The Roles of Steel Industries in the National Economy: The Case of Japan

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Abstract

The purpose of this study is to analyze the roles of steel industries in the national economy of Japan. This study employs Input-Output (IO) analysis as an analysis apparatus. More specifically, this study uses 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 instruments. The analysis period of this study is from 1985 through 2005. In this study, the analyzed sectors are (1) pig iron and crude steel, (2) steel products, and (3) steel castings and forgings, and other steel products. The results show that, by using simple output multiplier, one can say that one of the analyzed industries, steel products, attracted consistently the Japanese economy on the analysis period. The same attractiveness could be observed on pig iron and crude steel sector from 1985 through 1995. Meanwhile, by using both indices, one can claim that the analyzed industrial sectors had a consistent pattern regarding the quadrant location on the period of analysis. More specifically, pig iron and crude steel, and steel products sectors were in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector lied in quadrant IV on the same period. Based on these quadrant positions, one can say that the analyzed industries had strong effects on the entire Japanese industries on the analysis period.

Keywords
Steel Industries, National Economy, IO Analysis, Effects.

1. Introduction
The industrial sectors are important parts of a country. Their contributions can be seen on the micro and macro aspects of a national economy. Also, their important roles can be observed both in developed and developing countries. One of the industrial sectors that worth to be discussed in this matter is the steel industry.

There are many previous studies discuss the steel topic. For example, Al-Karawi (2022) examines the enhancement in local residual stresses and hardness in S355 welded structural steel by means of two post-weld treatment approaches, namely High-Frequency Mechanical Impact (HFMI) treatment and Tungsten Inert Gas (TIG) remelting. Latour et al. (2022) explain an experimental analysis to measure the mechanical properties of aluminium foams and describe Steel-

Aluminium Foam-Steel (SAS) sandwich panels in bending. Ahmed and Tsavdaridis (2019) review some historic and current expansions of Steel-Concrete Composite (SCC) systems, with emphasis on the evolution of lightweight and prefabricated systems as they have attracted significant consideration the last years.

Meanwhile, Ghafouri et al. (2022) develop a computational method based on the Finite Element (FE) approach to efficiently forecast welding deformations and residual stresses of fillet welded T-joints made of High Strength Steel (HSS), S700, applying different welding orders and external constraints. Tran et al. (2022) suggests an efficient process for the reliability analysis of frames with Concrete-Filled Steel Tubular (CFST) columns and composite beams. Tumbeva et al. (2022) present a numerical inquiry of the redundancy of steel truss bridges composed of original modular joints when subjected to the abrupt loss of diagonal components.

On the other hand, Inamasu and Lignos (2022) explores, by means of Continuum Finite Element (CFE) analysis, a newly developed idea that promotes controlled inelastic energy improvidence within the embedded portion of column base connections rather than in steel columns of traditional embedded column bases. Arrayago and Rasmussen (2022) analyze the effect of the way of initial imperfections modelled as linear superpositions of buckling modes on the counteraction of steel and stainless steel frames designed applying advanced analysis. The purpose of their study is to simplify the definition of initial imperfections in design.

Based on the aforesaid previous studies, one can argue that the study to analyze the economic aspect of the steel industry in a specific country is still needed. This study is done to fill the gap. One of the methods in conducting the analysis is Input-Output (IO) analysis, the approach in examining the linkages of industrial sectors in one or more nations. The importance and originality of this study are that it explores the roles of the steel industry by using several calculation procedures from IO analysis which focusing on the national economy of Japan.

The purpose of this study is to analyze the roles of steel industries in the Japanese national economy. This study employs IO analysis as an analysis apparatus. More specifically, this study uses 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 instruments. The analysis period 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 clarifies the results of calculations. The discussions for the results can be observed on this section too. The next section, section 4, defines 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 express 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 accomplishing the adjustment process, the tables have 78 industrial sectors. Those industrial sectors are presented in Appendix. The second step is to show the Japanese steel industries used in this study. Table 1 clarifies those industries.

Table 1. Japanese Steel Industries Used in This Study

Sector Number	Sector Name
35	Pig iron and crude steel
36	Steel products
37	Steel castings and forgings, and other steel products

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

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \quad (1)$$

$$m(h)_j = \sum_{i=1}^{n} a_{n+1}\, l_{ij}. \quad (2)$$

The former model describes the simple output multiplier while the latter one clarifies the simple household income multiplier. More specifically, $m(o)_j$, $m(h)_j$, $a_{n+1,i}$, 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 analyzed industries, and a sector-to-sector multipliers matrix, respectively.

The next step is to conduct the calculations in order to analyze the characteristics of Japanese industries on the period of analysis, especially the Japanese steel industries. The methods applied in the calculations are index of the power of dispersion and index of the sensitivity of dispersion. The former index is employed to analyze the strength of one specific industry in impacting entire industries. A larger impact is aligned with the higher index value. The detail of the index is elucidated by Ministry of Internal Affairs and Communications Japan (n.d.) as follows:

$$\text{Index of the power of dispersion by sector} = \frac{b_{*j}}{\bar{B}}. \quad (3)$$

The numerator is each sum of column 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 elucidated as follows:

$$b_{*j} = \sum_i^n b_{ij} \quad (4)$$

$$\bar{B} = \frac{1}{n}\sum_j b_{*j} = \frac{1}{n}\sum_i \sum_j b_{ij}. \quad (5)$$

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

$$\text{Index of the sensitivity of dispersion by sector} = \frac{b_{i*}}{\bar{B}}. \quad (6)$$

In this index, the numerator is each sum of row 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:

$$b_{i*} = \sum_j^n b_{ij} \quad (7)$$

$$\bar{B} = \frac{1}{n}\sum_i b_{i*} = \frac{1}{n}\sum_i \sum_j b_{ij}. \quad (8)$$

In order to get a compatibility sense with the previous index, equation (7) is slightly transformed from the original source. More specifically, the part states the total number of discussed industries, 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 researches 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 needed in order to accomplish a currency's worth of final demand for the output of sector j. They also elucidate that, for the simple output multiplier, the entire value of production is coming from the households exogenous model.

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

Interestingly, one of the analyzed industries, steel products, can be seen in the tables. This fact clarifies the consistency of the industry in attracting the Japanese economy from 1985 through 2005. The value of the industry in 2005 was 3.237. This result explains that in order to satisfy a yen's worth of final demand for the industry's output in 2005, all Japanese industries needed to produce the products which the total value was ¥3.237. The other analyzed industrial

sector that appears in above tables is pig iron and crude steel. The industrial sector can be observed in tables 2, 3, and 4.

Figures 1, 2, and 3 display the simple output multiplier values of analyzed industries on the analysis period. One can argue that those industrial sectors have a same pattern based on the figures. More specifically, the analyzed industries had the increasing-decreasing-increasing pattern from 1985 through 2005.

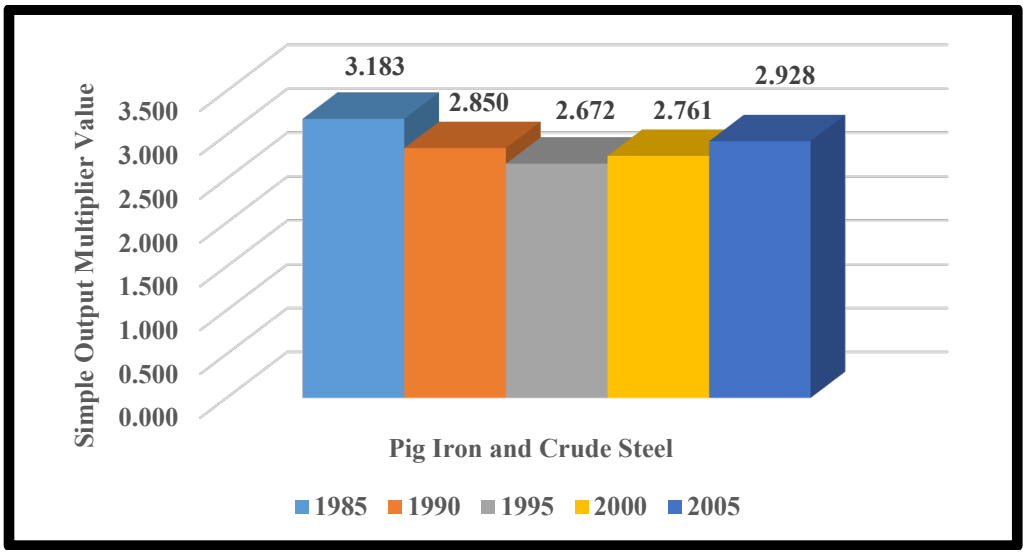

Figure 1. The Simple Output Multiplier Values of the Pig Iron and Crude Steel Sector, 1985-2005

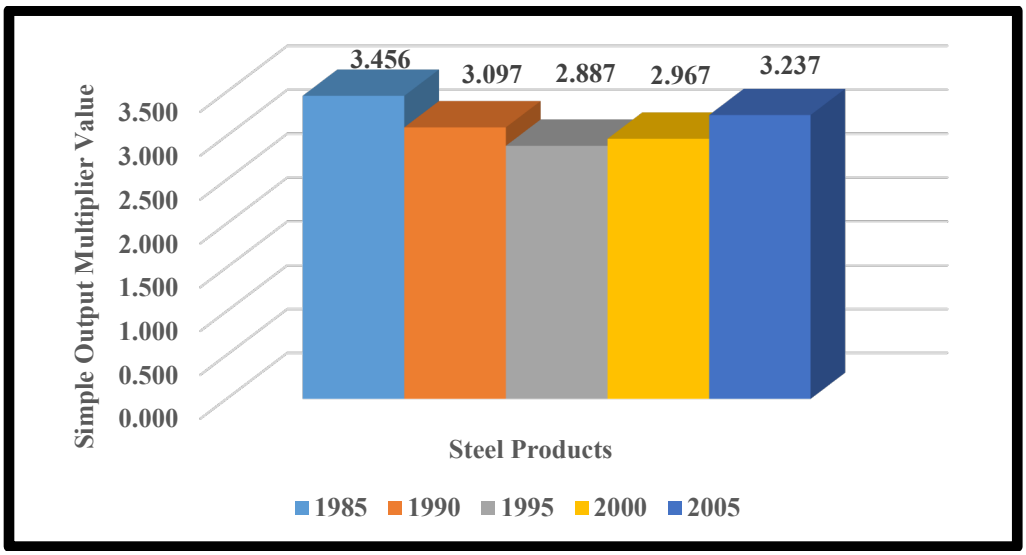

Figure 2. The Simple Output Multiplier Values of the Steel Products Sector, 1985-2005

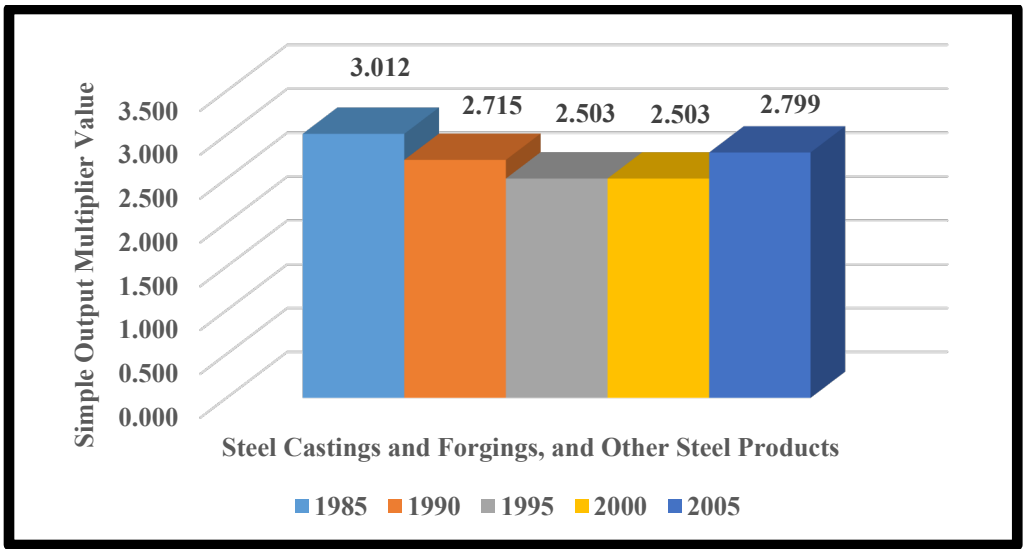

Figure 3. The Simple Output Multiplier Values of the Steel Castings and Forgings, and Other Steel Products Sector, 1985-2005

Tables 7, 8, 9, 10, and 11 explain the top five Japanese industrial sectors viewed from the values of simple household income multiplier in 1985, 1990, 1995, 2000, and 2005, respectively. Miller and Blair (2009) describe that the multiplier is applied to elucidate the economic impacts of new final demand as measured by new households income by using the households exogenous model. The configurations of the tables are different 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

Analyzed steel industries do not include in the tables. By using this result, one can argue that the industries did not make the attractive impact to the economy of Japan on the analysis period from point of view of new household income. One of the interesting points from the second multiplier is two industries include in the tables, namely road transport (except transport by private cars) and education. In 1995, the values of those industries were 0.720 and 0.838, respectively. These values show that, in 1995, an additional yen of final demand for the industries would generate ¥0.720 and ¥0.838 of new household incomes, respectively, when all direct and indirect impacts were transformed into yen estimates of incomes.

Figures 4, 5, and 6 clarify the simple household income multiplier values of analyzed industries on the analysis period. Generally, those industrial sectors have a same pattern based on the figures. More specifically, the analyzed industries had the decreasing-increasing-decreasing movement from 1985 through 2005.

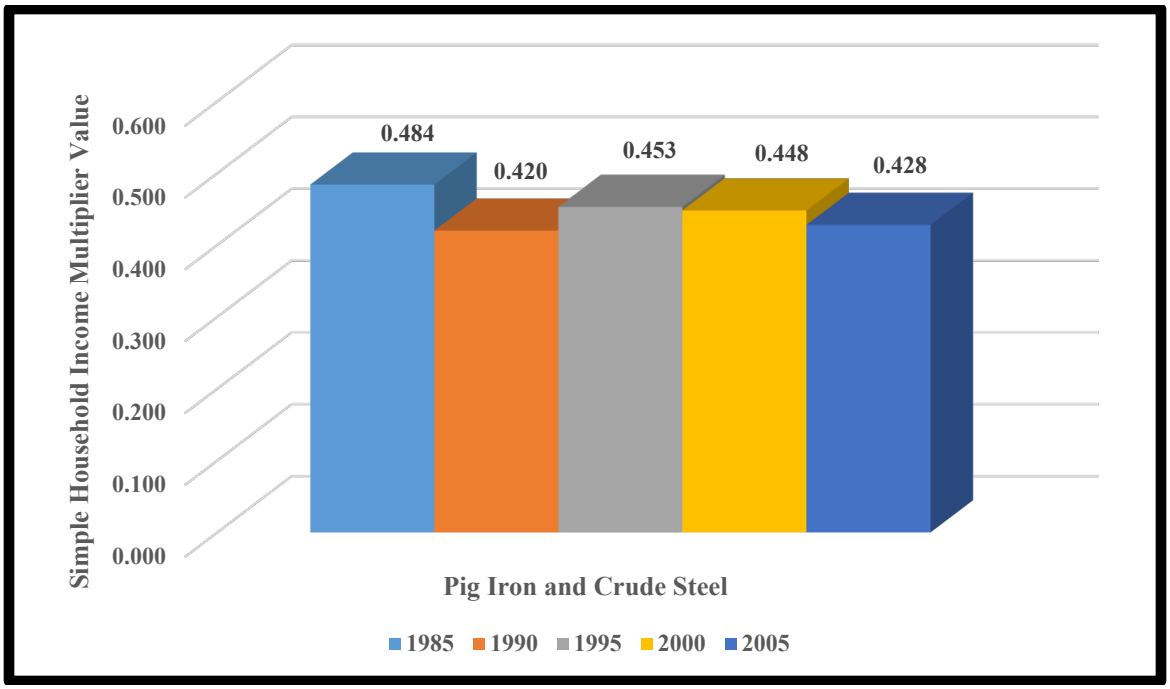

Figure 4. The Simple Household Income Multiplier Values of the Pig Iron and Crude Steel Sector, 1985-2005

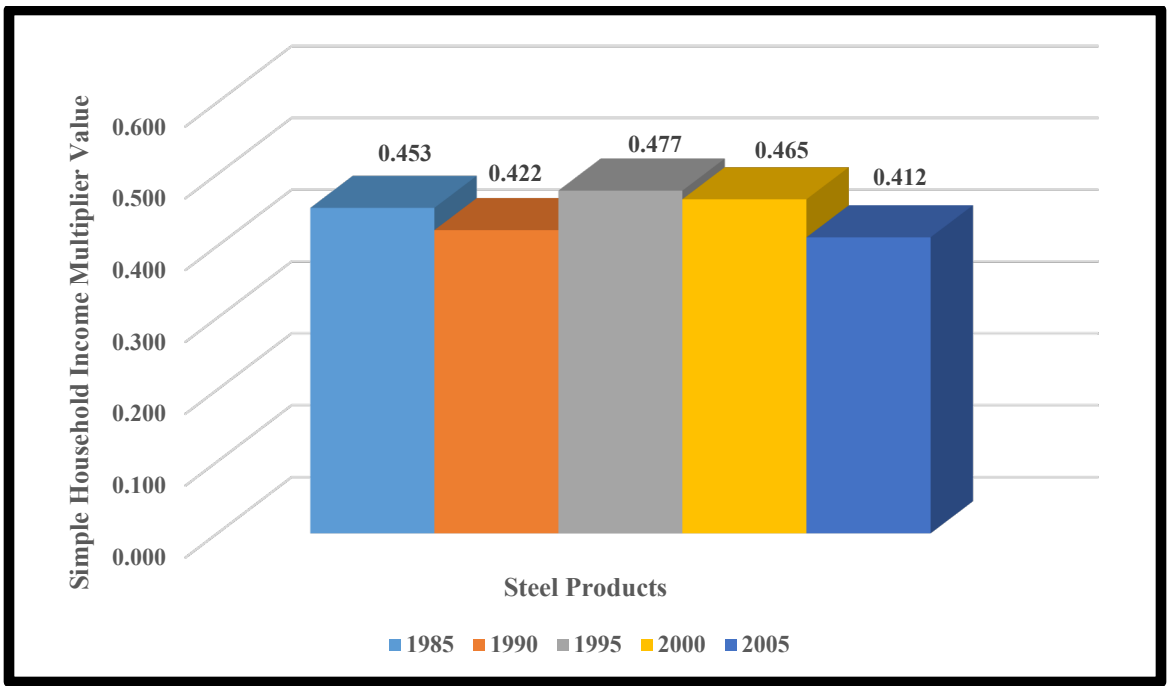

Figure 5. The Simple Household Income Multiplier Values of the Steel Products Sector, 1985-2005

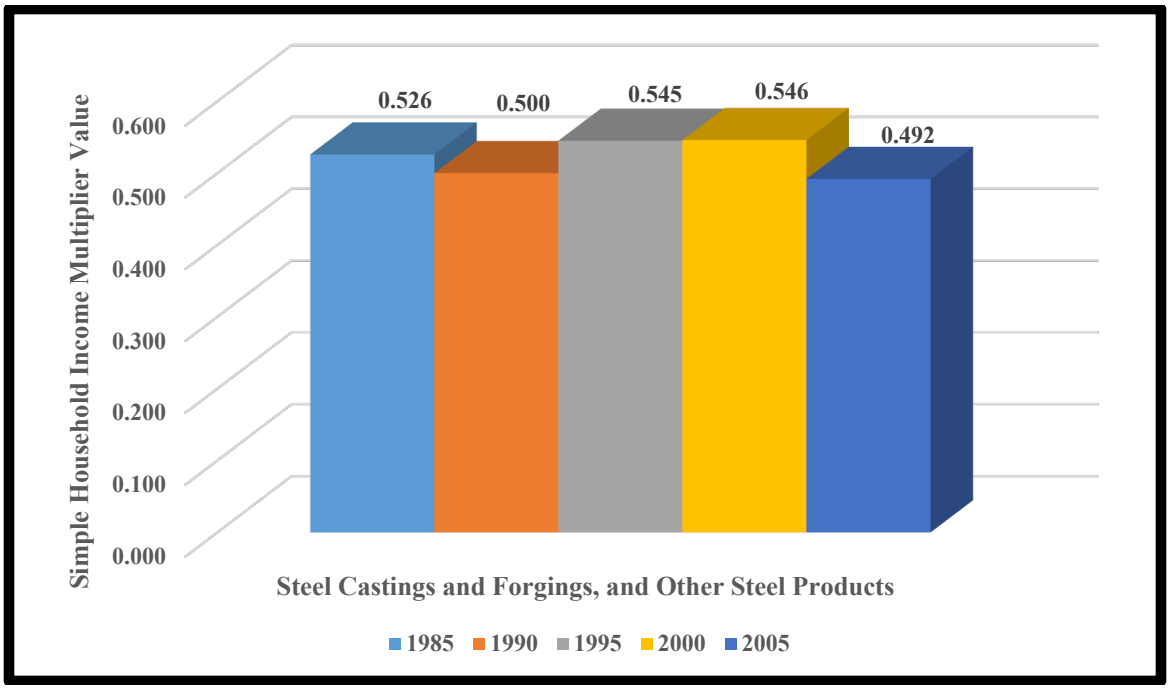

Figure 6. The Simple Household Income Multiplier Values of the Steel Castings and Forgings, and Other Steel Products Sector, 1985-2005

Table 12 reviews the quadrants of analyzed industries on the period of analysis. The quadrants come 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. Four quadrants appear from the combination.

Each quadrant has unique attributes. More specifically, quadrant I is a location where the values of both indices are more than one. In other words, the industries lie in this quadrant are those most impacted by the external aspects and have strong effects on the whole industries. The opposite phenomena can be viewed on the industries which lie in quadrant III. On the other hand, quadrant II is a location 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 claim that the industries lie in this quadrant are those which have weak impacts on the entire industries, but they get high influences from the alterations of external aspects. The industrial sectors lie in quadrant IV have the opposite characteristics.

Table 12. The Quadrants of Japanese Steel Sectors, 1985-2005

Sector Number	Sector Name	Quadrant				
		1985	1990	1995	2000	2005
35	Pig iron and crude steel	I	I	I	I	I
36	Steel products	I	I	I	I	I
37	Steel castings and forgings, and other steel products	IV	IV	IV	IV	IV

Based on the information in the table, one can claim that the analyzed industries had a consistent pattern regarding the quadrant position on the analysis period. More specifically, pig iron and crude steel, and steel products sectors lied in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector was in quadrant IV on the same period. These facts explain that the analyzed industries had strong impacts on the entire Japanese industries on the period of analysis.

4. Conclusions and Further Researches

This study analyzes the roles of Japanese steel 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 analysis period of this study is 1985-2005. The analyzed Japanese steel industries in this study are (1) pig iron and crude steel, (2) steel products, and (3) steel castings and forgings, and other steel products.

The results show that, by using simple output multiplier, one can argue that one of the analyzed industries, steel products, attracted consistently the Japanese economy from 1985 through 2005. The same attractiveness could be seen on pig iron and crude steel sector from 1985 through 1995. By using point of view of simple household income multiplier, one can argue that the analyzed industries did not make the attractive influence to the economy of Japan on the analysis period.

Meanwhile, by using both indices, one can claim that the analyzed industries had a consistent pattern regarding the quadrant location on the period of analysis. More specifically, pig iron and crude steel, and steel products sectors were in quadrant I from 1985 through 2005 while steel castings and forgings, and other steel products sector lied in quadrant IV on the same period. These facts elucidate that the analyzed industries had strong influences on the entire Japanese industries on the analysis period.

The understanding regarding the roles of Japanese steel industries in influencing the Japanese national economy on the analysis period is obtained from the current study. However, the study would gain a broader perception about the roles if the study could analyze the longer analysis period. Therefore, as one of the further studies, the study recommends the same analysis by utilizing the longer period of analysis, such as from 1985 through 2020. One of the important points that must be considered when conducting the recommended further study is the prices and industrial sectors used on the analyzed IO tables should be same.

The other suggested further research from the study is to organize 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 steel industries of compared countries so the similarities and differences among those regarding the industries can be analyzed. One of the examples of the suggested further research is the comparison between Japan and Malaysia.

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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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