

# **Model-Assisted Approach to Estimate Production of the Manufacturing Sector in the Philippines from the Monthly Integrated Survey of Selected Industries**

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## **Abstract**

The Monthly Integrated Survey of Selected Industries (MISSI), which is conducted by the Philippine Statistics Authority, is a national survey with 920 sample establishments. The survey generates indices on value and volume of production of the manufacturing sector to measure their changes over time. Aside from these indices, it is also relevant to generate high-frequency level of production to further monitor the manufacturing sector. However, MISSI is not designed to generate reliable levels of production as it utilizes a cut-off sampling design with value of production as the cut-off variable. Hence, the level of production from MISSI survey-based results will be biased upward as the sample establishments of the survey are the big players of the manufacturing sector.

This study proposes a model-assisted approach in the estimation of production using the results of the MISSI, instead of conducting a separate survey which requires higher sample size and additional resources. Results indicate that the model-assisted formula generates reliable estimate of level of production and reduces the upward bias from the MISSI survey-based results.

## **1. Introduction**

The manufacturing sector of a country has an important role in its economic development. This is particularly true in developing countries like the Philippines whose manufacturing sector contributes 16.4 percent to 20.8 percent of the national GDP on average from 2018 to 2022 (PSA, 2022). As a major driver of economic growth, monitoring the performance of manufacturing through high-frequency statistics could be very beneficial. Challenges arise, however, with the generation of these statistics due to the increasing cost of conducting a survey.

The Philippines' primary source of official statistics on manufacturing comes from the Philippine Statistics Authority (PSA). Several PSA surveys are sources of official statistics for manufacturing. One of these surveys is the Monthly Integrated Survey of Selected Industries (MISSI). This survey collects monthly data on value of production and sales from manufacturing establishments as inputs in the generation of indices and growth rates that measure the performance of the sector in terms of production and sales.

MISSI utilizes a cut-off sampling design with top manufacturing establishments in terms of the value of production as samples.

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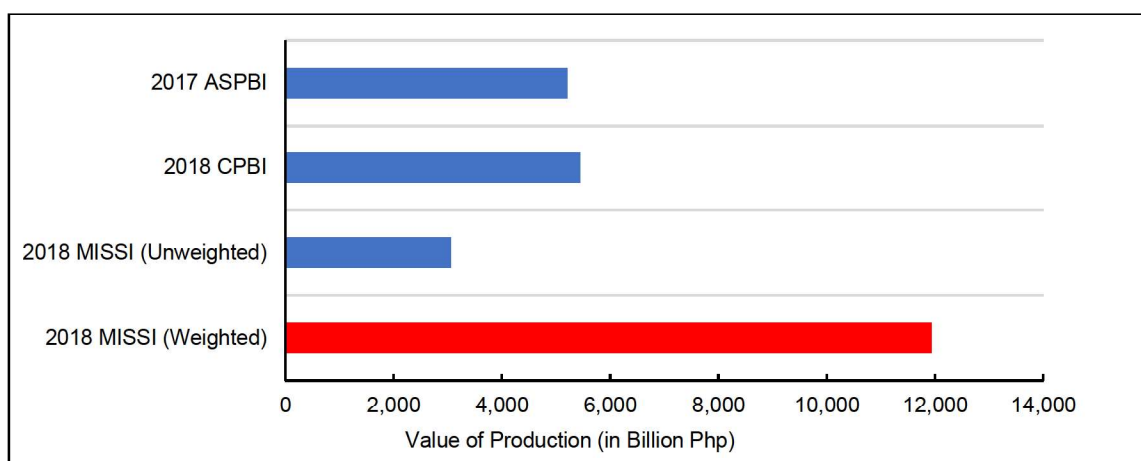
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Particularly, sampled establishments are those with total employment (TE) of 20 and over or large establishments and are within the cut-off threshold. The sampling frame of the MISSI is the Census of Philippine Business and Industry (CPBI) or the Annual Survey of Philippine Business and Industry (ASPBI), depending on the reference year. The ASPBI is conducted annually, except when there is no CPBI. For 2021, the sample size of MISSI is 920 establishments. Annually, the selection of samples is done but within the year, sample establishments are the same.

## 2. Rationale

While the production and sales indices provide information on relative changes and trends, additional information on the estimated levels of production and sales contributes to a more comprehensive analysis of performance. This information, however, cannot be computed accurately using survey-based estimators from the results of the MISSI due to its sampling design which covers only the top producing manufacturing establishments. When using the survey-based estimators, estimates of value of production for the sector tend to be overestimated as shown by the red horizontal bar in Figure 1. The estimate of the value of production for 2018 using the survey-based is far higher than the value of production estimated from the 2018 CPBI. (Figure 1).

**Figure 1.** Total Value of Production by Source: 2017, 2018



*CPBI – Census of Philippine Business and Industry; ASPBI – Annual Survey of Philippine Business and Industry*

Another option to generate reliable estimates of value production for the manufacturing sector is to redesign the MISSI, ensuring the selection of sufficient sample size and sample establishments that represent all sizes. However, this option requires a higher sample size of about 3,000 establishments in order to generate reliable estimate of value of production at the national level. This is far from the 920 establishments sample size of MISSI. Hence, redesigning MISSI to generate reliable estimates of value of production will entail higher budgetary requirement.

In view of these, a model-assisted formula was developed to reduce the bias in the value of production from survey-based estimation at no additional cost. Specifically, the study proposes a model-assisted estimator aimed to estimate a finite population parameter using the survey data from MISSI and auxiliary information from the population.



## 2. Model-Assisted Approach

Model-assisted estimation has a wide range of applications. To this day, the rapid development in the field of machine learning uses model-assisted estimation methods for its ability to generate precise estimates (McConville et al., 2020). Similarly, Breidt et al. (2005) used auxiliary information (e.g. GIS data) with penalized spline regression for their model and tested its applicability in the Forest Health Monitoring (FHM) survey.

The model-assisted approach employed in the study involves the formulation of a suitable model using survey data and auxiliary information from the population. This has been shown to ensure the efficiency of estimators while maintaining their design-based properties (Breidt and Opsomer, 2017).

As MISSI only considers a sample of large or those with TE of 20 or more manufacturing establishments, information about the contribution of unsampled large establishments, as well as small manufacturing establishments (those with TE of less than 20), to the total production of the sector is not known. The auxiliary information for the model is chosen to account for these unknown parts of the population. The auxiliary data used in the model came from the ASPBI or CPBI, depending on the reference year.

Estimation was done monthly, and by industry division and group of the manufacturing sector. Currently, 22 divisions and 37 groups comprise the industry classification of the manufacturing sector in MISSI (see Table 1 in Appendix A). Estimates are then aggregated to compute for the total value of production of the sector.

## 3. Determination of the Model-Assisted Formula

The model-assisted formula takes into consideration the known and unknown parts of the population. The general formula for the estimation of the total value of production of manufacturing,  $P$ , is given by:

$$P = P_1 + P_2 \quad (\text{Eq. 1})$$

where  $P_1$  is the value of production from large manufacturing establishments and  $P_2$  is the value of production from small manufacturing establishments.

Likewise, the estimator for  $P_1$  is:

$$P'_1 = \frac{X'}{(1 - a_1)} \quad (\text{Eq. 2})$$

where  $X'$  is the unweighted production of sampled large establishments from MISSI adjusted for non-responding and  $a_1$  is the percent share of unsampled large establishments to the total value of production of large establishments in the sampling frame (CPBI/ASPBI).

Meanwhile, the estimator for  $P_2$  can be represented as:

$$P'_2 = a_2 * P \quad (\text{Eq. 3})$$

where  $a_2$  is the percent share of small establishments to the total value of production,  $P$ , of the manufacturing sector.  $a_2$  is computed from the sampling frame (CPBI/ASPBI).

Incorporating equation 3 and 1, the model-assisted estimator of total value of production,  $\hat{P}$  is denoted by:

$$\hat{P} = \frac{P'_1}{(1 - a_2)} \quad (\text{Eq. 4})$$

This can be summarized further into:

$$\hat{P} = X' * \frac{(1 - a_2)}{(1 - a_1)} \quad (\text{Eq. 5})$$

#### 4. Variance and Precision of Estimates

Model-assisted estimates are evaluated in terms of their precision. Coefficient of variation (CV) are computed considering two cases: independent and dependent variances. The independent case assumes that the random variable,  $X$ , or the monthly value of production of manufacturing establishments is independent while the latter assumes that it is dependent. With the proposed model-assisted formula, the annual variance, assuming an independent case, is given by:

$$Var(\hat{P}_A) = \left( \frac{(1 - a_2)}{(1 - a_1)} \right)^2 * v \left( \sum_{i=1}^{12} X'_i \right) \quad (\text{Eq. 6})$$

where  $X'_i$  is the unweighted value of production for month  $i$ ,  $i = 1, 2, 3, \dots, 12$ .

Meanwhile, assuming dependent case, the annual variance is computed as:

$$Var(\hat{P}_A) = \left( \frac{(1 - a_2)}{(1 - a_1)} \right)^2 \sum_{i=1}^{12} Var(X'_i) + 2 \sum_i \sum_j cov(X'_i, X'_j) \quad (\text{Eq. 7})$$

Likewise, the CV is computed as:

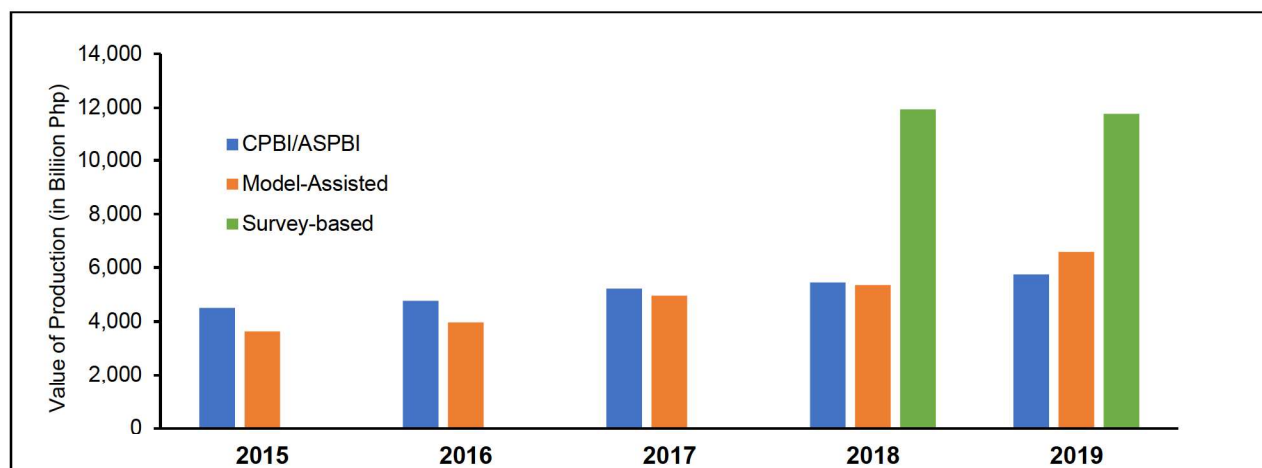
$$CV(\hat{P}_A) = \frac{\sqrt{Var(\hat{P}_A)}}{\hat{P}_A} * 100 \quad (\text{Eq. 8})$$

### 5. Results

#### a. Estimate of Value of Production

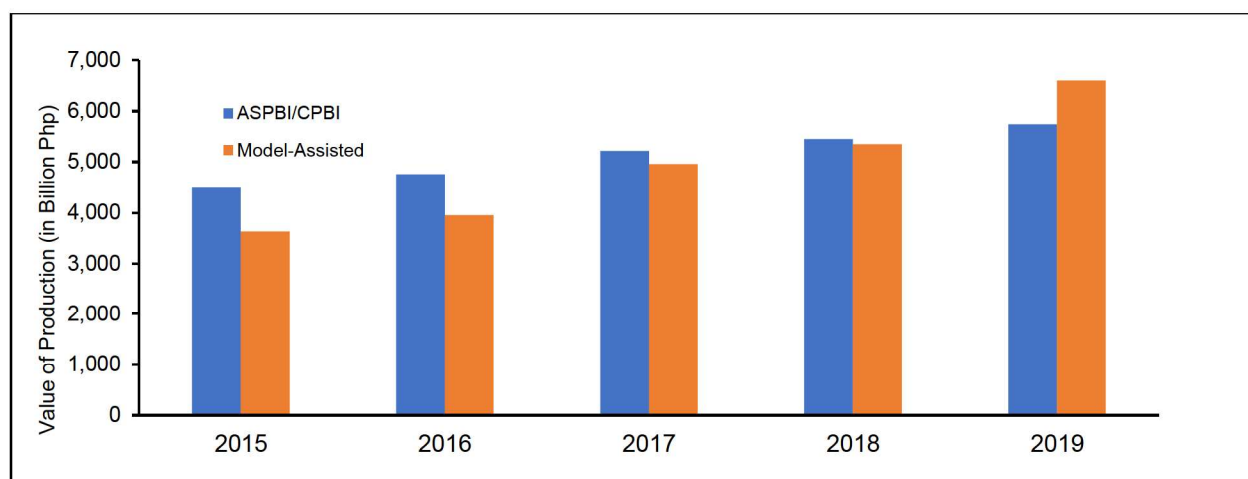
Results indicate that the survey-based estimate of value of production from MISSI consistently overestimate the annual total production of the manufacturing sector. However, using the model-assisted approach, this upward bias was reduced making the estimate close to the data of CPBI and ASPBI data (Figure 2).

**Figure 2.** Comparison of Total Value of Production of the Manufacturing Sector from CPBI, ASPBI, Model-Assisted (MISS), and Survey-based (MISSI): 2018 and 2019



From 2015 to 2018, the annual value of production from CPBI and ASPBI is increasing. Equivalently, this trend was also evident in the model-assisted estimates. (Figure 3).

**Figure 5.2.** Comparison of Annual Value of Production of the Manufacturing Sector from ASPBI/CPBI and Model-Assisted Procedure: 2015-2019



The annual growth rates of the monthly value of production generated from the model-assisted estimates were compared with the year-on-year growths of the VaPI generated from MISSI with 2018 as base year. The comparison showed that the annual growth rates of estimated monthly value of production and VaPI nearly follow the same trend, except in the period May to July 2021 when VaPI had sharp annual increases because of shocks such as the shut down of a big manufacturing company in 2020 and reopening in 2021. This indicates that VaPI is very sensitive even for one sample establishment with big drop or increase in its value of production. It can be noted, however, that the model-assisted estimate of the year-on-year growth rate of the value of



production from the model-assisted formula in the period May to July 2021 does not grow as abrupt as the annual growth in VaPI. (Figure 3).

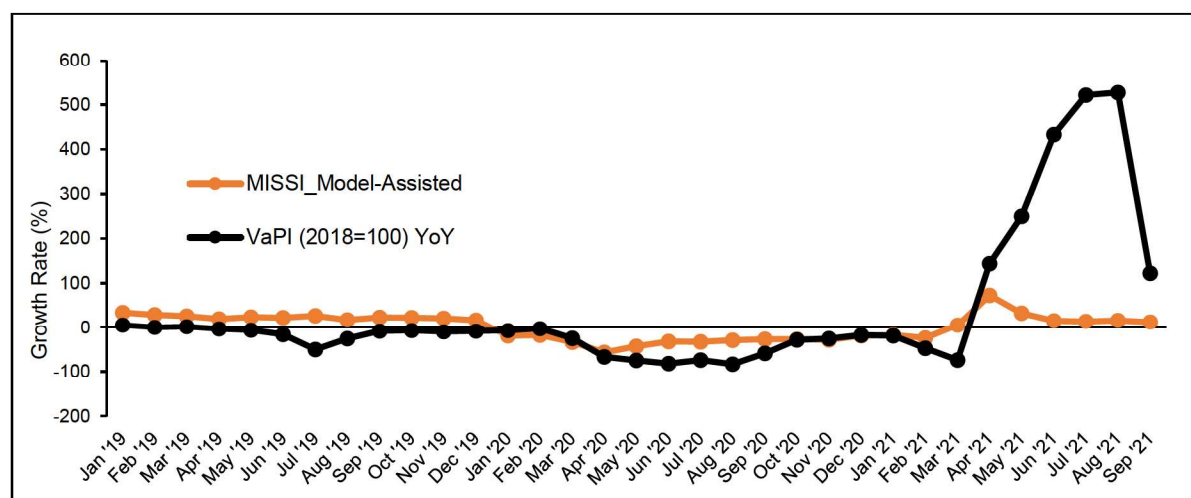


Figure 3. Comparison of Annual Growth Rates of MISSI Indices (VaPI and VoPI) and Model-Assisted Estimate of Production by Month: Jan. 2019 - Sept. 2021

#### **b. Precision of Estimates**

The two sets of variances were computed, the independent case and dependent case. With the sampling design of MISSI, the dependent case is more appropriate to use. However, for comparability, variances assuming independence was also computed. Based on the results, the CVs for the independent case is lower compared the the dependent case. This is expected, however, as the dependent case includes the covariances between months. For both cases, the CVS are lower than 10 percent. (Table A)

Table A. Comparison of Computed CVs for Independent and Dependent Case: 2015-2018

Case	2015	2016	2017	2018
Independent	3.01	2.91	3.74	3.47
Dependent	7.25	7.19	7.52	7.79

Table B also shows the 95 percent confidence interval of the estimates of value of production.

Table B. 95% CI for the Total Value of Production (in Billion Php)

Year	Case	95% Confidence Interval	
		Lower Limit	Upper Limit
2015	Independent	3,417.17	3,846.04
	Dependent	3,115.68	4,147.54
2016	Independent	3,729.68	4,180.17
	Dependent	3,397.61	4,512.24
2017	Independent <sup>a</sup>	4,587.20	5,313.93
	Dependent <sup>a</sup>	4,220.53	5,680.59
2018	Independent <sup>a</sup>	4,978.51	5,705.24

	Dependent <sup>a</sup>	4,526.18	6,157.57
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Note: <sup>a</sup> denotes CPBI/ASPBI estimate is within the 95% CI

### c. Cost Implication of Redesigning MISSI

This section illustrates the implication of redesigning the MISSI instead of doing model-assisted procedure. As previously mentioned, this is another option to generate reliable estimates of production for the manufacturing sector. Through this, the population of manufacturing establishments will be well-represented and design-based estimators, which are unbiased, can be utilized. However, choosing this option would require higher sample size, thus higher budget. Currently, MISSI has 920 sample establishments, and a redesigning would push the sample size to more than twice the current size (Table C).

Table C. Sample Size for the Redesigned MISSI

Target CV	
6 %	8%
3,000	2,500

Likewise, the resulting annual survey budget estimate would also increase depending on the frequency (Table D).

Table D. Annual Budget Estimate by Frequency of Conduct for Redesigned and Current MISSI

No. of Samples	Annual Budget Estimate	
	Monthly Survey	Quarterly Survey
<b>Redesigned MISSI</b>		
3,000	16,608,364	9,416,228
2,500	13,489,784	7,456,777
<b>Current MISSI</b>		
920	5,347,052	

## 6. Summary and Conclusion

The current sampling design of MISSI alone cannot accommodate the demand for reliable estimates of production. Redesigning MISSI to generate estimates would require more resources and processing time.

The model-assisted procedure enabled the estimation of total value of production with reliability for the manufacturing sector with no additional cost. The choice of the appropriate auxiliary information was found to be crucial in the formulation of a model. In the case of this study, the chosen auxiliary data were able to provide the information on the unknown parts of the population of manufacturing establishments.

The annual estimate of value of production were found to be precise and is close to the results of the ASPBI and CPBI. Their growth rates also have the same trend. With these results, the study was able to provide evidence on using model-assisted procedure as a method for generating estimates of production for the manufacturing sector.

## **7. Ways Forward**

This research study will be extended to the estimation of the Value of Sales and its annual growth rate for comparison with the Value of Sales Index (VanSI) year-on-year growth rate.

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## Appendix

Table 1. List of Manufacturing Industry Divisions and Groups (2018=100) in MISSI

<b>Industry Grp/Division of Manufacturing</b>
C10 Manufacture of food products
C101 Processing and preserving of meat
C102 Processing and preserving of fish, crustaceans and mollusks
C103 Processing and preserving of fruits and vegetables
C104 Manufacture of vegetable and animal oils and fats
C105 Manufacture of dairy products
C106 Manufacture of grain mill products, starches and starch products
C107 Manufacture of other food products
C108 Manufacture of prepared animal feeds
C11 Manufacture of beverages
C12 Manufacture of tobacco products
C13 Manufacture of textiles
C14 Manufacture of wearing apparel
C15 Manufacture of leather and related products, including footwear
C16 Manufacture of wood, bamboo, cane, rattan articles and related products
C161 Sawmilling and planing of wood
C162 Manufacture of products of wood, cork, straw and plaiting materials
C17 Manufacture of paper and paper products
C18 Printing and reproduction of recorded media
C19 Manufacture of coke and refined petroleum products
C20 Manufacture of chemical and chemical products
C201 Manufacture of basic chemicals
C202, C203 Manufacture of other chemical products, nec
C21 Pharmaceuticals & medicinal products
C22 Manufacture of rubber and plastic products
C221 Manufacture of rubber and plastic products
C222 Manufacture of plastics products
C23 Manufacture of other non-metallic mineral products
C231 Manufacture of glass and glass products
C239 Manufacture of non-metallic mineral products, nec
C24 Manufacture of basic metals
C241 Manufacture of basic iron and steel
C242 Manufacture of basic precious and other non-ferrous metals
C243 Casting of metals
C25 Manufacture of fabricated metal products, except machinery and equipment
C251 Manufacture of structural metal products, tanks, reservoirs and steam generators
C252 Manufacture of weapons and ammunition
C259 Manufacture of other fabricated metal products; metal working service activities
C26 Manufacture of computer, electronic and optical products
C261 Manufacture of electronic components
C262 Manufacture of computers and peripheral equipment and accessories
C263 Manufacture of communication equipment
C264 Manufacture of consumer electronics
C265 to C268 Manufacture of computer, electronic and optical products, nec

<b>Industry Grp/Division of Manufacturing</b>
C27 Manufacture of electrical equipment
C271 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
C272 Manufacture of batteries and accumulators
C273 Manufacture of wiring and wiring devices
C274 Manufacture of electric lighting equipment
C275 Manufacture of domestic appliances
C279 Manufacture of other electrical equipment
C28 Manufacture of machinery and equipment except electrical
C281 Manufacture of general purpose machinery
C282 Manufacture of special purpose machinery
C29, C30 Manufacture of transport equipment
C291-C293 Manufacture of motor vehicles, trailers and semi-trailers
C301-C309 Manufacture of other transport equipment
C31 Manufacture of furniture
C32, C33 Other manufacturing

Source: 2009 PSIC, PSA

Table 2. Model-Assisted Estimates of Annual value of Production: 2015-2020

Industry Description	2015	2016	2017	2018	2019	2020
<b>C Manufacturing</b>	<b>3,631.61</b>	<b>3,954.92</b>	<b>4,950.56</b>	<b>5,349.91</b>	<b>6,597.09</b>	<b>4,546.64</b>
<b>C10 Manufacture of food products</b>	<b>582.39</b>	<b>763.72</b>	<b>872.60</b>	<b>1,068.82</b>	<b>994.02</b>	<b>1,061.03</b>
C101 Processing and preserving of meat	42.34	99.98	99.10	105.40	107.17	121.82
C102 Processing and preserving of fish, crustaceans and mollusks	36.42	45.92	60.07	45.74	55.23	50.78
C103 Processing and preserving of fruits and vegetables	69.28	74.77	71.87	85.50	89.05	126.64
C104 Manufacture of vegetable and animal oils and fats	70.10	104.63	144.47	127.68	107.53	117.16
C105 Manufacture of dairy products	78.49	87.58	90.85	107.23	113.80	151.39
C106 Manufacture of grain mill products, starches and starch products	82.88	84.66	84.44	108.54	109.85	113.47
C107 Manufacture of other food products	171.27	208.63	257.05	419.44	329.84	305.27
C108 Manufacture of prepared animal feeds	31.61	57.56	64.76	69.29	81.55	74.51
<b>C11 Manufacture of beverages</b>	<b>284.39</b>	<b>415.10</b>	<b>410.07</b>	<b>538.47</b>	<b>431.63</b>	<b>593.33</b>
<b>C12 Manufacture of tobacco products</b>	<b>49.13</b>	<b>54.40</b>	<b>50.36</b>	<b>29.46</b>	<b>32.02</b>	<b>274.25</b>
<b>C13 Manufacture of textiles</b>	<b>34.53</b>	<b>16.11</b>	<b>14.64</b>	<b>17.45</b>	<b>15.58</b>	<b>12.82</b>
<b>C14 Manufacture of wearing apparel</b>	<b>110.33</b>	<b>66.87</b>	<b>47.87</b>	<b>52.17</b>	<b>45.89</b>	<b>49.40</b>
<b>C15 Manufacture of leather and related products, including footwear</b>	<b>28.55</b>	<b>35.73</b>	<b>28.31</b>	<b>24.02</b>	<b>25.47</b>	<b>18.54</b>
<b>C16 Manufacture of wood, bamboo, cane, rattan articles and related products</b>	<b>36.15</b>	<b>42.20</b>	<b>50.19</b>	<b>51.58</b>	<b>61.57</b>	<b>42.26</b>
C161 Sawmilling and planing of wood	1.31	1.02	0.84	1.08	1.29	1.12
C162 Manufacture of products of wood, cork, straw and plaiting materials	34.84	41.18	49.35	50.50	60.28	41.14
<b>C17 Manufacture of paper and paper products</b>	<b>61.35</b>	<b>66.20</b>	<b>70.92</b>	<b>98.16</b>	<b>94.93</b>	<b>74.15</b>
<b>C18 Printing and reproduction of recorded media</b>	<b>51.72</b>	<b>73.12</b>	<b>24.75</b>	<b>24.73</b>	<b>46.71</b>	<b>31.85</b>
<b>C19 Manufacture of coke and refined petroleum products</b>	<b>221.49</b>	<b>205.90</b>	<b>237.80</b>	<b>363.55</b>	<b>195.73</b>	<b>122.54</b>
<b>C20 Manufacture of chemical and chemical products</b>	<b>189.58</b>	<b>242.23</b>	<b>258.07</b>	<b>281.93</b>	<b>228.92</b>	<b>260.69</b>
C201 Manufacture of basic chemicals	119.94	141.92	151.66	182.28	129.30	112.85
C202, C203 Manufacture of other chemical products, nec	69.65	100.31	106.41	99.64	99.62	147.85
<b>C21 Pharmaceuticals &amp; medicinal products</b>	<b>57.67</b>	<b>65.61</b>	<b>102.18</b>	<b>47.25</b>	<b>70.68</b>	<b>58.31</b>



Industry Description	2015	2016	2017	2018	2019	2020
<b>C22 Manufacture of rubber and plastic products</b>	<b>101.47</b>	<b>139.38</b>	<b>121.14</b>	<b>131.51</b>	<b>129.29</b>	<b>136.82</b>
C221 Manufacture of rubber and plastic products	29.56	25.19	26.01	24.93	25.68	26.81
C222 Manufacture of plastics products	71.91	114.19	95.13	106.58	103.61	110.00
<b>C23 Manufacture of other non-metallic mineral products</b>	<b>86.02</b>	<b>80.69</b>	<b>93.99</b>	<b>105.31</b>	<b>115.15</b>	<b>133.13</b>
C231 Manufacture of glass and glass products	11.47	10.74	13.13	13.62	17.85	17.91
C239 Manufacture of non-metallic mineral products, nec	74.56	69.96	80.86	91.68	97.29	115.22
<b>C24 Manufacture of basic metals</b>	<b>162.72</b>	<b>183.54</b>	<b>274.19</b>	<b>255.67</b>	<b>224.65</b>	<b>238.58</b>
C241 Manufacture of basic iron and steel	90.75	85.14	137.97	138.66	105.36	110.63
C242 Manufacture of basic precious and other non-ferrous metals	65.30	92.06	127.01	106.79	110.29	120.55
C243 Casting of metals	6.67	6.34	9.21	10.23	9.00	7.41
<b>C25 Manufacture of fabricated metal products except machinery and equipment</b>	<b>90.04</b>	<b>84.81</b>	<b>95.74</b>	<b>109.68</b>	<b>104.93</b>	<b>109.49</b>
C251 Manufacture of structural metal products, tanks, reservoirs and steam generators	45.53	29.46	16.55	33.96	25.13	29.14
C252 Manufacture of weapons and ammunition	2.03	2.60	2.72	3.29	3.76	6.97
C259 Manufacture of other fabricated metal products; metal working service activities	42.49	52.75	76.47	72.43	76.04	73.38
<b>C26 Manufacture of computer, electronic and optical products</b>	<b>929.24</b>	<b>861.56</b>	<b>1,089.37</b>	<b>1,402.13</b>	<b>2,546.19</b>	<b>802.75</b>
C261 Manufacture of electronic components	653.77	517.14	595.52	841.51	520.29	496.03
C262 Manufacture of computers and peripheral equipment and accessories	198.09	272.10	366.50	485.41	400.79	250.93
C263 Manufacture of communication equipment	3.86	0.80	0.68	16.47	9.38	8.11
C264 Manufacture of consumer electronics	55.99	46.79	98.81	23.72	27.61	25.56
C265 to C268 Manufacture of computer, electronic and optical products, nec	17.52	24.73	27.86	35.02	1,588.12	22.12
<b>C27 Manufacture of electrical equipment</b>	<b>82.24</b>	<b>72.51</b>	<b>85.60</b>	<b>250.56</b>	<b>132.37</b>	<b>70.60</b>
C271 Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	5.35	8.63	13.22	15.88	5.15	9.95
C272 Manufacture of batteries and accumulators	20.52	13.87	15.86	173.55	75.84	8.38
C273 Manufacture of wiring and wiring devices	29.93	22.23	22.06	32.31	28.00	27.63
C274 Manufacture of electric lighting equipment	11.93	6.75	8.31	9.07	9.58	5.96

Industry Description	2015	2016	2017	2018	2019	2020
C275 Manufacture of domestic appliances	13.02	17.78	25.73	18.07	13.21	17.73
C279 Manufacture of other electrical equipment	1.49	3.25	0.42	1.67	0.59	0.96
<b>C28 Manufacture of machinery and equipment except electrical</b>	<b>91.42</b>	<b>55.33</b>	<b>74.05</b>	<b>72.25</b>	<b>121.91</b>	<b>65.70</b>
C281 Manufacture of general purpose machinery	47.48	43.66	62.50	55.20	103.37	53.44
C282 Manufacture of special purpose machinery	43.94	11.67	11.55	17.05	18.54	12.26
<b>C29, C30 Manufacture of transport equipment</b>	<b>346.27</b>	<b>382.11</b>	<b>895.67</b>	<b>377.55</b>	<b>391.67</b>	<b>324.20</b>
C29 Manufacture of motor vehicles	259.14	268.12	276.04	225.26	250.76	171.99
C30 Building of ships and boats	87.13	114.00	619.62	152.29	140.92	152.21
<b>C31 Manufacture of furniture</b>	<b>18.43</b>	<b>17.91</b>	<b>20.65</b>	<b>20.40</b>	<b>24.31</b>	<b>19.84</b>
<b>C32, C33 Other manufacturing</b>	<b>16.49</b>	<b>29.89</b>	<b>32.39</b>	<b>27.26</b>	<b>563.47</b>	<b>46.39</b>

