpreted with caution, given the extent of the recent change in behaviour of IOFCs' deposits. This article presents the results of the Bank of England's investigations into alternative approaches to compiling seasonally adjusted data for $M4^{ex}$ and proposes a change to the seasonal adjustment method. The focus in this article is on the deposit side, but the same principles apply to the broad lending data (denoted $M4Lx^{ex}$).

Background

In September 2007 the Bank of England undertook a user consultation setting out proposals to modify the measurement of broad money (M4) in the United Kingdom[1], in order to ensure that the measure remained the most relevant in a global financial system that was evolving rapidly. The main proposal was to exclude the money holdings of some types of 'other financial corporations' (OFCs) from M4, and thus to provide a measure of money more closely related to nominal spending in the economy. The OFCs whose money holdings are excluded are those that focus on intermediation between banks and building societies, effectively creating transactions that are similar to inter-bank business. An example of such 'intermediate' OFCs (IOFCs) are central clearing counterparties – facilitating the settlement of securities transactions – and securitisation special purpose vehicles and covered bond entities, used by monetary financial institutions (MFIs) as a source of funding and to transfer assets and/or risk from their balance sheets.

These quarterly measures of $M4^{ex}$ and $M4Lx^{ex}$ were first published in the May 2008 *Inflation Report*[2], with data available from 1997 Q4. Monthly series are available from June 2009.

Tables 1 and 2 show the relative contributions of the components to the total deposits of the IOFC and non-intermediate IOFC (NIOFC) sub-sectors respectively, at end July 2010.

Table 1: Break-down of intermediate OFCs' (IOFCs) deposits[3]

Category	%
Mortgage and housing credit corporations	41
Other financial intermediaries, within same group	30
Other activities auxiliary to financial intermediation	21
Bank holding companies	6
Non-bank credit grantors	2

Table 2: Break-down of non-intermediate OFCs' (NIOFCs) deposits

Category	%
Insurance companies and pensions funds	23
Securities dealers	21
Fund management activity	21
Other financial intermediaries, outside group	20
Investment and unit trusts excl. money market mutual funds	12
Financial leasing corporations	2
Credit unions, factoring corporations and money market mutual funds	1

Charts A and B show how the volatility of IOFCs' M4 has increased sharply since the start of 2008, and explains most of the recent variability in aggregate M4 and OFCs' deposits. Data in both charts are non-seasonally adjusted (NSA). This dramatic increase in volatility has affected both the seasonal adjustment of aggregate M4, and the derivation of $M4^{ex}$.

This change in behaviour has raised concerns about the current approach to seasonally adjusting $M4^{ex}$, and this article describes the results of work to investigate an alternative approach that deals better with the recent increased volatility in IOFCs' M4. Two alternative

[1] See 'Proposals to modify the measurement of broad money in the United Kingdom: a user consultation' by Stephen Burgess and Norbert Janssen, *Bank of England Quarterly Bulletin*, Vol. 47, No. 3, pages 402-14. 2007. http://www.bankofengland.co.uk/publications/quarterlybulletin/qb0703.pdf.

[2] See Section 1.3 on page 20 of the May 2008 *Inflation Report*. http://www.bankofengland.co.uk/publications/inflationreport/ir08may.pdf.

[3] Quarterly data are available from 1997 Q4 for the following four industrial categories: non-bank credit grantors, mortgage and housing credit corporations; bank holding companies and other activities auxiliary to financial intermediation. From 2005 Q1 data are available for 'intra-group' deposits, using approximate quantitative information from a larger sample of banks (accounting for over 80% of banks' business with other financial intermediaries).

approaches have been investigated: directly adjusting M4[ex], and deriving M4[ex] indirectly by summation of the seasonally adjusted components (see next section and Annex A for discussion of the terms direct and indirect). The indirect-by-summation approach has emerged as the preferred measure. Chart C shows how the preferred seasonally adjusted (SA) measure compares with the existing measure, and with the alternative direct measure.

Chart A: Flows of quarterly M4, M4[ex] and IOFCs' M4, non-seasonally adjusted (NSA)

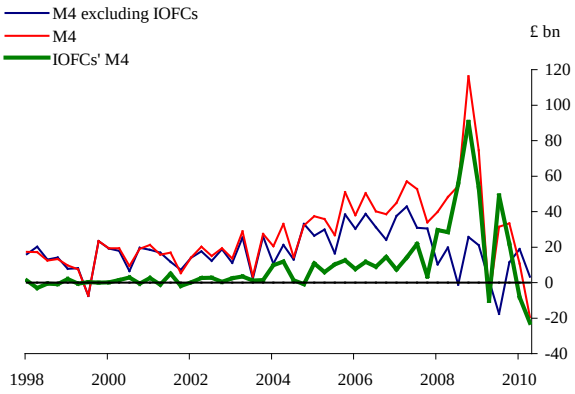


Chart B: Flows of quarterly sectoral components of OFCs (NSA)

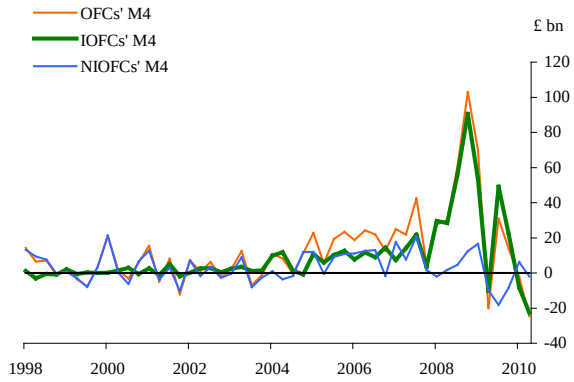
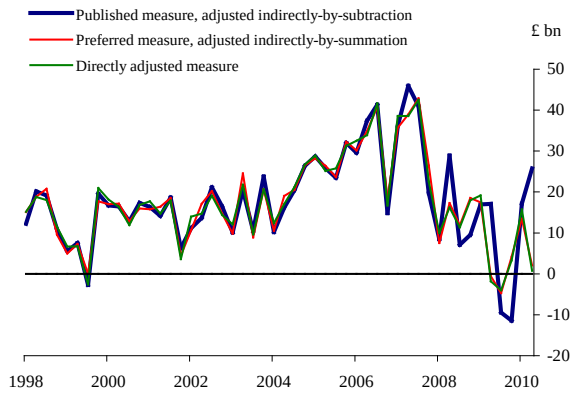


Chart C: Effect of change in seasonal adjustment approach on flows of quarterly M4[ex] (SA)



Seasonal adjustment method

Since 2004, the Bank of England has seasonally adjusted monetary data using the X-12-ARIMA[4] package. Prior to this an in-house package named General Linear Abstraction of Seasonality (GLAS) was used, when an over arching consideration was additivity in a flow of funds framework, achieved using linear filters. Across national statistical institutes and central banks, two of the common seasonal adjustment packages employed are TRAMO-SEATS and X-12-ARIMA[5]. The former uses a model-based approach, where the unobserved components are derived from an ARIMA-type time series model using signal extraction techniques. X-12-ARIMA uses a quasi non-parametric approach that applies moving averages to estimate the components. It was favoured as the Bank's seasonal adjustment package partly because it was used by the Office for National Statistics, thus allowing consistent methodology to be used for UK data, and is well documented and supported by the U.S. Census Bureau.

Where identifiable seasonality is detected in a time series published by the Bank, a seasonally adjusted version is also published. The seasonal adjustment process includes assessing whether there are calendar effects and selecting appropriate parameters (ARIMA models, outlier configuration and seasonal and trend filters) to adjust the series. The Bank of England conducts annual reviews of its monetary dataset and publishes the results in a spring issue of *Bankstats*[6].

Monetary aggregates that are composed of component aggregates can either be adjusted directly or indirectly. Annex A explains these terms and lists the criteria for choosing between the two approaches. In general, where there are no significant differences between the approaches in terms of diagnostics, revisions performance or economic story, then the indirect approach is selected on grounds of additivity i.e. it is convenient that the SA data will obey the same accounting constraints as the NSA data.

Current seasonal adjustment of M4[ex]

Diagram 1 outlines how the seasonal adjustment of M4[ex] is currently derived, indirectly by subtracting NSA sterling deposits held by IOFCs from aggregate M4 (SA). An advantage of this indirect method is that it enables us to publish quarterly and monthly seasonally adjusted data on a consistent basis[7].

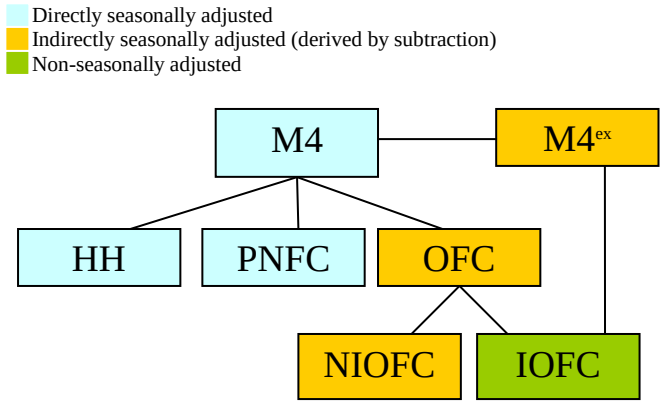
[4] For a more detailed exposition of the move to X-12-ARIMA and seasonal adjustment considerations see 'Change in seasonal adjustment method to X-12-ARIMA' by John Thorp, Bank *of England Monetary & Financial Statistics*, December 2003. http://www.bankofengland.co.uk/statistics/ms/articles/artdec03.pdf.

[5] Structural time series models e.g. STAMP represents an acceptable alternative.

[6] 'Seasonal adjustment: 2010 annual review' by Fida Hussain and Anjli Shah, *Bank of England Monetary & Financial Statistics*, April 2010. http://www.bankofengland.co.uk/statistics/ms/articles/art2apr10.pdf.

[7] 'Change in policy for seasonal adjustment of quarterly series" by Stephen Burgess, *Bank of England Monetary & Financial Statistics*, April 2007. http://www.bankofengland.co.uk/statistics/ms/articles/art2apr07.pdf.

Diagram 1: Current Aggregation Structure



The essential features of the current compilation method are summarised in Diagram 1 and Annex A, and below:

- Aggregate M4 (M4), Households' M4 ($M4^{HH}$), and Private Non-Financial Corporations' M4 ($M4^{PNFC}$) are directly seasonally adjusted on a monthly basis, with quarterly equivalents derived as the sum of the months;
- Seasonally adjusted OFCs' M4 $\left(M4_{SA}^{OFC}\right)$ is obtained indirectly as a residual, from $M4_{SA} - M4_{SA}^{HH} - M4_{SA}^{PNFC}$. Similarly seasonally adjusted NIOFCs' M4 $\left(M4_{SA}^{NIOFC}\right)$ is obtained indirectly as a residual, from $M4_{SA}^{OFC} - M4_{NSA}^{IOFC}$;
- IOFCs' M4, and four of the five industrial components within it are found to be not seasonal (bank holding companies are found to exhibit seasonality);
- M4 excluding IOFCs' M4 $\left(M4_{SA}^{ex}\right)$ is derived indirectly by $M4_{SA} - M4_{NSA}^{IOFC}$; and
- Since the seasonally adjusted versions of $M4_{SA}^{OFC}$ and $M4_{SA}^{NIOFC}$ are obtained indirectly, as residuals, the structure is additive both in a cross-sectional sense at a single point in time, and in terms of consistency between the monthly and quarterly aggregates (see Annex A).

Since it is derived as $M4_{SA} - M4_{NSA}^{IOFC}$, the currently published $M4_{SA}^{ex}$ measure is affected by the seasonal adjustment of M4. The current problems arise because the volatility in M4 driven by IOFCs' deposits, has been partly 'smoothed out' of $M4_{SA}$, but when the $IOFC_{NSA}$ series is subtracted, the full extent of its volatility feeds through to the resulting flows in $M4_{SA}^{ex}$. These flows are thus under- or over-stated to the extent that the volatility has been removed from $M4_{SA}$. This can be most clearly seen in the Q2 and Q4 periods from 2008 onwards.

One way of better understanding the seasonality of OFCs' M4 is through its direct adjustment, and Charts D and E show how the resulting seasonal factors have become unstable. Chart D illustrates how the quarterly seasonal factors[8] for OFCs have evolved. Each curved line shows the development of the seasonal factor for a quarter since 1998 Q1and the situations at 2006 Q4 and 2010 Q2 are shown by the different colours. The dashed horizontal lines correspond to the quarterly averages of the seasonal factors. A seasonal factor above 100 indicates a positive seasonal effect on the series, while a level below 100 signals a seasonal weakening. The stability of the seasonal factors for each quarter is shown by the variability of its curve around the dashed horizontal line. It is notable that the Q2 and Q4 seasonal factors are unstable and have changed significantly and rapidly, with serious consequences for the identification and estimation of seasonality.

Chart D: Seasonal factors of quarterly levels of OFCs' M4 at 2006Q4 and 2010Q2

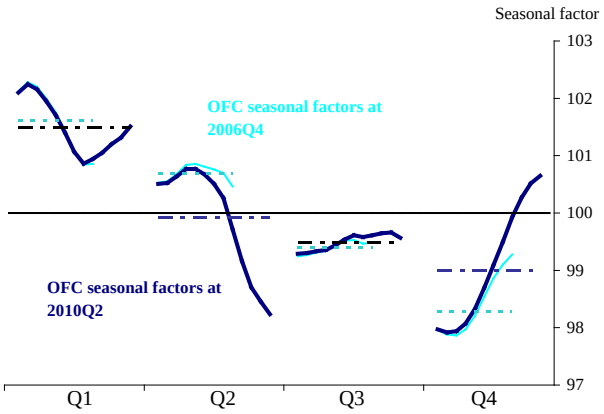
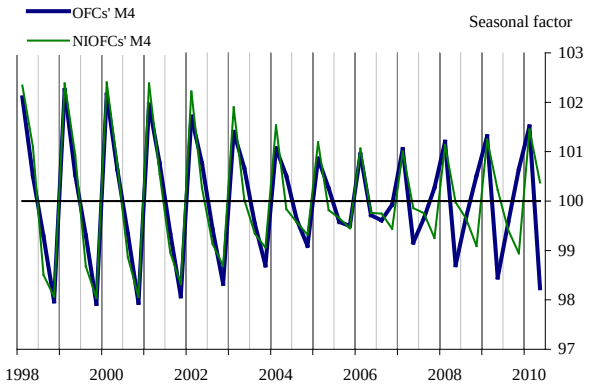


Chart E also shows how the seasonal factors have evolved; the changing amplitude and sign correspond to the curves in Chart D. Also notable is the similarity in seasonal factors of OFCs' M4 and NIOFCs' M4 prior to 2007. The divergence which opens up from 2007 arises from the large and volatile non-seasonal IOFC component, and by extension this has resulted in a problem in the seasonal adjustment of $M4^{ex}$.

[8] The Bank of England's seasonal adjustment policy for money and credit data is to adjust the levels (stock) data and derive flows from these by subtraction. These seasonal factors therefore relate to quarterly levels.

Chart E: Seasonal factors of quarterly levels of OFCs' M4 and NIOFCs' M4 at 2010Q2



Alternative methods

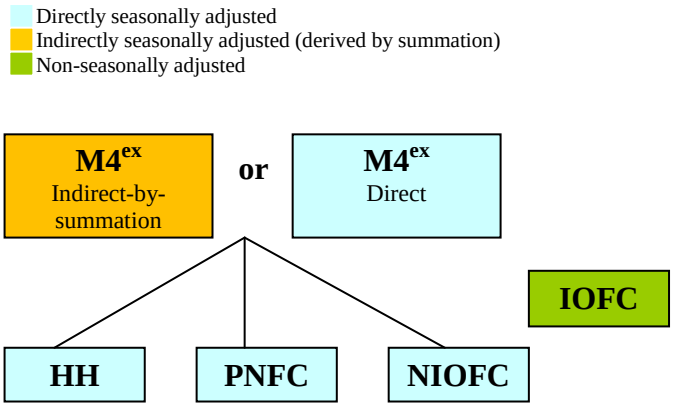
In order to address the problems highlighted above, the following methods have been compared:

1. Existing **published** measure (indirect-by-subtraction). See Diagram 1: $M4_{SA} - M4^{IOFC}_{NSA}$

2a. **Indirect** (by summation) approach. See Diagram 2: $M4^{HH}_{SA} + M4^{PNFC}_{SA} + M4^{NIOFC}_{SA}$

2b. **Direct** approach. See Diagram 2: $\left(M4^{HH}_{NSA} + M4^{PNFC}_{NSA} + M4^{NIOFC}_{NSA}\right)_{SA}$

Diagram 2: Indirect-by-summation and direct approaches



Under the direct approach, 2b, a residual will result which is equal to $M4^{ex}_{SA} - M4^{HH}_{SA} - M4^{PNFC}_{SA} - M4^{NIOFC}_{SA}$.

The choice between the approaches depends on:

- the quality of seasonal adjustment of the components and aggregate, determined by diagnostics;
- the revisions performance of the quarterly measure; and
- the implications for accounting additivity.

Results

Annex B contains the X-12-ARIMA diagnostics for the direct seasonal adjustment of $M4^{ex}$ (and $M4Lx^{ex}$) and its components, and real-time revisions assessment for the different approaches to adjusting quarterly $M4^{ex}$. In addition, a composite 'R2' roughness measure is presented.

The X-12-ARIMA diagnostics in Tables 1 and 2 of Annex B can be summarised as follows:

- quarterly IOFCs are not found to be seasonal. The weak forecast performance over the last year is also testament to the volatility of the series;
- quarterly NIOFCs are found to be seasonal; and
- the direct adjustment of $M4^{ex}$ is satisfactory with clear identification of seasonality and satisfactory forecast performance.

Revisions analysis is an important dimension of data quality assessment, and involves analysis of the reliability of a first estimate for a particular time period, as an indicator of the later or 'settled' estimate for that period. Seasonal adjustment revisions are typically larger and settle down later than other types of revision, and are a function of revisions to the underlying unadjusted data, new unadjusted data points, and the re-estimation of components including seasonal factors[9]. Nonetheless, seasonal adjustment revisions should be small and unbiased, and cause minimal switching in sign of the estimate.

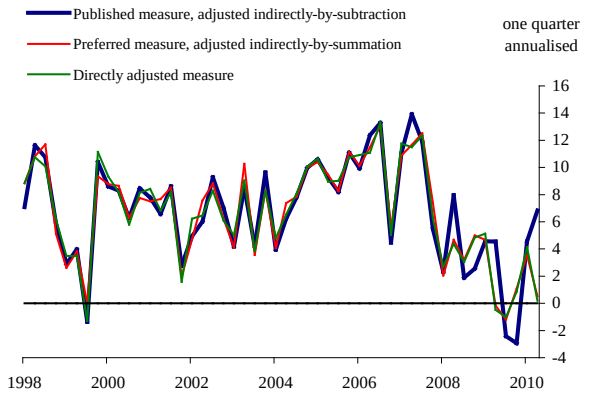
Table 3 in Annex B shows that the direct and indirect-by-summation adjustments of $M4^{ex}$ result in revisions of similar magnitude, which are both smaller than the currently published approach. None of the measures shows a switch in the sign of the quarterly flows as a result of revisions although for the lending data there is one switch in sign under the indirect-by-summation measure.

Chart C showed that the quarterly flows series for the indirect-by-summation and direct approaches move closely, and are less volatile than the published measure.

Chart F shows the one-quarter annualised growth rate of the three measures, which again confirms that the direct and indirect-by-summation approaches yield a similar outcome. Table 4 in Annex B shows that the X-12-ARIMA 'R2' measure of roughness indicates a preference for the indirect-by-summation method.

[9] 'An updated analysis of revisions to monetary and effective interest rates data' by Arpad G Morotz and Gayle Sansum, *Bank of England Monetary & Financial Statistics*, March 2010. http://www.bankofengland.co.uk/statistics/ms/articles/art1mar10.pdf.

Chart F: Comparison of aggregation approaches for quarterly M4 excluding intermediate OFCs (SA)



Conclusions

The judgement about whether to use a direct or indirect approach to produce a seasonally adjusted aggregate is often finely balanced, and the money (and credit) aggregates considered in this article have presented a particularly complex challenge.

In addition to consideration of the X-12-ARIMA diagnostics, comparison of revisions performance, and the user preference for accounting additivity, there are also several 'a priori' criteria to guide such judgements, as explained in Annex A. A final decision is therefore made based on the balance of all criteria.

Looking first at the 'a priori' criteria:

- no significant negative correlation was found between $M4^{ex}$ and its components, or between components, tested in terms of unadjusted flows and over various spans. This indicates little substitutability between components, and thus no necessity to use a direct adjustment;
- although the seasonal patterns of HHs' M4, PNFCs' M4 and $M4^{ex}$ itself are similar, the pattern of NIOFCs' M4 is different. This lack of similarity suggests that an indirect approach might be preferable; and
- although the relative contributions of the components to the aggregate appear to be stable prior to 2007, this stability breaks down in recent years. Again, this supports an indirect approach.

Turning next to the seasonally adjusted $M4^{ex}$ series from the different approaches:

- all three measures – published, indirect-by-summation and direct – pass the most critical seasonal adjustment test, i.e. the absence of residual seasonality;
- in terms of revisions, the indirect-by-summation and direct approaches yield similar results, although the direct is slightly better; and
- both the indirect-by-summation and direct approaches yield similar outcomes in terms of growth rates, although the X-12-ARIMA 'R2' measure of roughness indicates a preference for the indirect-by-summation approach.

So, on balance, although the X-12-ARIMA diagnostics for the directly adjusted approach are good, the indirect-by-summation approach is preferred based on the balance of factors described above, and the fact that accounting consistency (additivity) is maintained.

In conclusion, the preferred approach to seasonally adjusting $M4^{ex}$ is indirect-by-summation, with $M4^{ex}$ derived as the sum of its seasonally adjusted components. This preserves Bank of England policy on seasonally adjusting quarterly data in that two of the sectoral components, HHs' M4 and PNFCs' M4, will continue to be derived via summation of the seasonally adjusted monthly data. Quarterly NIOFCs' M4 will be seasonally adjusted directly but monthly data will not be adjusted directly until there are sufficient observations available.

Implications for published series

Simultaneous with publication of this article, Table A of the *Sectoral breakdown of aggregate M4 and M4 lending: August 2010* statistical release reports the recent seasonally adjusted four months for $M4^{ex}$ (and $M4Lx^{ex}$).

Tables 3 and 4 below display the recent seasonally adjusted four quarters for the published and preferred indirect-by-summation measures.

Table 3: M4 excluding intermediate OFCs, Published measure

			Growth rates (per cent)	
	Amount outstanding £ billions	Change £ billions	1q (ann)	4Q
2009 Q3	1 544.7	-8.2	-2.1	2.3
2009 Q4	1 529.5	-11.6	-3.0	0.9
2010 Q1	1 546.1	16.8	4.5	0.9
2010 Q2	1 571.2	24.5	6.5	1.4

Table 4: M4 excluding intermediate OFCs, Preferred measure

			Growth rates (per cent)	
	Amount outstanding £ billions	Change £ billions	1q (ann)	4Q
2009 Q3	1 537.5	-5.4	-1.4	2.0
2009 Q4	1 538.2	4.3	1.1	1.1
2010 Q1	1 552.4	13.9	3.7	0.8
2010 Q2	1 555.4	2.3	0.6	1.0

Tables 5 and 6 present the $M4Lx^{ex}$ quarterly published and preferred measures.

Table 5: M4 lending (exc. the effects of securitisations etc.) excluding intermediate OFCs, Published measure

			Growth rates (per cent)	
	Amount outstanding £ billions	Change £ billions	1q (ann)	4Q
2009 Q3	2 113.3	0.0	0.0	0.4
2009 Q4	2 107.8	10.2	2.0	1.5
2010 Q1	2 032.7	-2.4	-0.4	1.5
2010 Q2	2 033.3	-12.2	-2.4	-0.2

Table 6: M4 lending (exc. the effects of securitisations etc.) excluding intermediate OFCs, Preferred measure

			Growth rates (per cent)	
	Amount outstanding £ billions	Change £ billions	1q (ann)	4Q
2009 Q3	2 113.3	4.9	0.9	0.4
2009 Q4	2 113.5	16.0	3.1	1.4
2010 Q1	2 044.5	3.7	0.7	1.6
2010 Q2	2 029.6	-27.5	-5.3	-0.2

In implementing these changes, $M4^{ex}$ and its components will be given an even higher profile in the monthly *Sectoral breakdown of M4 and M4 lending* statistical release. This is in line with $M4^{ex}$ being the MPC's key measure of broad money. As a result of planned changes:

- Table B – M4 and M4 lending excluding all OFCs – will no longer be presented in the Release but the series will still be published on the Statistical Interactive Database; and
- Table C – Sectoral breakdown – will show NIOFCs instead of OFCs in the last columns.

On the basis of this analysis, the Bank of England intends to make these changes with effect from the Statistical Release to be published on 29th October 2010.

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ANNEX A Comparing Direct versus Indirect approaches

When a time series is constructed as the sum (or other composite) of a set of component series, the seasonally adjusted total series can be obtained by summing the individually seasonally adjusted components. This kind of adjustment is an indirect adjustment of the aggregate series. The alternative is direct adjustment, which is found by seasonally adjusting the aggregate series.

Direct and indirect adjustments will generally not coincide, since seasonal adjustment is a non-linear process. Only under some very restrictive assumptions, including the use of an additive decomposition, no outliers and same seasonal and trend filters, will the approaches coincide precisely. Ladiray et.al (2003) say that for a multiplicative decomposition model, the approaches are equivalent where there is no irregular, the sub-components have identical seasonal patterns or that the sub-series have identical or proportional trend-cycles.

The level at which to seasonally adjust is first determined; this should not be at too a granular level (to avoid noise clouding any underlying seasonal component) and should be at a publishable non-seasonally adjusted level. For example, we would not consider seasonally adjusting at the individual MFI level (most disaggregated source level) on grounds both that it is too granular, and we would not publish the non-seasonally adjusted time series on confidentiality grounds.

Direct adjustment is generally preferred when:

- component series show similar seasonal patterns - aggregation often reduces the impact of the irregular component of the component series through noise cancellation, which at the more detailed level may be too dominant for satisfactory seasonal adjustment. The aggregation will produce a smoother series with no loss of information on the seasonal pattern; and
- there is evidence of significant negative correlation between the aggregate and its components, or between components, indicating substitutability.

An **indirect** adjustment is likely to be better when:

- component series have different seasonal patterns or when the proportion of the total that a component accounts for changes over time - aggregation may cause large volatile non seasonal component series to overshadow seasonal component series making it difficult or impossible to identify any seasonality that is present in the aggregate series; or
- accounting additivity between the aggregate and its components is desirable - this is the case for quarterly national accounts. Indirect adjustment automatically yields additivity.

The lack of automatic additivity between the aggregate and its components that occurs with the direct adjustment will yield a difference (or residual) between the direct aggregate adjustment and the sum of its seasonally adjusted components. For such directly adjusted aggregates, the Bank publishes residuals as a separate time series on the Statistical Interactive Database.

Further consideration is production consequences where incomplete information is available to produce a timely aggregate using the indirect approach. For example, broad money and credit are currently seasonally adjusted directly because to produce the provisional estimates of M4 and credit (M4Lx) indirectly would require the sectoral components (Households, Private Financial Corporations' and Other Financial Corporations') to be of adequate quality to adjust. To date, incomplete information at the stage of the provisional release on these sectoral components has rendered this option infeasible. An article in the July 2010 edition of *Bankstats* [10] outlined a proposal to cease the publication of Provisional estimates of broad money and credit. Depending on the outcome of the consultation the constraint to adjust M4 directly may no longer be relevant. M4 and M4Lx are currently directly adjusted. A direct versus indirect assessment for quarterly M4 and M4Lx shows that the indirect adjustment is preferable on lower revisions grounds. No substitutability between components and aggregate is detected and the proportion of the component to aggregate changes over time. Quarterly M4 and M4Lx will be seasonally adjusted indirectly, subject to the outcome of the consultation as the sum of the seasonally adjusted Households', Private Non-Financial Corporations' and Non-intermediate OFCs' components and non-seasonally adjusted Intermediate OFCs'.

[10] 'Consultation to cease publication of Provisional estimates of broad money (M4) and credit (M4 lending)' by Norbert Janssen, *Bank of England Monetary & Financial Statistics*, July 2010. http://www.bankofengland.co.uk/statistics/ms/articles/art1jul10.pdf.

ANNEX B Seasonal adjustment – diagnostics and revisions analysis

The Money side: M4^{ex}

Table 1: Linearised series diagnostics

Series	Frequency	Span	Trading day[1]	Outliers[2]	Q(12)[3]	Q(24)[3]	Normality[4]	AAPE in within-sample forecasts [5] Last year	Last 3 years
M4	Monthly	1982.6-2010.7	Yes (0.00)	none	5.86 (0.75)	25.71 (0.22)	-0.05, 0.78, **3.85**	3.72	3.01
M4^{HH}	Monthly	1996.7-2010.7	Yes (0.00)	AO1996.12 (-4.06) AO1997.3 (5.95)	6.92 (0.73)	16.08 (0.81)	-0.17, 0.79, 3.46	1.07	1.23
M4^{PNFC}	Monthly	1996.7-2010.7	-	-	4.84 (0.90)	13.25 (0.93)	0.40, 0.76, 3.99	0.87	3.63
M4^{IOFC}	Quarterly	1997.4-2010.2	-	-	0.64 (0.73)	4.09 (0.66)	0.28, 0.86, -	**21.43**	13.92
M4^{NIOFC}	Quarterly	1997.4-2010.2	-	-	0.15 (0.99)	4.64 (0.70)	0.08, 0.85, 2.15	10.00	5.30
M4^{ex}	Quarterly	1997.4-2010.2	-	-	2.05 (0.56)	12.19 (0.09)	-0.27, 0.82, 2.64	2.16	1.42

Notes: **Bold** signifies a failure of the diagnostic.
[1] A chi-squared test is used to determine whether the stock trading day effect is significant. A p-value (stated in brackets) < 0.05 signifies a significant trading day effect.
[2] Outliers include additive outliers and level shift regressors and cater for one-off extreme movements and sustained changes in the levels respectively. The t-values are presented in brackets; the critical t-value is 3.92 for M4^{HH}.
[3] Model residuals should not be autocorrelated, particularly at the seasonal lags 12 and 24. The Ljung-Box Q is a general omnibus test that can be used to check whether the first *k* (12/24) autocorrelations in the correlogram deviate from zero. Here a p-value (stated in brackets) > 0.05 signifies that no significant autocorrelation is detected.
[4] Model residuals should be normally distributed with skewness and kurtosis of the distribution of the residuals consistent with a Normal Gaussian distribution. Presented are three statistics: Skewness coefficient, Geary's a and Kurtosis statistics with a failure in any one indicating that the model standardised residuals do not follow a standard normal distribution. For quarterly series the kurtosis statistic may not be computed, as there under 50 observations (dependent on degrees of freedom lost in formulating the ARIMA model).
[5] Average absolute percentage errors in within-sample forecasts give a goodness-of-fit assessment of forecast performance. Less than 15% is deemed acceptable.

Table 2: Seasonality and seasonal adjustment diagnostics

Series	Seasonality tests: F-test (Stable) [6]	KW[7]	F-test (Moving)[8]	G0[9]	Monitoring and Quality Assessment statistics: M7[10]	M8[11]	M10[12]	M11[13]	Q2[14]	G1[15]	G2[15]
M4	24.05	132.28	**1.2**	s2 s4	0.47	**1.24**	**2.38**	**2.35**	0.49	-	-
M4^{HH}	47.37	129.61	**0.73**	s2 s3 s4 (s6)	0.31	0.77	0.95	0.91	0.32	-	-
M4^{PNFC}	45.89	125.14	**1.47**	s2 s3 s4	0.35	0.94	**1.16**	0.99	0.36	-	-
M4^{IOFC}	**3.96**	**8.69**	**1.82**	s2	**1.26**	**2.47**	**3.00**	**3.00**	1.00	-	-
M4^{NIOFC}	14.49	24.55	**2.06**	-	0.67	**1.28**	0.75	0.32	0.60	-	-
M4^{ex}	22.98	31.39	2.2	-	0.54	0.90	0.95	0.94	0.39	-	-

Notes: **Bold** signifies a failure of the diagnostic.
[6] Parametric test for stable seasonality: a one-way ANOVA F-test; F-statistic presented.
[7] Non-parametric Kruskal-Wallis test; Kruskal-Wallis statistic presented.
[8] Moving seasonality test: a two-way ANOVA F-test; F-statistic presented.
[9] G0 is the spectrum of the differenced prior-adjusted series: a series is seasonal if there is at least one significant seasonal frequency (excluding the 5th and 6th seasonal frequencies) for monthly data; and at least one significant seasonal frequency at any of the two quarterly seasonal frequencies for quarterly data.
[10] M7 statistic ($0 \leq M7 \leq 3$) is one of eleven Monitoring and Quality Assessment Statistics available in X-12-ARIMA. It indicates whether seasonality is present and is constructed using the one-way and two way ANOVA seasonality tests. Less than 1.2 signifies seasonality and a value close to 3 indicates the series is clearly not seasonal.
[11] M8 is a function of the average absolute change in the estimated seasonal factors and indicates the size of the fluctuations in the seasonal component throughout the whole series. A value ≤ 1 is considered acceptable.
[12] M10 is the same as M8 but is calculated for the recent three years. A value ≤ 1 is considered acceptable.
[13] M11 captures the average linear movement in the seasonal component over the recent three years. A value ≤ 1 is considered acceptable.
[14] Q2 is an overall quality statistic calculated as a linear combination of statistics M1 to M11 (excluding M2) - the weights of the M-statistics to this Q2 measure differ with M7 having the most weight (0.18).
[15] G1 and G2 are spectra of the differenced seasonally adjusted series and of the modified irregulars respectively and are used to assess whether residual seasonality exists. A significant seasonal frequency shows evidence of residual seasonality and thus the seasonal adjustment is considered poor.

Table 3: Revisions assessment for the three approaches (SA, £bn)

	Published measure (indirect-by-subtraction)		
Vintage	**First estimate**	**Latest estimate**	**Revision**
2009 Q3	-6.7	-8.2	-1.5
2009 Q4	-1.8	-11.7	-9.9
2010 Q1	22.2	16.4	-5.9
2010 Q2	22.8		
Average absolute first to latest revision:			5.8
Residual seasonality at any of the four vintages:			None

	Preferred measure (indirect-by-summation)		
Vintage	**First estimate**	**Latest estimate**	**Revision**
2009 Q3	-1.5	-5.2	-3.7
2009 Q4	8.8	3.6	-5.2
2010 Q1	17.8	14.0	-3.8
2010 Q2	-0.1		
Average absolute first to latest revision:			4.2
Residual seasonality at any of the four vintages:			None

	Direct measure		
Vintage	**First estimate**	**Latest estimate**	**Revision**
2009 Q3	-2.9	-4.3	-1.4
2009 Q4	7.6	3.0	-4.6
2010 Q1	21.2	16.3	-4.9
2010 Q2	-2.0		
Average absolute first to latest revision:			3.6
Residual seasonality at any of the four vintages:			None

How to read the table above:

- The table shows a first to latest estimate revisions assessment for the three approaches under investigation i.e. published (indirect-by-subtraction), preferred (indirect-by-summation) and the direct approach.
- For the three quarterly vintages (2009 Q3, 2009 Q4 and 2010 Q1) the first estimate of the quarterly measure and the latest estimate (the first estimate of 2010 Q2 published in the July 2010 edition of *Bankstats*) of that vintage is presented alongside the revision.
- e.g. the first seasonally adjusted estimate of 2009 Q3, using the published indirect-by-subtraction method, is -£6.7bn (for the direct approach it would be -£2.9bn). The latest 2009 Q3 seasonally adjusted estimate conditional on data up to and including 2010 Q2 was -£8.2bn (-£4.3bn under the direct) yielding a revision of -£1.5bn using the published indirect-by-subtraction measure (-£1.4bn under the direct).

Table 4: R2 measure of roughness for seasonally adjusted series

	Full Series	**Last 3 years**
Published measure	0.003	0.003
Preferred measure	0.002	0.001
Direct measure	0.009	0.007

X-12-ARIMA has additional measures to compare the performance of direct and indirect seasonal adjustments. These 'roughness measures' (R1 and R2) describe the size of the deviations from a smooth trend of the adjusted series with R1 and R2 using different methods of trend estimation. Though smoothness is not necessarily the most desirable characteristic of a seasonally adjusted series, due to the presence of the irregular component, these measures-particularly R2- can give additional support for a particular type of adjustment. The R2 measure (over the whole span and over the past three years) supports the preferred indirect approach (lower R2 Root Mean Square Error metrics than the corresponding direct adjustment).

The Credit side: M4Lx^{ex}

Table 5: Linearised series diagnostics

Series[1a]	Frequency	Span	Trading day[1]	Outliers[2]	Q(12)[3]	Q(24)[3]	Normality[4]	AAPE in within-sample forecasts [5]	
								Last year	Last 3 years
M4Lx	Monthly	1982.6-2010.7	Yes (0.00)	-	11.23 (0.13)	**35.67 (0.01)**	0.22, 0.78, 3.42	1.11	1.11
M4Lx^{PNFC}	Monthly	1996.7-2010.7	Yes (0.00)	AO2000.5 (4.03)	2.65 (0.99)	15.54 (0.84)	0.26, 0.79, 2.94	1.66	4.46
M4Lx^{IOFC}	Quarterly	1997.4-2010.2	-	LS2007.1 (4.67)	2.89 (0.24)	7.84 (0.25)	0.65, 0.79, -	8.5	14.15
M4Lx^{NIOFC}	Quarterly	1997.4-2010.2	-	-	0.78 (0.68)	3.99 (0.68)	0.33, 0.74, -	3.59	5.25
M4Lx^{ex}	Quarterly	1997.4-2010.2	-	-	2.53 (0.28)	8.43 (0.21)	0.04, 0.75, -	1.11	2.46

Notes: **Bold** signifies a failure of the diagnostic.
[1a] M4Lx^{HH} is not presented as it is indirectly adjusted as the sum of Lending to individuals and Unincorporated Business & NPISH. Lending to Individuals is the sum of lending secured on dwellings and consumer credit.
[2] The critical t-values for PNFC and IOFC are 3.92 and 3.64 respectively.
See Table 1 for associated notes.

Table 6: Seasonality and seasonal adjustment diagnostics

Series	Seasonality tests				Monitoring and Quality Assessment statistics						
	F-test (Stable)[6]	KW[7]	F-test (Moving)[8]	G0[9]	M7[10]	M8[11]	M10[12]	M11[13]	Q2[14]	G1[15]	G2[15]
M4Lx	8.56	84.84	1.67	s4	0.84	**1.79**	**1.85**	**1.65**	0.53	-	-
M4Lx^{PNFC}[16]	3.81	32.23	**1.75**	-	**1.27**	**1.76**	**1.44**	**1.12**	0.66	**TD1**[17]	-
M4Lx^{IOFC}	**2.62**	**5.87**	**1.89**	-	**1.56**	**2.12**	**3.00**	**3.00**	0.99	-	-
M4Lx^{NIOFC}	**4.03**	11.84	**1.19**	-	1.15	**1.61**	**2.27**	**2.27**	0.86	-	-
M4Lx^{ex}	7.1	17.53	**2.07**	-	0.97	**1.49**	**1.35**	**1.35**	0.67	-	-

Notes: **Bold** signifies a failure of the diagnostic.
[16] This series shows features of non seasonality with the M7 diagnostic now exceeding 1.2. The decision to cease seasonal adjustment of a series is generally taken at the Annual Review and will be stopped if a series shows signs of non seasonality at two consecutive annual reviews.
[17] Though a significant spectral peak at the first trading day frequency has been identified, no significant trading day effect is detected in the associated seasonally adjusted flow series.
See Table 2 for associated notes.

Table 7: Revisions assessment for the three approaches (SA, £bn)

	Published measure (indirect-by-subtraction)		
Vintage	First estimate	Latest estimate	Revision
2009 Q3	-7.5	-2.8	4.8
2009 Q4	14.0	8.8	-5.1
2010 Q1	12.7	-1.1	-13.8
2010 Q2	-9.0		
Average absolute first to latest revision:			7.9
Residual seasonality at any of the four vintages:			None

	Preferred measure (indirect-by-summation)		
Vintage	First estimate	Latest estimate	Revision
2009 Q3	-2.5	5.2	7.8
2009 Q4	23.8	16.0	-7.8
2010 Q1	14.5	3.3	-11.2
2010 Q2	-27.3		
Average absolute first to latest revision:			8.9
Residual seasonality at any of the four vintages:			None

	Direct measure		
Vintage	**First estimate**	**Latest estimate**	**Revision**
2009 Q3	0.4	8.4	7.9
2009 Q4	24.3	17.3	-7.0
2010 Q1	14.1	3.2	-10.9
2010 Q2	-30.0		
Average absolute first to latest revision:			8.6
Residual seasonality at any of the four vintages:			None

See Table 3 for associated notes.

Table 8: R2 measure of roughness for seasonally adjusted series

	Full Series	Last 3 years
Published measure	0.007	0.005
Preferred measure	0.003	0.004
Direct measure	0.036	0.030

See Table 4 for associated notes.