Recovery from the Great Depression in the U.S., Britain, Germany, and Japan: A Comparative Input-Output Analysis*

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Previously, Leontief input-output analysis was utilized to compare the recovery process of the U.S. and Britain, and "guessed" that of Germany. With the newfound availability of the German I/O table of 1936, the inter-industry structure can be more fully understood. The Japanese table was investigated as well. The analysis presented effectiveness of investment allocation, government spending, *etc.*, all of which contribute to assessing the recovery from the Great Depression.

Keywords: Great Depression, Input-output analysis, Investment allocation

JEL Classification: C67, N10

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Recovery from the Great Depression was initiated by the abandonment of the gold standard of Britain and Japan in 1931, and the U.S. in 1933, as well as foreign exchange control in Germany. These measures allowed each country to pursue expansionary monetary policy. Liberal fiscal spending was an additional stimulus, and promoted private investment that led to the output and employment recovery.

On the micro level, a previous paper (Yang 1995) utilized input-output analysis to compare investment allocations in the U.S. and Britain. The study concluded that the U.S. pattern was more effective in enhancing output and employment because of the inter-industry repercussion. As for Germany, the study "guessed" that the country may have had even greater influence as a result of placing a high policy weight on the Motorisierung and rearmament where more backward linkage was expected. "Guessed" was deemed appropriate given that the input-output table for Germany was not yet available. Now that the German table for 1936 has been estimated (Fremdling, and Staeglin 2014a), we can more accurately analyze the probable effects of private investment allocation, as did Fremdling and Staeglin (2014b, 2015), for government spending. We investigate the inter-industry repercussion in Japan as well by using 1935 table (Nishikawa, and Koshihara 1981).

Before elaboration, we first define sectoral multipliers. An increase in investment demand in a certain industry sector generates production and employment in that particular sector and brings about similar increases in related sectors by repercussion. For example, civil construction stimulates production of steel plates, cement, and lumber, and steelworks demand more iron ore, coke and lime, and so on. The total production generated by one unit of final demand in a sector is called "sectoral multiplier," and this measure indicates the effectiveness of a particular investment in raising industrial production in general. A systematic way to estimate these multipliers is provided by an input-output table. Each figure in the table shows the value of goods and services originating in the sector specified by the row and directed to the sector specified by the column. Normalized into unit value of production for each sector specified by the column, this figure provides an input-coefficient matrix, A, and then the "Leontief inverse," $(I-A)^{-1}$, can be obtained. Formally, the sectoral production multiplier for sector (j) is the column sum ($\sum_i r_{ij}$) of the elements of the Leontief inverse. Each element (r_{ij}) of which indicates the total production directly and indirectly generated in the sector specified by row (i) by a unit increase in the final demand in the sector specified by column (j), thus summing up the total production

TABLE 1
SECTORAL MULTIPLIERS: GERMANY, 1936

	Industrial Sector	Production Multipliers	Employment Multipliers (Man-year per 1000 RM)
1	Agriculture	1.47	1.13
2	Forestry, fishery	1.63	0.30
3	Mining	1.80	0.29
4	Fuel industries	2.35	0.09
5	Basic iron and steel products	2.73	0.11
6	Non-ferrous metals	2.30	0.10
7	Foundries	1.92	0.31
8	Fabricated iron and steel products	2.22	0.32
9	Machinery	1.90	0.27
10	Constructional steel	2.11	0.35
11	Vehicles and aerospace	2.17	0.29
12	Electrical engineering	1.87	0.25
13	Precision engineering optics	1.61	0.34
14	Metal products	1.95	0.38
15	Stone and quarrying	1.51	0.33
16	Ceramics	1.48	0.40
17	Glass	1.65	0.36
18	Saw mills, timber processing	1.82	0.26
19	Manufactured wood products	1.67	0.56
20	Chemical industry	2.00	0.11
21	Chemical-technical industry	1.79	0.12
22	Rubber and asbestos manufacture	1.57	0.18
23	Manufacture of paper and paper products	2.00	0.17
24	Printing and duplicating	1.84	0.32
25	Leather industry	1.76	0.37
26	Textiles	1.97	0.29
27	Clothing	1.86	0.50
28	Edible oil and fats	1.76	0.04
29	Spirits industry	2.81	0.10
30	Food, beverages, and tobacco	1.80	0.22
31	Building and construction	1.49	0.28
32	Electricity, gas, and water	1.90	0.10
33	Wholesale trade	1.63	0.27
34	Retail trade	1.88	0.83
35	Transport and communication	1.55	0.25
36	Banking and insurance	1.32	0.12
37	Dwelling	1.65	0.01
38	Government	2.09	0.27
39	Other services	1.77	0.49
40	Domestic services	1.00	0.97
	Average	1.84	0.31

generated in all industry sectors. The employment multiplier can be computed as the column sum ($\sum_i r_{ij} l_i$) of the product of each element of the inverse matrix (r_{ij}), and labor coefficient (l_i), labor input in man-year per unit value of production, and indicates total labor demand generated by a unit increase in the final demand in the sector (j).

In Britain, old staples such as textiles, iron and steel, and shipbuilding have generally high multipliers. For the "new industries," the multipliers were not as high, with the exception of that of automobiles. By contrast, new industries in the U.S. indicated stronger inter-industry repercussions, including automobiles, chemicals, nonferrous metals, as well as old sectors like textiles, leather, and food industries (Yang 1995). A simple average of 24 sectors (Table 5) indicates the inter-industry relations in the U.S. were more intense than in Britain.

Sectoral multipliers were utilized to evaluate the investment allocation during the recovery from the Great Depression. Figure 1 (Yang 1995, p.76, Fig. 2) has shown higher correlation between the investment expenditure by industry and the sectoral multipliers in the U.S. than in Britain, with correlation coefficients 0.313 and 0.094, respectively.[1] This observation implies that investment in Britain was not allocated in a manner to maximize total production effects. Considering the high value of multipliers in old staples in Britain, and the long-term tendency of investment shift to new industries, this situation may appear natural. Alternatively, the mobility of resources may have been less than adequate to allow appropriate investment allocation. Often pointed out as a characteristic of the British economy, depression was structurally concentrated in old staples and in certain geographic regions, *i.e.*, the North.

Table 1 presents the production and employment multipliers, which were calculated via Leontief inverse, for the German case. The multipliers can be, among others, shown to be correlated with private investment allocation by industry (Figure 2). The same was performed for the Japanese case, as indicated in Table 2 and Figure 3. In Germany (Figure 4), work creation expenditure and military spending were far larger than private investment during the first years of the Hitler regime. Figure 5 indicates a different picture for the other Axis country, Japan, where military expenditure fell short of private investment until the outbreak of the Sino-Japanese War, although the classification method

[1] For the availability of data and the characteristics of the sources, investment expenditures were quoted as private investment, gross fixed capital formation, net investment, and gross investment as indicated in each figure.

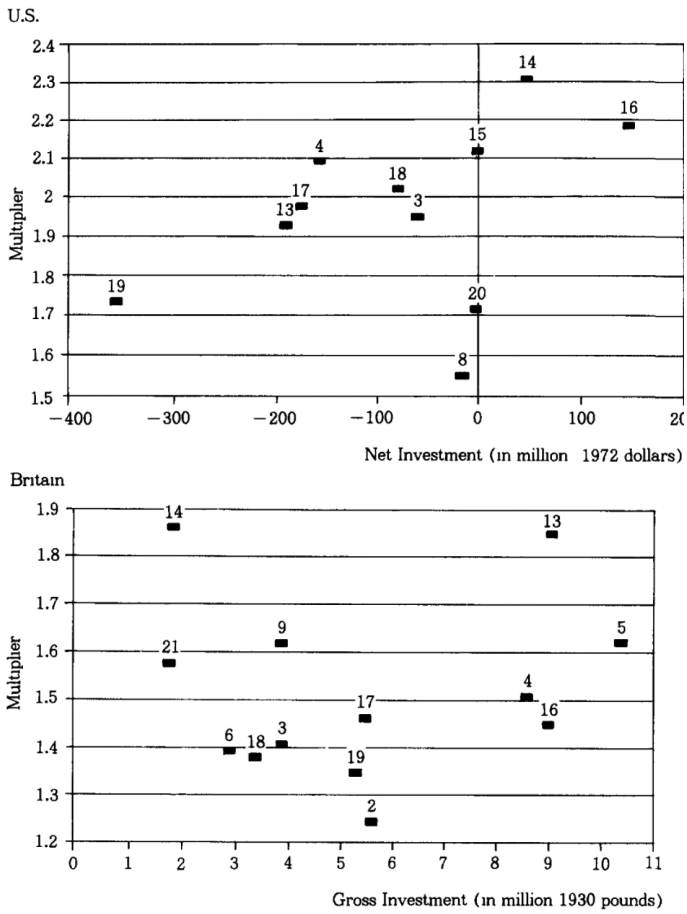
TABLE 2
SECTORAL MULTIPLIERS: JAPAN, 1935

Industrial Sector	Production Multipliers	Employment Multipliers (Man-year per 1000 Yen)	
		1930	1940
1. Agriculture	1.53	0.55	0.54
2. Fishery	1.38	0.20	0.19
3. Mining	1.95	0.15	0.29
4. Foods	2.41	0.03	0.02
5. Textiles and Apparels	3.05	0.11	0.11
6. Lumbers	1.63	0.17	0.16
7. Pulp and Paper	2.31	0.07	0.13
8. Publishing, Printing	3.25	0.09	0.10
9. Leather and Rubber	2.66	0.11	0.17
10. Chemicals	2.42	0.02	0.05
11. Pottery	1.60	0.08	0.11
12. Metal	2.95	0.06	0.10
13. Machinery	2.12	0.04	0.16
14. Other Manufacture	2.34	0.17	0.16
15. Construction	2.32	0.12	0.12
16. Utilities	1.20	0.02	0.02
17. Commerce	1.30	0.17	0.17
18. Finance, Insurance	1.03	0.01	0.02
19. Real Estate	1.09	-	0.01
20. Transportation	1.77	0.12	0.14
21. Public Service	1.00	0.12	0.10
22. Other Service	1.60	0.17	0.20
23. Stationaries	3.37	-	-
24. Unclassified	1.37	0.00	0.00
Average	1.99	0.12	0.13

may have differed.

For the sake of comparison, military spending by industry was put against sectoral multipliers in Figures 6 and 7 along with private investment expenditure. Military expenditure was heavily allocated to automobile, iron and steel, and machinery sectors where production multipliers are high.

On top of the direct production effect of the military spending, indirect production derived through backward linkage (indirect Leontief) and additional multiplier effect through consumption out of enlarged income (indirect Keynes) were estimated (Fremdling, and Staeglin 2015, p. 20, Table 9). We doubt the latter effect, however, because Keynes's multiplier



Source: Yang (1995), p.76, Fig. 2

FIGURE 1
INVESTMENT ALLOCATION: U.S. AND BRITAIN, 1935

either of government expenditure or of private investment would be subjected to long lags in realizing full potential.[2]

[2] Keynes's multiplier augmented input-output model was acclaimed by Pischner und Staeglin (1976). Fremdling, and Staeglin (2014b, p. 387, Table 5) estimated only indirect Leontief. Fremdling, and Staeglin (2015, p. 22, Table 10) computed both indirect Leontief, and indirect Keynes.

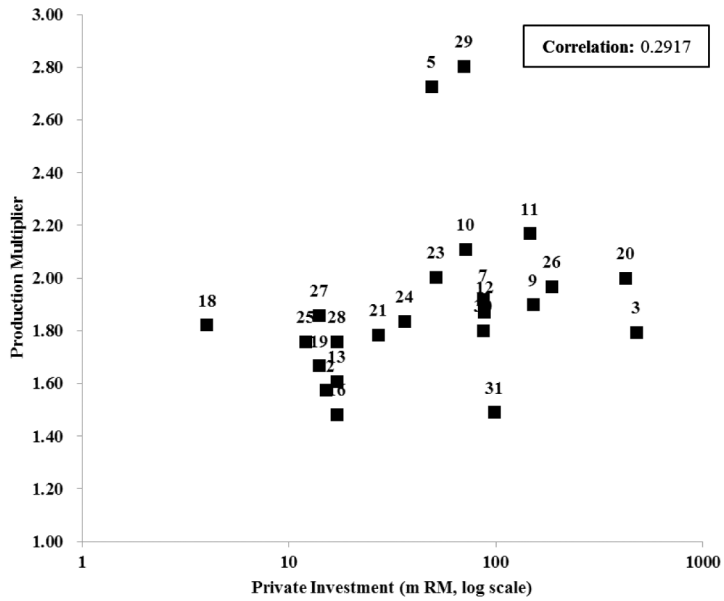


FIGURE 2
PRIVATE INVESTMENT – PRODUCTION MULTIPLIER: GERMANY, 1936

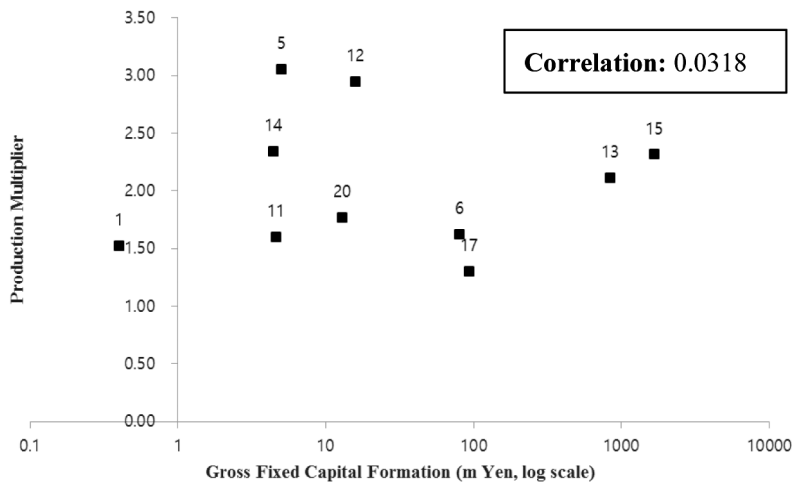
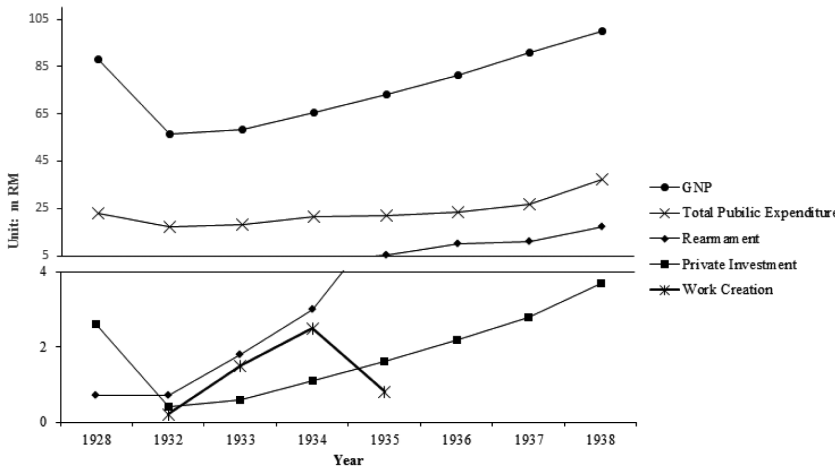


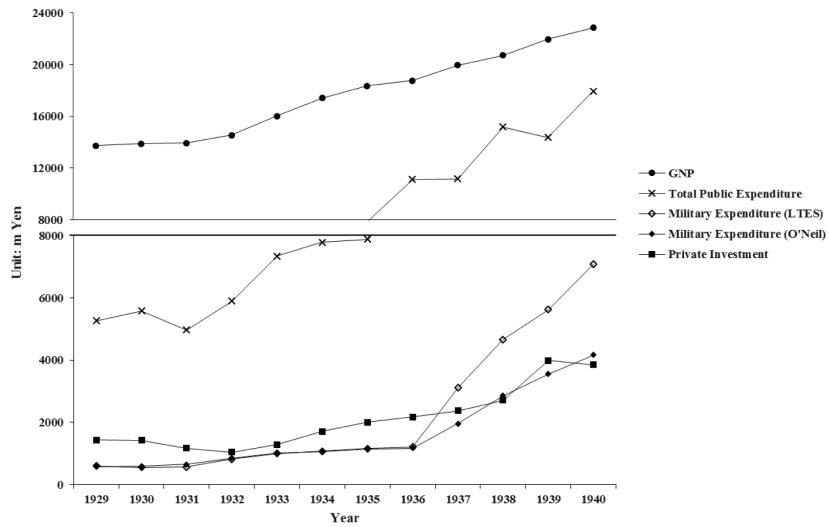
FIGURE 3
GROSS FIXED CAPITAL FORMATION – PRODUCTION MULTIPLIER: JAPAN, 1935



Source: Yang (1995, p.71, Table 2)

FIGURE 4

PUBLIC EXPENDITURE AND PRIVATE INVESTMENT: GERMANY, 1928-1938



Source: LTES (vol. 1, p.219, 225; vol. 7, p.213), O'Neil (2003, p.20, 21)

FIGURE 5

GROSS CAPITAL FORMATION AND MILITARY EXPENDITURE: JAPAN, 1929-1940

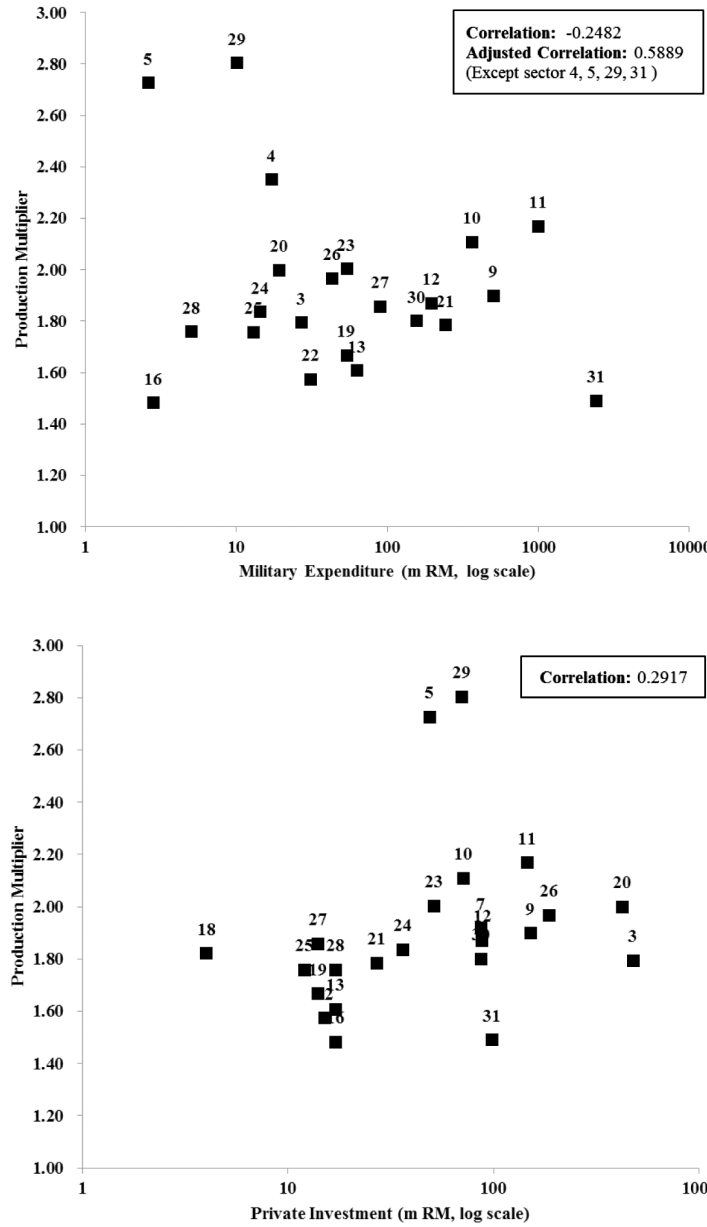
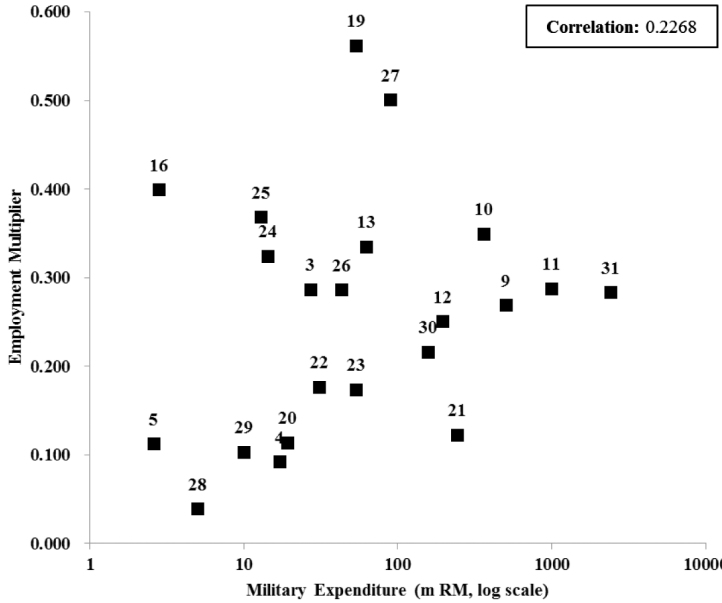


FIGURE 6

PRODUCTION EFFECT OF REARMAMENT AND PRIVATE INVESTMENT: GERMANY, 1936



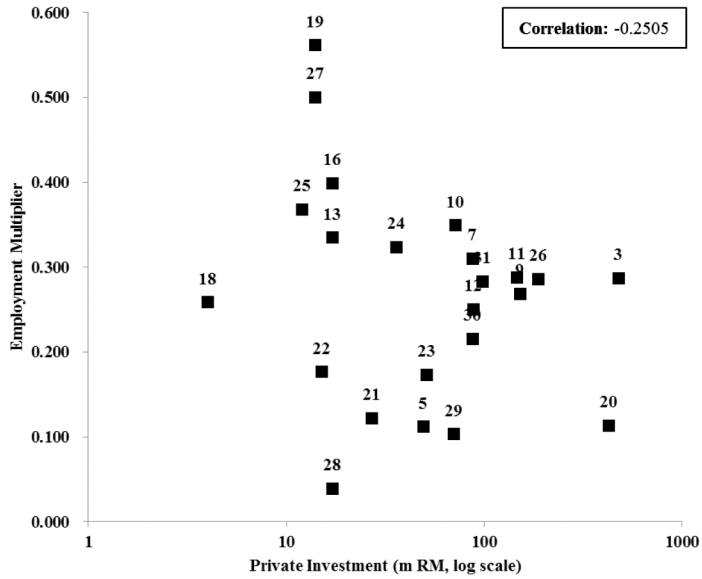


FIGURE 7

EMPLOYMENT EFFECT OF REARMAMENT AND PRIVATE INVESTMENT: GERMANY, 1936

TABLE 3
TOTAL EFFECTS OF REARMAMENT AND PRIVATE INVESTMENT: GERMANY, 1928-1938

		1928	1932	1933	1934	1935	1936	1937	1938
Production Effect (m RM)	Military Expenditure	-	1189	1861	7153	10890	18311	19748	31348
	Private Investment	5140	859	1092	2085	3177	4187	5500	7131
Employment Effect (1000s)	Military Expenditure	-	185	289	1111	1692	2845	3068	4871
	Private Investment	626	103	135	258	397	514	674	874

Source: Military Expenditure – Fremdling and Staeglin (2015, p. 22, Table 10), Private Investment – Σ(Investment×Sectoral Multiplier)

Table 3 summarizes the total direct and indirect effects of military spending and private investment for the period 1928-1938. The production and employment effects include "indirect Leontief" but not "indirect Keynes." The conclusion about military spending supports the traditional view that the National Socialist regime introduced a wide range of government policies designed to augment and accelerate existing recovery, but modified the chronology. Rearmament became increasingly important, but not from 1936 onwards, "Rearmament actually gathers momentum as early as 1934" (ibid., p. 24). Table 3 demonstrates that private investment expanded continuously and was allocated primarily to iron and steel, chemicals, machinery, and automobiles with higher sectoral multipliers. These allocations complemented government expenditure in promoting production and employment growth.

For Japan, where the Great Depression was relatively late, short, and minor (Nakamura 1998), we have the estimate that the growth of the total final demand in the amount of JPY 5,623 million derived total production of JPY 12,317 million during the years 1931-1936 (Tominaga 1986, p. 328, Table 1). Some industry-specific data are presented in Table 4.

Encompassing all four countries, we can reclassify the industry structure into 24 common sectors and develop a comparative table, as Table 5. We present the table as is and anticipate further research by scholars, including us. For now, we only intend to report immediate responses to the new information of the German 1936 input-output table.

TABLE 4

SECTORAL PRODUCTION MULTIPLIER EFFECTS: JAPAN, 1931-1936 (M YEN)

	Consumption Expenditure ΔC	Government Expenditure ΔG	Investment Expenditure ΔK	Export ΔE	Import Substitution ΔB	Total
4. Foods	156.7	17.0	7.1	131.1	78.1	390.1
5. Textiles and Apparels	680.4	16.4	27.7	1224.8	84.2	2,033.5
6. Lumbers	24.6	7.7	99.1	75.5	13.3	220.2
8. Publishing, Printing	53.2	22.3	6.4	25.3	2.5	110.0
10. Chemicals	332.4	75.6	119.6	646.0	86.0	1,259.6
11. Pottery	20.7	6.8	56.4	23.7	3.6	111.2
12. Metal	99.4	151.5	403.7	475.7	29.7	1,160.0
13. Machinery	67.5	350.8	813.1	312.2	98.7	1,642.3
14. Other Manufacturers	33.6	41.6	4.3	31.1	14.5	125.1
Total	1,468.8	689.7	1,537.4	2,945.5	410.6	7,052.0

Source: Tominaga (1986, p. 328, Table 2)

A preliminary discussion would call attention to relatively higher multipliers, such as a denser structure in Japan and to the other end of the spectrum, Britain. Gerschenkron (1962) observed that late industrializers tended to concentrate more on heavy industries. In a similar manner, we presume that the later each country industrializes, the closer the industry structure inside the country becomes, among "new" heavy and chemical industries. Hence, the order is Japan, the U.S., Germany, and Britain.

Noticeable are the low multipliers in the old staples, such as coal, textiles, iron and steel, and shipbuilding, except German iron and steel, and with the special exception of Japanese textiles. High multipliers in the "new" industries, such as chemicals and automobiles, as indicated with British outliers, presented patterns in the opposite direction. This behavior reflected relative decline.

Investment allocation by industry can be plotted against sectoral multipliers, as indicated in Figures 2 and 3, and compared to previous diagrams of Yang (Figure 1). At first glance, the U.S. had the most

TABLE 5

SECTORAL MULTIPLIERS: U.S. 1939, BRITAIN 1935, GERMANY 1936 AND JAPAN 1935

	Production Multipliers				Employment Multipliers (Man year)				
	U.S.	Britain	Germany	Japan	U.S. (per 1000$)	Britain (per 1000£)	Germany (per 1000RM)	Japan (1930) (per 1000¥)	Japan (1940) (per 1000¥)
1. Agriculture	1.9037	1.5169	1.4810	1.5146	1.11	3.7	1.32	0.52	0.50
2. Coal and Coke	1.9768	1.2439	-	-	0.45	5.3	-	-	-
3. Other Mining & Nonmetallic Minerals	1.9476	1.4057	1.6881	1.7682	0.32	3.3	0.31	0.11	0.19
4. Chemicals	2.0912	1.5079	2.0104	2.4247	0.27	2.0	0.10	0.02	0.05
5. Iron and Steel Manufactures	1.7919	1.6252	2.3638	2.9459	0.34	1.9	0.35	0.06	0.10
6. Nonferrous Metals	2.1007	1.3948	2.3000	-	0.22	1.7	0.07	-	-
7. Shipbuilding	1.6570	1.7575	-	-	0.39	3.3	-	-	-
8. Mechanical Engineering	1.5493	1.6384	1.8638	2.1153	0.29	3.6	0.25	0.04	0.16
9. Electrical Engineering	1.8538	1.6171	1.8714	-	0.32	3.5	0.20	-	-
10. Motor Vehicles	2.5616	1.8820	2.1692	-	0.35	3.2	0.22	-	-
11. Aircrafts	1.5186	1.5245	-	-	0.31	2.6	-	-	-
12. Railroads	1.7233	1.6504	-	-	0.31	3.0	-	-	-
13. Textile Manufactures	1.9276	1.8510	1.9681	3.0546	0.51	4.1	0.29	0.11	0.11
14. Clothing	2.3033	1.8609	1.8589	-	0.53	4.7	0.36	-	-
15. Leather	2.1166	1.6754	1.7590	2.6640	0.46	3.1	0.30	0.11	0.17
16. Food Industry	2.1833	1.4527	1.8489	2.4056	0.52	1.6	0.26	0.03	0.02
17. Wood Industry	1.9768	1.4612	1.7077	1.6253	0.49	3.5	0.39	0.17	0.16
18. Paper	2.0216	1.3806	2.0050	2.3108	0.34	1.6	0.12	0.07	0.13
19. Printing and Publishing	1.7340	1.3480	1.8374	3.2489	0.34	3.1	0.29	0.09	0.10
20. Rubber	1.7171	1.4665	1.5745	-	0.29	-	0.12	-	-
21. Miscellaneous Manufacturers	1.6784	1.5731	-	2.7519	0.33	-	-	0.10	0.09
22. Construction	1.8963	1.6071	1.4911	2.3170	0.27	3.4	0.32	0.12	0.12
23. Gas, Electricity, and Water	1.5339	1.5464	1.8963	1.2015	0.25	2.3	0.08	0.02	0.02
24. Service	1.4489	1.2167	1.7633	1.3834	0.36	3.0	1.33	0.13	0.14
Average	1.8839	1.5502	1.8662	2.2488	0.39	2.9	0.35	0.11	0.14

favorable investment allocation and other countries had room for hypothetical improvement.

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Appendix

Reclassifying the industry category by merging similar sectors and thus reducing the number of "industries" generally decreased the size of multipliers. Even worse, those sectors that were not agglomerated, but carried original content, resulted in lower multipliers in every case. This situation suggests that reclassification involves systemic bias.[3]

We propose a simple experiment with a three-sector economy, as in Appendix Table 1, where we merged sectors 1 and 2. Then, the newly created sector will have a production input coefficient b_1 somewhere between a_1 and a_2. If $a_1 < a_2$ but $X_1 > X_2$, b_1 will be close to a_1. That is, the new coefficient b_1 underestimates multiplier effects given that the figure does not reflect the size effect. Considering all possible cases, the probable direction of bias is shown in Appendix Table 2. Except for the extreme case of the same technology and size, reclassification for convenience or brevity, we risk misrepresenting multiplier effects.

To minimize this misrepresentation, we take weighted averages of initially calculated sectoral multipliers out of the original table, rather than to obtain coefficients from the reclassified merged table. The new

APPENDIX TABLE 1
3-SECTOR INPUT COEFFICIENTS AND THE AMOUNT OF PRODUCTION

Sector	Before		After	
	Coefficient	Size	Coefficient	Size
1	a_1	X_1	b_1	X_1+X_2
2	a_2	X_2		
3	a_3	X_3	b_2	X_3

[3] Witness the discrepancies in the total effects of military expenditure reported in Fremdling and Staeglin (2014a, p. 387) having 19 sectors, and those in Fremdling and Staeglin (2015, p. 22) having 40 sectors. See discussions in Kang (1991) and Bank of Korea (2014).

APPENDIX TABLE 2
NEW PRODUCTION INPUT COEFFICIENT BY CASE

Coefficient	Size	New coefficient b_1
$a_1 < a_2$	$X_1 > X_2$	Underestimate
$a_1 < a_2$	$X_1 < X_2$	Overestimate
$a_1 < a_2$	$X_1 = X_2$	Biased
$a_1 > a_2$	$X_1 > X_2$	Overestimate
$a_1 > a_2$	$X_1 < X_2$	Underestimate
$a_1 > a_2$	$X_1 = X_2$	Biased
$a_1 = a_2$	$X_1 > X_2$	Overestimate
$a_1 = a_2$	$X_1 < X_2$	Overestimate
$a_1 = a_2$	$X_1 = X_2$	No error

multipliers are:

$$b_1 = a_1 \times \left(\frac{X_1}{X_1 + X_2} \right) + a_2 \times \left(\frac{X_2}{X_1 + X_2} \right)$$

$$b_2 = a_3 \times \left(\frac{X_3}{X_3} \right) = a_3$$

Thus, we can solve the problem of contaminating b_2, and minimize the information loss coming from the reclassification.

Statistical sources

* Input-Output tables: the U.S. 1939, Leontief (1951); Britain 1935, Barna (1952); Germany 1936, Fremdling and Staeglin (2014a); Japan 1935, Nishikawa and Koshihara (1981)
* Military spending by industry in Germany: Fremdling and Staeglin (2015, p. 19, Table 8)
* Private investment by industry in Germany: *Statistisches Jahrbuch fuer das Deutsche Reich*, 1938, S.566, 1940, S.584
* Gross investment by industry in Britain: Feinstein (1965)
* Net investment by industry in the U.S.: Bernstein (1987, p. 115-118)
* Gross fixed capital formation by industry in Japan: from the I/O table of Japan

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