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Two-Step Seasonal Adjustment of NYC Employment Data*

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The Current Employment Statistics (CES) data published monthly by the New York State Department of Labor (DOL) is considered the most timely and comprehensive gauge of the State and City's economy. The monthly data at the City level are derived from the national CES survey managed by the U.S. Bureau of Labor Statistics (BLS). At the national level, CES relies on responses from approximately 149,000 businesses and government agencies. At the state and city level, the samples are much smaller and therefore more volatile. One source of volatility is the regular seasonal patterns that affect many of the sectors. However, DOL only publishes adjusted data for the top-line, total nonfarm series. Due to this deficiency and the need to understand monthly and quarterly activity at the sectoral level, the NYC Office of Management and Budget (OMB) has applied its own seasonal adjustment methodology to the seasonally unadjusted series. OMB shares this adjusted data with other parties and posts the monthly seasonally adjusted data on its website.

Over the past several years, the stability and reliability of the seasonally adjusted estimates has deteriorated. In particular, the adjusted data suffers from excessive gains in January and early summer. These gains consistently attenuate or disappear after the benchmark revisions in the subsequent year, a phenomenon that has led OMB to reexamine its seasonal adjustment approach.[1] This paper summarizes OMB's current methodology and documents a new method that is more closely aligned with the current practices at the national and state level and promises better performance.

Hybrid Data

An important feature of the not-seasonally adjusted (NSA) data published by BLS and DOL is that each series is actually a *hybrid*, consisting of two separate sections derived from distinct data sources. The most contemporary data is a direct result of the CES establishment survey. The older data reflects the benchmark revision, which annually re-anchors the CES series to the more reliable but less timely Quarterly Census of Employment and Wages (QCEW). The QCEW is generated from the state unemployment insurance (UI) program and covers approximately 97 percent of total non-agricultural employment. The benchmarking process adds an estimate of the missing three percent (i.e. the non-covered employment) to the QCEW, and the CES values are then replaced by the new population universe counts for 21 months of

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[1] This phenomenon at the state level was also noted by researchers at the Dallas Fed. See Franklin D. Berger and Keith R. Phillips (1994).

the sample.[2] More details of this process will be described in the next section since it provides the key to estimating the proper seasonal adjustment factors.

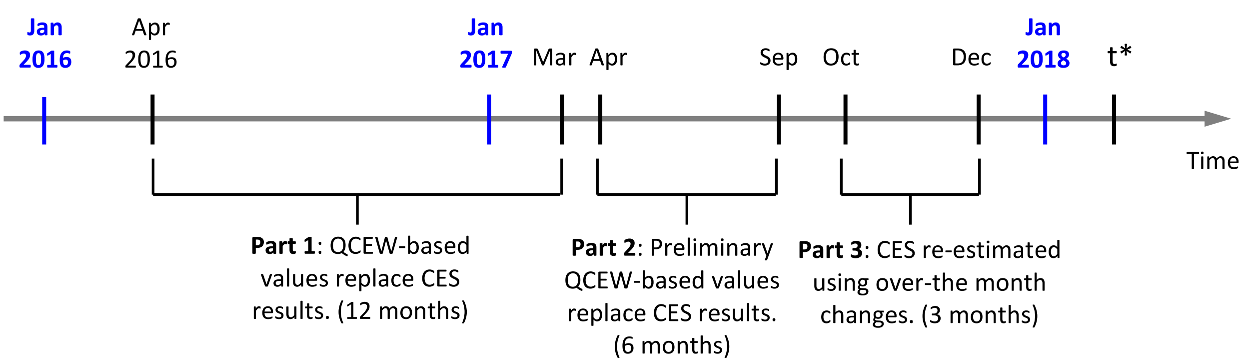
Prior to 1994, the seasonal adjustment process at the national level did not take account of this hybrid character and simply derived seasonal weights from the full sample of data and applied them to the new data in one step. However, Berger and Phillips (1994) suggested an alternative method that separately adjusts each part of the series and effectively removed known artifacts such as the January blip and produced smoother seasonal patterns. This alternative "two-step" process was adopted by BLS starting in 1994. OMB's methodology was identical to the pre-1994 one-step BLS process, but our recent findings show that adopting the two-step methodology greatly reduces the variability in the current data and reduces the size of subsequent revisions. As such, we believe that this alternative methodology produces a more accurate snapshot of the City's current economic status.

Benchmark Details

The design of OMB's new seasonal adjustment methodology is influence largely by the details of the annual benchmark revision, which adjusts the CES survey values to the higher-quality QCEW data. Since the latter source covers 97 percent of employment, it includes nearly the entire labor force tracked by the CES estimates.[3]

In early March, the NYS DOL releases the January NYC data for the current year (e.g. January 2018) combined with the benchmark revision for the prior 21 month period. Separate intervals of the CES data are replaced with values derived from different sources and must be accounted for in the seasonal adjustment process.

Figure 1. Timeline for NYC CES employment benchmark updates.



[2] For more details see Mueller (2017).

[3] For more details see the November 2017 edition of the *Monthly Labor Review* published by BLS, which was dedicated to benchmarking history, practice, and research. https://doi.org/10.21916/mlr.2017.24

At the state, metro area, and city level, new benchmark population values are created from the QCEW UI data, which includes an accounting for "non-covered" employment that is included in the CES definition but not part of the state UI system. This new estimate replaces the 12-month segment (see Part 1 in Figure 1) spanning the April two years earlier to March of the prior year. Likewise, preliminary QCEW data is available for the second and third quarters (Part 2) of the prior year so the April through September replacement values are based on this data – also corrected for the non-covered employment. Part 2 will ultimately be updated again in the subsequent benchmark using a newer vintage of the QCEW and updated non-covered employment estimates. At the time of the benchmark, fourth quarter QCEW data is not available. As a result, the October through December values (Part 3) are generated as a sample-based estimate linking to the September level via newly estimated growth rates, incorporating any new CES survey data and newly forecasted net birth/death factors.

From this diagram, we see that as of the release of the January reference month data (with benchmark), the series contain QCEW-based values through September of the prior year, and CES-based estimates from October through January. With each subsequent monthly data release (e.g. month t* in Figure 1), the CES-based portion of the series grows from its original fourth month span to a maximum of 15 months when the subsequent December CES estimate is published.

Estimation of Seasonal Factors

The structure of the data series implies that the CES-based portion of the series (Part 3 and newer) should be adjusted using seasonal factors derived from the CES sample data. Likewise, the QCEW-based benchmark section (Part 2 and older) should be adjusted separately using seasonal information derived from the QCEW data. While the QCEW history goes back to 1990, the CES-based section is too short (4 to 15 months) to derive meaningful seasonal patterns. The Census X-13 seasonal adjustment procedure requires about five years of monthly data to produce adequate estimates.

For any given reference month, the CES data releases consist of a preliminary (first) estimate, followed by a final (second) estimate released in the subsequent month. Since we are interested controlling for the seasonality in the most recent month of data (i.e. a first estimate), one strategy to work around the lack of training data is to construct a series of first estimates from the initial CES data releases and base the X-13 seasonal factors on first-estimate series, suitably corrected for the impact of benchmarks.

OMB has archived monthly employment reports published by the NY State DOL starting from January 2004.[4] From this archive we have assembled 14-year spans of first and second estimates

[4] The one exception is October 2013, when the federal government shutdown prevented the release of the jobs report.

for all of the major employment categories in New York City. However, these first estimates cannot be used directly to produce seasonal factors since the series will contain discontinuities corresponding to the impact of the annual benchmarks. Instead, we follow the strategy described by Berger and Phillips (1994) and Phillips and Wang (2015) to create a "calculated" series that is purged of level shifts. More details of this process are described in the appendix.
The calculated series is then used to estimate the seasonal factors to adjust the CES-based portion of the NSA data series released by DOL. This would include Part 3 in Figure 1 and any subsequent data releases, such as t* in the figure. The seasonal weights for the NSA data prior to Part 3 are derived from the historical QCEW-based benchmarked data in the usual fashion.

Performance

One known artifact in the seasonally adjusted NYC data is the January jump phenomenon, which ultimately shrinks or disappears with the subsequent benchmark. The following table provides evidence that the 2-Step seasonal adjustment approach significantly reduces the initial estimates of total employment gains in January and reduces the size of the subsequent revision.

Table 1. January Change in NYC Total Employment (thousands)

Reference Month	1-Step SA	2-Step SA	2-Step Direct SA	Benchmark (QCEW SA)	DOL Direct SA (Jan)	DOL Direct SA (Jan 2018)
Jan-13	19.9	10.6	3.8	2.7	13.0	7.0
Jan-14	21.4	9.3	3.3	0.5	4.7	3.4
Jan-15	13.2	-7.0	-7.7	10.6	-11.9	8.7
Jan-16	34.7	15.5	11.8	6.8	13.3	4.3
Jan-17	39.1	13.2	7.7	15.6	5.1	9.4

The second column in Table 1 shows the change in total employment for January, estimated using the 1-Step seasonal adjustment process. This change is given for the preliminary (first) estimate at the time the data for the reference month was initially released. Switching to the 2-Step methodology (column 3) shows a large decrease, which brings the estimates closer to the benchmark values released a year later (column 5, shaded). The one exception is January 2015, when the 1-Step results were closer to the benchmark. However, this is probably due to sheer luck as there were substantial data revisions that year. The DOL's own direct seasonally adjusted estimate of the change as of January 2015 (-11.9 in column 6) was even further from the benchmark value than the 2-Step result (-7.0). As of the most current available data, the NYS DOL's direct SA estimate of the January 2015 flipped sign to 8.7, much closer to the ultimate benchmark value of 10.6.

An important attribute to keep in mind when comparing the values in Table 1 is the distinction between indirect vs. direct seasonal adjustment. Since we are interested in the sectoral patterns, data for each major industry is adjusted first. Then the seasonally adjusted aggregates (e.g. total employment, private employment) are derived indirectly by summing the seasonally adjusted components. The alternative is to adjust the total employment series directly. Since the NYS DOL does not publish the seasonally adjusted components, they are able to take this direct approach. Comparing columns 3 and 4 demonstrates that there are gains from using direct seasonal adjustment since the direct approach values are typically closer to the final benchmark values. However, the cost is the loss of sectoral detail. Since OMB and other users are interested in how the separate sectors behave, we will employ the 2-Step indirect seasonal adjustment methodology, despite the lower precision of the top-line values.

Table 2 compares the one-step, two-step, and benchmark monthly changes for the prior benchmark period by sector. The one and two-step results were generated in an iterative fashion. In other words, each month's observation represents the seasonally adjusted value that would have been produced at the time that the reference month's raw data was released, so it represents the "first look" at that particular month's data. The benchmark values are the seasonally adjusted monthly changes estimated from the first available benchmark data (e.g. published with the January 2017 data release).

For total employment, the 2-Step method has a smaller absolute deviation from the benchmark values (which we treat here as the true value) in 10 of 12 months. As a result the Mean Absolute Deviation (MAD) is smaller than the 1-Step method. Another common summary measure of forecasting performance is the Mean Squared Error (MSE). For total employment, the MSE for the 2-Step process is almost one-third of the original 1-Step method. Thus, the results from the updated approach are, on average, significantly more accurate than the older method.

Table 2 provides evidence where these improvements are occurring. In particular, the MSE for the education sector is significantly lower (dropping from 31.1 to 9.3). While the 2-Step results smooth out the January jump that is nearly always evident in this sector and helps smooth some of the summer volatility, it is important to point out that significant deviations still exist over the summer – which are ultimately smoothed out in the benchmark. This phenomenon remains to be examined in more depth.

Another observation from Table 2 is that the MSE is not universally improved in all sectors. In fact, of the 11 sectors listed, only four show an improved MSE. However, the improvement in these four sectors are so large that the overall MSE declines since the degradation in the other sectors' MSE is relatively minor.

Table 2. Change in Monthly NYC Employment by Sector

Sector		Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	MSE	MAD
Total Employment (ETOT)	1-Step	11.1	13.0	0.7	34.7	4.5	2.8	4.1	-6.2	27.0	21.7	3.7	-2.8	**114.1**	**8.6**
	2-Step	17.9	18.5	4.0	15.5	8.1	4.0	5.4	-6.2	8.1	19.4	5.9	4.5	**39.0**	**5.5**
	Bench	18.4	7.6	7.9	6.8	5.0	9.6	8.2	-13.5	16.7	12.0	11.0	6.9		
Education (EEDU)	1-Step	0.0	3.0	-0.4	9.1	-6.3	2.6	0.2	1.6	14.2	7.2	3.0	-9.9	**31.1**	**4.3**
	2-Step	-0.9	2.0	0.5	3.3	2.2	1.3	0.8	0.1	3.5	8.4	1.2	0.1	**9.3**	**2.3**
	Bench	1.2	0.5	0.6	1.2	-0.4	-0.4	0.5	1.4	1.9	0.6	5.7	-2.5		
Health Care & Social Assistance (EHEA)	1-Step	6.2	3.4	0.6	3.3	2.5	1.8	0.6	-0.3	2.3	-0.4	1.5	-1.1	**4.8**	**1.8**
	2-Step	8.0	1.3	0.0	1.4	2.0	2.1	2.9	0.4	1.7	0.7	0.6	-1.1	**5.2**	**1.8**
	Bench	5.2	3.3	4.3	-0.4	2.5	2.1	2.8	0.9	2.9	3.1	2.0	3.2		
Leisure & Hospitality (ELAH)	1-Step	2.0	1.0	-0.1	4.6	0.6	-2.2	2.4	4.1	6.8	5.6	0.6	0.6	**15.6**	**2.7**
	2-Step	3.3	2.8	2.3	3.1	0.4	-0.2	2.4	2.2	1.4	2.9	2.0	1.8	**10.1**	**2.1**
	Bench	2.5	-1.2	2.0	1.2	0.2	2.2	1.7	-7.0	4.1	2.0	0.4	1.6		
Trade, Transportation & Utilities (ETTPU)	1-Step	1.5	-1.8	-3.6	8.2	1.4	-3.9	0.7	-4.8	2.2	2.7	1.3	-3.5	**8.5**	**2.3**
	2-Step	2.8	-2.0	-4.2	4.0	2.4	-3.9	0.6	-3.1	1.9	-0.5	1.4	-0.7	**3.5**	**1.6**
	Bench	0.3	-0.2	-1.8	2.3	0.9	-0.4	1.5	-2.9	-0.1	-0.2	-0.6	0.0		
Financial Activities (EFIA)	1-Step	0.2	0.4	0.0	-0.6	-0.3	0.4	1.9	-2.5	-3.2	4.1	0.0	2.6	**5.9**	**2.1**
	2-Step	-1.5	3.8	-1.6	-1.2	0.6	1.7	-0.9	-0.5	-3.2	2.0	3.2	-1.5	**7.0**	**2.2**
	Bench	2.2	0.0	-0.4	3.7	-0.5	0.8	0.2	0.5	0.0	-0.8	0.4	-1.6		
Construction (ECNN)	1-Step	-0.2	3.7	-1.0	-0.3	3.8	0.2	-1.1	0.2	0.7	-1.3	0.4	0.5	**2.5**	**1.1**
	2-Step	1.3	4.1	0.3	-0.3	2.1	-0.1	-2.7	-0.3	-1.7	1.0	-0.5	1.9	**2.3**	**1.3**
	Bench	2.0	0.9	0.8	0.7	0.5	0.7	-0.7	0.1	0.2	-0.4	0.7	0.6		
Information (EIFF)	1-Step	2.1	-0.9	1.0	1.6	0.9	-0.4	-0.1	-3.5	5.7	2.8	-0.3	-0.6	**3.0**	**1.6**
	2-Step	1.1	-0.5	2.6	0.0	-0.2	0.1	-0.9	-2.5	7.7	0.7	0.6	1.2	**6.2**	**2.0**
	Bench	1.3	0.8	-0.2	-1.6	-0.6	0.8	3.0	-6.7	5.6	5.2	-0.7	0.2		
Professional & Business Services (EPRS)	1-Step	-0.1	3.6	1.1	7.3	-0.9	3.6	-0.1	-0.3	-3.2	-0.1	-3.1	6.3	**11.1**	**2.5**
	2-Step	1.4	4.8	2.0	7.5	-5.0	3.9	1.4	-1.7	-3.1	4.0	-2.3	0.7	**14.8**	**3.3**
	Bench	4.2	2.1	0.8	1.9	1.3	3.1	0.7	0.8	2.1	1.6	2.9	5.3		
Other Services (EOTH)	1-Step	-1.0	-0.2	2.4	0.1	1.8	0.1	1.0	-1.0	0.3	0.9	0.1	0.9	**0.6**	**0.6**
	2-Step	-0.1	0.1	2.5	-2.1	2.3	-0.8	2.1	-1.2	-0.5	0.0	0.5	0.8	**1.2**	**0.9**
	Bench	-0.3	0.0	0.7	-0.5	0.7	0.4	0.4	-0.3	0.1	0.8	0.3	0.6		
Manufacturing (EMFG)	1-Step	0.6	0.4	0.1	1.7	0.7	0.2	-1.2	-0.2	0.5	0.0	-0.6	1.1	**0.5**	**0.7**
	2-Step	0.5	0.6	0.1	1.5	0.9	-0.3	-0.5	0.3	-0.2	0.5	-1.4	0.9	**0.7**	**0.7**
	Bench	-0.1	0.0	0.0	-0.2	0.2	-0.5	-0.3	-0.3	-0.4	-0.1	-0.5	-0.4		
Government (EGOV)	1-Step	0.0	0.4	0.6	-0.3	0.3	0.4	-0.2	0.6	0.6	0.2	0.8	0.3	**0.5**	**0.5**
	2-Step	2.0	1.5	-0.6	-1.8	0.4	0.2	0.3	0.1	0.5	-0.1	0.6	0.3	**1.0**	**0.7**
	Bench	-0.1	1.5	1.1	-1.3	0.4	0.9	-1.6	0.0	0.3	0.3	0.4	-0.2		

Conclusion

This paper summarizes OMB's efforts to address the seasonal volatility in the NYC employment data. The seasonal adjustment methods used by OMB to-date have not recognized the hybrid nature of the employment data and the distinct data generating processes stemming from the QCEW and CES sources. Details of the benchmark revision dictate the way that the sample is divided and adjusted. In particular, the most contemporary data that reflects the CES patterns is adjusted using seasonal factors derived from archived first and second-estimate vintage data. Seasonal weights for the benchmarked sections are derived from the QCEW-based series.

Switching to this 2-Step methodology – currently used by BLS and state labor departments to seasonally adjust State and Metro Area data, albeit mainly at the top line level – significantly improves and smooths changes in monthly employment values and brings average estimates closer to the ultimate benchmark values. The January jump in total employment is significantly attenuated and measures of average errors improve using the new approach.

Technical Appendix

This appendix describes how the first and second estimates are used to produce a "constructed" data series that controls for the shifts induced by the annual benchmark.

For any given series, most of the historical data is either benchmarked or a second estimate – only the newest observation is a first estimate. However, it is the data generating process underlying the first estimate that we want to control for through our seasonal factors. To generate these factors, we construct a synthetic data series through backwards iteration via growth rates generated primarily from archived first-estimate data. However, these must be corrected for the seam that is introduced by the benchmark process.

Table 3. Benchmark Impact on First and Second Estimates

	Benchmark (QCEW)							CES					
	Mar-16	**Apr-16**	**May-16**	**Jun-16**	**Jul-16**	**Aug-16**	**Sep-16**	**Oct-16**	**Nov-16**	**Dec-16**	**Jan-17**	**Feb-17**	**Mar-17**
1st Estimate	X_{Mar}	X_{Apr}	X_{May}	X_{Jun}	X_{Jul}	X_{Aug}	X_{Sep}	X_{Oct}	X_{Nov}	X_{Dec}	X_{Jan}	X_{Feb}	X_{Mar}
2nd Estimate	Y_{Mar}	Y_{Apr}	Y_{May}	Y_{Jun}	Y_{Jul}	Y_{Aug}	Y_{Sep}	Y_{Oct}	Y_{Nov}	Y_{Dec}	Y_{Jan}	Y_{Feb}	Y_{Mar}
3rd Estimate								Z_{Oct}	Z_{Nov}				

Table 3 shows the situation from the standpoint of March 2017. We have an archive of every first and second estimate through time (beginning in 2004) as shown by the X_t (first) and Y_t (second) values. From this we can construct growth rates such as $\varphi_t = X_t / X_{t-1}$. We then create a new constructed series using these growth rates to iterate backwards from the last available observation, $X_{Mar\text{-}17}$. This constructed series preserves the seasonal variability inherent in the first estimates and is used to estimate the seasonal adjustment factors.

However, there is one growth rate that must be altered due to the benchmark process. Starting with the October observation, the newly benchmarked series is projected by BLS using growth rates starting from the (new) QCEW-replacement series that terminates at the end of the third quarter. Thus, when the January benchmark data is released, there is now a level shift between the first estimate December ($X_{Dec\text{-}16}$) and first estimate January ($X_{Jan\text{-}17}$) value. Constructing the growth rate purely from the first estimates will misleadingly reflect the effect of this shift. To show this in another way, note that all of the shaded cells in Table 2 contain post-benchmark information. October and November get three estimates X_t, Y_t, and Z_t. December's first estimate is pre-benchmark, but December's second estimate is post-benchmark. Any growth rates calculated from values between a non-shaded and shaded cell, will contain artifacts from the benchmark "shift."

Berger and Phillips (1994) suggested a way of working around this problem. To calculate growth rates purged of benchmark artifacts, they suggest using values that are both post-benchmark. The pair selected is the December second estimate and January first estimate. Thus the January growth rate is calculated as: $\varphi_{Jan\text{-}17} = X_{Jan\text{-}17}/Y_{Dec\text{-}16}$.

This new growth rate replaces the January value in our first-estimate growth series. Then the constructed series (CS_t) is produced by iterating backward from the last available observation at time T=Mar-17, by setting: $CS_T = X_{Mar\text{-}17}$ and $CS_{t-1} = CS_t / \varphi_t$.

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