MACROECONOMIC ADVISERS
By IHS Markit

Ben Herzon
ben.herzon@ihsmarkit.com

Joel Prakken
joel.prakken@ihsmarkit.com

Recently Asked Questions

Residual Seasonality in GDP Growth After the Comprehensive Revisions

August 23, 2018

Has BEA resolved the issue of residual seasonality in GDP growth?

The answer depends on the criteria used to detect it. Using our preferred criteria, we find statistical evidence that residual seasonality remains in top-line real GDP growth.

Over the last several years, BEA has been engaged in an effort to identify the sources of residual seasonality in GDP growth and develop methodologies to mitigate its occurrence in the data. With the comprehensive revisions released late last month, BEA had the opportunity to apply these methodologies to the entire quarterly history of GDP growth, which extends back to 1947. In this RAQ, we investigate the extent to which these efforts worked. In a recent publication, BEA demonstrates that by some criteria residual seasonality has essentially been removed from the data.[1] However, using the criteria presented in this RAQ, we conclude that residual seasonality has been reduced, but not eliminated from GDP growth.

Our Approach and Results

Prior to the comprehensive revisions, our most recent effort to detect residual seasonality in GDP growth was in the context of an econometric regression, which jointly estimated the effect of unusual weekday snowfall and residual seasonality.[2] Column 1 of the table at right reproduces those regression results. Over a sample that extended from 2005 Q4 to 2016 Q2, we estimated that annualized GDP growth was reduced below trend in first quarters by an average of 0.8 percentage point and boosted above trend over second, third and fourth quarters by one-third of this amount.[3] This result was significant at 10% and was below a point estimate of 1.2 percentage points (significant at 5%) estimated one and a half years prior.[4] The preparation of these two estimates were separated by two annual revisions to the NIPA's (both the 2015 and 2016 annual revisions) in which BEA applied methodological improvements to data beginning in 2012 to address residual seasonality in GDP growth.

Residual Seasonality in GDP Growth

Dependent Variable: Annualized 1-qtr GDP Growth

	(1)	(2)	(3)	(4)	(5)
Intercept	2.1 ***	2.3 ***	2.3 ***	2.9 ***	3.0 ***
Recession dummy	-4.8 ***	-4.9 ***	-4.9 ***	-4.8 ***	-4.7 ***
Q1 seasonal dummy	-0.8 *	-0.4	-0.6 **	-0.7 ***	-0.6 **
Q2 seasonal dummy			0.6 ††	0.7 ††	0.6 ††
Q2, Q3, Q4 seasonal dummy	0.3 †	0.1 †			
Unusual Weekday Snowfall	-1.2 ***	-1.3 ***	-1.3 ***		
R-squared	0.59	0.56	0.59	0.38	0.37
Adjusted R-squared	0.56	0.53	0.56	0.37	0.35
DW	1.91	1.89	1.87	1.71	1.78

Notes: *** indicates statistical significance at 1%, ** indicates statistical significance at 5%, * indicates statistical significance at 10%. † indicates the coefficient was restricted to equal minus one-third of the coefficient on the Q1 seasonal dummy. †† indicates the coefficient was restricted to equal the negative of the coefficient on the Q1 seasonal dummy. Estimation samples are as follows: (1) '05q4 - '16q2, (2) & (3) '05q4 - '18q2, (4) & (5) '88q1 - '17q4.

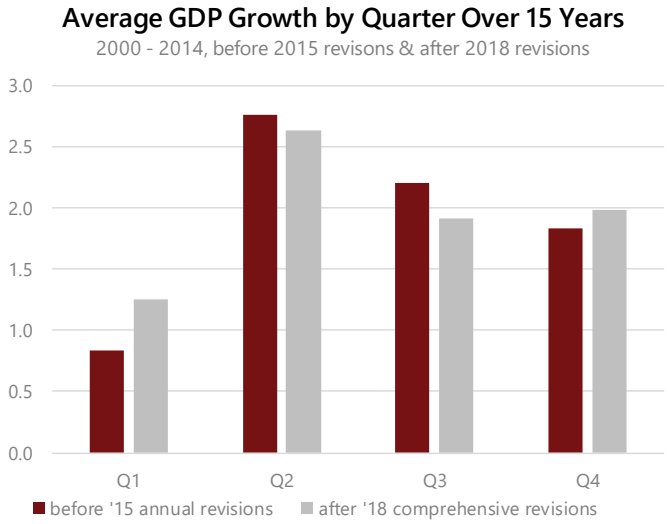
[1] Residual seasonality is when seasonal patterns remain in data that are reported to have been adjusted for seasonal variation. The improved methodologies generally involve additional seasonal adjustment of underlying source data. More information on BEA's efforts and results can be found here: https://apps.bea.gov/scb/2018/08-august/pdf/0818-gdp-seasonality.pdf.

[2] See *Macroeconomic Advisers Macro Focus*, "Updating MA's Snowfall GDP Tracking Methodology," November 29, 2016.

[3] We freely estimated the coefficient on the Q1 seasonal dummy and imposed the restriction that the coefficients on Q2, Q3, and Q4 seasonal dummies equal minus one-third of the coefficient on the Q1 dummy.

[4] See *Macroeconomic Advisers Macro Focus*, "Residual Seasonality in GDP Growth Rates – Part 2: Residual Seasonality and Weather Effects Together Lowered Q1 by More Than 3 Percentage Points," May 15, 2015. The point estimate on the Q1 seasonal dummy was actually 1.6, but the functional form of that regression was such that this implied a reduction below trend growth of three-quarters of this, or 1.2 percentage points.

Please see the important disclaimer on the last page of this report.



Source: Macroeconomic Advisers by IHS Markit, BEA

This year's comprehensive revisions provided the first opportunity for BEA to apply the improved methodology to data prior to 2012. The second column of the table reports the results of estimating the same regression on the updated data.[5] Notice that the magnitude of the point estimate on the first-quarter seasonal dummy is cut in half and is no longer significant. On the surface, this suggests that residual seasonality, at least over this sample, has been eliminated from the data. A more accurate assessment, though, is that residual seasonality, over this sample, *of this functional form*, has been eliminated from the data. Given that the data have been restated prior to 2012, we thought it necessary to re-evaluate the functional form of residual seasonality implicit in the regression model.

The chart above shows average real GDP growth by quarter from 2000 to 2014 both before the 2015 annual revisions (prior to BEA's first wave of methodological improvements to address residual seasonality) and after this year's comprehensive revisions. BEA's methodological improvements are evident in that the seasonal pattern is less pronounced. But a seasonal pattern is, nonetheless, still evident in the data.

In our work pre-dating the 2015 annual revisions, we adopted a functional form for residual seasonality which maintained that growth in second, third, and fourth quarters were each boosted by one-third of the amount that growth in first quarters was reduced.[6] The post-revision data are suggestive of a different functional form. From 2000 to 2014, average growth for third and fourth quarters (1.9% and 2.0%, respectively) is about equal to average growth over all quarters (1.9%), while average growth in first quarters (1.3%) is below the sample average and average growth in second quarters (2.6%) is above the sample average. This suggests a function form for residual seasonality in which growth is reduced below trend in first quarters, boosted above trend by the same amount in second quarters, and is unaffected in third and fourth quarters.[7] This is equivalent to a temporary seasonal *level* effect in first quarters.

To be clear, neither functional form can be ruled out by either data set.[8] Our selection of the new functional form reflects our judgment that it is a better representation of the residual seasonality that is apparent in the data.

The third column of the table reports the regression results assuming this functional form for residual seasonality. The coefficient on the first-quarter seasonal dummy is significant at 5% and indicates that GDP growth is reduced by six-tenths in first quarters and boosted by the same amount in second quarters. The coefficients on other terms are little changed. Therefore, over this sample (2005 Q4 to 2018 Q2), after controlling for recessions and unusual snowfall, there is statistical evidence that residual seasonality in GDP growth remains in the data, although the magnitude of the effect has been reduced relative to estimates in previous vintages of data.

[5] The estimating sample includes two additional years of data, but the point estimates and t-statistics on the non-seasonal terms are quite similar to those estimated on the updated data over the prior sample (2005 Q4 through 2016 Q2).

[6] The null hypothesis that this restriction on the coefficients held could not be rejected at any reasonable level of significance.

[7] Beginning with a regression with seasonal dummies for Q1, Q2, and Q3 estimated freely (and also with a recession dummy and our snowfall term), one cannot reject the joint null at any reasonable level of significance that the coefficient on the Q2 dummy is equal to the negative of the coefficient on the Q1 dummy and that the coefficient on the Q3 dummy equals zero. This is the null hypothesis that yields the functional form explored here.

[8] The null hypotheses necessary to arrive at both functional forms cannot be rejected at any reasonable level of significance.

This is a fairly short sample over which to reach such a conclusion, but we are limited by the snowfall data, which go back only to 2005 Q4. To investigate the effect of lengthening the sample, we estimated the same regression model over the 30-year span from 1988 to 2017 excluding the snowfall term using both the pre-comprehensive-revision data and the post-comprehensive-revision data.[9] The regression estimated on the pre-revision data appears in the fourth column of the table and the regression estimated on the post-revision data appears in the fifth column of the table.

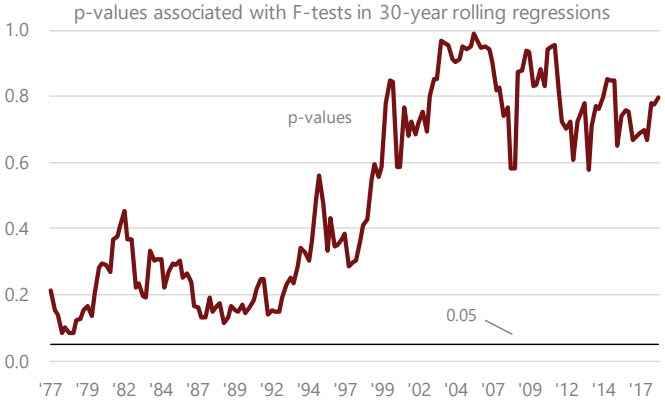
Two points stand out. First, in the post-revision data, the coefficient on the first-quarter seasonal dummy did not change in magnitude or significance when we lengthened the sample and dropped the snowfall term (this is a comparison of columns 3 and 5). This gives us confidence that the size and significance of the first-quarter seasonal dummy in our short-sample (with unusual snowfall) regression (column 3) is not a statistical fluke. Second, in the longer-sample regressions (columns 4 and 5), there is not much difference in the magnitude of the first-quarter seasonal between the equation estimated on the pre-revision data and the one estimated on the post-revision data. To be sure, the seasonal is more significant in the pre-revision regression, but the seasonal in the post-revision data is still significantly different from zero at 5%. We view this as the strongest evidence supporting our claim that residual seasonality has not entirely been removed from top-line GDP growth.

To check the robustness of this result, we performed the following steps on every 30-year sample in the post-revision data.[10] We estimated a regression of GDP growth on a constant, a recession dummy, and quarterly seasonal dummies for the first, second, and third quarters. We tested the joint null hypothesis that yields the functional form of the regressions in columns 4 and 5 of the table. We recorded the p-value from this F-test. We estimated a regression with these restrictions imposed and recorded the point estimate and p-value associated with the coefficient on the first-quarter seasonal dummy.

The results are summarized in the charts below. The first chart shows, for each 30-year sample, the p-value from the F-test of the null hypothesis that yields the functional form we are exploring. We also included a value of 0.05 for reference. There isn't a single 30-year sample in which the null hypothesis can be rejected at 5%. It is close in some of the earlier samples, but we are more interested in seasonal effects in more recent history, when the null cannot be rejected at any reasonable

Tests for Functional Form of Residual Seasonality

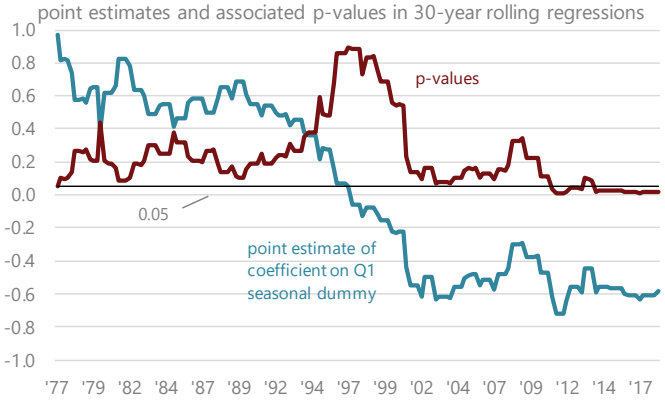
p-values associated with F-tests in 30-year rolling regressions



Source: Macroeconomic Advisers by IHS Markit

Estimated Coefficient on Q1 Seasonal Dummy

point estimates and associated p-values in 30-year rolling regressions



Source: Macroeconomic Advisers by IHS Markit

[9] The "pre-comprehensive-revision data" are the data as published just prior to the comprehensive revisions. In a regression with a recession dummy and freely estimated seasonal dummies for Q1, Q2, and Q3, we were not able to reject the joint null hypothesis, at 5%, that gives us this function form for residual seasonality. This was true in both the pre- and post-revision data.

[10] There are 166 such samples, with the first extending from 1947 Q2 to 1977 Q1 and the most recent extending from 1988 Q3 to 2018 Q2.

level of significance. This gives us confidence in the functional form for residual seasonality that we have chosen.

The second chart shows, for each 30-year sample, the point estimate on the first-quarter seasonal dummy from the regression with the null hypothesis imposed, the associated p-value, and a value of 0.05 for reference. The point estimate is negative and significantly different from zero at 5% in every overlapping 30-year sample beginning with the one ending in 2011 Q1 save three. Combined with the F-tests supporting the functional form, this gives us confidence that the estimated six-tenths subtraction from GDP growth in first quarters is a fairly robust result.[11]

BEA's Approach and Results

Our approach is not the only way to test for the presence of residual seasonality in the data. In the article cited above (*Survey of Current Business 2018*), BEA uses four types of tests on both aggregate and disaggregate data spanning periods of various length. Three of the tests they employ are diagnostics coded into Census X-13ARIMA-SEATS Seasonal Adjustment Program. Based on these diagnostics, BEA finds no evidence of residual seasonality in aggregate real GDP, nominal GDP, and the GDP price index over the full span of the data (1947 – 2017), the most recent 30 years (1988 – 2017), and the most recent 15 years of data (2003 – 2017). BEA did find that a small number of disaggregate series still do exhibit some evidence of residual seasonality over certain spans. But even these occurrences are far fewer than the occurrences observed prior to the comprehensive revisions.

We do not quibble with these results. However, we do have concerns about the fourth type of test BEA employs to test for residual seasonality. BEA's employs a one-way analysis of variance (ANOVA) to test the null hypothesis that mean GDP growth by quarter is the same across quarters against the alternative hypothesis that at least two quarters exhibit different mean growth rates. A rejection of the null would indicate residual seasonality. In each of the samples over which BEA performed this one-way ANOVA, they were not able to reject the null hypothesis of equal means across quarters, supporting the conclusion that residual seasonality has been removed from the data.

The problem with reaching this conclusion is that the null hypothesis of equal means cannot be rejected when the same test is applied to the data as published prior to the 2015 annual revisions as well.[12] By this criterion, there was no residual seasonality to be removed in the first place! The problem with the one-way ANOVA test is that it does not allow us to control for factors that are not seasonal and that we know affect mean GDP growth. These factors add non-seasonal variation to the data, making seasonal patterns more difficult to detect. In our application, two such factors are recessions and unusual snowfall. Once we control for the effect on GDP growth of recessions and unusual snowfall, seasonal patterns in the data are easier to detect.

Concluding Thoughts

BEA's efforts over the last several years to identify the sources of residual seasonality in GDP growth and mitigate its occurrence have paid off. By some criteria, residual seasonality in the data has been mitigated, and by other criteria, it has been removed. By the criteria we employ in this note, the effect of residual seasonality in first-quarter GDP growth has been cut in half — from an estimated subtraction of 1.2 percentage points to 0.6 percentage points — but it has not been eliminated.

[11] On a side note, we find it quite fascinating that, in deeper history, the point estimate of the coefficient on the Q1 seasonal dummy was positive. In these 30-year rolling regressions, though, it was never significantly different from zero … but it was close.

[12] This is true for every comparable sample length BEA included in its ANOVA tests on the post-revision data; last 30 years through 2014, last 15 years through 2014 (both including and excluding 2008 Q4 and 2009 Q1) and last seven and a half years through 2014.

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