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An Economic Analysis of the Roles of Metal Industries in the National Economy: The Case of Japan

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An Economic Analysis of the Roles of Metal Industries in the National Economy: The Case of Japan

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Abstract

This study aims to analyze the roles of metal industries in the Japanese national economy. This study applies Input-Output (IO) analysis as an analysis instrument. More specifically, this study employs the parts of IO analysis, namely simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis devices. The analysis period of this study is from 1985 through 2005. In this study, the analyzed industries are non-ferrous metals, non-ferrous metal products, metal products for construction and architecture, and other metal products. The results display that, by using both multipliers, the analyzed metal industries did not include in the top five Japanese industries from 1985 through 2005. By using both indices, one can argue that the quadrant change on the analysis period was experienced by non-ferrous metals and other metal products industries. Interestingly, both industries experienced the change in 2000. On the other hand, the remaining industries did not experience the quadrant movement from 1985 through 2005. In other words, the industries showed consistency in terms of the quadrant position on the analysis period.

Keywords
Metal Industries, National Economy, IO Analysis, Quadrant.

1. Introduction
The industrial sectors are significant aspects from the point of view of a national economy. Their contributions can be detected not only on the micro part, but also on the macro part of a country. Also, their imperative roles can be seen both in developed and developing countries. One of the industries that worth to be discussed in this matter is the metal industry.

There are many previous studies that explain the metal aspect. For example, Jahns et al. (2021) analyze the metal-dusting behavior of additively manufactured binary Ni–Cu alloys with 30 and 50 wt% Cu, respectively, and the technical Monel Alloy 400 with a Cu content of 30 wt% under metal dusting circumstances. Touileb et al. (2022)

investigate the impacts on the hot cracking vulnerability of fluoride powders such as CaF_2, NaF, and LiF; and metal powders such as Mn, Ti, Nb, and mixed Ti-Nb placed on the 316L stainless steel during the Tungsten Inert Gas (TIG) welding process.

On the other hand, Jamari et al. (2022) analyze three dissimilar metallic materials for application in metal-on-metal bearing of total hip implant in terms of contact pressure. The materials are cobalt chromium molybdenum or CoCrMo, stainless steel 316L or SS 316L, and titanium alloy or Ti6Al4V. Jarfors et al. (2022) analyze the in-process behaviour of a production slurry utilizing an engineering approach to estimate the properties. In their study, a method to measure the rheological properties of a semi-solid metal slurry is tested and found capable of making meaningful measurements. Kroupová et al. (2022) present the possibility of making cast porous metals or metallic foams in a low-tech way by the use of conventional foundry technologies, namely the common procedures and resources. Meanwhile, by means of differential thermal analysis, X-ray diffractometer, scanning electron microscopy, energy-dispersive spectrometer, etc., Wu et al. (2022) investigate systematically the impact of Ga content on the melting temperature, wettability, microstructure, and mechanical properties of low-silver 12AgCuZnSn-2In-0.15Pr cadmium-free filler metal.

Based on the aforementioned previous studies, one can claim that the study to analyze the economic aspects of the metal industry in a particular country is still needed. This study is done to fulfill the gap. One of the devices in conducting the analysis is Input-Output (IO) analysis, the tool in investigating the connections of industrial sectors in one or more nations. The importance and originality of this study is that it explores the roles of the metal industry by applying several calculation approaches from IO analysis which focus on the Japanese national economy.

This study aims to analyze the roles of metal industries in the national economy of Japan. This study uses IO analysis as an analysis instrument. More specifically, this study employs the parts of IO analysis, namely simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis devices. The period of analysis of this study is from 1985 through 2005.

The rest of this paper is elucidated as follows. Section 2 describes the methodology of this study. Section 3 explains the results of calculations. Also, the discussions for the results can be viewed on this section. The next section, section 4, clarifies the conclusions of this study and proposed further studies.

2. Methodology

The methodology of this study is clarified as follows. The first step is to describe the data used. This study employs Japanese IO tables for 1985, 1990, 1995, 2000, and 2005 as data. Initially, the tables consist of 84, 91, 93, 104, and 108 industries, respectively. After performing the adjustment procedure, the tables have 78 industries. Those industries are presented in Appendix. The second step is to show the Japanese metal industries used in this study. Table 1 clarifies those industries.

Table 1. Japanese Metal Industries Used in This Study

Sector Number	Sector Name
38	Non-ferrous metals
39	Non-ferrous metal products
40	Metal products for construction and architecture
41	Other metal products

The third step is to complete the calculations by employing simple output multiplier and simple household income multiplier. Miller and Blair (2009) elucidate the equations of both multipliers as follows:

$$moj=i=1nlij \quad (1)$$

$$mhj=i=1nan+1lij. \quad (2)$$

The former model describes the simple output multiplier while the latter one explains the simple household income multiplier. More specifically, $m(o)_j$, $m(h)_j$, $a_{n+1,j}$, n, and l_{ij} are simple output multiplier for sector j, simple household income multiplier for sector j, the coefficients of labor-input, the number of industrial sectors, and a sector-to-sector multipliers matrix, respectively.

The next step is to conduct the calculations in order to investigate the characteristics of Japanese industries on the period of analysis, especially the Japanese metal industries. The approaches used in the calculations are index of the power of dispersion and index of the sensitivity of dispersion. The former index is applied to inspect the strength of one specific industry in influencing entire industries. A larger influence is associated with the higher index value. The detail of the index is elucidated by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

Index of the power of dispersion by sector =b*jB. (3)

The numerator is each sum of columns in the table of inverse matrix coefficients while the denominator clarifies the mean value of the entire vertical sum in the table of inverse matrix coefficients. More specifically, the equations of numerator and denominator are described as follows:

b*j=inbij (4)

B=1njb*j=1nijbij. (5)

Further, b_{ij} and n are the value of Leontief inverse from sector i to sector j and number of industrial sectors, respectively. The latter index is employed to investigate the sensitivity of the particular industrial sector to external influences. A larger sensitivity is associated with the greater index value. More specifically, one specific industrial sector is called more sensitive to the effects from the external aspects if it has a higher index value. The detail of the index is clarified by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

Index of the sensitivity of dispersion by sector =bi*B.(6)

In this index, the numerator is each sum of rows in the table of inverse matrix coefficients while the denominator explains the mean value of the entire horizontal sum in the table of inverse matrix coefficients. Further, the equations of the numerator and denominator of the index are elucidated as follows:

bi*=jnbij (7)

B=1nibi*=1nijbij. (8)

In order to get a compatibility sense with the previous index, equation (7) is slightly transformed from the original source. More specifically, the part describing the number of industrial sectors, n, is added into the equation. As with the previous explanation, b_{ij} is the Leontief inverse value from sector i to sector j. Conclusions of the study and suggested further research are clarified on the last step.

3. Results and Analysis

Tables 2, 3, 4, 5, and 6 display the top five Japanese industrial sectors viewed from the value of simple output multiplier in 1985, 1990, 1995, 2000, and 2005, respectively. Miller and Blair (2009) clarify that an output multiplier for sector j is the total value of production in all industrial sectors of the economy that is essential in order to achieve a currency's worth of final demand for the output of sector j. They also explain that, for the simple output multiplier, the total value of production is coming from the household's exogenous model.

Analyzed metal industries are not included in the tables. By using this outcome, one can argue that the industries did not make an attractive impression to the economy of Japan during the analysis period through an additional final demand. The other interesting fact from the multiplier is the industry number 36, steel products, can be viewed in the tables. This fact clarifies the consistency of the industry in attracting the Japanese economy from 1985 through 2005.

The same phenomenon can be detected on sector 65, self-transport by private cars. The other interesting phenomenon is that sector number 47, motor vehicles and repair of motor vehicles, inhabits the first position in almost all tables. For example, the sector occupies the first rank in table 4 with the value is 3.063. This result elucidates that in order to satisfy a year's worth of final demand for the sector's output in 1995, all Japanese industries required to produce the products of which the total value was ¥3.063.

Table 2. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1985 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	36	Steel products	3.456
2	65	Self-transport by private cars	3.283
3	23	Synthetic resins	3.266
4	22	Chemical basic and intermediate products	3.197
5	35	Pig iron and crude steel	3.183

Table 3. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1990 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.104
2	36	Steel products	3.097
3	65	Self-transport by private cars	2.852
4	35	Pig iron and crude steel	2.850
5	23	Synthetic resins	2.805

Table 4. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 1995 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.063
2	36	Steel products	2.887
3	65	Self-transport by private cars	2.748
4	11	Feeds and organic fertilizer, n.e.c.	2.717
5	35	Pig iron and crude steel	2.672

Table 5. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 2000 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.112
2	36	Steel products	2.967
3	23	Synthetic resins	2.916
4	22	Chemical basic and intermediate products	2.882
5	65	Self-transport by private cars	2.820

Table 6. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Output Multiplier, 2005 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Output Multiplier
1	47	Motor vehicles and repair of motor vehicles	3.449

2	23	Synthetic resins	3.302
3	22	Chemical basic and intermediate products	3.296
4	36	Steel products	3.237
5	65	Self-transport by private cars	2.952

Figures 1, 2, 3, and 4 display the simple output multiplier values of discussed industrial sectors on the analysis period. Generally, those industrial sectors have the same pattern based on the figures, namely decreasing-increasing pattern. A small difference could be seen in the non-ferrous metals sector in 2000. More specifically, compared with other discussed industrial sectors, the simple output multiplier value of the sector in 2000 was larger than the one in 1995.

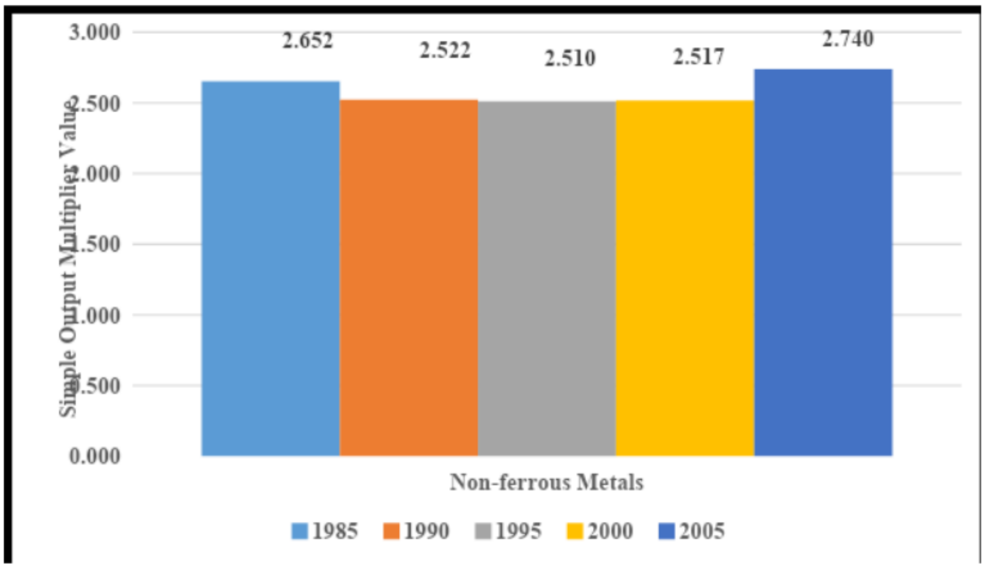

Figure 1. The Simple Output Multiplier Values of the Non-ferrous Metals Sector, 1985-2005

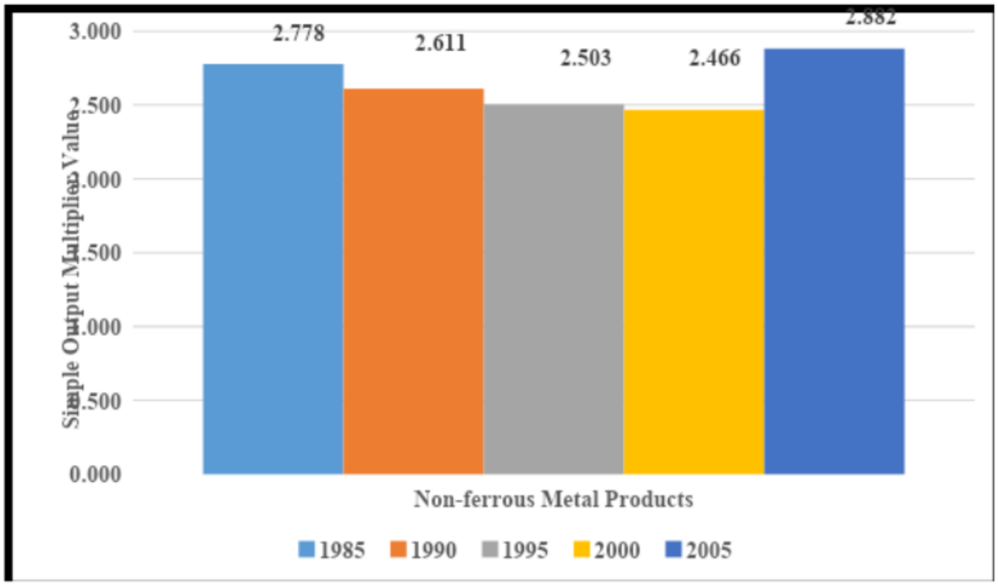

Figure 2. The Simple Output Multiplier Values of the Non-ferrous Metal Products Sector, 1985-2005

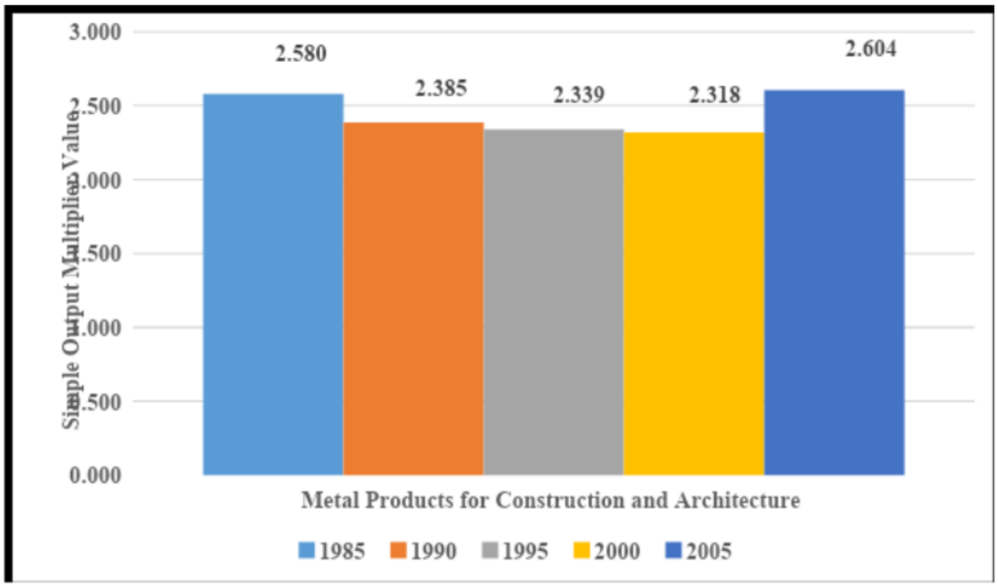

Figure 3. The Simple Output Multiplier Values of the Metal Products for Construction and Architecture Sector, 1985-2005

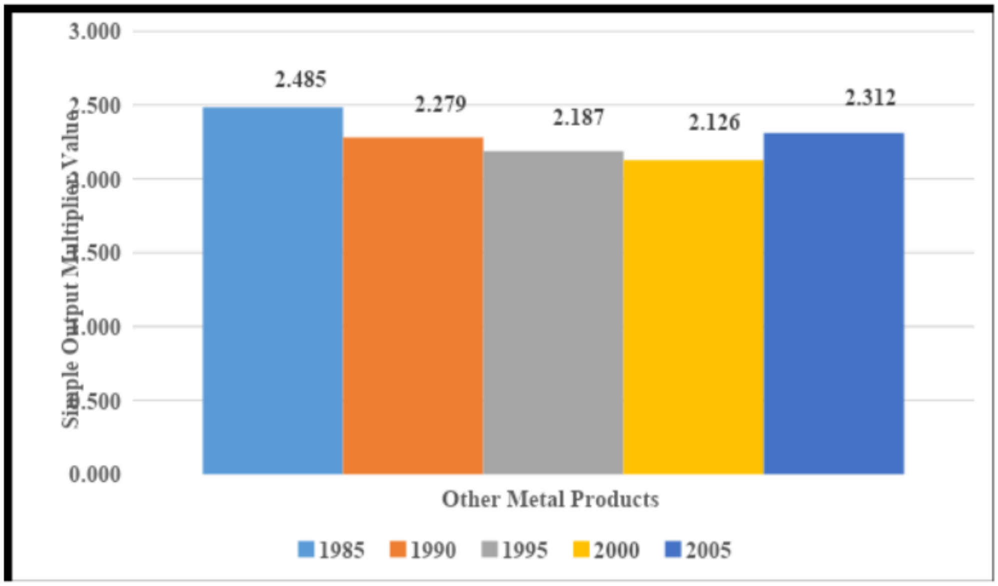

Figure 4. The Simple Output Multiplier Values of the Other Metal Products Sector, 1985-2005

Tables 7, 8, 9, 10, and 11 show the top five Japanese industrial sectors viewed from the values of simple household income multipliers in 1985, 1990, 1995, 2000, and 2005, respectively. Miller and Blair (2009) state that the multiplier is used to elucidate the economic impacts of new final demand as measured by new households' income by using the household's exogenous model. The contents of the tables are not the same with the ones of the tables of the previous multiplier.

Table 7. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1985 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	63	Railway	0.848
2	73	Education	0.836
3	64	Road transport (except transport by private cars)	0.736
4	58	Waste management service	0.719
5	72	Public administration and activities not elsewhere classified	0.691

Table 8. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1990 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.833
2	58	Waste management service	0.739
3	64	Road transport (except transport by private cars)	0.720
4	72	Public administration and activities not elsewhere classified	0.719
5	76	Other public services	0.709

Table 9. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 1995 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.838
2	72	Public administration and activities not elsewhere classified	0.723
3	76	Other public services	0.721
4	64	Road transport (except transport by private cars)	0.720
5	74	Research	0.706

Table 10. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 2000 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.795
2	74	Research	0.715
3	76	Other public services	0.712
4	64	Road transport (except transport by private cars)	0.709
5	75	Medical service, health and social security	0.688

Table 11. Top Five Japanese Industrial Sectors Viewed from the Value of Simple Household Income Multiplier, 2005 (Source: Zuhdi et al. (2021))

No.	Sector Number	Sector Name	Simple Household Income Multiplier
1	73	Education	0.780
2	76	Other public services	0.716
3	64	Road transport (except transport by private cars)	0.684
4	75	Medical service, health and social security	0.676
5	74	Research	0.658

One of the interesting facts from the second multiplier is two industries included in the tables, namely road transport (except transport by private cars) and education. In 1995, the values of those industrial sectors were 0.720 and 0.838, respectively. These values indicate that, in 1995, an additional yen of final demand for the industries would make ¥0.720 and ¥0.838 of new household incomes, respectively, when all direct and indirect impacts were transformed into yen estimates of incomes. The other interesting point is that the analyzed metal industries are not included in the tables. This circumstance is the same with the condition on the previous multiplier.

Figures 5, 6, 7, and 8 explain the simple household income multiplier values of discussed industries on the period of analysis. From the point of view of the multiplier, the industries had no specific pattern from 1985 through 2005. The industry with the most complex pattern on the analysis period was the non-ferrous metal products. On the other hand, the industry that had the simplest pattern from 1985 through 2005 was the other metal products.

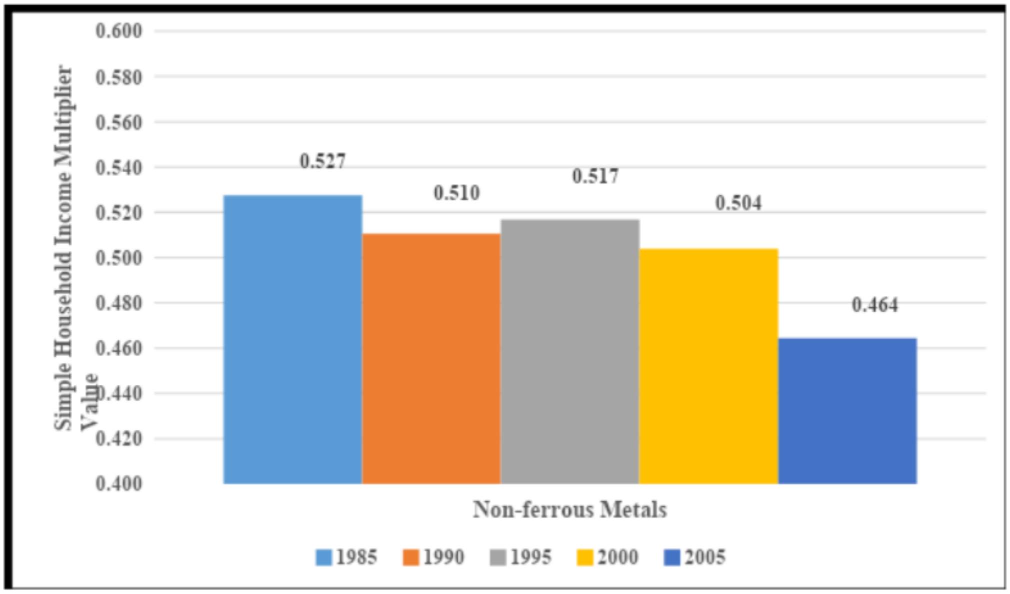

Figure 5. The Simple Household Income Multiplier Values of the Non-ferrous Metals Sector, 1985-2005

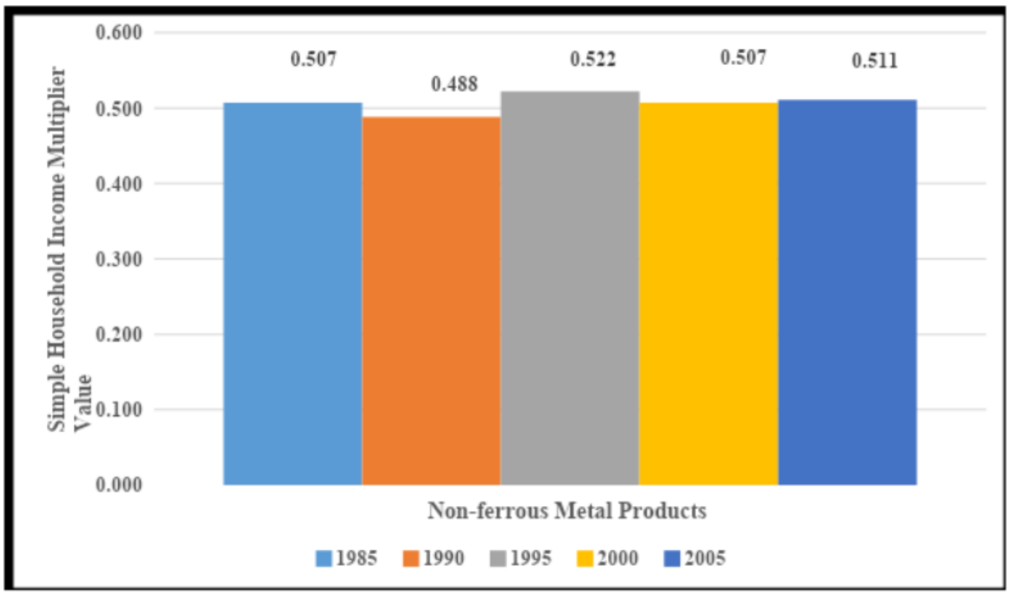

Figure 6. The Simple Household Income Multiplier Values of the Non-ferrous Metal Products Sector, 1985-2005

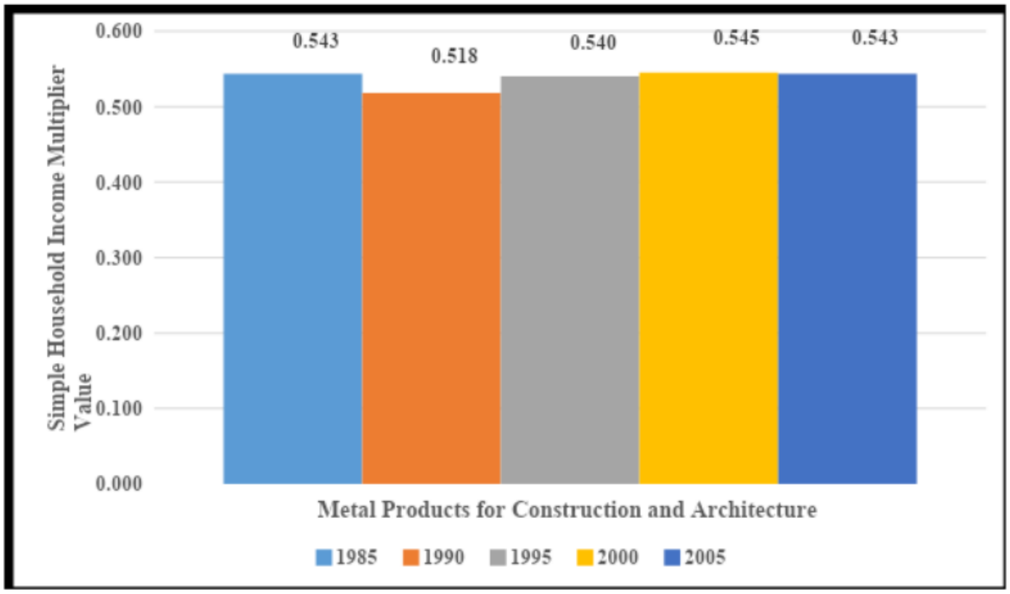

Figure 7. The Simple Household Income Multiplier Values of the Metal Products for Construction and Architecture Sector, 1985-2005

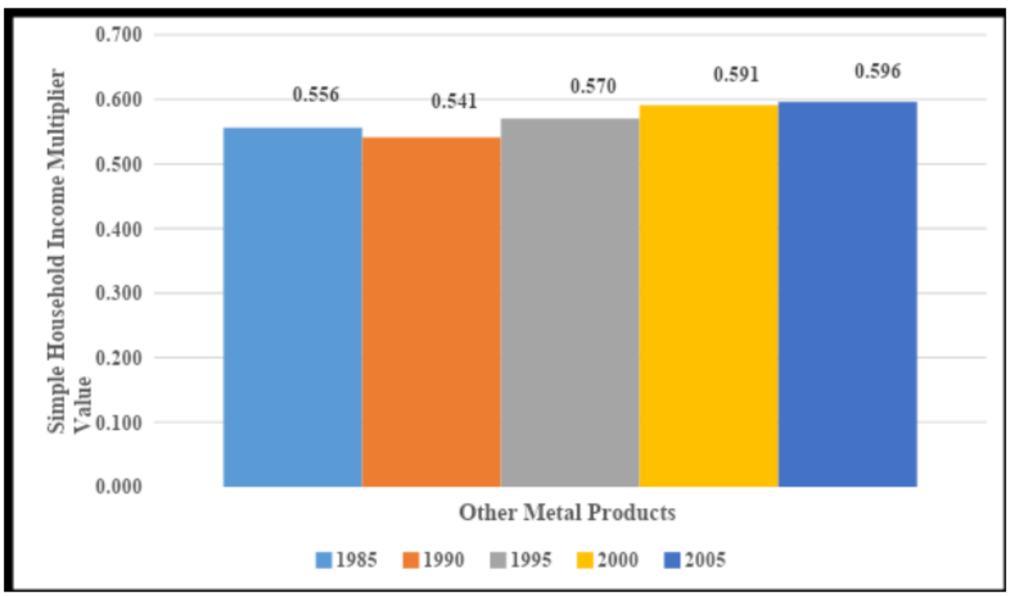

Figure 8. The Simple Household Income Multiplier Values of the Other Metal Products Sector, 1985-2005

Table 12 recaps the quadrants of discussed industries in 4e analysis period. The quadrants are generated from the combination of both indices used in this study, namely the index of the power of dispersion and the index of the sensitivity of dispersion. Further, four quadrants appear from the combination.

Each quadrant has unique features. More specifically, quadrant I is a position where the values of both indices are more than one. In other words, the industries that lie in this quadrant are those most impacted by the external aspects as well as have strong impressions on the entire industries. The opposite phenomena can be seen in the industries which lie in quadrant III. On the other hand, quadrant II is a position where the value of the index of the power of dispersion is less than one while the value of the other index is more than one. One can say that the industries that lie in this quadrant are those which have weak stimuluses on the entire industries, but they get high effects from the changes of external aspects. The opposite features are owned by the industrial sectors which lie in quadrant IV.

Table 12. The Quadrants of Japanese Metal Industries, 1985-2005

Sector Number	Sector Name	Quadrant				
		1985	1990	1995	2000	2005
38	Non-ferrous metals	I	I	I	IV	I
39	Non-ferrous metal products	IV	IV	IV	IV	IV
40	Metal products for construction and architecture	IV	IV	IV	IV	IV
41	Other metal products	I	I	I	II	I

Based on the information in Table 12, one can argue that the quadrant movement in the analysis period was experienced by non-ferrous metals and other metal products sectors. Interestingly, both sectors experienced the movement in 2000. On the other hand, the remaining sectors did not experience the quadrant change from 1985 through 2005. In other words, the sectors showed consistency in terms of the quadrant position on the period of analysis.

4. Conclusions and Further Research

This study explores the roles of Japanese metal industries in the Japanese national economy by using IO analysis. More specifically, this study employs simple output multiplier, simple household income multiplier, index of the power of dispersion, and index of the sensitivity of dispersion as analysis apparatuses. The period of analysis of this study is 1985-2005. The analyzed Japanese metal industries in this study are non-ferrous metals, non-ferrous metal products, metal products for construction and architecture, and other metal products.

The results show that, by using both multipliers, the analyzed metal industries were not included in the top five Japanese industrial sectors from 1985 through 2005. By using both indices, one can claim that the quadrant movement on the analysis period was experienced by non-ferrous metals and other metal products industries. Interestingly, both industries experienced the movement in 2000. On the other hand, the remaining industries did not experience the quadrant alteration from 1985 through 2005. In other words, the industries showed consistency in terms of the quadrant location on the period of analysis.

The understanding regarding the roles of Japanese metal industries in affecting the Japanese national economy during the period of analysis is obtained from the current study. However, the study would gain a broader insight about the roles if the study could apply the longer analysis period. Therefore, as one of the further studies, the study proposes the same analysis by using the longer period of analysis, such as from 1985 through 2015. One of the vital aspects that must be considered when conducting the proposed further study is the prices and industrial sectors used on the analyzed IO tables should be the same.

The other recommended further research from the study is to do an international comparison using the same approaches. The comparison can be focused on developed-developed, developed-developing, or developing-developing nations. The comparison might explore the roles of the metal industries of compared countries so the similarities and differences among those regarding the industrial sectors can be examined. One of the examples in this matter is the comparison between Japan and Indonesia.

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Appendix

The Japanese Industries (Source: Zuhdi et al. (2014) with Slight Modifications)

Sector Number	Sector Name
1	Crop cultivation
2	Livestock
3	Agricultural services
4	Forestry
5	Fisheries
6	Metallic ores
7	Non-metallic ores
8	Coal mining, crude petroleum, and natural gas
9	Foods
10	Beverage
11	Feeds and organic fertilizer, n.e.c.
12	Tobacco
13	Textile products
14	Wearing apparel and other textile products
15	Timber and wooden products
16	Furniture and fixtures
17	Pulp and paper
18	Paper products
19	Publishing and printing
20	Chemical fertilizer
21	Basic industrial inorganic chemicals
22	Chemical basic and intermediate products
23	Synthetic resins
24	Synthetic fibers
25	Final chemical products, n.e.c.
26	Petroleum refinery products
27	Coal products
28	Plastic products
29	Rubber products
30	Leather, fur skins, and miscellaneous leather products
31	Glass and glass products
32	Cement and cement products
33	Pottery, china, and earthenware
34	Other ceramic, stone, and clay products
35	Pig iron and crude steel
36	Steel products
37	Steel castings and forgings, and other steel products
38	Non-ferrous metals

39	Non-ferrous metal products
40	Metal products for construction and architecture
41	Other metal products
42	General industrial machinery
43	Special industrial machinery
44	Other general machines
45	Machinery for office and service industry
46	Electrical appliance
47	Motor vehicles and repair of motor vehicles
48	Ships and repair of ships
49	Other transportation equipment and repair of transportation equipment
50	Precision instruments
51	Miscellaneous manufacturing products
52	Building construction
53	Repair of construction
54	Civil
55	Electricity
56	Gas and heat supply
57	Water supply
58	Waste management service
59	Commerce
60	Finance and insurance
61	Real estate agencies and rental services
62	House rent
63	Railway
64	Road transport (except transport by private cars)
65	Self-transport by private cars
66	Water transport
67	Air transport
68	Storage facility service
69	Services relating to transport
70	Communication
71	Broadcasting
72	Public administration and activities not elsewhere classified
73	Education
74	Research
75	Medical service, health, and social security
76	Other public services
77	Business and office supplies
78	Personal services

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Biographies

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An Economic Analysis of the Roles of Metal Industries in the National Economy: The Case of Japan

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