Modification to the Current Employment Statistics (CES) Birth / Death Methodology to Improve State and Area Employment Estimates during the Coronavirus Pandemic October 2022

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Abstract:
The onset of the COVID-19 pandemic had a huge impact on the labor market, leading to a breakdown in the historical relationship between business openings (births) and closings (deaths), thus breaking the assumptions underlying the BLS birth/death model, which is an important element of the normal BLS methodology. BLS subsequently modified the CES methodology to better reflect the effect of the contribution of business births and deaths to monthly payroll employment estimates. This paper examines the impacts of modifications to the birth/death methodologies on statewide industry-level employment estimates, as well as the correlation between employment estimates and the number of coronavirus cases in states with high infection rates. Results show that the modified procedure modestly improved the overall accuracy of monthly estimates, in turn reducing total benchmark revision.

Key words: Current Employment Statistics (CES), Birth/Death Model, CES Benchmark Revision, Coronavirus impact on employment, employment estimation, industry employment

1. Introduction

The U.S. Bureau of Labor Statistics (BLS) publishes monthly Current Employment Statistics (CES) for the nation, all fifty states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and close to 450 metropolitan areas. Employment is estimated from a monthly survey of approximately 131,000 businesses and government agencies, representing approximately 670,000 individual worksites.[1] Most changes in employment are derived from units reporting as part of the probability-based survey. However, because of the time lag that exists in reporting business birth employment in real time, CES accounts for such birth employment through the imputation of business deaths, with the residual estimated by a net birth/death model that "calculates the effect of the imputation, measures the imputation error, and generates a forecast of this error to adjust the current estimate". [2]

The net birth/death residual forecasts added between 800,000 and 1,000,000 jobs to the national CES employment level on an annual basis from 2003 to 2008, i.e., less than 0.1% of total nonfarm employment[3]. During the 2008 recession, the birth/death residual dropped to less than 300,000. (An overview of employment loss and the 2007-2009 recession is provided by Goodman and Mance.[4]) The forecasting model did not pick up the change and this contributed to substantial revisions to the CES employment estimates for this time period. CES conducted research to determine if the CES birth/death model would benefit from the incorporation of an additional, timelier regression variable.[5]

Changes in estimation due to the COVID-19 pandemic

The widespread disruption to labor markets due to the coronavirus pandemic and its potential impact on the birth/death model prompted BLS to revisit the research conducted in the aftermath of the Great Recession (2008-2009) and the experiences of major hurricanes in 2017 and 2018[6]. As a result, four important changes to methodology were made to CES state and area monthly estimation from April 2020 through September 2021:[7]

1. A portion of both reported zeros and returns from zero in the current month's sample, typically excluded from monthly estimates, were included in estimation to better account for the fact that business births and deaths did not offset like usual.

2. Current sample links were included in the net birth/death forecasting model at the national level to better account for the changing relationships between business openings and closings. Rather than building birth/death forecasts based solely on history, a regression variable that includes data up to the current month was added to the model. This change at the national level filtered down to the state and area level.[8]

3. Where it was possible to do so, sample-based estimates were produced at more detailed state and area levels and summed to replace the estimation supersectors, to alleviate sample biases from business nonresponse filtering into the estimates. Where not feasible, nonresponse adjustments were applied based on prior hurricanes experiences or other preidentified factors.

4. A new model that relaxes the assumptions of the normal Fay-Harriet estimator was introduced and utilized in smaller series, creating a tighter correlation between metropolitan estimates and their corresponding statewide estimates.

BLS describes these changes in more detail as part of its monthly update on the CES reports[9] and in the April 2021 paper by Mance.[10]

Implementing the changes described above established the foundation for a more responsive CES state and area monthly report during the pandemic. Nevertheless, the unprecedented rate of change with the pandemic also suggested additional changes may be needed. For CES state and area, as with CES national, measuring actual business deaths vs. temporary shutdowns vs. respondents simply ceasing to report to CES amidst the chaos was challenging, and due to the more granular and regional level of detail involved with the estimates, could be more impactful. What would be the best way to capture these business deaths in the birth/death model? And what's the best way to capture the nature of the turning points, where the impact and recovery from coronavirus would be different across individual states? CES state and area made additional modifications to birth/death processing to address these questions, with the goals of improving monthly estimate performance compared to the benchmark and to capture differing coronavirus trends. These modifications are described below, followed by a quantitative comparison of the results from the modified and unmodified rakes. The unmodified rake is the control case, the results if we used normal estimations methodologies without any changes.

2. Unmodified and Modified Birth/Death Rakes

April 2020: Initial change to raking methodology

Under normal estimation, the CES state and area birth/death process consists of raking CES national birth/death values across all states according to their relative employment size. Larger states, whose employment constitute a larger contribution to the Sum of States (SOS) total for a given 3-digit 2017 North American Industry Classification System (NAICS), receive a larger proportion of the CES national birth/death values.[11]

During the coronavirus pandemic, CES national updated their methodology to include the CES total current sample link as a regressor variable, to capture more real-time information in the model. The effects of this change filtered to CES state and area by changing the total value of the birth/death residuals raked across states. But it did not inform how the rake would be distributed to individual states.

To better capture business deaths amidst the coronavirus pandemic and account for state differences in the economic impact of coronavirus across regions, state and area modified the rake process to distribute CES national birth/death values based on states' contributions to a Sum of States total for employment dropping to zero.

Typically, reports that drop to zero employment are not counted in CES estimates, at the national, state and area levels. During the depths of the pandemic, these reporters were included in estimates to better capture the impact of coronavirus on economic activity. Following this, reports of employment dropping to zero were used to create a Sum of States total for how much employment was lost for each 3-digit NAICS. CES national birth/death values were raked using the ratios of State contributions to this Sum of States total, rather than the share of the state's private employment for that industry, as under normal estimation. It was assumed that states showing a larger drop to zero employment were being more heavily impacted by coronavirus, and thus warranted more of the rake, in most cases a negative factor. State and area implemented this change to the rake methodology for April 2020 final estimates.

May 2020: Further refinement of raking methodology

The initial modification to the raking procedure worked appropriately for April 2020 final estimates. But with subsequent months, it became clear the methodology had assumptions that did not hold true.

The modified rake worked for April 2020 because the drops to zero employment were wide-spread and consistently large in scale. But in May 2020 instances where smaller states would, by reporting

coincidences, constitute large majorities of the Sum of States total of drops down to zero employment for a 3-digit NAICS, qualified them for an unrealistic share of the rake. State and area developed a mechanism to cap the birth/death value raked to a given state to address this issue. The capping mechanism limited a state from receiving more than twice the value of the rake it would receive with the normal rake process, ensuring small states hit by coronavirus would still see an impact on their birth/death values but would not receive factors that were unreasonable. The mechanism works iteratively, checking for any excess rake beyond what states received with the cap and then redistributes that excess proportionally repeatedly until there was no remaining excess. This cap was first implemented for May 2020 preliminary estimates.

The original modified rake also worked well for April 2020 because all the employment movement was in one direction. There were only employment losses across nearly all states and areas. Beginning in May 2020, some reporters that had reported zero employment in April 2020 were reporting some return of employment. The rake methodology needed to account for the return to positive employment as well. It was assumed that employment returning from zero was indicative of the coronavirus situation improving, the end of government-mandated lockdowns, and the economy starting to rebound.

At first, a net value of employment dropping to zero and employment returning from zero for the Sum of States total was created, and then each states' contribution to this total was its rake proportion. This method was used for May 2020 and June 2020 estimates. But this method produced a rake that was considered too erratic, producing unreasonable factors for some states in efforts to offset movements from other states.

This was resolved by using the CES National birth/death value as a guide for whether employment should be dropping or returning. In situations where the CES National birth/death factor was positive, indicating employment should be returning, state contributions to a Sum of State total of employment returning from zero were used as the proportions for the rake. In situations where the CES National birth/death factor was negative, indicating employment should continue to drop, state contributions to a Sum of State total of employment dropping down to zero were used as the proportions for the rake. This solution was implemented for June 2020 estimates, and completed the modified rake as applied in this study.

3. Results of Modified Rake

The goals of the modified rake were to bring the monthly estimates closer to final benchmark values, and to allow the monthly estimates to better reflect the spread of coronavirus within both the states that posted job losses and those that started to report job growth.[12] To control for both sampling and nonsampling error, CES payroll employment estimates are benchmarked annually to employment counts from a census of the employer population. These counts are derived primarily from employment data provided in unemployment insurance (UI) tax reports that nearly all employers are required to file with state workforce agencies.

Did the Modified rake improve estimates compared to the benchmark at the state and metro area levels?

The modified rake did produce results that were closer to the benchmark when compared to the unmodified or normal rake. The absolute difference between the monthly estimates and the final benchmark value was smaller when using the modified rake compared to the unmodified rake. As shown in Table 1 below, over the five-month period from May 2020 to September 2020, the period for which the estimates using the modified rake were benchmarked, the modified rake reduced the absolute difference by 21,287 across all states at total nonfarm. The net difference of positive and negative revisions at total nonfarm between the modified and unmodified rakes was also close, with a difference of only 23,

indicating that the May 2020 capping mechanism was successful in distributing the rake in its entirety and without distorting the birth/death factor totals. The absolute benchmark revisions of both the modified and unmodified estimates, at 0.07%, are within the historical benchmark revision range of 0.05% to 0.7% at the national level.[13] The differences between rakes largely wash out at summary levels; however, when comparing the components at the supersector level, the modified rake performed better than the unmodified rake.

The variability of the differences as measured by the Root Mean Squared Error (RMSE, aka "standard deviation") shows the two rakes as being nearly interchangeable, with only about 0.2% difference in favor of the modified rake. The differences as measured by a simple counting of the quantity of series where each rake produced the superior result also showed the rakes as being nearly interchangeable, with the modified having a slight edge by 9 series, a count of 771 versus 762. The rakes produced equal values for 987 out of 2520 published series. These counts suggest that the improvements were not uniform across all states and series, but were a result of greater accuracy gains in some series at loss of accuracy in other series.

Table 1. Summary of modified vs unmodified rake performance

Modified vs Unmodified Performance	Modified	Unmodified	Difference
Which rake produced estimates closer to the benchmark values?	771	762	**9**
Total 5-month supersector absolute difference from benchmark	13,186,937	13,208,224	**-21,287**
Total 5-month supersector difference from benchmark	4,151,857	4,151,834	**23**
Total 5-month revision to benchmark	0.07%	0.07%	**0**
Average standard deviations across supersectors	7,413	7,428	**-15**

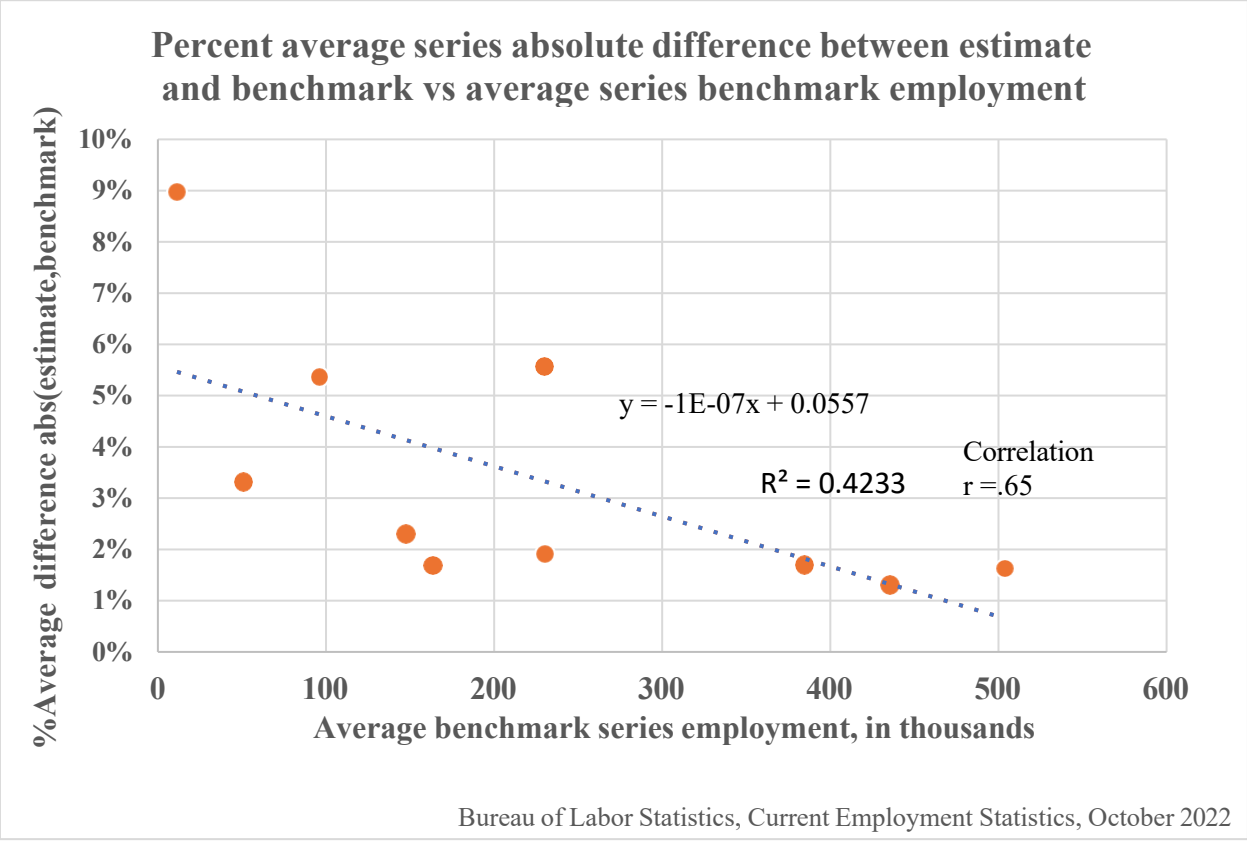
In chart 1, the relationship between the estimates produced with the modified rake and the final benchmark value is shown as a function of series employment for ten two-digit NAICS supersectors. These supersectors are listed below:

Table 2. 2017 NAICS codes and CES supersector titles

2017 NAICS code	Supersector
10000000	Mining and logging
20000000	Construction
30000000	Manufacturing
40000000	Trade, transportation, and utilities
50000000	Information
55000000	Financial activities
60000000	Professional and business services
65000000	Education and health services
70000000	Leisure and hospitality
80000000	Other services

The percentage difference between the monthly estimates of these basic series and their final benchmark values decreases as the employment level of the series increases. Larger series, in terms of employment size will have smaller differences by percent, and smaller series show more volatility in their estimates. This is historically the case, but does vary by state and series as further explained below. It does indicate that the modified rake performed better for larger series.

Chart 1. Percent average series absolute difference from benchmark versus series employment



The overall conclusion is that the modified rake does give a modest improvement in the accuracy of the estimate compared to the unmodified rake, in terms of their difference from the final benchmark value.

Did the modified rake capture the effects of coronavirus?

The other goal of modifying the rake was to produce monthly estimates that better captured the effects of coronavirus on a state level. To analyze the results of modifying the rake, the number of coronavirus cases per month[14] in a state was used as the metric for how large the impact of coronavirus was. States with more cases per month were assumed to have a larger economic impact from coronavirus, and states with fewer cases per month were assumed to have a smaller economic impact from coronavirus.

The modified rake did provide more gains than losses in the accuracy of estimate for the states experiencing the greatest number of cases per month of coronavirus during the five-month window of May 2020 to September 2020. This relationship is shown in comparing Table 3 for the ten states with the largest numbers of cases per month, and Table 4 for the ten states with the smallest number of cases per month. The modified rake is closer to the benchmark value in five of the ten states in Table 3. In contrast, the modified rake is closer to the benchmark in only one of the ten states in Table 4, the states with the smallest number of cases.

Table 3. Modified versus unmodified performance for states with largest number of coronavirus cases per month (May 2020 to September 2020)

10 states with largest number covid-19 cases	Modified - Unmodified Rakes: average supersector difference from benchmark values	Average correlation between supersector series and covid-19 cases		
		with Modified Rake	with Unmodified Rake	Benchmark
FL	-40.56	0.4615	0.4616	0.3844
CA	98.04	0.4061	0.4079	0.3752
TX	-296.76	0.5193	0.513	0.4807
GA	14.66	0.4731	0.4738	0.4237
AZ	-45.62	0.1625	0.1636	0.3536
IL	-39.92	0.3086	0.3091	0.1952
TN	7.9	0.6296	0.6331	0.6212
NC	14.82	0.642	0.6418	0.6983
LA	-14.56	0.5029	0.4987	0.4646
SC	0.8	0.5354	0.537	0.502
Averages	**-30.12**	**0.4557**	**0.4552**	**0.425**

Table 4: Modified versus unmodified performance for states with smallest coronavirus cases per month (May 2020 to September 2020)

10 states with smallest number covid-19 cases	Modified - Unmodified Rakes: average supersector difference from benchmark values	Average correlation between supersector series and covid-19 cases		
		with Modified Rake	with Unmodified Rake	Benchmark
MT	4.16	0.6506	0.6514	0.576
RI	0.06	0.6387	0.6388	0.494
WV	-3.14	0.7846	0.7834	0.7799
DE	0.38	0.515	0.5149	0.5538
DC	3.14	0.6802	0.6798	0.5366
AK	1.14	0.5117	0.5124	0.5917
NH	0.54	0.822	0.8221	0.8055
WY	2.86	0.6985	0.6985	0.4618
ME	0.56	0.7353	0.7354	0.7286
VT	0.24	0.4956	0.4956	0.3705
Averages	**0.64**	**0.6796**	**0.6795**	**0.6238**

The average correlation of the modified rake to the coronavirus cases per month over the five-month period is slightly better for the states with the largest per month cases (.4557 vs .4552) as well as for the states with the smallest per month cases (.6796 vs .6795), as shown in Tables 3 and 4. This indicates that the modified rake did a slightly better job at capturing impact from coronavirus.

The modified rake meets the goal of "improving the accuracy of estimates relative to the benchmark" as shown by the overall reduction in difference from the benchmark, and "better reflecting the spread of coronavirus" as shown by the improved correlation with case numbers. However, the final benchmark

values had the least correlation with coronavirus cases. This suggests that the modified rake overcompensated for the effects of coronavirus, and additional improvement in relating coronavirus to birth/death factors is possible.

The correlation between coronavirus case numbers and the final benchmark value does not prove causation either. Businesses rely on regulations and government policies to operate, and while these laws and policies were altered at points due to coronavirus, they were not always altered in some direct correlation with coronavirus case numbers specifically. While case numbers can be used to draw correlations to impacted employment, they are not necessarily a direct causation of employment changes.

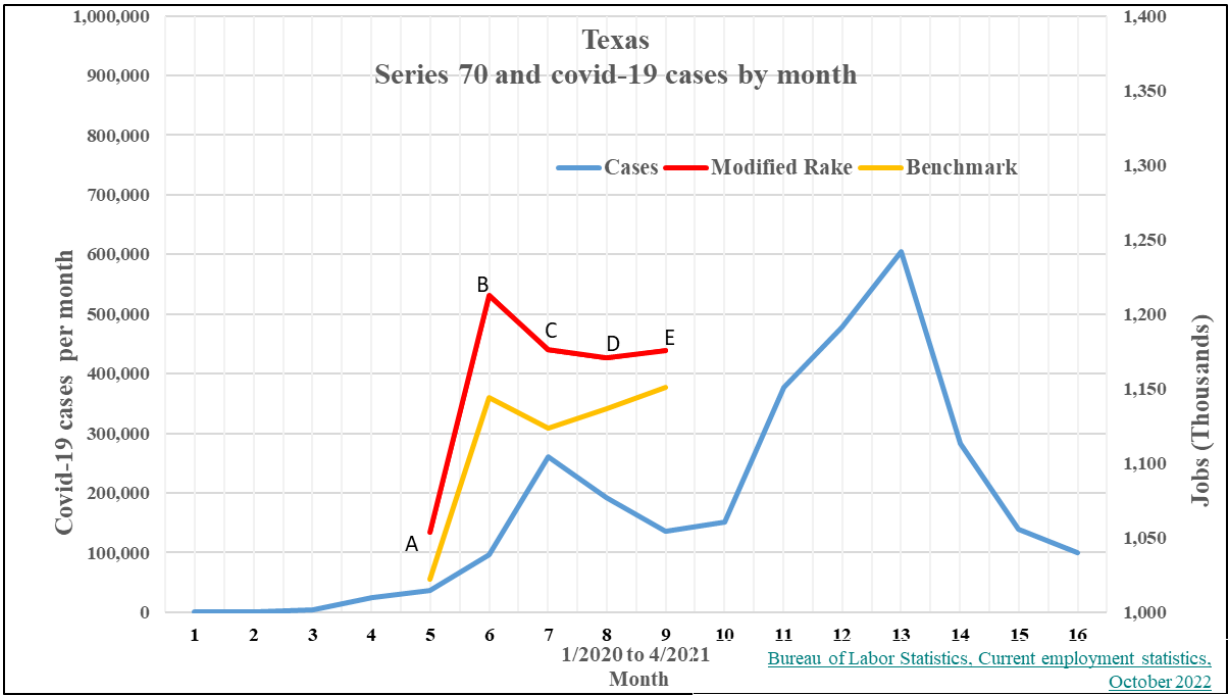
How did the modified rake perform on an individual state-basis: Texas

Results from two states, New Hampshire and Texas, are examined in more detail to see how the modified rake performed for individual states. Texas, selected from table 3, had the largest average differences between the modified rake estimates and unmodified rake estimates, and had the third largest volume of coronavirus cases according to Center for Disease Control (CDC) from May to September 2020.[15] The benefit of the modified rake, in terms of being closer to the final benchmark value, is most pronounced in Texas, as shown in Table 3. Looking at Texas by supersector series, given in Table 5, shows improved accuracy in the leisure and hospitality industry by 2,256, the largest improvement for any supersector. Chart 2 shows the performance of the modified rake estimates, final benchmark values, and coronavirus cases in this supersector. Note that the scales are set to facilitate comparison of the curves.

Table 5: Modified versus unmodified performance by supersector for Texas per month (May 2020 to September 2020)

TEXAS		Values			
Statewide supersector	**Description**	**Benchmark**	**Difference of modified rake estimate**	**Difference of unmodified rake estimate**	**Difference between rakes**
10	Mining and logging	175,517	17,248	17,267	-20
20	Construction	725,269	19,467	19,654	-187
30	Manufacturing	854,821	18,424	18,487	-63
40	Trade, transportation, and utilities	2,426,517	-18,939	-18,977	38
50	Information	193,045	1,977	1,978	-1
55	Financial activities	798,735	6,691	6,709	-18
60	Professional and business services	1,719,520	36,487	36,870	-383
65	Education and health services	1,668,538	-3,572	-3,515	-56
70	Leisure and hospitality	1,115,520	39,954	42,210	-2,256
80	Other services	382,896	30,497	30,518	-21

Chart 2. Texas series 70 relationship between modified estimate, benchmark and coronavirus cases per month



Interpretation of the chart is keyed to the labels on the modified rake curve. At point A, May 2020, the five-month window of analysis begins. At point B, June, coronavirus cases increase gradually while the summer seasonal buildup of employment begins. Employment rose sharply from point A to point B. At point C, July, coronavirus cases begin rapidly increasing, while employment significantly drops. At point D, August, the number of coronavirus cases begins to decrease, the drop in employment also stabilizes. At point E, September 2020, the coronavirus cases continue to drop, and employment growth begins to return.

Overall, the chart shows the estimate reflects the coronavirus impact in Texas to the extent of aligning with the case numbers. The estimate also aligns properly with the benchmark value. However, the estimate may be overcompensating for the coronavirus effect, responding more quickly to case increases than case decreases. This indicates the possibility of further improving our modifications.

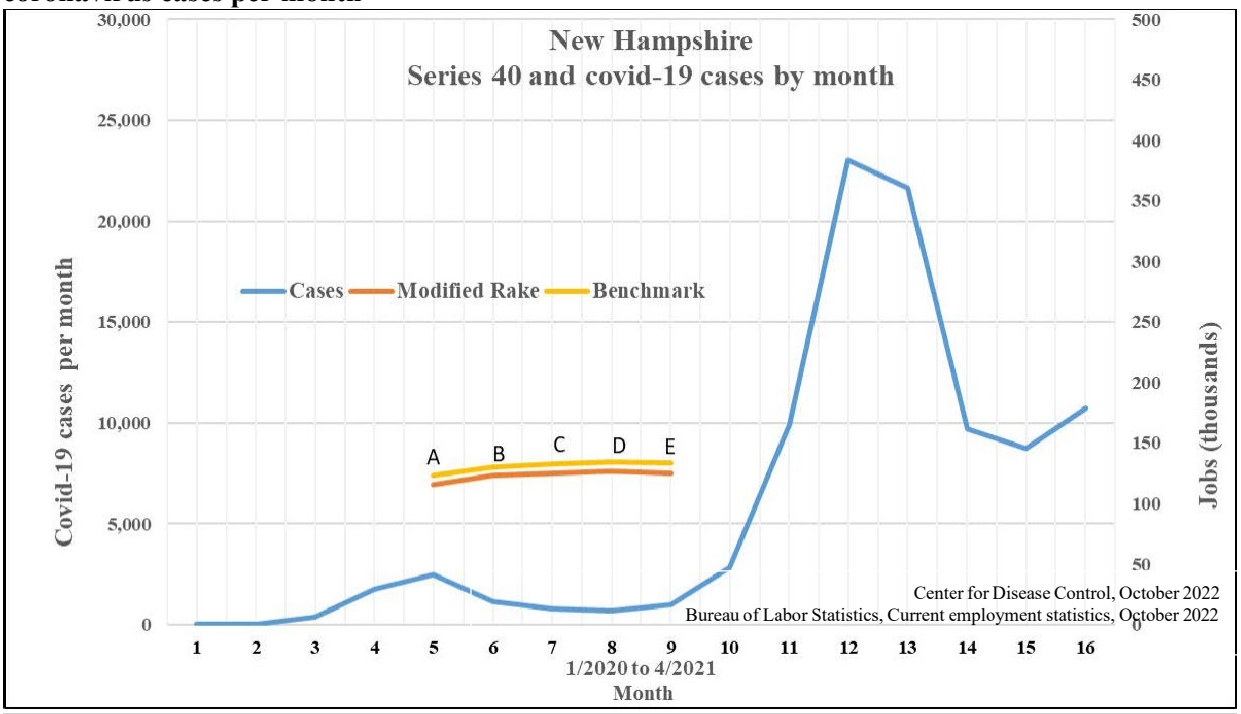
How did the modified rake fare on an individual state level: New Hampshire

Of the 10 states with the least coronavirus cases, New Hampshire has the greatest correlation level between the estimates and the number of coronavirus cases. The benefit of the modified rake is much smaller for the smaller case levels, as shown in Table 4. Table 6 shows that for eight out of ten supersectors in New Hampshire, there is no difference between the modified and unmodified rake. With very low cases, coronavirus is not generating the business deaths which the modified rake is designed to be sensitive to. Businesses in the sample were not widely reporting drops to zero employment, so the modified rake was, in effect, identical to what the unmodified rake would have been for New Hampshire. The trade, transportation and utilities supersector, has the greatest difference, with just 5. Performance for this series is shown in Chart 3.

Table 6: Modified versus unmodified performance by supersector for New Hampshire per month (May 2020 to September 2020)

NEW HAMPSHIRE		Values			
Statewide supersector	**Description**	**Benchmark**	**Difference of modified rake estimate**	**Difference of unmodified rake estimate**	**Difference between rakes**
10	Mining and logging	1,012	-30	-30	0
20	Construction	28,410	-481	-481	0
30	Manufacturing	66,303	-624	-624	0
40	Trade, transportation, and utilities	130,733	-7,598	-7,603	5
50	Information	11,592	88	88	0
55	Financial activities	33,805	1,262	1,262	0
60	Professional and business services	81,083	-3,405	-3,405	0
65	Education and health services	111,853	4,178	4,177	1
70	Leisure and hospitality	55,983	-2,963	-2,963	0
80	Other services	21,608	4,056	4,506	0

Chart 3: New Hampshire Series 40 Relationship between modified estimate, benchmark and coronavirus cases per month



Point A, May 2020, begins the five-month window of analysis. This was a relative peak in coronavirus cases. At Point B, June, coronavirus cases are going down and employment is returning to normal. At Point C, July, as the cases stay low, employment remains stable, with only modest growth in employment corresponding to the modest reduction in cases. The same situation maintains through Point D, August. In September 2020, Point E, coronavirus cases increase slightly, and employment goes down slightly. Note the scales on the chart, as before, are set to facilitate comparison of the curves. The scale of employment and number of cases is much smaller for New Hampshire than Texas, and the correlation with the cases is much higher for New Hampshire than Texas. Overall, the charts reflect the general interpretation that the modified rake produces bigger gains in accuracy where coronavirus is having larger impacts than diminishing in accuracy where coronavirus is having smaller impacts.

Separately, it is interesting that in the case of New Hampshire, the monthly estimates are lower than the benchmark curve. This difference is consistent with the summary result in Table 1 that across all the data points the overall difference of positive and negative revisions between the estimates and the benchmarks is small.

4. Conclusion and Future Research

The modified birth/death rake for state and area employment estimates described above showed modest improvements to the overall accuracy of the monthly estimates in terms of their difference from the final benchmark values. The modifications have also been shown to improve the estimates' reflection of the effect of coronavirus to the extent such improvement is indicated by overall correlation of the estimate with coronavirus cases. The indicated goals were met.

The differences are evaluated across five months of data for ten two-digit NAICS supersectors for the fifty states plus the District of Columbia. The modified rake performed slightly better for more series than the unmodified rake performed better for, and the level of improvement seen from the modified rake was

larger than the successes of the unmodified rake. However, the greatest number of series saw the exact same estimates with each rake methodology. This raises the question of how valuable further refinements would be to the methodology.

The correlation of the estimates with the number of coronavirus cases is consistently higher, although not by much, than the correlation of the benchmark with the number of coronavirus cases. Furthermore, the modified rake increases, slightly, the estimates correlation with the number of coronavirus cases. This increased correlation suggests future research may be able to further improve the modified rake in its reflection of such dynamic changes as caused by the coronavirus. Maybe there is a more accurate way of considering pandemic and economic shocks as an influencer of employment changes, or maybe there is a better way of accounting for business births and deaths in times of unprecedented change.

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