

Seasonal Adjustment in the National Income and Product Accounts

Results From the 2018 Comprehensive Update

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On July 27th, the Bureau of Economic Analysis (BEA) released the results of its 15th comprehensive, or benchmark, update of the National Income and Product Accounts (NIPAs). Comprehensive updates provide the opportunity to introduce major improvements to the NIPAs as outlined in BEA's strategic plan ([Bureau of Economic Analysis 2016](#)). The changes are generally of three types: (1) statistical changes to introduce new and improved methodologies and to incorporate newly available and revised source data, (2) changes in definitions to portray the evolving U.S. economy more accurately and to provide consistent comparisons with data for other national economies, and (3) changes in presentations to reflect definitional and statistical changes where necessary or to provide additional data or perspectives for users.

One major initiative of this year's comprehensive update is an improvement to seasonal adjustment in the NIPAs.¹ In early 2015, several reports noted that over the last decade or longer, first-quarter gross domestic product (GDP) has tended to grow, on average, at a slower pace, compared with other quarters. Analysts debated the extent to which this phenomenon reflects special factors, such as unusually harsh winter weather, and/or "residual seasonality."² BEA considers residual seasonality to be present in any series if, after seasonally adjusting the series, additional statistical tests indicate the presence of a seasonal pattern. In response, BEA launched a multiyear strategy designed to improve and modernize our seasonal adjustment practices. One of the primary goals was to investigate the presence of residual seasonality and mitigate any occurrences. This strategy was executed in three phases ([McCulla and Smith 2015, 4](#)):

- **Phase 1.** As part of the 2015 annual update, BEA introduced seasonal adjustments to series or source data that were previously not seasonally adjusted for the years 2012–2014. The evaluation of series and source data for emerging seasonal patterns continued through the 2018 comprehensive update.³

- **Phase 2.** BEA conducted an extensive review of the component estimates of GDP and gross domestic income (GDI) to assess the presence of residual seasonality in the building blocks of its featured aggregates to identify causes and to design strategies for resolution. The results of this study were presented in [Moulton and Cowan \(2016\)](#). In addition, as part of the 2016 annual update, additional refinements and improvements to seasonal adjustment were introduced to component estimates ([McCulla and Smith 2016, 3](#)).
- **Phase 3.** The third phase, which concluded with the release of the NIPA comprehensive update, primarily involved applying the improvements introduced earlier to the historical time series and publishing not seasonally adjusted estimates for GDP, GDI, and their major components.

This article details the causes of residual seasonality, BEA's efforts to address such seasonality, and the results of this multiyear effort.

Causes of Residual Seasonality

The 2016 review identified two leading causes of residual seasonality in the NIPA estimates: (1) inconsistencies arising from the way monthly source data are utilized in the compilation of quarterly estimates and (2) issues arising from revision policies and practices that prevented the most recent seasonal adjustments from being applied to historical time series. In addition to these primary causes, the review noted that residual seasonality may also arise from transformations of the adjusted series—such as aggregation, interpolation, or deflation—that are necessary to derive the NIPA estimates ([Moulton and Cowan 2016](#), [Wright 2016](#)). Lastly, a more specific cause relates to the NIPA treatment of certain federal government transactions, such as wages and salaries, particularly pay raises for civilian and military personnel.

The results of the 2016 review found that identification of residual seasonality was quite sensitive to the time span analyzed. For example, statistically significant residual seasonality was identified in real GDP and the GDP price index over a 30-year time span but not over a 15-year span.⁴ Several real GDP components—including nonresidential structures, exports of goods, federal government spending (especially defense spending), and state and local government spending—showed evidence of residual seasonality over several time spans.

In response to these findings, BEA committed to the following:

- Maintain its policy of applying indirect seasonal adjustment where seasonally adjusted component series are aggregated to derive a top-line aggregate such as GDP.
- Adjust BEA's seasonal adjustment practices to routinely evaluate source data and NIPA estimates for residual seasonality.
- Regularly collaborate with BEA's source data providers to monitor and mitigate quarterly residual seasonality in underlying seasonally adjusted source data.

- Apply improvements in seasonal adjustment methods identified in previous annual updates over longer time spans, including the “full” quarterly time series (1947–present).
- Evaluate and modify the revision time spans for seasonally adjusted estimates, both within BEA and in collaboration with major source data providers.
- Provide quarterly estimates of GDP, GDI, and their major components on a not seasonally adjusted (NSA) basis.
- Upgrade BEA’s seasonal adjustment software to the Census Bureau’s X-13ARIMA-SEATS (X-13) seasonal adjustment program.⁵

Because assessment of residual seasonality is highly sensitive to the time span analyzed, BEA evaluated numerous time spans to test and ensure that the seasonal adjustment improvements introduced to the estimates mitigate residual seasonality over multiple spans. As shown in this article, as part of the 2018 comprehensive update of the NIPAs, BEA has addressed residual seasonality in GDP, GDI, and their major components for the “full” quarterly time span (1947–present) and for the most recent 15 years (2003–present), along with additional time spans.⁶

Addressing Residual Seasonality

Summary of major seasonal adjustment improvements

Over the last several years, BEA incorporated several methodological improvements that addressed residual seasonality in GDP components in recent periods. In general, these improvements introduced additional seasonal adjustment to the underlying source data used for estimating components of personal consumption expenditures (PCE) services, inventory investment, government consumption expenditures, and government investment. With this comprehensive update, these adjustments were extended back in history. Table 1 lists the improvements and the date to which the improved adjustments were extended.

To address residual seasonality that resulted from aggregating monthly seasonally adjusted source data to a quarterly frequency, BEA tested quarterly aggregations of monthly source data. For example, BEA collaborated with the Census Bureau to refine the seasonal adjustment of data on trade in goods and on construction spending to mitigate residual seasonality in the aggregated quarterly estimates. The impact of these adjustments in the source data carried through to the corresponding NIPA estimates, mainly to current-dollar exports and imports of goods as well as private and government investment in structures.

In the fall of 2017, BEA and the Census Bureau conducted a joint investigation into the potential impact of the agencies’ revision policies on residual seasonality; the two agencies concluded that best practices require that seasonally adjusted series be open to revision for periods longer than the unadjusted series. Consequently, both agencies committed to adopt longer revision spans for annual updates of the seasonally adjusted statistics where needed. For example, the Census Bureau’s update of monthly construction spending statistics, released in early July 2018, reflect a

7-year revision span for the seasonally adjusted series rather than a previously used 2-year span (Census Bureau 2018). In addition, future annual updates of the NIPAs will span at least 5 years, rather than the 3 years used in the past. BEA’s expanded revision period of 5 years is also consistent with the revision practices of the Bureau of Labor Statistics.

A regular part of NIPA annual and comprehensive updates is the recalculation of seasonal factors that underlie the quarterly and monthly estimates to capture changes in seasonal patterns that emerge over time and that reflect revised source data. The revised NIPA estimates released on July 27, 2018, incorporate updates to seasonal factors for 2002–forward.

In examining the full quarterly time series, 1947–present, BEA found evidence of residual seasonality in the quarterly current-dollar and quantity indexes for exports of services and narrowed the cause to the pattern of exports in the 1960s. After confirming that the observed quarterly patterns over this decade were not linked to any significant economic events that should be preserved in the adjusted series, BEA revised the quarterly estimates over this period using our updated seasonal adjustment practices. As a result, the series no longer exhibits residual seasonality over the full time span.

Estimates of federal consumption expenditures also displayed residual seasonality over longer time spans. The major contributing factor to residual seasonality in current-dollar estimates and price index estimates for this series was the treatment of federal wages and salaries. Specifically, the pay raises that federal government military and civilian employees often receive in January were reflected in the first-quarter seasonally adjusted NIPA estimates of federal government wages and salaries. Prior to this comprehensive update, BEA included these seasonal movements in this series to illustrate the effects of the federal employee pay raise. However, this approach resulted in residual seasonality in both the current-dollar estimates and price estimates for federal consumption expenditures.⁷ With the estimates released on July 27, estimates of federal wages and salaries removed this seasonal impact from the first quarter estimates for 1978–present.

Table 1. Extensions of Previously Introduced Seasonal Adjustment Improvements

Description	Period of revision
From 2015 annual update	
Seasonal adjustment of:	
Census Bureau Quarterly Financial Report inventory data for mining industries	2002–forward
Census Bureau Quarterly Financial Report inventory data for information industries	2009–forward
Treasury Department data for components of government spending	1972–forward
Treasury inflation protected securities	2002–forward
Census Bureau Quarterly Services Survey revenue and expense data for various industries	2009–forward
From 2016 annual update	
Seasonal adjustment of:	
Census Bureau construction spending data for state and local governments	2003–forward
Bureau of Labor Statistics price indexes for transportation	2011–forward
Bureau of Labor Statistics price indexes for communication	2009–forward
Federal Reserve Board price indexes for communication equipment	2002–forward

Methodology to evaluate the updated estimates

BEA's evaluation of residual seasonality in the updated NIPA estimates follows the same general approach as presented in the 2016 review: Census Bureau's X-13 seasonal adjustment program was applied to the seasonally adjusted NIPA series, including the most detailed data sets used to compute GDP (current-dollar, real, and price estimates). To facilitate the evaluation of more than 10,000 data series, BEA implemented standardized criteria to identify seasonality in a series. Specifically, a joint decision rule, using three statistical tests, was used to determine whether a series exhibits residual seasonality (Lytras 2015). The three statistical tests evaluated were the following:

1. The "D8" F-test statistic is a test for stable seasonality. Values greater than 7.00 indicate the series is seasonal.
2. The "M7" diagnostic is designed to evaluate moving seasonality in a time series. An M7 value less than 1.0 indicates identifiable seasonality.
3. The QS statistic, which evaluates seasonal autocorrelation in a series, was also considered. This statistic has been identified as a robust test for seasonality (Lytras 2015; Findley, Lytras, and McElroy 2017; and Maravall 2012). A p-value for the QS statistic of 0.01 or less indicates the series is seasonal.

BEA tested the updated series for the presence of residual seasonality over numerous time spans, including two span lengths that were evaluated as part of the 2016 review: a 30-year span and a 15-year span. Results of the tests over three span lengths—the "full" quarterly time series (1947–2017), the most recent 30 years (1988–2017), and the most recent 15 years (2003–2017)—are presented in the next section.⁸

Results

Table 2 presents the results of tests for residual seasonality for the major aggregates of nominal GDP, real GDP, and the GDP price index over three spans (the full span, the 30-year span, and the 15-year span). The results indicate that GDP and its major components do not exhibit residual seasonality for any of the spans presented. That is, no component tests positive for residual seasonality under all three criteria. While some of the individual tests provide evidence of residual seasonality for a handful of GDP series in certain spans, notably nonresidential fixed investment and structures, and prices of exports of goods, there is no evidence of residual seasonality in top-line GDP (current-dollar, real, and price estimates) based on any of the three individual tests. Moreover, these results represent a marked decrease in the number of series with evidence of residual seasonality compared with the results presented in the 2016 review, which found evidence of residual seasonality in top-line GDP over the 30-year span and in the government components for all spans considered.

Table 3 presents the results of tests for residual seasonality for current-dollar GDI and its major components. These results also indicate that GDI and its major components do not exhibit residual seasonality under all three criteria for any of the spans analyzed. [Moulton and Cowan \(2016\)](#) found evidence of residual seasonality in net interest and current surplus of government enterprises; however, in the updated series, there is no longer evidence of residual seasonality. The GDI series examined in this article are more detailed than those examined in [Moulton and Cowan \(2016\)](#). Some of the individual tests indicate that a handful of updated series exhibit residual seasonality in longer time spans, notably supplements to wages and salaries as well as business current transfer payments (net). For the most recent span, subsidies as well as undistributed corporate profits exhibit partial evidence.

Table 2. Tests for Residual Seasonality in Gross Domestic Product (GDP), Real GDP, and Price Indexes

		Current dollars								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
1	Gross domestic product	0.228	3.000	0.758	3.625	1.225	0.866	2.626	1.648	0.570
2	Personal consumption expenditures	1.772	1.765	1.000	0.913	2.323	1.000	0.214	2.774	0.936
3	Goods	1.388	1.881	0.987	1.864	1.592	0.882	0.836	2.325	0.899
4	Durable goods	3.045	1.416	0.367	0.640	2.622	0.984	1.045	1.961	0.816
5	Nondurable goods	0.347	3.000	1.000	0.678	2.695	1.000	1.344	1.788	1.000
6	Services	2.115	1.783	1.000	0.883	2.577	1.000	3.878	1.133	1.000
7	Gross private domestic investment	0.484	3.000	0.749	1.352	1.973	1.000	2.049	1.685	0.728
8	Fixed investment	1.092	2.168	0.969	3.253	1.273	0.985	4.468	1.254	0.985
9	Nonresidential	6.467	(*) 0.924	0.655	5.115	(*) 0.973	0.787	(*) 7.319	(*) 0.863	0.795
10	Structures	3.306	1.268	0.643	5.644	(*) 0.957	1.000	4.318	1.242	0.956
11	Equipment	5.009	1.124	0.222	4.085	1.116	0.756	4.790	1.026	0.987
12	Intellectual property products	0.299	3.000	0.112	0.514	2.736	0.069	0.006	3.000	0.877
13	Residential	0.572	2.594	1.000	0.034	3.000	1.000	0.663	2.740	1.000
14	Change in private inventories	0.534	3.000	1.000	0.345	3.000	1.000	0.615	2.900	1.000
15	Net exports of goods and services	(*) 9.947	1.115	1.000	4.901	1.123	1.000	0.459	2.787	1.000
16	Exports	1.257	2.227	1.000	1.641	1.747	1.000	1.875	1.695	1.000
17	Goods	0.716	2.889	1.000	1.279	2.082	1.000	1.101	2.306	1.000
18	Services	4.013	1.233	(*) 0.003	1.395	1.979	0.692	0.796	2.470	0.085
19	Imports	3.932	1.234	1.000	2.605	1.590	1.000	2.207	1.522	1.000
20	Goods	6.147	1.000	1.000	2.086	1.725	1.000	0.909	2.409	1.000
21	Services	2.200	1.619	(*) 0.000	1.178	2.097	1.000	0.471	2.936	1.000
22	Government consumption expenditures and gross investment	1.746	1.758	0.196	3.332	1.216	0.481	2.026	1.542	0.742
23	Federal	3.534	1.268	0.928	3.495	1.198	1.000	1.159	2.193	1.000
24	National defense	3.217	1.325	(*) 0.000	5.559	(*) 0.931	(*) 0.000	1.858	1.564	1.000
25	Nondefense	2.214	1.608	0.144	2.863	1.408	0.122	2.223	1.578	0.435
26	State and local	1.743	1.811	0.964	0.447	3.000	0.993	1.586	1.790	0.998
		Chained dollars								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
1	Gross domestic product	2.824	1.535	0.055	4.356	1.182	1.000	1.924	1.925	0.991
2	Personal consumption expenditures	0.190	3.000	1.000	1.571	1.873	1.000	0.624	2.873	1.000
3	Goods	1.101	2.206	1.000	0.473	2.785	0.247	0.170	3.000	0.509
4	Durable goods	4.253	1.198	1.000	1.019	2.233	0.508	1.992	1.421	1.000
5	Nondurable goods	0.445	2.829	(*) 0.004	2.333	1.495	1.000	2.844	1.304	1.000
6	Services	1.264	2.468	1.000	1.918	1.636	1.000	2.809	1.294	1.000
7	Gross private domestic investment	2.490	1.510	1.000	1.652	1.833	1.000	1.523	1.916	1.000

		Current dollars								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
8	Fixed investment	2.707	1.516	0.992	6.405	(*) 0.924	1.000	5.308	1.033	0.997
9	Nonresidential	(*) 7.865	(*) 0.794	0.012	(*) 8.115	(*) 0.795	0.334	3.663	1.180	0.913
10	Structures	3.891	1.197	0.831	(*) 7.574	(*) 0.806	0.798	(*) 9.112	(*) 0.747	0.796
11	Equipment	6.113	(*) 0.936	0.689	4.962	1.005	1.000	5.457	(*) 0.938	1.000
12	Intellectual property products	0.947	2.340	0.982	0.662	2.781	0.403	2.674	1.432	1.000
13	Residential	0.685	2.812	0.013	0.219	3.000	1.000	0.195	3.000	1.000
14	Change in private inventories	1.220	2.491	1.000	0.422	3.000	1.000	0.448	3.000	1.000
15	Net exports of goods and services	0.978	2.509	(*) 0.005	0.890	2.681	0.114	0.498	2.939	0.490
16	Exports	0.699	2.850	0.937	1.980	1.645	1.000	3.535	1.268	0.264
17	Goods	2.184	1.776	1.000	1.405	1.978	1.000	3.356	1.337	0.842
18	Services	2.134	1.712	(*) 0.008	3.359	1.425	0.583	1.809	1.726	0.192
19	Imports	1.340	2.061	0.627	0.960	2.274	1.000	0.721	2.478	0.996
20	Goods	0.407	3.000	0.938	1.236	2.002	1.000	1.245	1.991	1.000
21	Services	0.453	3.000	1.000	0.446	3.000	1.000	0.371	3.000	1.000
22	Government consumption expenditures and gross investment	3.121	1.262	0.469	3.316	1.190	0.880	1.703	1.624	0.734
23	Federal	5.022	1.033	0.824	2.920	1.350	(*) 0.004	1.625	1.850	1.000
24	National defense	4.444	1.140	0.963	5.377	(*) 0.979	(*) 0.006	1.746	1.874	0.029
25	Nondefense	3.399	1.299	0.731	3.403	1.284	0.890	3.611	1.220	0.993
26	State and local	0.464	2.995	0.982	1.076	2.299	1.000	1.882	1.530	1.000
		Prices								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
1	Gross domestic product	0.313	3.000	0.486	2.704	1.403	0.717	2.648	1.336	0.715
2	Personal consumption expenditures	1.525	1.872	1.000	0.166	3.000	1.000	0.266	2.708	1.000
3	Goods	0.683	2.602	1.000	0.366	3.000	1.000	2.732	1.350	1.000
4	Durable goods	4.219	1.098	1.000	3.777	1.094	0.750	5.057	(*) 0.965	1.000
5	Nondurable goods	0.960	2.346	1.000	1.838	1.825	1.000	3.965	1.133	1.000
6	Services	4.246	1.161	1.000	1.002	2.313	0.122	0.568	2.527	0.986
7	Gross private domestic investment	1.266	2.290	0.520	1.302	1.980	0.132	2.023	1.863	0.444
8	Fixed investment	1.840	1.895	0.900	2.830	1.452	0.890	2.591	1.597	0.945
9	Nonresidential	2.029	1.676	1.000	2.293	1.535	0.528	1.721	1.859	1.000
10	Structures	(*) 10.198	(*) 0.835	1.000	0.913	2.593	0.061	4.917	1.230	0.779
11	Equipment	0.742	2.987	0.582	1.768	1.890	0.399	0.087	3.000	1.000
12	Intellectual property products	1.458	1.986	1.000	1.573	1.949	1.000	1.624	1.728	1.000
13	Residential	2.129	1.804	0.991	0.890	2.443	1.000	1.834	1.893	0.973
14	Change in private inventories	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Net exports of goods and services	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Exports	(*) 8.704	(*) 0.856	0.022	(*) 7.200	(*) 0.853	1.000	3.653	1.124	1.000
17	Goods	(*) 10.566	(*) 0.784	0.013	(*) 9.715	(*) 0.857	1.000	(*) 13.115	(*) 0.622	0.997

		Current dollars								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
18	Services	2.470	1.491	1.000	0.637	3.000	1.000	1.493	1.856	1.000
19	Imports	4.805	1.096	1.000	1.317	2.271	1.000	0.433	3.000	1.000
20	Goods	6.639	(*) 0.964	1.000	2.089	1.842	1.000	0.325	3.000	1.000
21	Services	0.630	2.922	1.000	3.393	1.311	1.000	1.080	2.543	1.000
22	Government consumption expenditures and gross investment	0.695	2.524	1.000	0.867	2.292	0.579	1.599	1.645	0.928
23	Federal	5.132	1.014	0.846	2.543	1.428	0.690	4.043	1.087	0.865
24	National defense	3.774	1.201	0.882	3.492	1.328	0.631	2.927	1.257	0.822
25	Nondefense	1.986	1.810	0.207	3.925	1.253	0.580	(*) 11.946	(*) 0.663	0.774
26	State and local	1.165	2.359	1.000	0.376	2.785	0.629	1.095	1.966	0.971

(*) Diagnostic indicates evidence of residual seasonality when $F > 7.00$, $M7 < 1.00$, or QS p-value < 0.01 .

F Statistical test for stable seasonality

M7 Statistical diagnostic for identifiable moving seasonality

QS Statistic for seasonal autocorrelation

Table 3. Tests for Residual Seasonality in Gross Domestic Income

		Current dollars								
		Full span			30 year			15 year		
		F	M7	QS	F	M7	QS	F	M7	QS
1	Gross domestic income	0.552	2.942	1.000	1.910	1.722	1.000	1.238	1.964	1.000
2	Compensation of employees, paid	4.315	1.207	1.000	2.452	1.581	1.000	1.862	1.858	0.801
3	Wages and salaries	1.853	1.767	1.000	0.941	2.536	1.000	1.562	1.962	0.800
4	To persons	1.203	2.186	1.000	0.873	2.628	1.000	1.541	1.976	0.803
5	To the rest of the world	(*) 7.711	(*) 0.800	1.000	5.450	(*) 0.990	1.000	6.215	(*) 0.930	1.000
6	Supplements to wages and salaries	(*) 66.716	(*) 0.348	0.960	(*) 9.058	(*) 0.806	0.178	4.455	1.177	1.000
7	Taxes on production and imports	2.773	1.426	0.394	1.072	2.196	0.089	1.419	1.892	0.748
8	Less: Subsidies	0.685	3.000	1.000	4.730	1.074	1.000	(*) 11.350	(*) 0.692	1.000
9	Net operating surplus	0.215	3.000	0.124	2.059	1.543	1.000	2.108	1.713	1.000
10	Private enterprises	0.376	2.985	0.121	2.471	1.404	0.913	2.109	1.709	1.000
11	Net interest and miscellaneous payments, domestic industries	0.495	2.923	0.146	2.902	1.425	0.472	2.223	1.512	0.676
12	Business current transfer payments (net)	(*) 17.765	(*) 0.599	1.000	(*) 36.767	(*) 0.384	1.000	2.236	1.591	1.000
13	Proprietors' income with IVA and CCAdj	1.046	2.371	(*) 0.000	0.303	2.859	0.658	0.020	3.000	0.811
14	Rental income of persons with CCAdj	0.198	3.000	1.000	2.286	1.890	1.000	2.275	1.645	1.000
15	Corporate profits with IVA and CCAdj, domestic industries	0.580	2.769	1.000	1.182	2.101	1.000	1.449	1.829	1.000
16	Taxes on corporate income	0.166	3.000	0.781	2.328	1.637	0.859	1.431	1.749	0.854
17	Profits after tax with IVA and CCAdj	2.325	1.498	0.985	3.011	1.348	1.000	1.975	1.558	1.000
18	Net dividends	0.782	2.855	1.000	0.620	3.000	1.000	2.130	1.563	1.000
19	Undistributed corporate profits with IVA and CCAdj	4.429	1.351	1.000	1.670	1.854	1.000	(*) 7.803	(*) 0.748	1.000
20	Current surplus of government enterprises	3.752	1.297	0.428	2.176	1.544	0.558	1.296	2.293	0.380
21	Consumption of fixed capital	5.346	1.275	1.000	1.253	2.287	1.000	2.103	2.164	1.000
22	Private	0.491	3.000	1.000	1.223	2.646	0.999	1.608	2.019	0.989
23	Government	1.772	1.797	1.000	1.113	2.168	1.000	0.509	2.765	1.000

(*) Diagnostic indicates evidence of residual seasonality when F > 7.00, M7 < 1.00, or QS p-value < 0.01.

CCAdj Capital consumption adjustment

F Statistical test for stable seasonality

IVA Inventory valuation adjustment

M7 Statistical diagnostic for identifiable moving seasonality

QS Statistic for seasonal autocorrelation

Comparison of GDP growth across quarters

As previously discussed, some analysts have noted that in recent years real GDP growth for the first quarter has been, on average, lower than growth in other quarters. To determine whether first quarter growth rates in the updated series are significantly different from other quarters, first-quarter real GDP growth rates were compared with growth rates from the other quarters of the year for selected time spans—those tested for residual seasonality in the previous section plus the most recent six and a half years, 2012 through the second quarter of 2018. The 15-year period 2003–2017 was analyzed both with and without the fourth quarter of 2008 and the first quarter of 2009, which were the most extreme quarters of the previous recession and arguably outliers. Removal of these quarters illustrates the impact of extreme economic phenomena on average quarterly growth rates over relatively short time spans. A one-way analysis of variance test (ANOVA) was used to evaluate the difference between average rates of growth to determine if the mean growth rates were statistically different across quarters for the time spans analyzed.⁹

As shown in table 4, first-quarter growth is on average lower than growth in all other quarters of the year for the 30-year span and the 15-year span. Fourth-quarter growth is weakest for the full period and the most recent span. However, the ANOVA test does not find these differences to be statistically significant at the 1 percent or 5 percent levels in any of the spans considered.¹⁰ Removing the fourth quarter of 2008 and the first quarter of 2009 from the 15-year span has a demonstrable impact on the average growth in the first quarter and fourth quarter during this period, but it does not change the finding of no significant difference between quarters during this span.

Table 4. Comparison of Quarterly GDP Growth Rates

Span	Average annualized growth rate by quarter				F	P-Value
	Q1	Q2	Q3	Q4		
Full	3.4	3.4	3.4	2.7	0.521	0.668
30 year	2.0	3.2	2.4	2.6	1.345	0.263
15 year (a)	1.4	2.4	2.3	2.0	0.437	0.727
15 year (b)	1.9	2.4	2.3	2.7	0.556	0.646
2012–2018Q2	2.1	2.9	2.4	1.7	0.748	0.535

- (a) Series tested includes all quarters
 (b) Series tested excludes 2008Q4 and 2009Q1
 F One-way ANOVA F-test

Introduction of not seasonally adjusted estimates

While some analysts have called for BEA to directly seasonally adjust its real GDP aggregate, BEA's featured seasonally adjusted aggregates will continue to reflect indirect seasonal adjustment. As discussed in [Moulton and Cowan \(2016\)](#), there are several advantages to the indirect approach including maintaining linkages with underlying seasonally adjusted source data and ensuring an additive decomposition of the chain-type price and quantity measures. However, BEA now provides quarterly estimates of GDP, GDI, and their major components that are not seasonally adjusted (NSA) for the period 2002–forward. These estimates are now released concurrently with BEA's seasonally adjusted current quarterly estimates and provide greater transparency by distinguishing movements attributable to NSA source data from those attributable to seasonal adjustment.¹¹ The introduction of NSA estimates also provides analysts the opportunity to evaluate the outcome of applying a direct seasonal adjustment to real GDP, GDI, and their components.

Conclusion

BEA has completed its three-phase plan to enhance its approach to seasonal adjustment and resolve residual seasonality in its NIPA estimates. As documented in this article, although results are sensitive to the time span considered, no significant evidence of residual seasonality remains in the updated NIPA estimates for any time span presented in this article. Moreover, there is no statistically significant evidence of a weaker first-quarter growth rate across time spans.

Going forward, BEA will continue to produce seasonally adjusted estimates derived from the indirect approach as well as publish not seasonally adjusted estimates. BEA will continue to evaluate and address any residual seasonality in GDP, GDI, and their major components in the most recent 15-year span as part of each successive annual and comprehensive update. BEA will also continue to collaborate with source data providers to ensure consistent seasonal adjustment procedures and revision practices. Finally, BEA will continue to evaluate its seasonal adjustment procedures and will adopt new methods that significantly improve the quality of its seasonally adjusted statistics. Any major changes to BEA's methodology will be announced in advance of implementation through the *Survey of Current Business*.

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1. The September issue of the *Survey of Current Business* will include a discussion of the results of the 2018 comprehensive update of the NIPAs in greater detail.
2. See Furman (2015), Gilbert and others (2015), Rudebusch and others (2015), and Groen and Russo (2015).
3. For example, the Census Bureau's Quarterly Services Survey (QSS) data used to prepare estimates for several components of consumer spending for services was first introduced in 2009 for a limited number of industries. Since 2009, the QSS has expanded its industry coverage. Once 5 years of observations for an industry were available, BEA introduced seasonal adjustment to those data when identifiable seasonal patterns were present. With the 2018 comprehensive update, BEA now seasonally adjusts all the QSS data used to derive its consumer spending estimates.
4. The review also examined a 10-year span and found evidence of statistically significant residual seasonality in real GDP, but not in the GDP price index. See Moulton and Cowan (2016, 4).
5. X-13 is a software program developed and maintained by the U.S. Census Bureau that identifies and removes seasonal effects from a time series; it is the successor to the X-12-ARIMA (X-12) software package. In general, the seasonal factors derived from the X-12 and X-13 moving average adjustment processes are similar, however, X-13 introduces additional diagnostics for evaluating seasonality in a time series. For more information, see the "X-13ARIMA-SEATS Seasonal Adjustment Program" on the Census Bureau's website.
6. The results presented in this article are a subset of the many spans evaluated. Results for additional spans are available from the authors upon request. For future annual updates of the NIPAs, in which revisions to seasonally adjusted data will span at least 5 years, BEA will monitor its estimates for residual seasonality over the most recent 15-year span.
7. In the NIPAs, the annual pay raise for federal government employees reflects an increase in the costs of the services provided by government employees. As government output is measured as the sum of the costs associated with producing the output, these federal pay raises impact current-dollar estimates and price estimates for federal government consumption expenditures and GDP as well as compensation. Real measures of federal government compensation, consumption expenditures, and GDP are not impacted by the pay raises.
8. Results for additional spans are available from the authors upon request.
9. For more information on ANOVA tests, see Lee, Lee, and Lee (2013, 8).
10. In addition, BEA examined the components of GDP and has not identified any specific, consistent component as a driver of weaker aggregate GDP growth in first quarters. This analysis is consistent with findings from Lengermann and others (2017).
11. The NSA estimates are presented in "Section 8" of the NIPA Interactive Tables database. BEA's FAQ "Does BEA produce not seasonally adjusted estimates of GDP and GDI?" provides more information on how to access the data. For a discussion of the methods used to construct the NSA estimates, see Chute, McCulla, and Smith (2018).



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