Lessons Learned from the COVID-19 Pandemic

Jonathan Weinhagen

Bureau of Labor Statistics

Produce Price Index

8/12/2021

The COVID-19 pandemic, officially announced by the World Health Organization (WHO) on March 11, 2020, resulted in an unexpected economic shock impacting a wide range of industries. This shock led to supply-chain disruptions, increased unemployment, shifting demand, and volatile price movements, all of which created new challenges for calculating the U.S. Producer Price Index (PPI). This paper describes the effects of the COVID-19 pandemic on the U.S. PPI's response rates, seasonal adjustment, variance estimates, weighting, and data collection efforts. In addition, it outlines lessons the program has learned from dealing with this unprecedented economic shock.

Response Rates

Reponses rates measure the percentage of data received by a survey. For price index data, response rates can be calculated using a number of methods. This discussion will focus on the monthly repricing response rate, which is calculated as: (number of prices received for a month)/(number of prices requested for a month)*100. The U.S. PPI's average response rate for all industrial sectors for the 12 months prior to the COVID 19 pandemic was approximately 69 percent at first index publication. The U.S PPI allows for late prices and corrections for a four month cycle following first index publication. Typically, by the end of the 4 month cycle PPI's overall response rate is approximately 74 percent.

Initially, the PPI program was concerned that stay at home orders and mandatory shutdowns of nonessential businesses would adversely affect response rates. Overall, however, PPI response rates increased during the COVID-19 pandemic relative to the 12 months prior. For all industry sectors, first publication PPI response rates averaged 73 percent from March 2020 through March 2021, compared to 69 percent for the 12-months prior to March 2020. Importantly, the increase in response rates during the pandemic resulted from a reduction in the denominator of the response rate calculation, *number of prices requested for a month.* Data collection has become increasingly challenging over time and this number has been declining for several years, a trend which continued in 2020 and 2021. The numerator of the response rate equation, *number of prices received for a month*, in contrast, changed very little from March 2020 through March 2021 (decreasing slightly), indicating that during the pandemic reporters continued to provide PPI with repricing information at levels similar to before the pandemic.

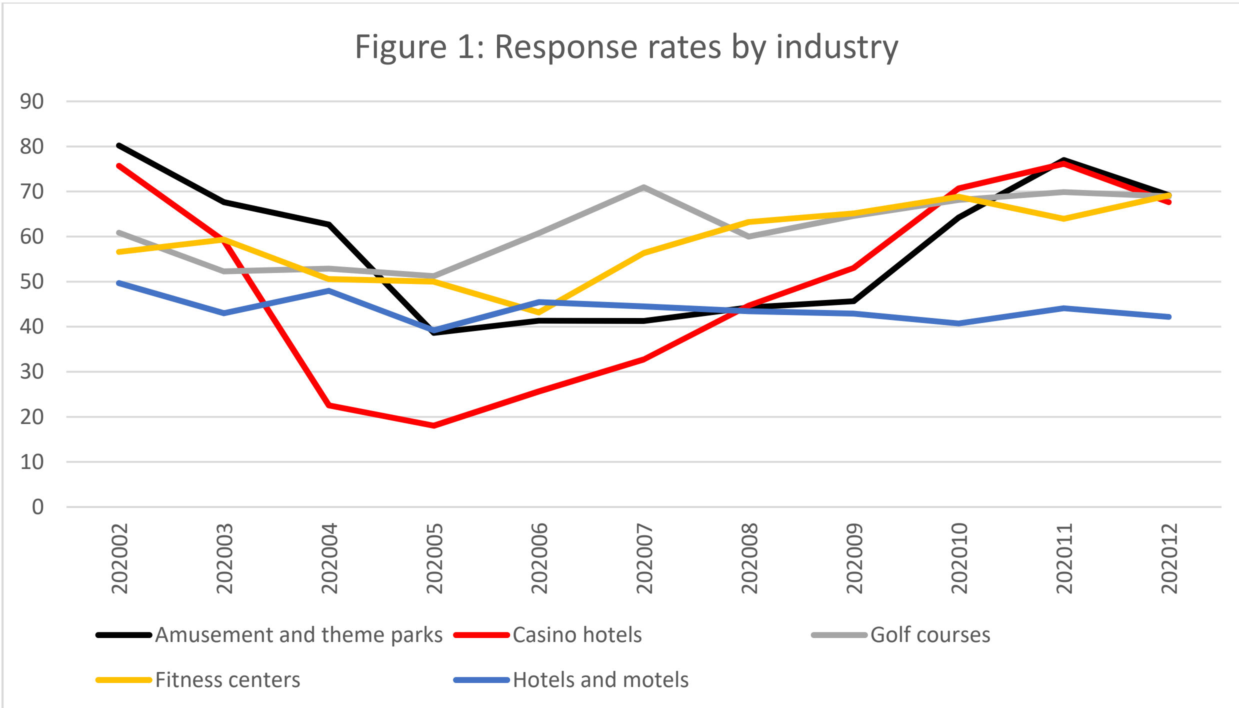
In spite of the rise in overall PPI repricing response rates during the pandemic, a closer look at the data shows that for certain industries response rates did decline. Table 1 presents response rates by industry sector from March 2020 through March 2021 as well as the average response rate over that same period. As a comparison, the table also includes the average response rate by sector for the 12-months prior to March 2021.

Table 1: PPI Response rates by sector

Industry sectors	Average Mar 2019 to Feb 2020	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Average Mar 2020 to Mar 2021
All industrial sectors	69	72	76	72	72	73	72	73	73	73	72	73	73	74	73
Agriculture, forestry, fishing and hunting	47	49	44	44	48	47	47	50	51	51	46	50	49	46	48
Mining, utilities, and construction	66	69	71	70	66	70	72	71	72	71	69	74	71	73	71
Manufacturing	74	75	78	73	74	75	75	75	75	74	73	74	74	76	75
Wholesale trade	62	60	65	61	64	63	61	63	63	64	60	65	64	64	63
Retail trade	75	75	74	75	70	76	74	76	75	75	74	75	76	79	75
Transportation and warehousing	80	81	81	83	84	79	77	77	80	77	78	84	79	79	80
Finance, real estate, and other information services	79	76	79	78	77	77	76	79	76	78	78	76	78	80	78
Health care services	59	54	62	60	57	62	60	57	62	63	63	60	66	61	61
Entertainment, accommodation and food services	66	52	47	38	43	46	46	47	54	53	54	56	52	46	49
Other services, except public administration	80	84	96	95	95	95	100	100	91	87	83	92	90	90	92

Across the vast majority of sectors, response rates were not heavily affected by the COVID-19 pandemic. For the ten sectors included in Table 1, six sectors showed higher average response rates during the COVID-19 pandemic period than for the 12 months prior. For two sectors, response rates were on average the same during the pandemic as they were pre-pandemic. Only two sectors showed declines in response rates during the pandemic period relative to the 12 months earlier. However, for one of the two, finance real estate and other information services, the response rate was on average only one percentage point lower during that pandemic than the previous 12 months. The only sector that experienced a large decline in response rates during the pandemic was entertainment, accommodation, and food services. The average response rate for entertainment, accommodation, and food services during the pandemic dropped 17 percentage points relative to its pre-pandemic level of 66 percent. In May 2020, the response rate fell to a low of 38 percent before beginning a slow recovery. As of March 2021, the response rate for entertainment, accommodation, and food services had still not reached its pre-pandemic level.

For the U.S PPI, the entertainment, accommodation, and food services sector is composed of amusement and theme parks, golf courses and country clubs, fitness centers, hotels and motels, and casino motels. Looking within this sector, certain industries were more affected than others. Specifically, amusement and theme parks and casino hotels experienced very large declines in response rates. Figure 1 presents response rates for amusement and theme parks, golf courses and country clubs, fitness centers, hotels and motels, and casino motels. The response rate for casino hotels fell from 75.7 in February 2020 to 18.5 in May 2020. Likewise, the response rate for amusement parks decreased from 80.0 percent in February 2020 to 39.2 in May 2020. Importantly, casinos and amusements parks experienced broad-based mandated shutdowns during the pandemic.[i] [ii] By contrast, there were much smaller changes in response rates for hotels and motels, golf courses and country clubs, and fitness centers during the pandemic. Response rates for golf courses and country clubs and fitness centers actually increased.



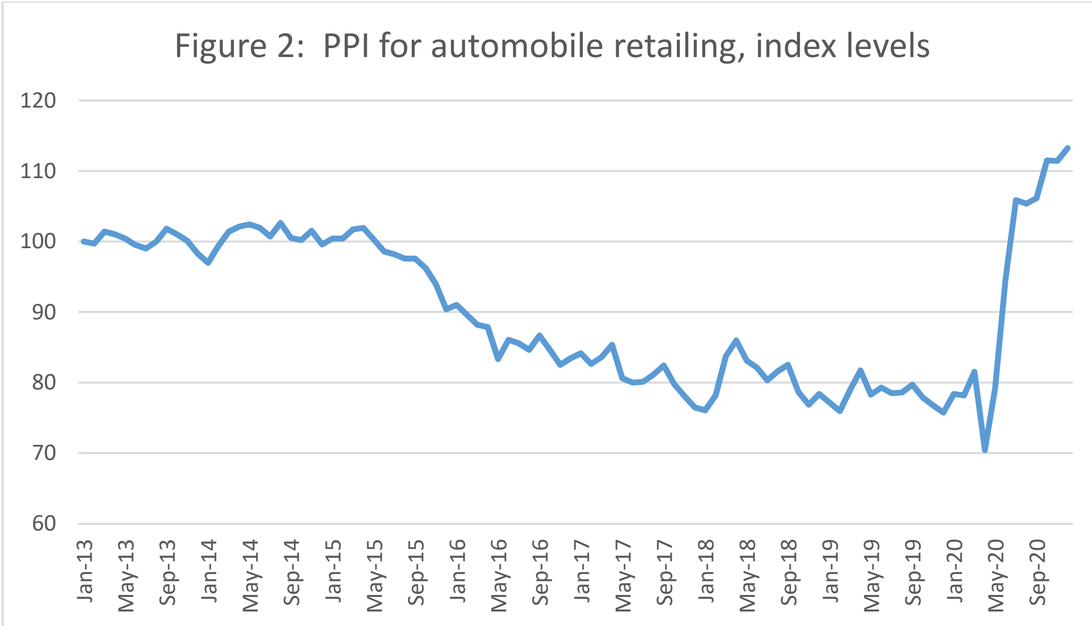
At the beginning of the COVID-19 pandemic, BLS Associate Commissioner, Jeffrey Hill, sent a letter to all BLS respondents emphasizing the importance of their continued participation in BLS surveys. In general, respondents continued to participate in the PPI survey throughout the pandemic. In many cases, their participation actually improved. Anecdotally, industry analysts said that at the beginning of the pandemic, they were able to reach reporters more easily because many were working from home and more available to answer the phone. The only sectors that experienced substantial declines in participation were those that were hit especially hard by the pandemic. Even within the highly affected entertainment, accommodation, and food services sector, the specific industries that experienced long, mandated shutdowns were much more affected than others. The main lesson learned related to response rates was that, even though the U.S PPI survey is voluntary, respondents continued to participate in spite of the pandemic with the exception of industries that were deeply affected by shutdowns.

Seasonal Adjustment

The BLS publishes seasonally adjusted PPI time-series data on a monthly basis. Seasonal adjustment removes within-year seasonal patterns from the data. In the case of price indexes, these within-year patterns may result from changing climatic conditions, production cycles, model changeovers, holidays, and sales. Seasonally adjusted data are usually preferred for short-term price analysis as they allow data users to focus on changes that are not typical for the time of year. To seasonally adjust data, the PPI uses a filter-based approach that employs moving averages of eight years of historical data to estimate the seasonal factors of a time series. (Seasonal factors are the estimated seasonal pattern of an index.) In addition, PPI uses historical data to conduct statistical tests for seasonality and only seasonally adjusts data that exhibit statistically significant seasonality.[iii]

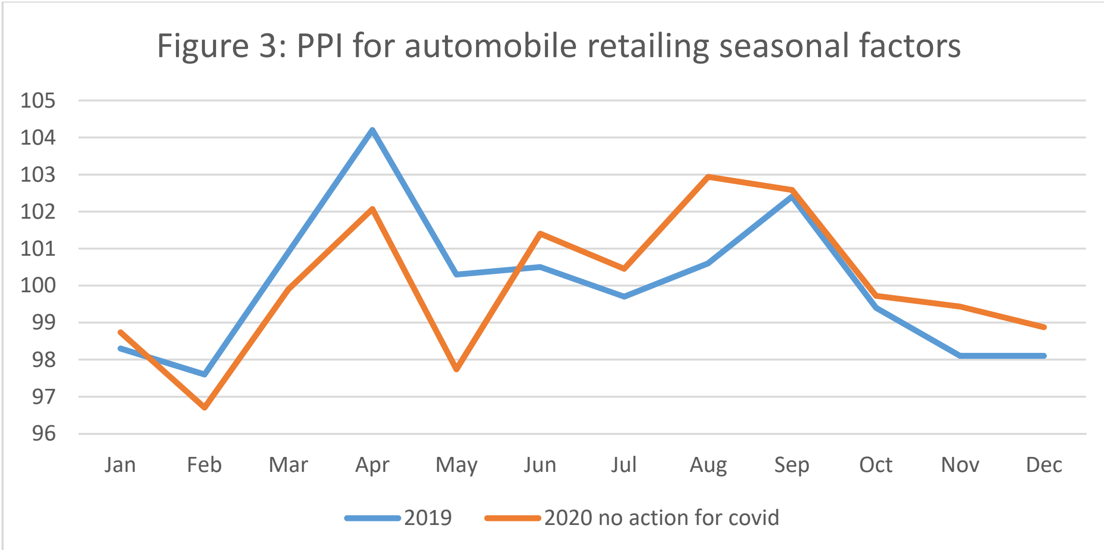
In 2020, a number of indexes were affected by extreme price movements resulting from the COVID-19 pandemic.[iv] [v] [vi] For example, the PPI for gasoline decreased 53 percent in April 2020. Because the PPI program uses historical data to estimate seasonal patterns, the extreme price movements in 2020 could potentially adversely affect seasonal adjustment of its data. To offset the effects of pandemic driven price movements on seasonal adjustment, PPI expanded their use of intervention analysis. Intervention analysis entails estimating and removing the effects of important nonseasonal events (using regression modeling) from indexes prior to testing them for seasonality and developing seasonal factors. The goals of intervention analysis are to determine whether a seasonal pattern exists and to correctly estimate seasonal factors in spite of any distortion that might arise in the pattern.

PPI began by examining all of its seasonally adjusted indexes to determine whether COVID-related price movements would negatively affect their seasonal adjustment. In cases where they would, the series were added to the set of indexes for intervention analysis. The PPI commodity index for automobile retailing, which measures the difference between selling prices and acquisition costs for automobiles, provides an example of a series whose seasonal adjustment could have been negatively affected by COVID-related price movements. The index rose rapidly from April through August 2020 and then again later in 2020. (See figure 2.) From May 2020 through the end of the year, the PPI for automobile retailing rose over 60 percent.



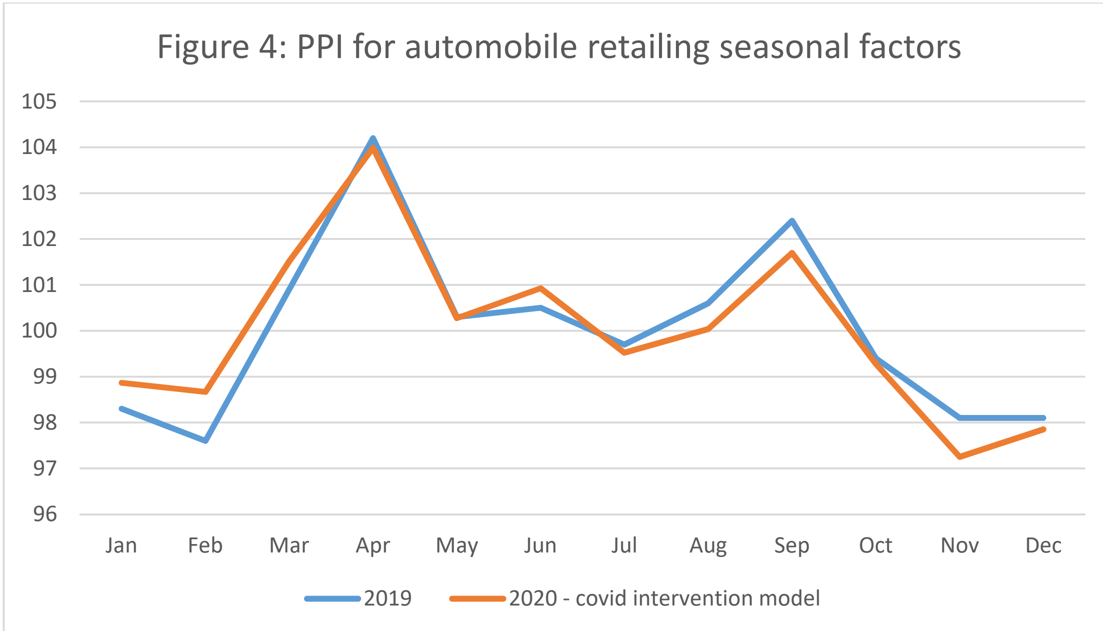
To better understand how the extreme COVID-related price movements would affect seasonal adjustment of automobile retailing, seasonal factors and seasonality tests estimated with data from 2013-2020 were compared to those estimated with data from 2012-2019. If large changes were observed between seasonality tests and factors it could be concluded that COVID-related price movements would adversely affect seasonal adjustment of the series. (By its nature seasonality should not change substantially over short periods of time.) The F(s) test statistic for seasonality estimated using 2012 through 2019 data was 9.66, as compared to 1.73 when estimated with data from 2013-2020. For an index to be deemed seasonal, the F(s) statistic must be at least 7.0. The tests, therefore, clearly indicated a decrease in seasonality when 2020 data were included.

Continuing the analysis, Figure 3 compares seasonal factors for automobile retailing estimated with 2013-2020 data to those developed using data from 2012-2019. The seasonal factors estimated including data from 2020 differ substantially from those estimated with pre-COVID data. In particular, the factors estimated with 2020 data expect an increase from May to June which is not expected when 2020 data is not included in the estimation.



The examination of price movements, seasonality tests, and seasonal factors all suggest that COVID-19 driven price movements would adversely affect seasonal adjustment of automobile retailing. For these reasons, PPI chose to conduct intervention modeling on the series. The intervention model included variables that controlled for movements from March 2020 through April 2020, April 2020 through July 2020, and November 2020. After including interventions, the F(s) test statistic rose to 9.97, which indicates seasonality.

Figure 4 compares seasonal factors for automobile retailing estimated with data from 2012-2019 to those estimated with data from 2013-2020 employing the intervention model presented earlier. The interventions included to offset COVID-related price movements clearly result in factors more similar to those estimated in 2019, which highlights the necessity of intervention modeling to mitigate the effect of COVID-19 on seasonal adjustment.



The automobile retailing example shows how extreme price movements reduced the amount of detectable seasonality for the series and distorted the normally observed seasonal patterns and is indicative of what occurred for many price indexes in 2020. After considerable analysis, the U.S. PPI substantially expanded the scope of their intervention work in 2020 to offset the effects of the COVID-19 pandemic on seasonal adjustment. Intervention analysis was conducted on 76 series in 2020, as compared to 41 in 2019. Of the 76 series, 36 series were added strictly to mitigate COVID effects on seasonal adjustment and thereby only contained interventions in 2020. The total number of interventions for PPI increased 64 percent from 2019 to 2020.

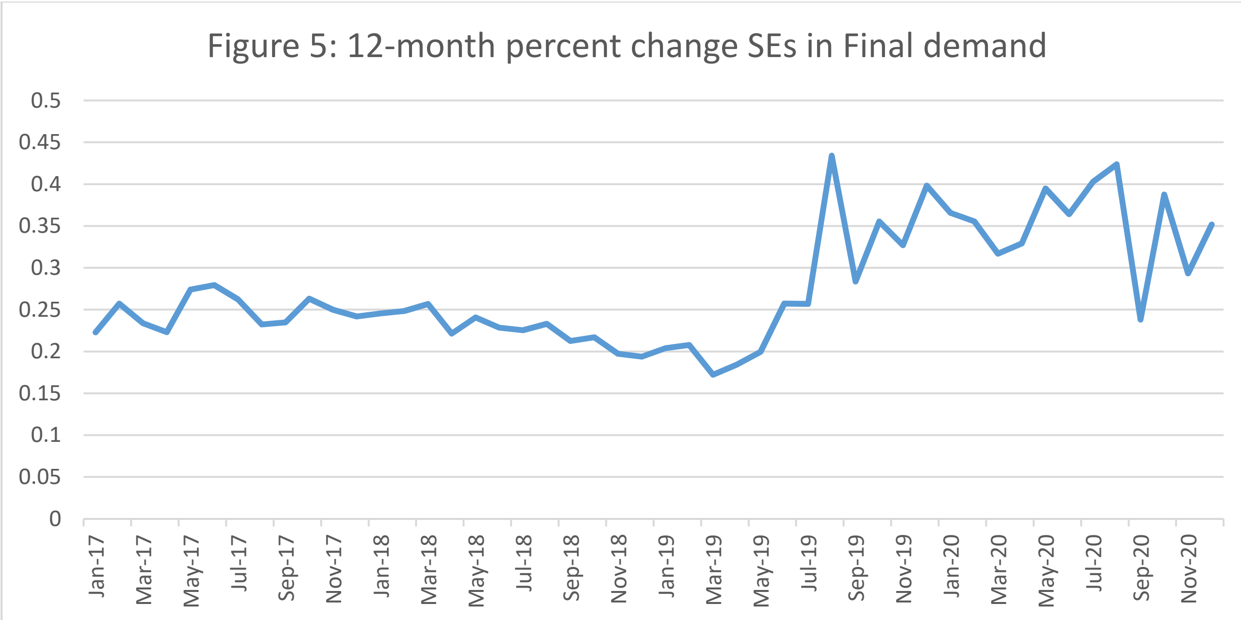
The main lesson learned from the pandemic with respect to seasonal adjustment is that a large economic shock, such as the COVID-19 pandemic, requires considerable resources to be reallocated to intervention analysis work. Without this intervention work, a substantial numbers of previously seasonal series would have failed seasonality tests in 2020. In turn, seasonally adjusted aggregate series that are constructed by combining seasonally adjusted components, such as the PPI for final demand, would also have been adversely affected. In the end, the PPI was able to reallocate resources to increase the scope of intervention work in 2020 and offset the negative effects of the pandemic on seasonal adjustment of its data. However, because PPI employs eight years of historical data to estimate seasonal factors, additional resources will need to be devoted to intervention analysis until COVID-period data is no longer included in the eight-year estimation window.

Variance statistics

The U.S. PPI program began publishing variance estimates in 2016 based on data for 2015 and has since published variance estimates annually.[vii] Variance estimates reflect the sample distribution of the population. If the sample estimates are tightly grouped about the sample mean, the variance is small. If they are widely distributed, the variance is larger. The PPI program uses a simulation method of variance estimation called *bootstrapping*, which involves drawing 150 replicate samples, with replacement, from the original sample and then calculating the percent change estimates for each replicate sample. A commonly used measure of sampling variability is the standard error (SE), which is the square root of the variance estimate. The SE estimates the sample distribution, or spread of the sample estimates, for comparison with the true population value. The SE is used to calculate a confidence interval around the sample percent change estimate. To calculate a 95-percent confidence interval, data users commonly add and subtract 2 times the SE value from its corresponding percent change estimate to obtain a range of values that likely contains the true population percent change. If this range includes zero, then the percent change is not significantly different from zero.

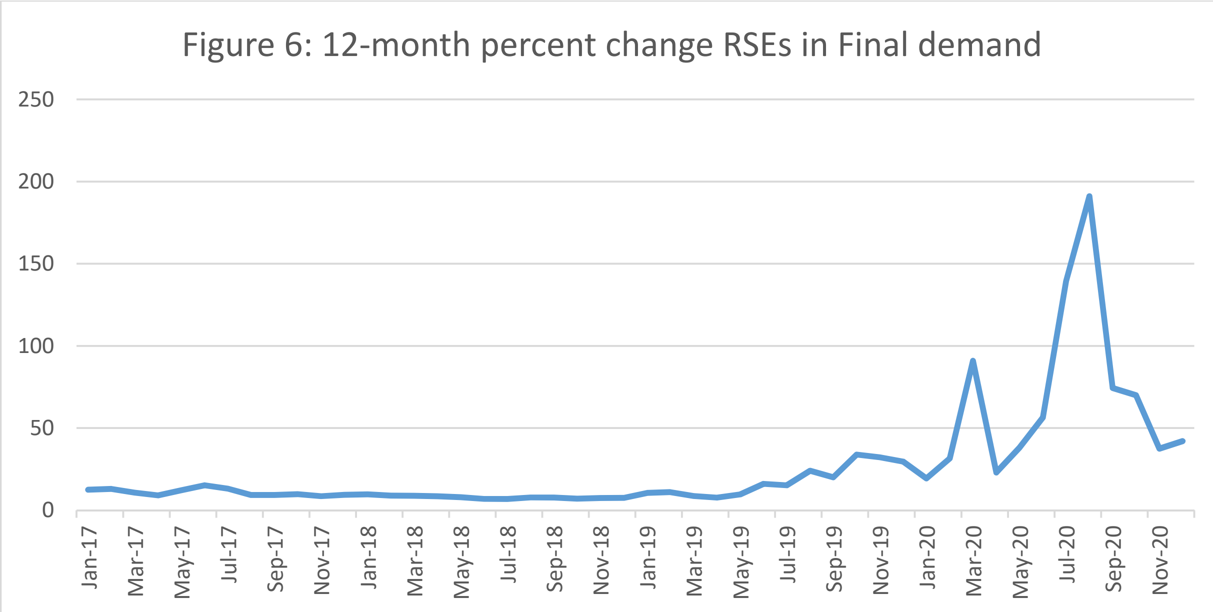
It was initially unclear how the COVID-19 pandemic would affect U.S. PPI variance and standard error estimates. In general, there were expectations of increased monthly price volatility in some areas. However, an increase in price volatility of a time series does not necessarily imply an increase in variance of the estimate. Variances tend to increase when there is more *variability* of price changes in an estimate, but not necessarily when there is more monthly *volatility* in the series. For example, if a series is very volatile from month-to-month but all prices used to estimate the series within a month behave similarly, the variance of the estimate would likely be low.

To examine how variances and standard errors were affected by the pandemic, Figure 5 presents the monthly standard errors in the estimate of the 12-month percent change of the index for final demand from 2017 through 2020. The standard errors in 2020 are clearly higher than those in 2017 and 2018. The standard errors, however, appear to begin rising in 2019 (before the COVID-19 pandemic begun) which makes linking the increase to the pandemic more difficult. Nonetheless, it does appear that variances for final demand during 2020 were at high levels relative to earlier periods examined.

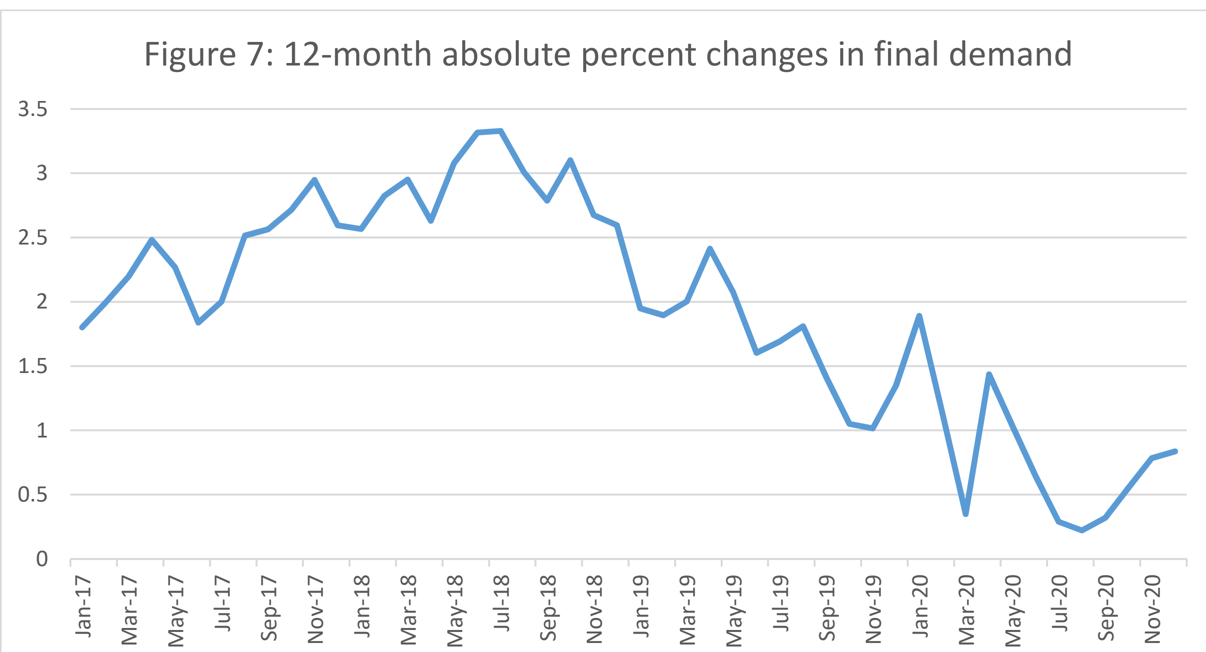


It is often expected by statisticians that standard errors will increase as the absolute value of the percent change of the series rises. For this reason, relative standard errors (RSE) are often calculated. RSE are calculated by dividing the SE by a reference statistic (in this case the index percent change), and multiplying by 100. An RSE of less than 50 reflects an SE that is half as large as the reference statistic, suggesting a relatively narrow confidence interval and 95-percent confidence relative to no change. An RSE of 50 or more but less than 100 represents an intermediate-width confidence interval that does not provide 95-percent confidence relative to no change. An RSE of 100 or more generally identifies an index with a wide 95-percent confidence interval; however, if a reference statistic is close to zero, the usefulness of RSE as an analysis tool diminishes substantially.

Examining relative standard errors during the COVID-19 pandemic provides additional insight on the effect of the pandemic on standard errors. Figure 6 presents monthly RSEs in the 12-month percent change of final demand from 2017 to 2020. Although RSEs begin to rise in mid-2019, they have several notable spikes during the pandemic and are on average higher than the previous periods examined, suggesting that the pandemic likely did lead to more variation in PPI estimates.



As previously mentioned, the RSE is calculated by dividing the SE by the reference statistic, which in the case is the 12-month percent change in final demand. Figure 7 presents the 12-month absolute changes in the PPI for final demand from 2017 through 2020 and provides additional insight into the observed increase in relative standard errors in 2020. The absolute 12-month percent change in the PPI for final demand has been mostly declining from mid-2018 through most of 2020 (it began to rise towards the end of 2020) and is relatively low throughout 2020. The combination of higher SEs in 2020 and lower 12-month absolute percent changes therefore resulted in higher RSEs in 2020.



The previous analysis has shown that the COVID-19 pandemic likely resulted in higher standard errors in the PPI for final demand, in particular when measured by relative standard error. To understand whether specific components of final demand were more affected, Table 2 presents the median relative standard error by year for the major subcomponents of final demand. Consistent with the previous analysis, there was a large increase in the median relative standard error for final demand in 2020 as compared to earlier periods. Interestingly, the median relative standard error in overall goods fell in 2020 as compared to 2019, however, it remained above the levels of 2018 and 2017. Within goods, the median standard error in foods (which were heavily affected by the pandemic) was substantially higher in 2020 than in previous years. Likewise, the median relative standard error in goods less food and energy was higher in 2020 than in 2017-2019. For energy, the median relative standard error decreased in 2020 in comparison to the previous periods examined. The median relative standard error for final demand services (which compose approximately 67 percent of final demand) rose substantially in 2020 as compared to previous years. Within services, the median relative standard error rose in 2020 for all categories with the exception of transportation and warehousing services.

Table 2: Median RSEs in final demand and its components

Index	**12-month median RSE**			
	2020	**2019**	**2018**	**2017**
Final demand	50.7	14.9	8.0	10.5
Final demand goods	11.6	21.9	5.7	5.3
Final demand foods	48.8	16.2	32.7	20.3
Final demand energy	6.2	8.7	7.0	7.8
Final demand goods less foods and energy	25.0	13.8	10.0	6.0
Final demand services	50.5	16.7	12.4	19.9
Final demand trade services	110.3	44.4	51.1	65.2
Final demand transportation and warehousing services	18.7	20.1	8.6	23.2
Final demand services, other	28.5	11.3	10.2	12.6

The main lesson learned with respect to variances from the pandemic was that variances did on average increase as a result of the economic shock. The shocks led to more price volatility, which seemed to increase the variability of price changes within PPI's indexes. The increases in standard errors were relatively broad based across categories, but some areas, such as foods, were more affected.

Index Weights

The U.S Producer Price Index is calculated using a modified Laspeyres index formula, which uses fixed weights over a set period of time. Weights are based on value of shipments and revenue data from the U.S. Economic Census and are generally updated every five years subsequent to the release of new Economic Census data. Currently, PPI weights are based on values from the 2012 Economic Census and the program is in the process of updating weights to be based on values from the 2017 Census.

The weight of a product or industry included in a PPI should ideally reflect the share of revenue for the product or industry relative to the other products or industries included in the index. For this reason, infrequent weight updates can become problematic when revenue for industries or products are shifting relative to each other over time. In such instances, the price index may not accurately reflect current production patterns.

The COVID-19 pandemic led to large shifts in production patterns, which caused concerns over the accuracy of PPI weights. To illustrate, Appendix A compares changes in gross output by industry from 2018-2019 to 2019-2020.[viii] (The data in Appendix A are from the U.S Bureau of Economic Analysis and do not represent actual PPI weight data, but are presented to show how output values changed in 2020 as Census data is not available for 2020.) In many cases, changes in gross output from 2019 to 2020 are much larger than from 2018 to 2019. For example, the gross output in air transportation declined approximately 58 percent from 2019 to 2020, after increasing 6.3 percent from 2018 to 2019. In addition, changes in gross output in 2020 were often non-uniform across categories. Overall gross output fell 2.9 percent, but there was considerable variation across industries. Gross output for mining; transportation and warehousing; and arts, entertainment, recreation, accommodation, and food services fell 29.5, 15.0 percent, and 25.6 percent, respectively, while gross output for construction, retail trade, and finance and insurance rose 4.3 percent, 2.7, 3.4 percent, respectively.

Ideally, under conditions where revenues are shifting relative to each other, weights would be updated every period to accurately reflect shifts across time. A chain weighted Tornqvist (such as used in constructing the U.S. superlative CPI) or a chain weighted Fisher index, for example, could be used to better reflect changes in production patterns as weights for these indexes are updated in each period and the formulas allow for substitution. Unfortunately, because chain weighted superlative indexes require current period revenue data, they are generally not feasible for most countries. For the U.S PPI, weights during the COVID period have been based on 2012 Census values and probably do not effectively represent revenue shares from 2020 and 2021. Additionally, due to data and system constraints, there was little the program could do to modify its weights to better reflect conditions during the COVID-19 pandemic. The drastic and sudden changes brought on by the pandemic did, however, illustrate the importance of working towards developing an index that better accounts for shifting revenue patterns.

The next PPI weight update will most likely occur in January 2023 and weights will be updated to be based on 2017 Economic Census data. The programs anticipates that by January 2023 production patterns will return to more historically normal levels, and weights will be as accurate as they have been after past weight updates. Unlike the U.S. PPI, some countries update their weights annually. (For example, Sweden and Australia.)[ix] As weight data is generally not available in real time, new weights are typically introduced with a lag. For this reason, countries will need to decide whether 2020 or 2021 data should be used for weighting, as data from that period may not accurately reflect revenue shares from the period the data is introduced. Alternatives would be to delay introducing new weights until production patterns have returned to more historically normal levels or to adjust COVID period weights. For example, time series models could be used to forecast 2020 data based on past trends and the forecasted data could be used instead of the actual 2020 data. Fortunately, unlike when the pandemic first struck, countries have time to potentially make adjustments to weight data based on 2020 values.

In terms of weighting, the main lesson learned from the COVID-19 pandemic is that using a modified Laspeyres index formula can be very problematic when economic shocks affect revenue shares disproportionality. The problem not only occurs concurrently during the time period of the shock, but also when data from the shock period is subsequently used for weighting other periods. The best solution to overcome these problems would be to use a chain weighted superlative formula.

Data collection

The COVID-19 pandemic changed the manner in which PPI initially collects data from respondents. Prior to the pandemic, BLS field economists would make first contact with potential respondents via an in person initiation visit. At this visit, the field economist attempts to secure participation in the PPI survey and determines the set of items the respondent would provide prices for on a monthly basis. As of mid-March 2020, PPI Field Economists were no longer able to make personal visits to potential respondents due to the COVID -19 pandemic. As a result, a number of steps were taken to help facilitate data collection. First, initiation by phone was made an option for all potential respondents. Second, encrypted video conferencing was introduced for Field Economists to offer for use in data collection activities. Third, data collection via phone and video were also supplemented by email, and a set of email templates to help better connect with respondents was developed. (For example, templates to help respondents prepare for their interviews.) Finally, to facilitate the use of video conferencing, a number of resources were developed for field economists, including: a guide to create conference calls and an industrial prices telephone initiation tips collection aid.

In spite of these new measures, field economists still encountered difficulties making contact with potential respondents during the pandemic. Examples of these difficulties include businesses that shut down temporarily; businesses that shut down and were uncertain as to whether they would reopen; businesses that were unreachable; and businesses that were on a much reduced capacity. Total transmittals, which include both positive and negative responses to participate in the PPI survey, declined by approximately 9 percent in 2020. Transmittals, however, had generally been declining prior to the pandemic. Therefore, the pandemic may not have caused the entire decline in 2020. In addition to fewer transmittals, the proportion of transmittals that were positive (respondents agreed to participate) also fell by approximately 8.5 percent relative to the previous year.

Data collection at initiation clearly became more difficult during the pandemic due to the inability to conduct in person visits and business shutdowns. In general, PPI found it more difficult and time consuming to gain cooperation to their voluntary survey using video and telephone contact as opposed to in person. A number of efforts were instituted to offset these difficulties, which did prove to be somewhat effective at minimizing reduction in data collection. As a result of the pandemic and the introduction of new tools such as video conferencing, PPI will generally be less reliant on personal visit data collection. The pandemic accelerated PPI’s shift away from in person data collection to alternative methods. PPI expects to continue using video interviews during the initiation process along with telephone and personal visit interviews.[x]

Conclusion

This paper examined the affects the COVID-19 pandemic had on the U.S. PPI’s response rates, seasonal adjustment, variance estimates, weighting, and data collection efforts. The five main lessons learned from the pandemic are as follows: 1) response rates remained at or above normal levels during the pandemic for almost all areas with the exception of specific industries that were substantially impacted by the pandemic. 2) Seasonal adjustment became substantially more difficult during the pandemic as a result of increased price volatility, which necessitated devoting extra resources to intervention modeling. The increased use of intervention modeling largely counteracted the negative effect of the pandemic on seasonal adjustment. 3) In general, variances increased during the pandemic. The increased monthly volatility in prices seemed to induce more within-month variability in price relatives. 4) There were likely large relative shifts in revenues across industries which reduced the accuracy of index weights due to the use of a modified Laspeyres formula with fixed base period weights. The pandemic therefore highlighted the importance of using a chain weighted superlative index. 5) Initiation data collection became more difficult during the pandemic due to the inability to conduct in- person visits and business shutdowns. The pandemic accelerated PPI's shift away from in person data collection to alternative methods. PPI expects to continue using video interviews during the initiation process along with telephone and personal visit interviews.

[i] For information on casino shutdowns see: https://www.americangaming.org/new/covid-19-drives-commercial-gaming-revenue-down-31-in-2020/

[ii]For information on amusement park shutdowns see: https://www.cnbc.com/2020/08/04/coronavirus-shut-down-theme-parks-costing-disney-3point5-billion.html

[iii] For additional information on seasonal adjustment of the U.S. PPI see: https://www.bls.gov/ppi/seasonal-adjustment/seasonal-adjustment-in-the-ppi.htm.

[iv] Dave Mead, Karen Ransom, Stephen B. Reed, and Scott Sager, "The impact of the COVID-19 pandemic on food price indexes and data collection," Monthly Labor *Review,* U.S. Bureau of Labor Statistics, August 2020, https://doi.org/10.21916/mlr.2020.18.

[v] Sarah Eian and Brett Matsumoto, "The impact of the COVID-19 pandemic on the input and output prices of the airline and hotel industries: Insights from new BLS data," *Beyond the Numbers: Prices & Spending*, vol. 10, no. 3 (U.S. Bureau of Labor Statistics, February 2021), https://www.bls.gov/opub/btn/volume-10/impact-of-covid-19-pandemic-on-input-and-output.htm

[vi] Kevin M. Camp, David Mead, Stephen B. Reed, Christopher Sitter, and Derek Wasilewski, "From the barrel to the pump: the impact of the COVID-19 pandemic on prices for petroleum products," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, October 2020, https://doi.org/10.21916/mlr.2020.24.

[vii]U.S PPI variance data is available at: https://www.bls.gov/ppi/variances/variance-estimates-for-the-producer-price-index.htm

[viii] GDP by industry data, including gross output, is available at: https://www.bea.gov/data/gdp/gdp-industry
[ix] For weight update frequency by country see table 4 from the "Producer Priced Indices- Comparative Methodological Analysis" at: https://www.oecd.org/sdd/prices-ppp/48370389.pdf

[x] Ongoing data collection for monthly repricing had been transitioned to solely web repricing in 2018 prior to the pandemic so it was not affected.

Appendix A: Percent changes in U.S gross output by industry

	Gross output percent change 2018-2019	Gross output percent change 2019-2020
All industries	3.3	-2.9
Private industries	3.3	-3.2
Agriculture, forestry, fishing, and hunting	-0.7	0.4
Farms	-0.7	1.1
Forestry, fishing, and related activities	-0.5	-4.9
Mining	-5.0	-29.5
Oil and gas extraction	-7.4	-34.5
Mining, except oil and gas	1.7	-8.4
Support activities for mining	-2.6	-35.1
Utilities	-2.5	-3.3
Construction	2.9	4.3
Manufacturing	0.8	-5.5
Durable goods	2.4	-4.8
Wood products	-2.0	4.6
Nonmetallic mineral products	3.5	1.7
Primary metals	-5.4	-6.7
Fabricated metal products	2.7	-5.4
Machinery	2.5	-4.2
Computer and electronic products	3.2	4.2
Electrical equipment, appliances, and components	3.3	-3.2
Motor vehicles, bodies and trailers, and parts	4.6	-7.3
Other transportation equipment	2.9	-22.5
Furniture and related products	5.5	-2.5
Miscellaneous manufacturing	1.6	11.3
Nondurable goods	-0.9	-6.3
Food and beverage and tobacco products	1.5	0.4
Textile mills and textile product mills	-1.0	-8.3
Apparel and leather and allied products	1.0	-3.0
Paper products	0.9	1.1
Printing and related support activities	3.8	-3.1
Petroleum and coal products	-10.8	-32.1
Chemical products	2.7	1.2
Plastics and rubber products	0.9	-4.3
Wholesale trade	2.4	-3.8
Retail trade	4.1	3.7
Motor vehicle and parts dealers	4.1	0.6
Food and beverage stores	3.1	11.3
General merchandise stores	1.8	2.1
Other retail	4.9	3.2
Transportation and warehousing	4.9	-15.0
Air transportation	6.3	-58.6

Rail transportation	-2.1	-11.0
Water transportation	3.2	-32.0
Truck transportation	2.8	-6.2
Transit and ground passenger transportation	12.4	-28.1
Pipeline transportation	9.5	-1.6
Other transportation and support activities	6.2	9.6
Warehousing and storage	3.8	1.4
Information	6.2	2.1
Publishing industries, except internet (includes software)	8.7	5.5
Motion picture and sound recording industries	2.7	-24.1
Broadcasting and telecommunications	3.2	0.0
Data processing, internet publishing, and other information services	11.6	12.5
Finance, insurance, real estate, rental, and leasing	4.6	2.8
Finance and insurance	4.0	3.4
Federal Reserve banks, credit intermediation, and related activities	2.6	1.9
Securities, commodity contracts, and investments	4.3	1.7
Insurance carriers and related activities	4.8	5.0
Funds, trusts, and other financial vehicles	5.1	8.1
Real estate and rental and leasing	5.1	2.3
Real estate	5.2	3.9
Housing	4.8	4.2
Other real estate	5.9	3.3
Rental and leasing services and lessors of intangible assets	4.1	-12.8
Professional and business services	5.1	-2.1
Professional, scientific, and technical services	4.7	-2.4
Legal services	3.4	-0.4
Computer systems design and related services	4.8	-1.2
Miscellaneous professional, scientific, and technical services	5.1	-3.2
Management of companies and enterprises	5.5	-1.3
Administrative and waste management services	5.6	-1.9
Administrative and support services	5.6	-1.7
Waste management and remediation services	5.5	-3.7
Educational services, health care, and social assistance	4.0	-2.8
Educational services	3.2	-4.9
Health care and social assistance	4.1	-2.5
Ambulatory health care services	3.4	-4.9
Hospitals	5.3	-0.9
Nursing and residential care facilities	2.7	0.4
Social assistance	4.0	-0.8
Arts, entertainment, recreation, accommodation, and food services	4.0	-25.6
Arts, entertainment, and recreation	4.1	-37.4
Performing arts, spectator sports, museums, and related activities	4.2	-44.6
Amusements, gambling, and recreation industries	4.0	-28.4
Accommodation and food services	4.0	-21.9
Accommodation	3.9	-40.2
Food services and drinking places	4.0	-15.8

Other services, except government	2.4	-12.3
Government	3.5	0.4
Federal	4.7	4.1
General government	5.2	4.0
National defense	6.4	3.3
Nondefense	3.4	5.2
Government enterprises	-1.2	4.5
State and local	3.0	-1.3
General government	2.9	-1.2
Government enterprises	3.4	-1.7