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Determination of Appropriate Imputation Technique for the Producer Price Survey (PPS) of Manufacturing Sector

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Abstract

The Producer Price Survey (PPS) for Manufacturing is a nationwide survey conducted by the Philippine Statistics Authority (PSA) to gather monthly data on producer prices of industry products produced by sample manufacturing establishments. The collected data are used in the generation of the monthly Producer Price Index (PPI) for the manufacturing sector. Sample establishments with no collected producer prices are inevitable due to various reasons and are therefore critical in the estimation of PPI. Imputation techniques such as the Last Observation Carried Forward (LOCF) and geometric mean are applied to reduce the bias in the estimation of producer price of non-responding sample establishments. However, it was observed that the preliminary and revised estimates of PPI had large discrepancies when using varying imputation technique for non-responding establishments during the preliminary estimation.

The research study compared LOCF with geometric mean in terms of accuracy through simulation. Results show that in general, LOCF yield higher accuracy than geometric mean in imputing producer price of non-responding establishments.

Keywords: missing data, producer price, manufacturing, imputation, last observation carried forward (LOCF), geometric mean, simulation,

1.0 Introduction

1.1 Background and Rationale

The Producer Price Survey (PPS) for Manufacturing is conducted nationwide by the Philippine Statistics Authority (PSA) to collect monthly producer prices of industry products produced by sample establishments in the manufacturing sector. The compiled producer prices are used in the generation of the monthly Producer Price Index (PPI). The PPI measures the changes in the prices of products produced by domestic manufacturers and sold at factory gate prices to wholesalers and/or other consumers in the domestic market. It also serves as deflator to the Value of Production Index (VaPI) and Value of Net Sales Index (VaNSI) in the estimation of the Volume of Production Index (VoPI) and Volume of Net Sales Index (VoNSI) for the Monthly Integrated Survey of Selected Industries (MISSI).

The PPI utilizes the Normalized Paasche-type method of index computation where the basic data of weight computation is the value of production. The sources of the weights are the Census of Philippine Business and Industry (CPBI) for the base year 2018 and the Annual Survey of Philippine Business and Industry (ASPBI) for the succeeding years until the next rebasing.

In PPS, sample establishments with no collected producer prices are inevitable due to various reasons and are therefore critical in the estimation of PPI. Currently, PPS employed two imputation techniques: (1) Last Observation Carried Forward (LOCF); and (2) Geometric Mean. These two imputation techniques are applied to reduce the bias in the estimation of producer price of non-responding sample establishments. However, it was observed that the preliminary and revised estimates of PPI had large discrepancies when using varying imputation technique for non-responding establishments during the preliminary estimation.

1.2 Objectives

The objective of the study is to identify the best imputation technique for PPS. Specifically, to determine the most appropriate imputation technique by:

a) Phase (Pre-pandemic and Pandemic phase)
b) Manufacturing Sector
c) Industry Division
d) Industry Group

1.3 Scope and Delimitation

The base year of the prices on the data set used in this study was 2000 but the industry groupings were already based on the 2009 Philippine Standard Industrial Classification (PSIC). Since the PPS uses two imputation techniques, only these imputation techniques were compared in terms of accuracy. Also, accuracy of no imputation [served as control] was also computed.

1.4 Significance of the study

Upon determination of the most appropriate imputation technique for PPS, the preliminary and revised estimates of PPI may have significantly reduced its discrepancies. Thus, more accurate estimates of PPI are produced.

2.0 Review of Related Literature

According to Statistics Canada (2003), imputation is the process used to determine and assign replacement values for missing, invalid or inconsistent data that have failed edits. This is done by changing some of the responses or assigning values when they are missing on the record being edited to ensure that estimates are of high quality and that a plausible, internally consistent record is created. Various imputation techniques are available but the most appropriate may be different for every survey.

From Moody's Analytics, Switzerland Producer Price Index treatment in missing prices is they carried forward the last price collected for the product that is temporarily unavailable. Other countries that use this method is Thailand and Turkey. Also from Moody's Analytics, Turkey PPI's treatment of missing prices for one or two months unavailable, the previous month's price is treated as the current month price. Thailand PPI treatment in missing prices is that if a price of a certain item is unavailable for three months or fewer, last available price is carried forward (SDDS - DQAF View : Thailand - Price index: Producer prices (imf.org).

In Canada's Industrial Product Price Index (IPPI), when the data provider failed to report on time or because it was impossible to supply them, parental imputation is utilized and the price movement is imputed by a weighted average of existing survey data collected from the respondents that did provide prices. Beginning in 2020, the IPPI started releasing flash releases mid-month. These are calculated using all available data at the time. Because petroleum data is unavailable by mid-month, it is estimated using ARIMA models and later revised with respondent data for the main release (Surveys and statistical programs - Industrial Product Price Index (IPPI) (statcan.gc.ca).

For Singapore PPI which is also known as Domestic Supply Price Index (DSPI), estimates for missing prices are made on the basis of trends for similar products. In Poland's PPI, when a price observation is unavailable in a given month, this price is not imputed and this item is removed from index calculation. Its replacement is selected during next month survey. When a previous price observation reappears after one or more months then the enterprise estimates this price for the previous month (https://dsbb.imf.org/sdds/dqaf-base/country).

For monthly surveys like PPS which has time constraint in data validation, generation and dissemination, a fast and efficient methodology to estimate missing data should be implemented.

3.0 Methodology

The current imputation techniques employed by PPS are last observation carried forward (LOCF) and geometric mean. Detailed procedures in determining the best imputation technique by phase, total manufacturing, industry division, industry group are discussed in this section. R and RStudio are the statistical software used in data preparation and simulation of the study.

3.1 Data Used

The imputed values in all data set used are assumed to have no trend or that values are missing completely at random. For the simulation, there are two types of data set created, namely, complete, and pseudo-incomplete data sets, which will further be discussed on the sections below.

A. Selection of starting data set

The month selected as the starting data set contains the highest response rate or number of good establishments in the preliminary and revised releases from January 2020 to November 2020. Response rate is computed as the quotient of good establishments in the preliminary release and good establishment in the revised release.

The monthly data sets were divided into two phases called Pre-pandemic phase (January to February) and Pandemic phase (March to November). One month is selected as starting data in the Pre-pandemic phase while two months are selected in the Pandemic phase.

For PPS, producer price per commodity/product for February, March and June of the December 2020 preliminary release was used.

B. Construction of Complete and Pseudo-incomplete Datasets

Complete data set and pseudo-incomplete data set are the two types of data set used in the simulation. Both data sets should come from the revised release and should contain the following information by sample establishment:

1. ECN
2. Establishment name (optional)
3. Industry class
4. Industry group
5. Current and previous month's producer price

For each of the selected starting data sets, complete data set that contains only the sample establishments with actual value for the current month is created. Also, the previous month's value of these sample establishments, whether imputed or not, is retained.

The inverse of the computed response rate determines the percentage of missing data or sample establishments to be remove from the complete data set.

For PPS, the percentage of sample establishments removed from the complete data set are 20%, 40% and 60%. These data sets are now the pseudo-incomplete datasets.

3.2 Simulation Procedure

The complete data set will be used to simulate 500 pseudo-incomplete data sets for each of the 3 different percentages of missing data. Selection of sample establishment from the complete data set should have no replacement. Therefore, in every pseudo-incomplete data set per percentage of missing data, there are different set of missing values of sample establishments. These missing values from the pseudo-incomplete data set are imputed using LOCF and geometric mean.

After the creation of simulated pseudo-incomplete data sets, necessary computations are done to estimate the bias of using the two imputation techniques. Also, bias is computed for pseudo-incomplete data sets without using imputation. In this case,

missing values are treated as zero. This is to determine if imputation is necessary to produce estimates with a lower bias.

3.3 Bias Computation

For each of the incomplete data set by imputation technique and percentage of missing data, one of the measures of accuracy which is the Mean Absolute Percentage Error (MAPE) is computed using the following formula:

$$MAPE = \frac{\sum_{i=1}^{n} \left| \frac{(Y_i - \hat{Y}_i)}{Y_i} \right|}{n} * 100$$

where,

Y_i = actual weighted producer price
$\hat{Y}_i$ = imputed weighted average producer price
n = number of establishments

The average MAPE by imputation technique and percentage of missing data is then computed as follows:

$$Average\_MAPE = \frac{\sum_{i=1}^{b} MAPE}{b}$$

where,

b = number of incomplete data sets (500)

The imputation technique that has the lowest average bias is considered the best imputation technique. The best imputation technique may vary per industry class and industry group.

4.0 Results and Discussions

The results of the bias computation using the two imputation techniques are presented in this section. For the tabular values of the average bias (percent) by imputation technique, phase, and industry description refer to Annex A.

4.1 Manufacturing Sector

For both the pre-pandemic phase and pandemic phase, higher bias can be observed if no imputation is performed, as illustrated in figure 1.1. For the period of February 2020 and May 2020, the average bias increases as the percentage of missing data also increases. Marginally higher bias is observed using geometric mean than using LOCF for the Pandemic phase (March and June 2020) as opposed with the Pre-pandemic phase (February 2020) which marginally higher bias is observed using LOCF.

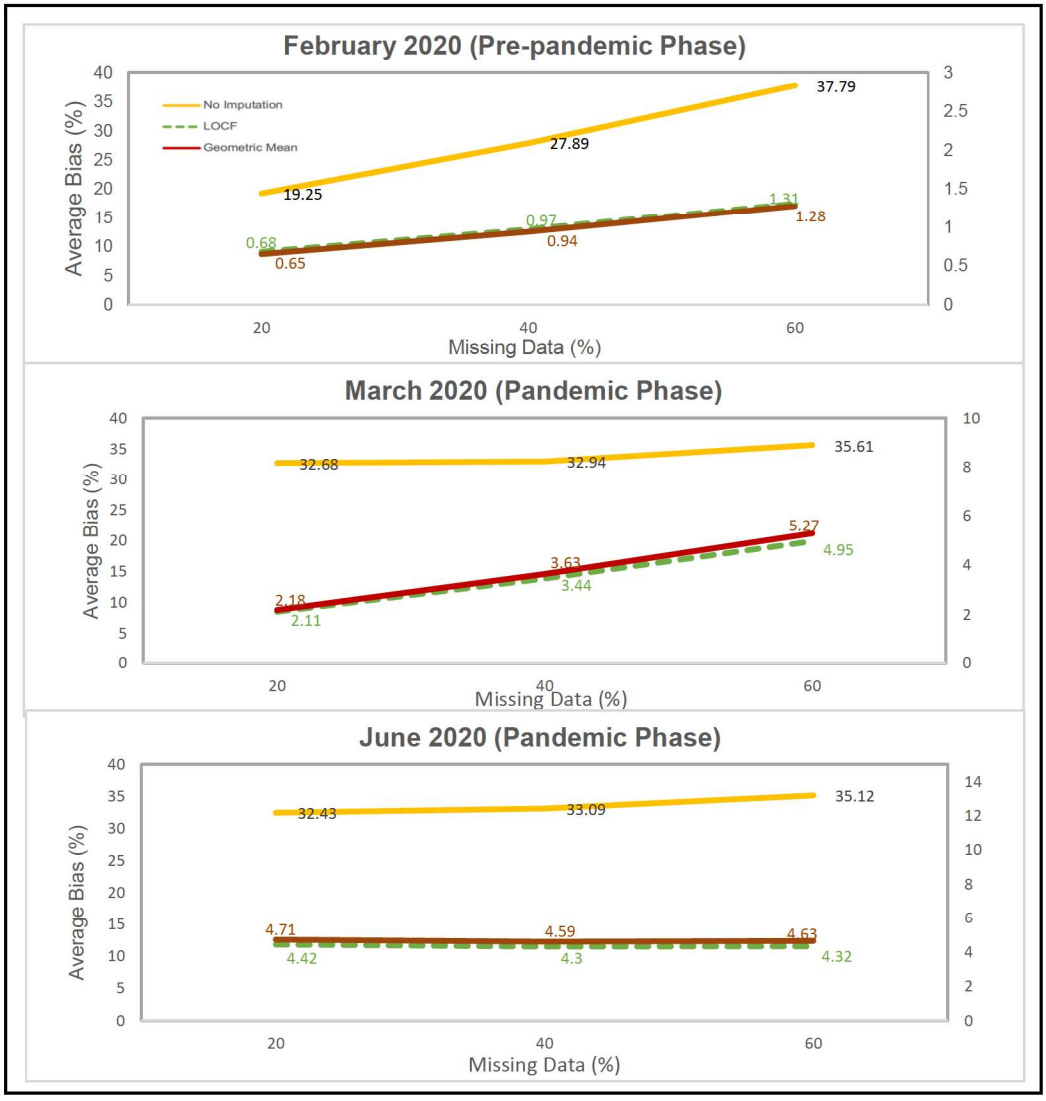

Figure 1.1. Average Bias by Percentage of Missing Data in the Pre-pandemic and Pandemic Phases for the Manufacturing Sector.

4.2 Industry Division

In the Pre-pandemic phase, higher bias can be observed if no imputation is performed and generally, average bias increases as the percentage of missing data also increases for all industry division (*See figure 2.1*).

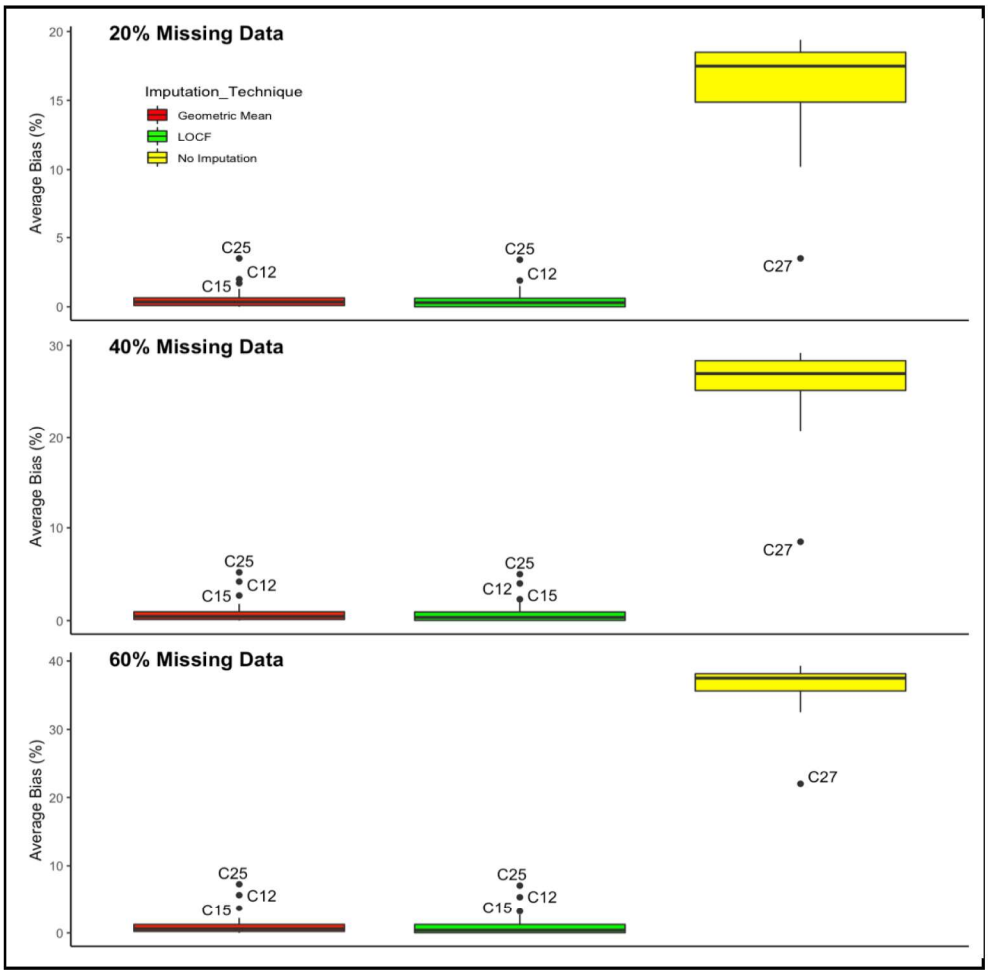

Figure 2.1. Boxplot of the Average Bias of all Industry Divisions by Percentage of Missing Data in the Pre-pandemic Phase.

The industry divisions that have significantly different average bias using geometric mean and LOCF are *Manufacture of tobacco products* (C12), *Manufacture of leather and related products* (C15), *and Manufacture of fabricated metals except machinery and equipment* (C25). These notable industry divisions are almost consistently observed on other percentages of missing data. Nevertheless, the average bias using either of the two imputation techniques is still less than 10%.

For the period of March (Pandemic phase), higher bias can still be observed if no imputation is performed for all industry division and generally, average bias is higher compared to the Pre-pandemic phase (*See figure 2.2*).

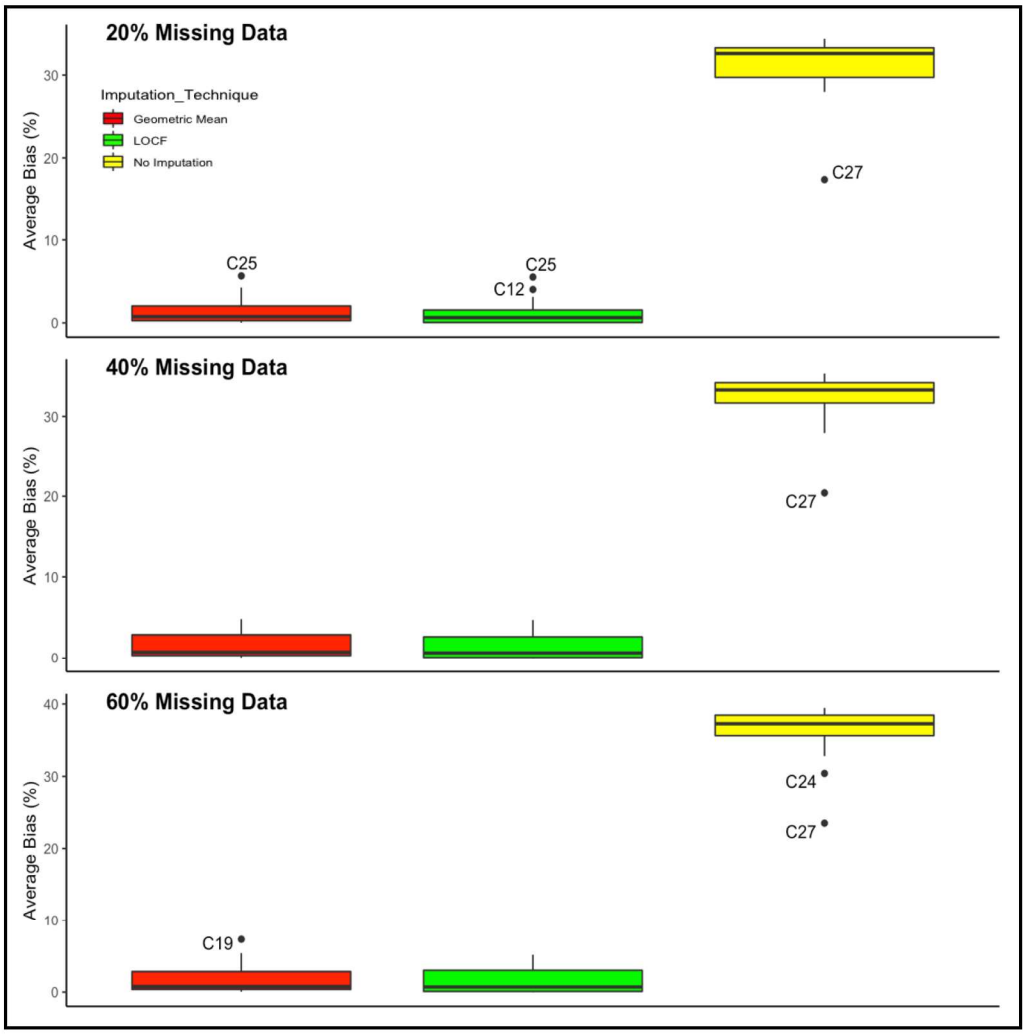

Figure 2.2. Boxplot of the Average Bias of all Industry Divisions by Percentage of Missing Data for the Period of March 2020 (Pandemic Phase).

The average bias by industry division using geometric mean is marginally higher than LOCF for scenarios with 20% and 40% missing data. Also, there are industry divisions, varying on the percentage of missing data, that has significantly different average bias using geometric mean and LOCF, namely, *Manufacture of tobacco products* (C12), *Manufacture of coke and refined petroleum products* (C19), *and Manufacture of fabricated metals except machinery and equipment* (C25). The aforementioned industry divisions together with the remaining industry divisions have an average bias less than 10% using either of the two imputation techniques.

For the period of June (Pandemic Phase), consistently higher bias is observed if no imputation is performed for all industry division and higher bias is also observed compared to the Pre-pandemic phase.

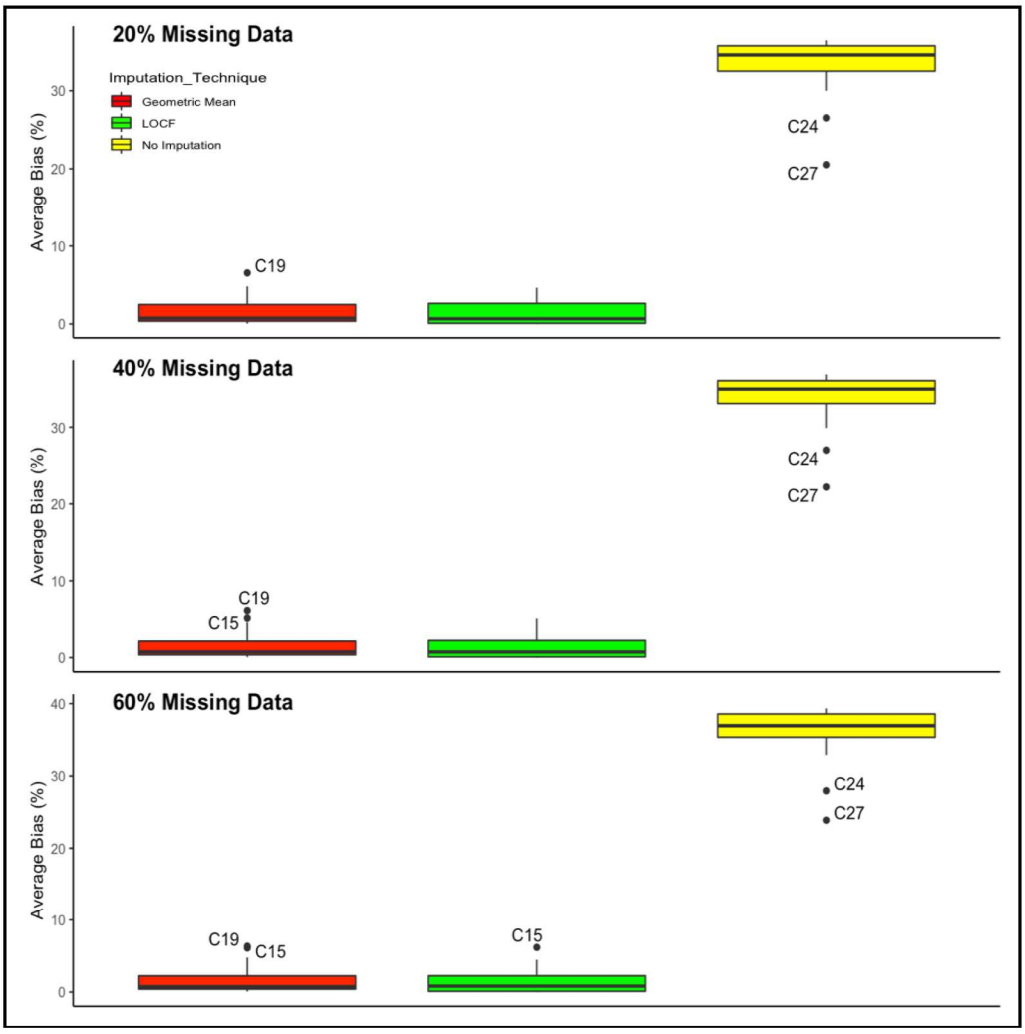

Figure 2.3. Boxplot of the Average Bias of all Industry Divisions by Percentage of Missing Data for the Period of March 2020 (Pandemic Phase).

Also in figure 2.3, wider range of average bias by industry division using LOCF is observed than geometric mean for all percentages of missing data. Also, there are common industry divisions, varying on the percentage of missing data, that has significantly different average bias using geometric mean and LOCF, namely, *Manufacture of leather and related products, including footwear* (C15) and *Manufacture of coke and refined petroleum products* (C19). The aforementioned industry divisions together with the remaining industry divisions also have an average bias less than 10% using either of the two imputation techniques for the period of June.

4.3 Industry Group

As illustrated in figure 3.1, higher bias can be observed during the pre-pandemic phase if no imputation is performed and generally, average bias increases as the percentage of missing data also increases for all industry group. Some of the industry groups that have significantly different average bias using geometric mean and LOCF are *Manufacture of other fabricated metal products* (C259), *Manufacture of glass and glass products* (C231), *and Manufacture of electric components* (C261). These notable industry groups are almost consistently observed on other percentages of missing

data. Even so, the average bias using either of the two imputation techniques is still less than 10%.

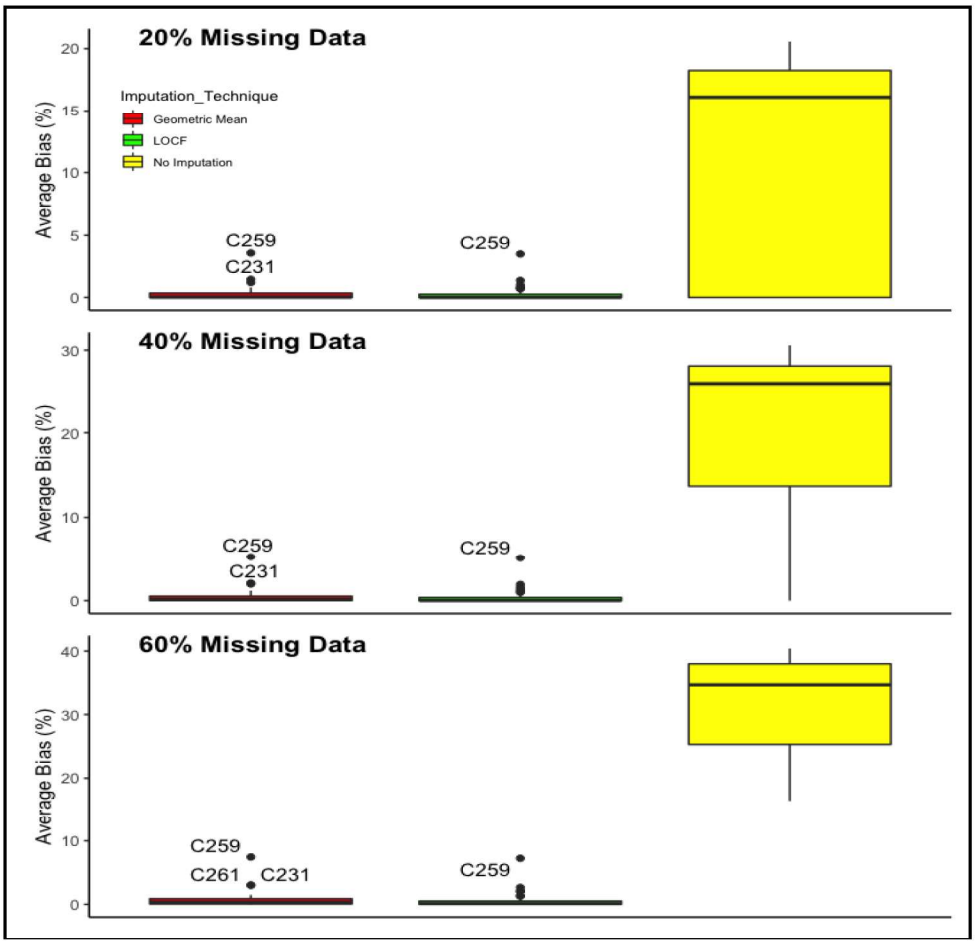

Figure 3.1. Boxplot of the Average Bias of all Industry Groups by Percentage of Missing Data in the Pre-pandemic Phase.

For the period of March (Pandemic phase), higher bias can still be observed if no imputation is performed for all industry groups and generally, average bias is slightly higher compared to the Pre-pandemic phase. The average bias by industry group using geometric mean is marginally higher than LOCF for the three varying percentages of missing data. Some of the industry groups that have significantly different average bias using geometric mean and LOCF are *Manufacture of other fabricated metal products* (C259), *Manufacture of electric components* (C261), and *Manufacture of motor vehicles, trailers and semi-trailers* (C291-293), as seen in figure 3.2. Also, the aforementioned industry groups together with the remaining industry groups still have an average bias less than 10% using either of the two imputation techniques.

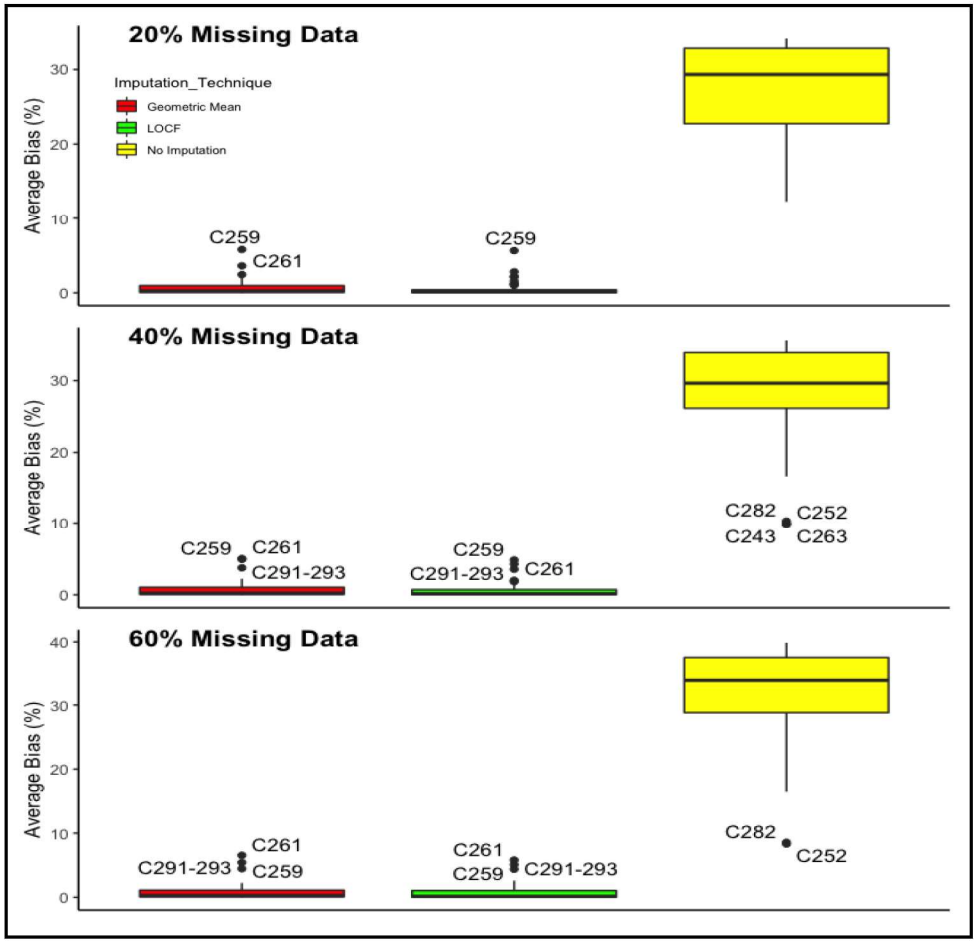

Figure 3.2. Boxplot of the Average Bias of all Industry Groups by Percentage of Missing Data for the Period of March 2020 (Pandemic Phase).

Lastly, for the period of June in the pandemic phase, higher bias is consistently observed if no imputation is performed for all industry groups, as illustrated in figure 3.3. Comparing to the pre-pandemic phase, the average bias from June period is slightly higher using both of two imputation techniques. Same with the March period, the average bias by industry group using geometric mean is marginally higher than LOCF for the three varying percentages of missing data. The industry groups that have significantly different average bias using geometric mean and LOCF are *Manufacture of other fabricated metal products* (C259), *Manufacture of electric components* (C261), and *Manufacture of motor vehicles, trailers and semi-trailers* (C291-293). These industry groups together with the remaining industry groups consistently have an average bias less than 10% using either of the two imputation techniques.

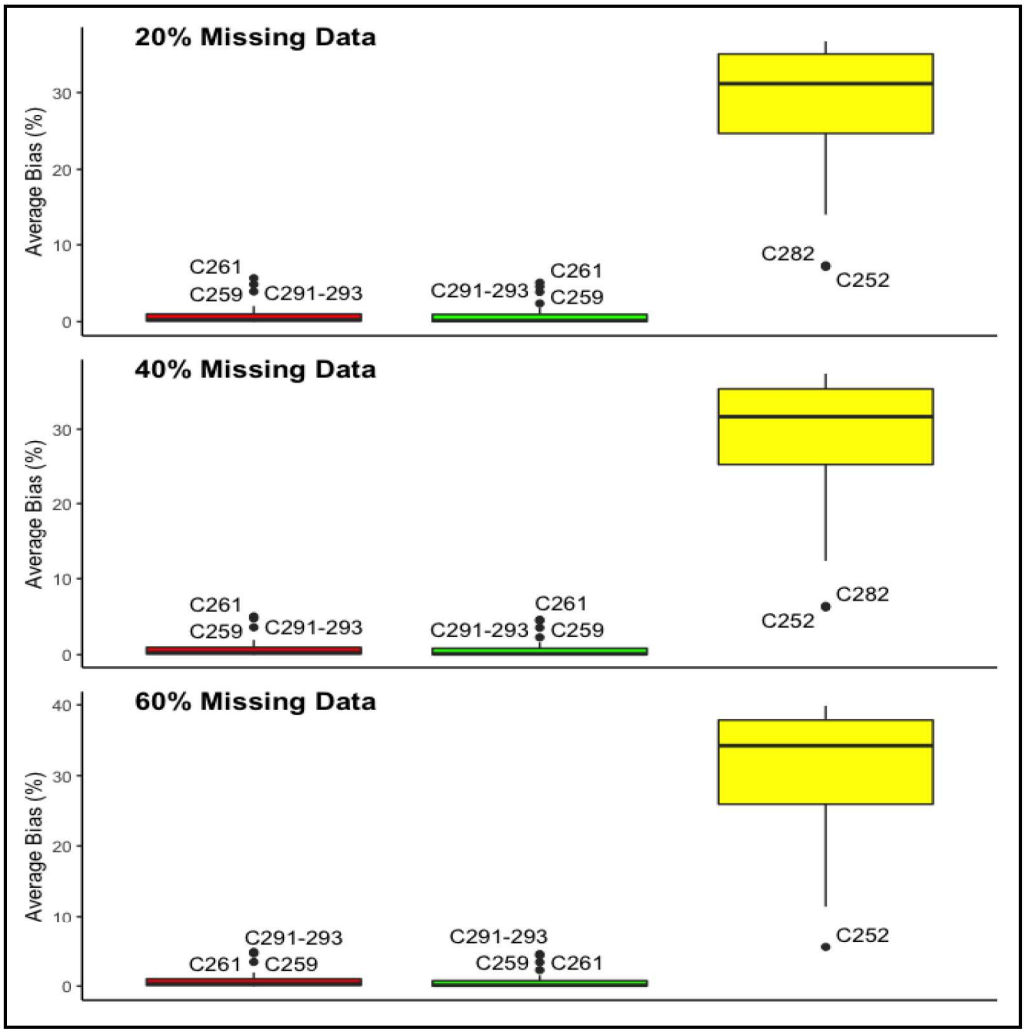

Figure 3.3. Boxplot of the Average Bias of all Industry Groups by Percentage of Missing Data for the Period of June 2020 (Pandemic Phase).

5.0 Summary and Conclusions

Based on the results of the study, it is concluded that the bias increases as the percentage of missing data increases and not applying imputation significantly increases the bias by manufacturing sector, industry division, and industry group. In terms of the phase, imputation on a non-pandemic month yields lower bias than on a pandemic month.

Further, Table 1.1 below shows which imputation technique has lower average bias by phase, manufacturing sector, industry division, and industry group in general.

Table 1.1 Summary of Results by Phase for Manufacturing Sector, Industry Division and Industry Group

Industry	Pre-pandemic Phase	Pandemic Phase	
	February	May	June
Manufacturing	Geometric Mean	LOCF	LOCF
Division	LOCF	LOCF	LOCF
Group	LOCF	LOCF	LOCF

Evidently, LOCF yield higher accuracy than geometric mean in imputing producer price of non-responding establishments. Hence, LOCF is the best imputation technique appropriate for PPS.

6.0 Recommendation

Further study comparing the accuracy of using LOCF on non-responding establishments to other imputation techniques such as hot deck and cold deck is recommended.

7.0 References

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ANNEX A

Table 2.1 Average Bias by Imputation Technique, Percentage of Missing Data, and Industry Description: February 2020 (Pre-pandemic Phase)

Industry Description	Average Bias (%) per Percentage of Missing Data								
	20%			40%			60%		
	w/o	LOCF	GM	w/o	LOCF	GM	w/o	LOCF	GM
C Total Manufacturing	19.25	0.68	0.65	27.89	0.97	0.94	37.79	1.31	1.28
C10 Manufacture of food products	15.44	0.42	0.42	26.44	0.61	0.62	36.56	0.77	0.77
C101 Processing and preserving of meat	12.28	0.00	0.01	25.98	0.01	0.02	34.70	0.01	0.03
C102 Processing and preserving of fish, crustaceans and mollusks	11.16	0.47	0.53	22.43	0.74	0.92	33.46	0.84	1.26
C103 Processing and preserving of fruits and vegetables	14.25	0.05	0.10	21.91	0.08	0.18	34.03	0.13	0.35
C104 Manufacture of vegetable and animal oils and fats	17.40	0.76	0.80	28.55	1.10	1.20	38.15	1.30	1.48
C105 Manufacture of dairy products	20.56	0.01	0.01	30.58	0.02	0.03	40.41	0.02	0.04
C106 Manufacture of grain mill products, starches and starch products	19.59	0.10	0.14	29.79	0.15	0.22	39.91	0.19	0.32
C107 Manufacture of other food products	18.25	0.53	0.51	28.87	0.82	0.78	38.52	1.06	1.00
C108 Manufacture of prepared animal feeds	0.00	0.00	0.00	12.83	0.17	0.28	25.30	0.33	0.54
C11 Manufacture of beverages	16.89	0.04	0.08	25.03	0.05	0.11	36.25	0.07	0.17
C12 Manufacture of tobacco products	12.85	1.90	2.03	26.49	4.00	4.25	35.40	5.36	5.69
C13 Manufacture of textiles	19.29	0.38	0.55	29.06	0.56	0.79	38.18	0.73	1.02
C14 Manufacture of wearing apparel	19.40	1.36	1.32	29.07	2.09	1.77	38.41	2.74	2.16
C15 Manufacture of leather and related products, including footwear	18.53	1.45	1.68	28.89	2.31	2.67	39.24	3.22	3.71
C16 Manufacture of wood, bamboo, cane, rattan articles and related products	17.73	0.02	0.08	27.20	0.03	0.15	38.00	0.04	0.23
C161 Sawmilling and planing of wood	16.10	0.00	0.00	24.28	0.00	0.00	32.49	0.00	0.00
C162 Manufacture of products of wood, cork, straw and plaiting materials	17.73	0.02	0.08	27.20	0.03	0.15	38.00	0.04	0.24

C17 Manufacture of paper and paper products	17.51	0.09	0.18	28.84	0.13	0.29	38.62	0.15	0.37
C18 Printing and reproduction of recorded media	10.19	0.00	0.00	21.17	0.00	0.00	32.66	0.00	0.00
C19 Manufacture of coke and refined petroleum products	11.63	0.04	0.14	24.30	0.05	0.30	32.47	0.06	0.44
C20 Manufacture of chemical and chemical products	19.10	0.38	0.40	28.21	0.46	0.51	37.61	0.50	0.62
C201 Manufacture of basic chemicals	19.09	0.51	0.56	28.11	0.65	0.73	37.28	0.75	0.89
C202, C203 Manufacture of other chemical products, n.e.c.	19.11	0.26	0.16	28.43	0.38	0.23	38.32	0.52	0.34
C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	19.40	0.00	0.14	29.24	0.00	0.21	39.34	0.00	0.29
C22 Manufacture of rubber and plastic products	16.65	0.01	0.22	26.49	0.01	0.35	36.30	0.02	0.48
C221 Manufacture of rubber products	16.93	0.02	0.34	26.29	0.02	0.54	35.60	0.03	0.73
C222 Manufacture of plastics products	16.16	0.00	0.03	26.85	0.00	0.05	37.50	0.01	0.08
C23 Manufacture of other non-metallic mineral products	17.45	0.02	0.03	27.29	0.03	0.05	37.36	0.04	0.07
C231 Manufacture of glass and glass products	14.98	1.36	1.45	22.08	1.94	2.11	34.03	2.65	3.03
C239 Manufacture of non-metallic mineral products, n.e.c.	17.47	0.01	0.02	27.35	0.01	0.04	37.39	0.02	0.07
C24 Manufacture of basic metals	17.76	0.80	0.55	28.20	1.23	0.85	37.80	1.61	1.11
C241 Manufacture of basic iron and steel	16.51	0.16	0.14	27.13	0.28	0.22	37.70	0.40	0.34
C242 Manufacture of basic precious and other non-ferrous metals	18.19	1.01	0.69	28.60	1.59	1.07	37.87	2.11	1.41
C243 Casting of metals	0.00	0.00	0.00	0.00	0.00	0.00	16.41	0.08	0.08
C25 Manufacture of fabricated metal products, except machinery and equipment	17.93	3.40	3.48	26.70	5.03	5.16	37.88	7.07	7.27
C251 Manufacture of structural metal products, tanks, reservoirs and steam generators	0.00	0.00	0.00	13.68	0.00	0.02	25.72	0.01	0.03

C252 Manufacture of weapons and ammunition	0.00	0.00	0.00	0.00	0.00	0.00	16.63	0.40	1.35
C259 Manufacture of other fabricated metal products; metal working service activities	18.35	3.48	3.56	27.06	5.14	5.28	38.20	7.23	7.44
C26 Manufacture of computer, electronic and optical products	10.42	0.44	0.65	20.70	0.74	1.08	32.67	1.11	1.64
C261 Manufacture of electronic components	15.61	0.80	1.20	25.08	1.35	1.99	36.69	2.02	3.00
C262 Manufacture of computers and peripheral equipment and accessories	0.00	0.00	0.00	11.68	0.01	0.01	24.75	0.03	0.02
C263 Manufacture of communication equipment	0.00	0.00	0.00	0.00	0.00	0.00	16.45	0.25	0.32
C264 Manufacture of consumer electronics	19.71	0.00	0.02	28.97	0.00	0.03	38.67	0.00	0.04
C265-C268 Manufacture of computer, electronic and optical products, n.e.c.	18.69	0.12	0.35	29.11	0.18	0.52	39.18	0.25	0.65
C27 Manufacture of electrical equipment	3.54	0.00	0.02	8.50	0.01	0.04	21.97	0.03	0.08
C271 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	18.73	0.00	0.14	28.54	0.01	0.22	38.63	0.01	0.30
C272 Manufacture of batteries and accumulators	0.00	0.00	0.00	16.56	0.00	0.00	22.08	0.00	0.00
C273 Manufacture of wiring and wiring devices	0.00	0.00	0.00	11.25	0.09	0.11	23.42	0.19	0.23
C274 Manufacture of electric lighting equipment	17.17	0.01	0.03	25.86	0.02	0.04	34.46	0.02	0.06
C275 Manufacture of domestic appliances	0.00	0.00	0.00	16.53	0.00	0.00	22.04	0.00	0.00
C279 Manufacture of other electrical equipment	0.00	0.00	0.00	0.00	0.00	0.00	16.63	0.03	0.07
C28 Manufacture of machinery and equipment except electrical	14.65	0.05	0.05	22.02	0.07	0.10	34.01	0.10	0.24
C281 Manufacture of general-purpose machinery	14.99	0.05	0.05	22.53	0.07	0.10	34.40	0.10	0.25
C282 Manufacture of special purpose machinery	0.00	0.00	0.00	0.00	0.00	0.00	17.13	0.00	0.00

C29, C30 Manufacture of transport equipment	19.24	0.68	0.66	27.91	0.99	0.96	37.79	1.33	1.30
C291-C293 Manufacture of motor vehicles, trailers, and semi-trailers	19.37	0.69	0.66	28.01	0.99	0.96	37.87	1.34	1.31
C301-C309 Manufacture of other transport equipment	0.00	0.00	0.00	13.48	0.14	0.26	25.93	0.24	0.44
C31 Manufacture of furniture	18.51	0.16	0.25	28.36	0.22	0.43	38.28	0.27	0.66
C32, C33 Other manufacturing	17.53	0.35	0.36	25.52	0.49	0.48	36.74	0.69	0.62

Table 2.2 Average Bias by Imputation Technique, Percentage of Missing Data, and Industry Description: March 2020 (Pandemic Phase)

Industry Description	**Average Bias (%) per Percentage of Missing Data**								
	20%			**40%**			**60%**		
	w/o	**LOCF**	**GM**	**w/o**	**LOCF**	**GM**	**w/o**	**LOCF**	**GM**
C Total Manufacturing	32.68	2.11	2.18	32.94	3.44	3.63	35.61	4.95	5.27
C10 Manufacture of food products	31.66	0.71	0.71	32.88	0.77	0.76	37.00	0.88	0.85
C101 Processing and preserving of meat	28.76	0.02	0.04	29.63	0.04	0.06	33.84	0.07	0.09
C102 Processing and preserving of fish, crustaceans and mollusks	27.87	0.82	1.14	29.12	0.94	1.25	33.58	1.11	1.51
C103 Processing and preserving of fruits and vegetables	29.09	0.11	0.28	29.18	0.11	0.24	34.03	0.11	0.24
C104 Manufacture of vegetable and animal oils and fats	33.05	1.18	1.31	34.31	1.28	1.42	38.08	1.49	1.63
C105 Manufacture of dairy products	33.06	0.03	0.06	33.22	0.05	0.10	37.01	0.09	0.16
C106 Manufacture of grain mill products, starches and starch products	34.13	0.28	0.35	35.01	0.47	0.43	38.43	0.70	0.54
C107 Manufacture of other food products	33.57	1.01	0.97	34.47	1.07	1.05	38.68	1.10	1.12
C108 Manufacture of prepared animal feeds	23.75	0.27	0.45	26.91	0.26	0.44	32.26	0.27	0.45
C11 Manufacture of beverages	31.68	0.15	0.21	32.75	0.26	0.29	36.39	0.40	0.44
C12 Manufacture of tobacco products	31.13	4.02	4.27	32.35	3.22	3.41	35.96	2.68	2.84
C13 Manufacture of textiles	32.61	0.58	0.80	32.92	0.52	0.70	37.35	0.53	0.69
C14 Manufacture of wearing apparel	33.85	2.53	2.10	35.28	2.75	2.40	39.44	3.13	2.81
C15 Manufacture of leather and related products, including footwear	34.06	3.13	3.48	35.05	3.65	3.90	38.98	4.42	4.58

C16 Manufacture of wood, bamboo, cane, rattan articles and related products	32.82	0.05	0.25	33.86	0.08	0.33	37.44	0.09	0.43
C161 Sawmilling and planing of wood	28.39	0.00	0.00	29.21	0.00	0.00	32.49	0.00	0.00
C162 Manufacture of products of wood, cork, straw and plaiting materials	32.83	0.05	0.25	33.86	0.08	0.33	37.44	0.09	0.43
C17 Manufacture of paper and paper products	33.04	0.15	0.33	33.79	0.17	0.33	37.90	0.21	0.35
C18 Printing and reproduction of recorded media	28.12	0.00	0.03	28.43	0.00	0.06	32.84	0.00	0.11
C19 Manufacture of coke and refined petroleum products	27.93	1.12	1.87	27.95	2.63	3.93	32.80	5.17	7.31
C20 Manufacture of chemical and chemical products	33.36	0.91	0.93	34.59	1.47	1.34	38.79	2.15	1.83
C201 Manufacture of basic chemicals	33.11	1.18	1.21	34.28	1.82	1.67	38.50	2.60	2.24
C202, C203 Manufacture of other chemical products, n.e.c.	33.94	0.40	0.29	35.63	0.33	0.29	39.88	0.29	0.31
C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	34.35	0.00	0.32	35.30	0.00	0.43	39.34	0.01	0.60
C22 Manufacture of rubber and plastic products	32.55	0.02	0.38	34.18	0.01	0.35	38.55	0.01	0.35
C221 Manufacture of rubber products	32.02	0.02	0.58	33.72	0.02	0.52	38.10	0.02	0.52
C222 Manufacture of plastics products	33.47	0.01	0.07	35.00	0.01	0.07	39.39	0.01	0.08
C23 Manufacture of other non-metallic mineral products	32.76	0.04	0.07	33.61	0.03	0.07	37.54	0.03	0.08
C231 Manufacture of glass and glass products	29.87	2.16	2.44	30.55	2.00	2.22	33.74	2.04	2.21
C239 Manufacture of non-metallic mineral products, n.e.c.	32.80	0.02	0.06	33.65	0.02	0.06	37.59	0.02	0.08
C24 Manufacture of basic metals	29.13	1.21	0.83	29.56	1.26	0.84	30.41	1.29	0.84
C241 Manufacture of basic iron and steel	32.40	0.30	0.26	33.90	0.25	0.22	37.51	0.22	0.20
C242 Manufacture of basic precious and other non-ferrous metals	28.41	1.58	1.06	28.65	1.62	1.06	28.81	1.66	1.06
C243 Casting of metals	12.30	0.06	0.06	9.84	0.05	0.05	16.58	0.09	0.19
C25 Manufacture of fabricated metal	33.49	5.52	5.66	34.15	4.71	4.82	37.19	4.28	4.36

products, except machinery and equipment									
C251 Manufacture of structural metal products, tanks, reservoirs and steam generators	19.29	0.01	0.02	20.90	0.01	0.05	25.72	0.02	0.08
C252 Manufacture of weapons and ammunition	12.47	0.30	1.01	9.98	0.24	0.81	8.31	0.20	0.68
C259 Manufacture of other fabricated metal products; metal working service activities	33.82	5.64	5.79	34.46	4.82	4.93	37.47	4.38	4.46
C26 Manufacture of computer, electronic and optical products	29.19	1.67	2.12	31.43	2.62	3.04	35.78	3.61	3.99
C261 Manufacture of electronic components	32.45	2.81	3.61	34.23	4.26	5.01	38.05	5.80	6.54
C262 Manufacture of computers and peripheral equipment and accessories	23.07	0.18	0.30	26.44	0.41	0.79	31.84	0.68	1.43
C263 Manufacture of communication equipment	12.34	0.18	0.24	9.87	0.15	0.19	16.45	0.15	0.21
C264 Manufacture of consumer electronics	29.00	0.00	0.03	27.98	0.00	0.03	31.37	0.00	0.03
C265-C268 Manufacture of computer, electronic and optical products, n.e.c.	33.97	0.41	0.77	35.04	0.72	1.10	38.96	1.06	1.49
C27 Manufacture of electrical equipment	17.38	0.02	0.06	20.41	0.02	0.06	23.50	0.02	0.05
C271 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	32.36	0.01	0.23	31.40	0.01	0.19	35.46	0.00	0.16
C272 Manufacture of batteries and accumulators	16.56	0.00	0.00	19.87	0.00	0.00	22.08	0.00	0.00
C273 Manufacture of wiring and wiring devices	22.72	0.16	0.20	26.14	0.16	0.20	31.72	0.17	0.22
C274 Manufacture of electric lighting equipment	29.33	0.02	0.04	29.22	0.01	0.03	33.80	0.01	0.03
C275 Manufacture of domestic appliances	16.53	0.00	0.00	19.87	0.00	0.00	22.10	0.00	0.00
C279 Manufacture of other electrical equipment	12.47	0.02	0.05	16.65	0.02	0.05	19.43	0.03	0.05
C28 Manufacture of machinery and	29.25	0.08	0.21	29.41	0.09	0.22	34.20	0.10	0.27

equipment except electrical									
C281 Manufacture of general-purpose machinery	29.55	0.09	0.22	29.65	0.09	0.22	34.40	0.10	0.27
C282 Manufacture of special purpose machinery	12.85	0.00	0.00	10.28	0.00	0.00	8.57	0.00	0.00
C29, C30 Manufacture of transport equipment	32.68	2.15	2.22	32.94	3.52	3.71	35.58	5.06	5.39
C291-C293 Manufacture of motor vehicles, trailers, and semi-trailers	32.77	2.17	2.24	33.03	3.54	3.74	35.65	5.10	5.43
C301-C309 Manufacture of other transport equipment	19.45	0.18	0.33	20.94	0.19	0.35	25.92	0.23	0.41
C31 Manufacture of furniture	33.73	0.26	0.57	35.03	0.29	0.56	39.26	0.33	0.60
C32, C33 Other manufacturing	32.58	0.93	0.91	33.95	1.41	1.40	38.17	1.98	1.95

Table 2.3 Average Bias by Imputation Technique, Percentage of Missing Data, and Industry Description: June 2020 (Pandemic Phase)

Industry Description	**Average Bias (%) per Percentage of Missing Data**								
	20%			**40%**			**60%**		
	w/o	**LOCF**	**GM**	**w/o**	**LOCF**	**GM**	**w/o**	**LOCF**	**GM**
C Total Manufacturing	32.43	4.42	4.71	33.09	4.30	4.59	35.12	4.32	4.63
C10 Manufacture of food products	33.87	0.77	0.75	34.23	0.69	0.69	36.73	0.63	0.65
C101 Processing and preserving of meat	30.91	0.06	0.08	31.76	0.06	0.07	33.74	0.05	0.06
C102 Processing and preserving of fish, crustaceans and mollusks	30.39	0.96	1.30	30.88	0.85	1.16	33.71	0.77	1.07
C103 Processing and preserving of fruits and vegetables	31.21	0.11	0.23	31.00	0.11	0.23	34.03	0.12	0.28
C104 Manufacture of vegetable and animal oils and fats	35.12	1.30	1.43	35.69	1.17	1.31	38.10	1.09	1.26
C105 Manufacture of dairy products	33.30	0.07	0.14	33.37	0.06	0.13	35.87	0.06	0.12
C106 Manufacture of grain mill products, starches and starch products	35.14	0.64	0.51	35.34	0.63	0.54	37.85	0.63	0.59
C107 Manufacture of other food products	35.88	0.98	1.00	36.23	0.92	0.93	38.66	0.89	0.90
C108 Manufacture of prepared animal feeds	27.65	0.23	0.39	27.40	0.24	0.40	29.94	0.28	0.47
C11 Manufacture of beverages	33.75	0.37	0.43	34.16	0.38	0.46	36.43	0.41	0.53
C12 Manufacture of tobacco products	33.12	2.30	2.50	33.07	2.01	2.30	36.23	1.79	2.25

C13 Manufacture of textiles	34.52	0.57	0.77	34.85	0.77	1.08	36.73	1.01	1.47
C14 Manufacture of wearing apparel	36.03	2.74	2.47	36.15	2.51	2.29	38.58	2.38	2.22
C15 Manufacture of leather and related products, including footwear	36.19	4.52	4.64	36.46	5.20	5.24	38.71	6.18	6.10
C16 Manufacture of wood, bamboo, cane, rattan articles and related products	34.79	0.09	0.40	35.47	0.10	0.41	38.23	0.11	0.45
C161 Sawmilling and planing of wood	30.68	0.00	0.00	31.78	0.00	0.00	34.85	0.00	0.00
C162 Manufacture of products of wood, cork, straw and plaiting materials	34.79	0.09	0.40	35.47	0.10	0.41	38.23	0.11	0.45
C17 Manufacture of paper and paper products	35.30	0.23	0.34	35.80	0.28	0.35	38.54	0.35	0.39
C18 Printing and reproduction of recorded media	29.98	0.00	0.10	30.90	0.00	0.08	33.06	0.00	0.07
C19 Manufacture of coke and refined petroleum products	30.15	4.65	6.55	29.89	4.38	6.19	32.89	4.35	6.33
C20 Manufacture of chemical and chemical products	36.12	1.96	1.67	36.55	1.88	1.60	39.13	1.87	1.57
C201 Manufacture of basic chemicals	35.94	2.37	2.04	36.34	2.28	1.95	38.93	2.26	1.92
C202, C203 Manufacture of other chemical products, n.e.c.	36.72	0.25	0.27	37.36	0.21	0.24	39.87	0.19	0.21
C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations	36.49	0.01	0.57	36.82	0.01	0.59	39.34	0.01	0.65
C22 Manufacture of rubber and plastic products	35.86	0.01	0.31	36.38	0.01	0.29	38.82	0.02	0.28
C221 Manufacture of rubber products	35.70	0.02	0.46	36.30	0.02	0.43	38.93	0.03	0.42
C222 Manufacture of plastics products	36.18	0.01	0.07	36.53	0.01	0.06	38.65	0.01	0.06
C23 Manufacture of other non-metallic mineral products	34.73	0.03	0.08	35.13	0.03	0.10	37.68	0.03	0.13
C231 Manufacture of glass and glass products	31.41	1.78	1.93	31.66	1.62	1.74	33.65	1.52	1.61
C239 Manufacture of non-metallic mineral products, n.e.c.	34.77	0.02	0.08	35.17	0.02	0.10	37.73	0.02	0.13
C24 Manufacture of basic metals	26.52	1.11	0.73	27.02	1.15	0.78	27.94	1.19	0.83

C241 Manufacture of basic iron and steel	34.57	0.22	0.21	34.73	0.24	0.24	37.40	0.27	0.29
C242 Manufacture of basic precious and other non-ferrous metals	24.69	1.42	0.91	25.32	1.46	0.97	25.80	1.50	1.02
C243 Casting of metals	14.21	0.08	0.17	12.43	0.07	0.14	16.63	0.09	0.22
C25 Manufacture of fabricated metal products, except machinery and equipment	34.77	3.78	3.85	35.02	3.47	3.53	36.95	3.30	3.35
C251 Manufacture of structural metal products, tanks, reservoirs and steam generators	22.04	0.02	0.07	22.71	0.02	0.06	25.72	0.01	0.06
C252 Manufacture of weapons and ammunition	7.13	0.17	0.58	6.23	0.15	0.51	5.54	0.13	0.45
C259 Manufacture of other fabricated metal products; metal working service activities	35.07	3.86	3.93	35.31	3.55	3.61	37.23	3.37	3.42
C26 Manufacture of computer, electronic and optical products	33.45	3.17	3.46	34.20	2.92	3.08	36.94	2.78	2.83
C261 Manufacture of electronic components	35.52	5.08	5.66	36.01	4.61	5.04	38.56	4.33	4.63
C262 Manufacture of computers and peripheral equipment and accessories	29.87	0.64	1.26	31.14	0.67	1.15	34.23	0.74	1.09
C263 Manufacture of communication equipment	14.10	0.13	0.18	12.34	0.11	0.16	16.45	0.23	0.18
C264 Manufacture of consumer electronics	29.86	0.00	0.17	30.98	0.00	0.37	34.00	0.00	0.60
C265-C268 Manufacture of computer, electronic and optical products, n.e.c.	36.02	0.95	1.29	36.43	0.92	1.14	38.89	0.93	1.03
C27 Manufacture of electrical equipment	20.52	0.02	0.05	22.17	0.05	0.06	23.87	0.07	0.08
C271 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	32.35	0.00	0.14	33.16	0.00	0.12	35.06	0.00	0.11
C272 Manufacture of batteries and accumulators	18.93	0.00	0.00	20.70	0.00	0.00	22.08	0.00	0.00
C273 Manufacture of wiring and wiring devices	27.18	0.15	0.19	26.61	0.13	0.16	28.97	0.11	0.15
C274 Manufacture of electric lighting equipment	30.96	0.01	0.02	30.69	0.01	0.02	33.57	0.01	0.02

C275 Manufacture of domestic appliances	18.94	0.00	0.00	20.73	0.00	0.00	22.12	0.00	0.00
C279 Manufacture of other electrical equipment	16.66	0.02	0.05	18.74	0.07	0.07	20.37	0.10	0.10
C28 Manufacture of machinery and equipment except electrical	31.41	0.09	0.25	31.15	0.09	0.26	34.12	0.10	0.31
C281 Manufacture of general-purpose machinery	31.62	0.09	0.25	31.43	0.09	0.27	34.39	0.10	0.31
C282 Manufacture of special purpose machinery	7.34	0.00	0.00	6.42	0.00	0.00	11.42	0.00	0.00
C29, C30 Manufacture of transport equipment	32.36	4.53	4.82	33.06	4.42	4.72	35.05	4.47	4.78
C291-C293 Manufacture of motor vehicles, trailers, and semi-trailers	32.46	4.56	4.86	33.19	4.47	4.77	35.16	4.53	4.84
C301-C309 Manufacture of other transport equipment	22.21	0.20	0.35	22.80	0.18	0.32	25.91	0.17	0.31
C31 Manufacture of furniture	36.08	0.31	0.54	35.75	0.31	0.51	38.22	0.33	0.51
C32, C33 Other manufacturing	35.58	1.81	1.75	36.07	1.79	1.66	38.66	1.85	1.63