How can we evaluate the contribution of intangible assets on productivity growth ?
- Measurement in IO & SNA -

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Story on Productivity Paradox

Productivity Paradox:

- R.Solow remarked in1987 that "you see the computer revolution everywhere except in the productivity data."

Conceptualization Problem:

- Greenspan pointed out that the negative trends in measured productivity in many service sectors seemed inconsistency with the facts that they ranked among the top computer-using industries.

- Questions raised by Greenspan on the accuracy of the computer price index.

Productivity Trends in 1990s
- U.S. vs. Japan and Europe -

Robert E. Rubin, former Secretary of the Treasury, pointed out that the return of the productivity in the U.S. at the first half of 1990s and raised several factors for the recovery.

1. The restoration of sound fiscal policy.

2. Advances in technology contributed to the US productivity growth. Why Europe and Japan did not experience increased productivity growth, although they had access to the same technologies the US did in the 1990s.

3. America's culture and historical disposition to take risks and embrace change.

4. More flexible labor market .

5. Openness of the market: Japan's and Europe's relatively less open markets protected companies and reduced their incentive to become more efficient.

-Contents-

- **At first, I will observe the facts on productivity growth by commodity by 7 Japanese linked Input-Output tables since 1960 and summarize recent features on the productivity growth in Japan.**

- **How to evaluate the contribution of intangible assets on productivity growth.**

    / Classification of intangible assets.

    / Treatment of intangible assets in current SNA and Input-Output framework

    - **Software**
    - **Innovative property**
    - **Economic competencies**

  - **Problems to be solved**

Linked IO Tables and Related Data

- **Linked IO Tables**

   /60-65-70 Linked: 339 commodities
   /65-70-75 Linked: 392 commodities
   /70-75-80 Linked: 394 commodities
   /75-80-85 Linked: 349 commodities
   /80-85-90 Linked: 353 commodities
   /85-90-95 Linked: 394 commodities
   /90-95-00 Linked: 394 commodities

- **Time-series Labor and Capital Service**
  (Keio Economic Observatory Data)
   Input Quantity and price Index: 43 Industrial sectors : (1960-2000)

Triangulation and Technology Linkage

Construction

Machinery

Electric Products

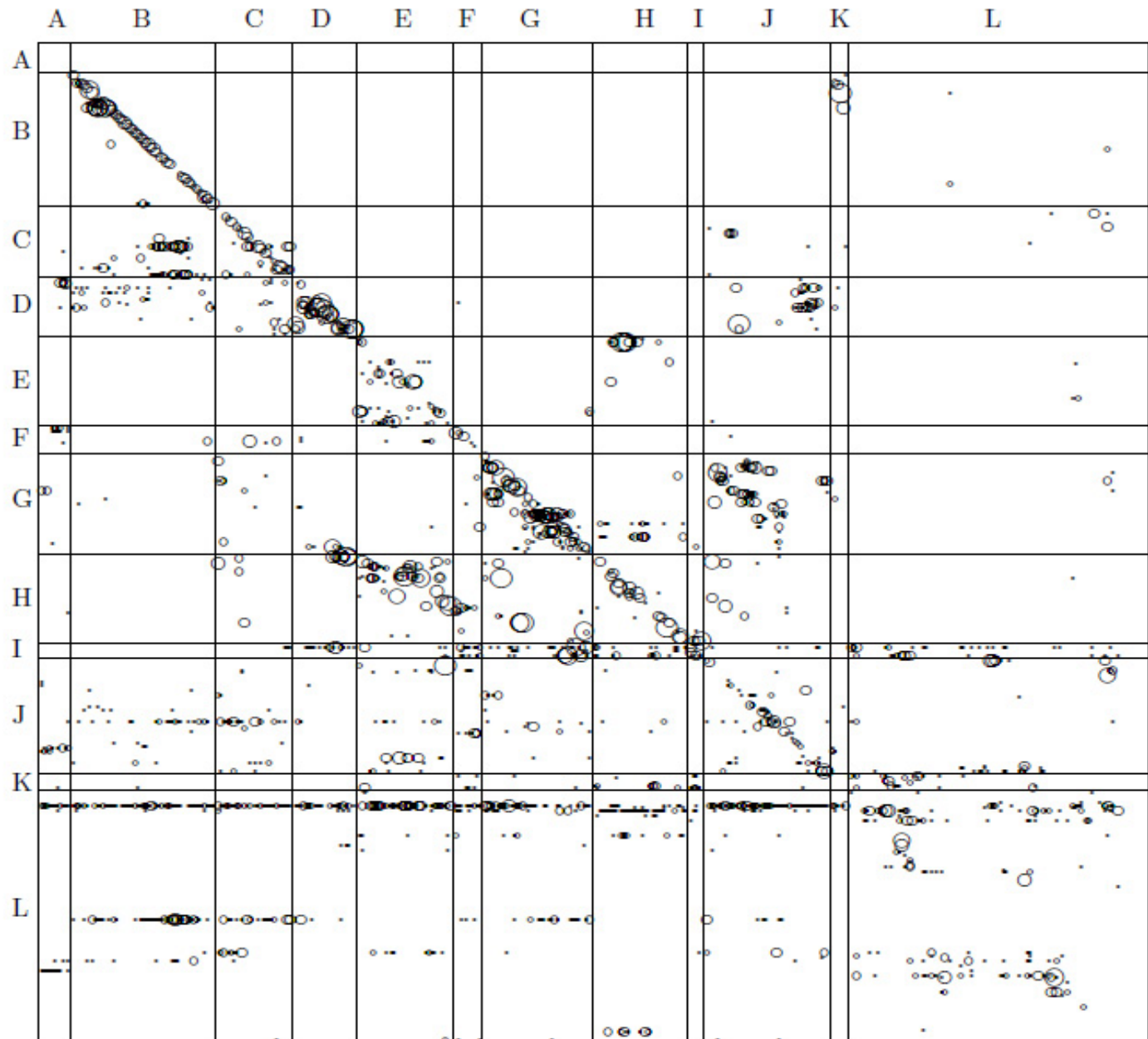Metal Products

Food Products

Stone & Clay

Mnf. Final Prod.
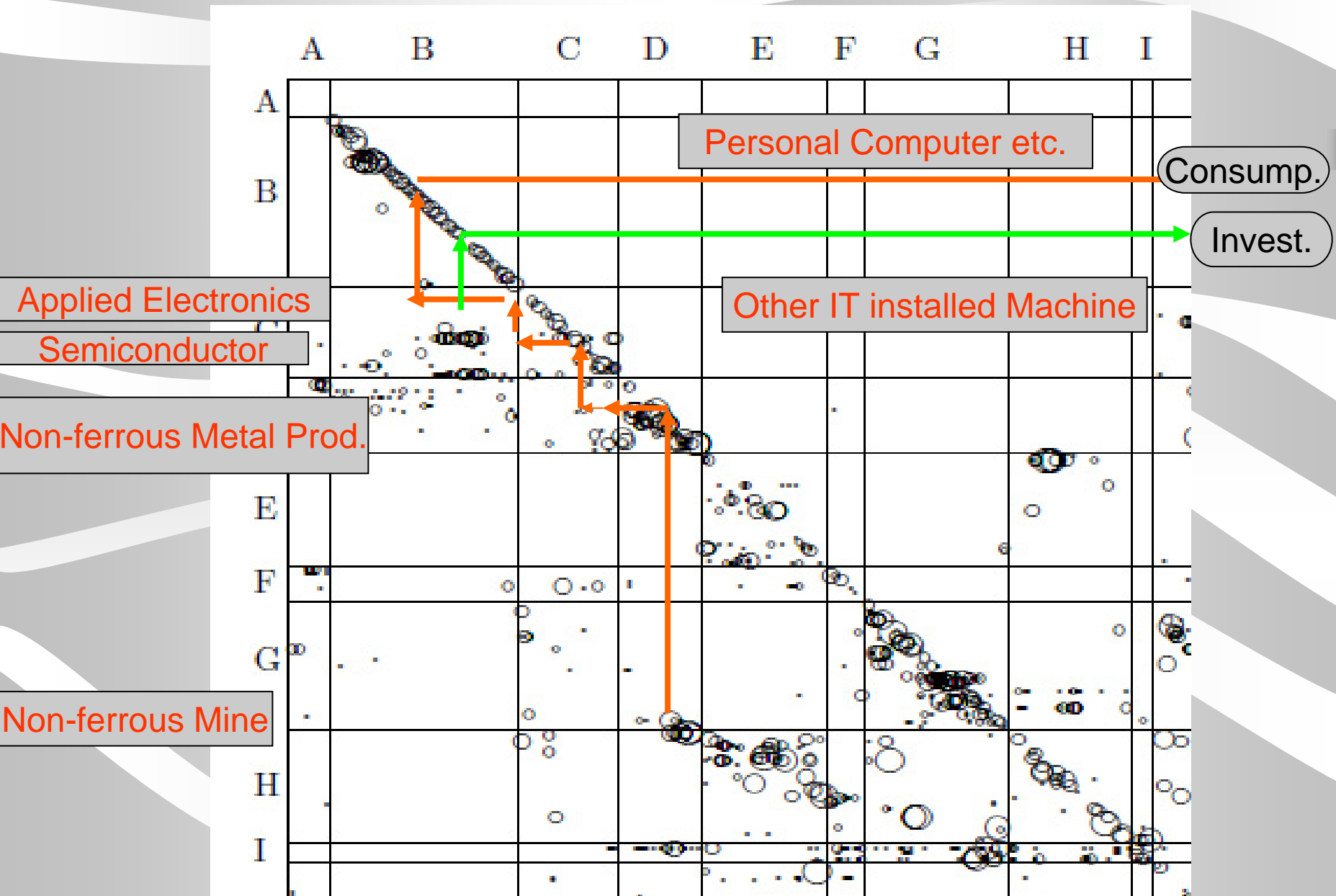
Material Prod.

Energy

Auxiliary

Repairs

Service

Block Classification

A	Construction
B	Machinery & Equipment
B1	Construction & Transportation Equipment
B2	General Machinery
B3	Electric Machinery
B4	Precision Instruments
C	Electric & Erectronic Products
C1	Miscellaneous Manufacturing Products
C2	Electronic Equipment & Components
C3	Heavy and Other Electrical Equipment
D	Metal Products
E	Food Products
F	Stone & Clay Products
G	Other Manufacturing Final Products
G1	Textile Products
G2	Paper Products
G3	Chemical Products
H	Material Products
H1	Metal and Non-Metal Material Products
H2	Food and Wood Material Products

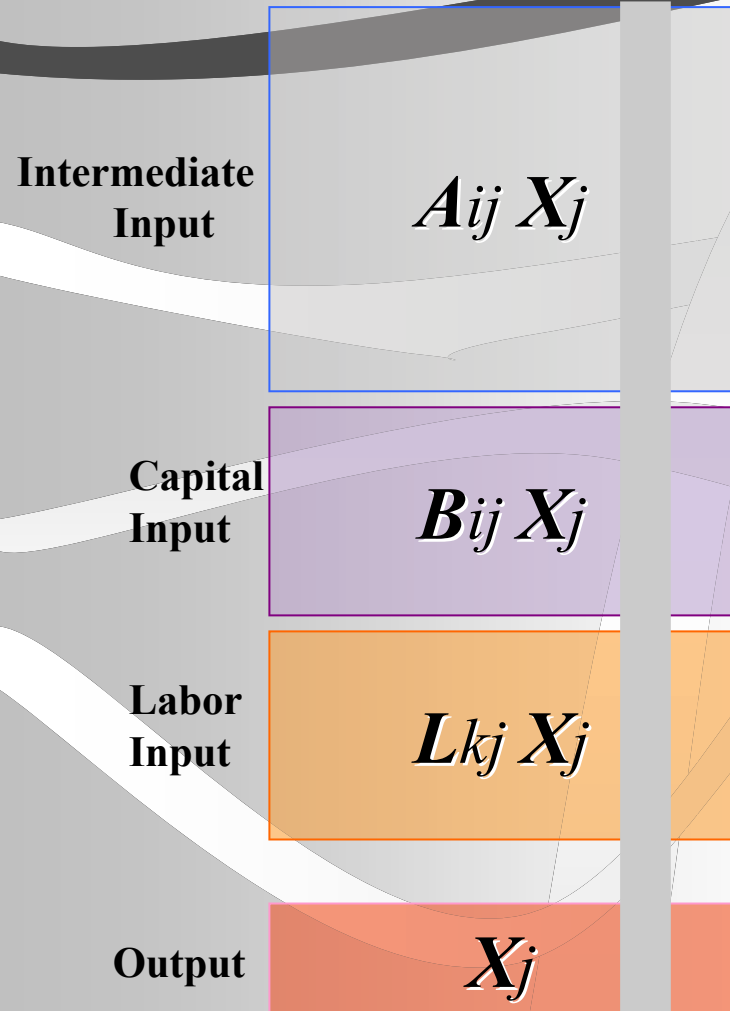|	
I	Secondary Energy Products
J	Auxialry Material
J1	Auxiliary Material: Medical Products
J2	Auxiliary Material:Textile Products
J3	Auxiliary Material: Paper
J4	Auxiliary Material: Metal
J5	Auxiliary Material :Prastic
J6	Auxiliary Material: Chemical
J7	Auxiliary Material: Construction
J8	Auxiliary Material: Others
K	Repairs
L	Service
L1	Water Supply and Waste Management
L2	Transportation & Comminication service
L3	Education & Research
L4	Medical Service
L5	Other service

Technology Linkage: Semiconductor production

Personal Computer etc.

Consump.

Invest.

Applied Electronics

Semiconductor

Other IT installed Machine

Non-ferrous Metal Prod.

Non-ferrous Mine

Productivity Analysis：
Commodity-base Own TFP

I-O Table

j-Industry

TFP ; T_j

Intermediate Input

$A_{ij} X_j$

Capital Input

$B_{ij} X_j$

Labor Input

$L_{kj} X_j$

Output

X_j

・ Commodity-base

・ Structural Change
$$X_j, K_j, L_j$$

・ **Production Function**

$$X_j = f(K_j, L_j, X_{ij}, T_j)$$

・ **Own Total Factor Productivity**

$$\frac{\dot{T_j}}{T_j} = \frac{\dot{X_j}}{X_j} - \sum_n s_{x_{ij}} \frac{\dot{X_{ij}}}{X_{ij}} - s_{Lj} \frac{\dot{L_j}}{L_j} - s_{Kj} \frac{\dot{K_j}}{K_j}$$

# Unit Structure & Static Unit TFP

Intermediate Input

$$A_{ij}\, X_j$$

Capital Input

$$B_{ij}\, X_j$$

Labor Input

$$L_{kj}\, X_j$$

Output

$$X_j$$

·Unit Structure

Taking f*=e(i), where e(i) denotes the i-th unit
Vector with a one in position I and all other entities
Equal to zero, the matrices of intermediate deliveries,
X*, labor L*, and capital K* required for producing
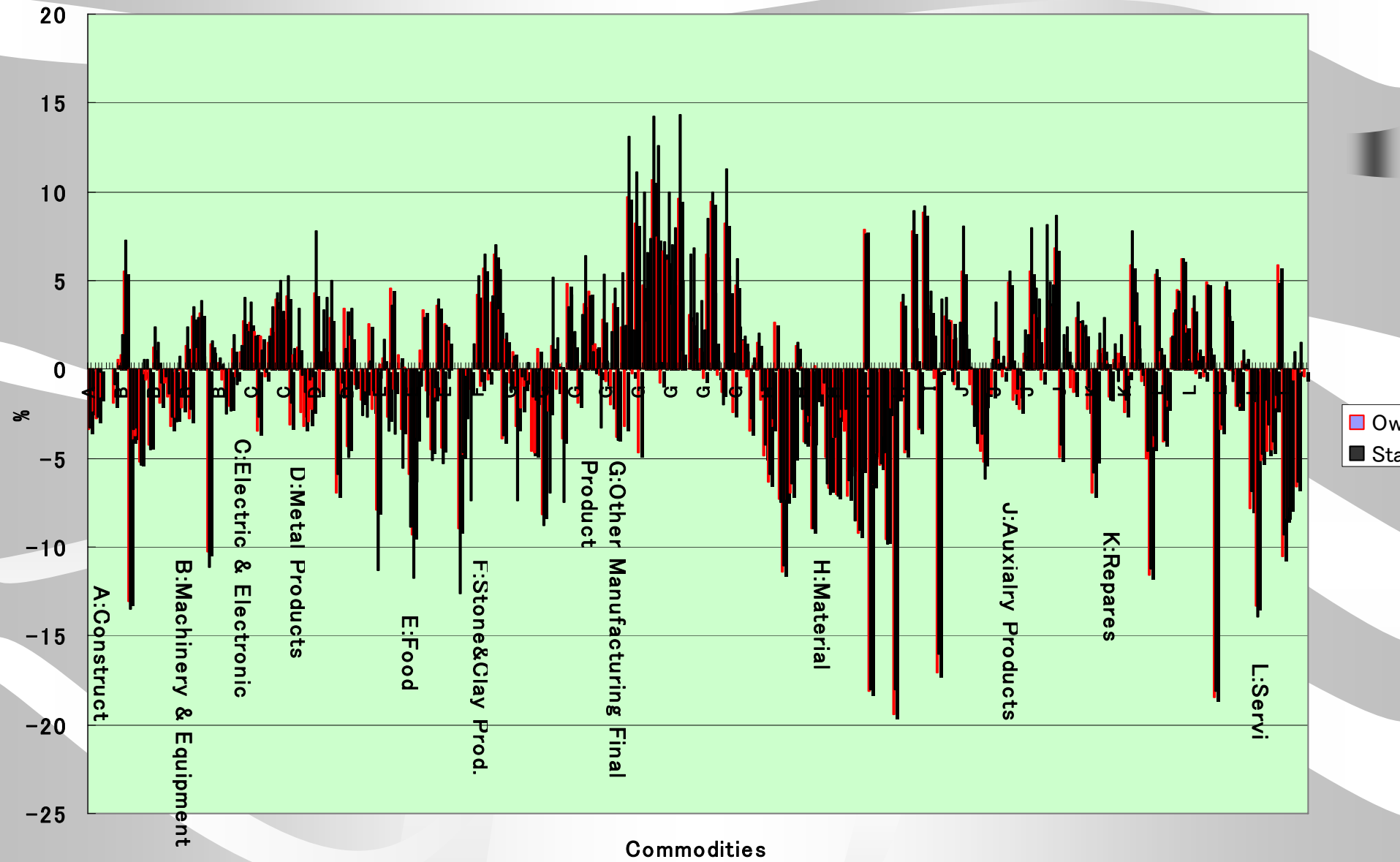*A single unit of final demand of commodity are given*
as follows:

$$\mathbf{U}_{t/f_t^* = e_{(i)}} = \begin{bmatrix} X_t^* \\ L_t^* \\ K_t^* \end{bmatrix} = \begin{bmatrix} A_t \left\langle (I - A_t)^{-1} f_t^* \right\rangle \\ B_t^L \left\langle (I - A_t)^{-1} f_t^* \right\rangle \\ B_t^K \left\langle (I - A_t)^{-1} f_t^* \right\rangle \end{bmatrix}$$

$$\frac{\dot{T_i}}{T_i} = \sum_j \frac{P_j X_j}{P_v V} \frac{\dot{T_j}}{T_j}$$

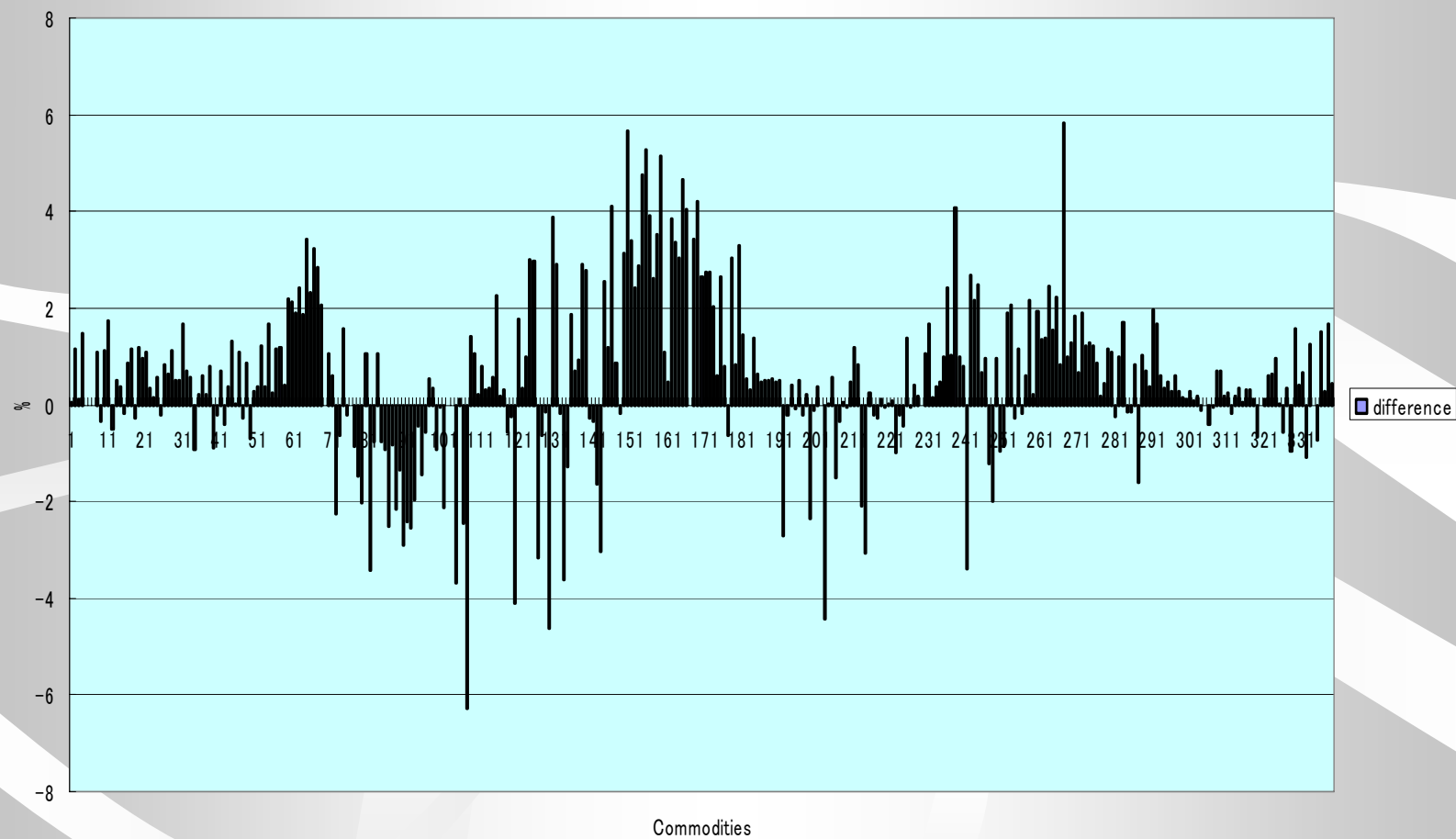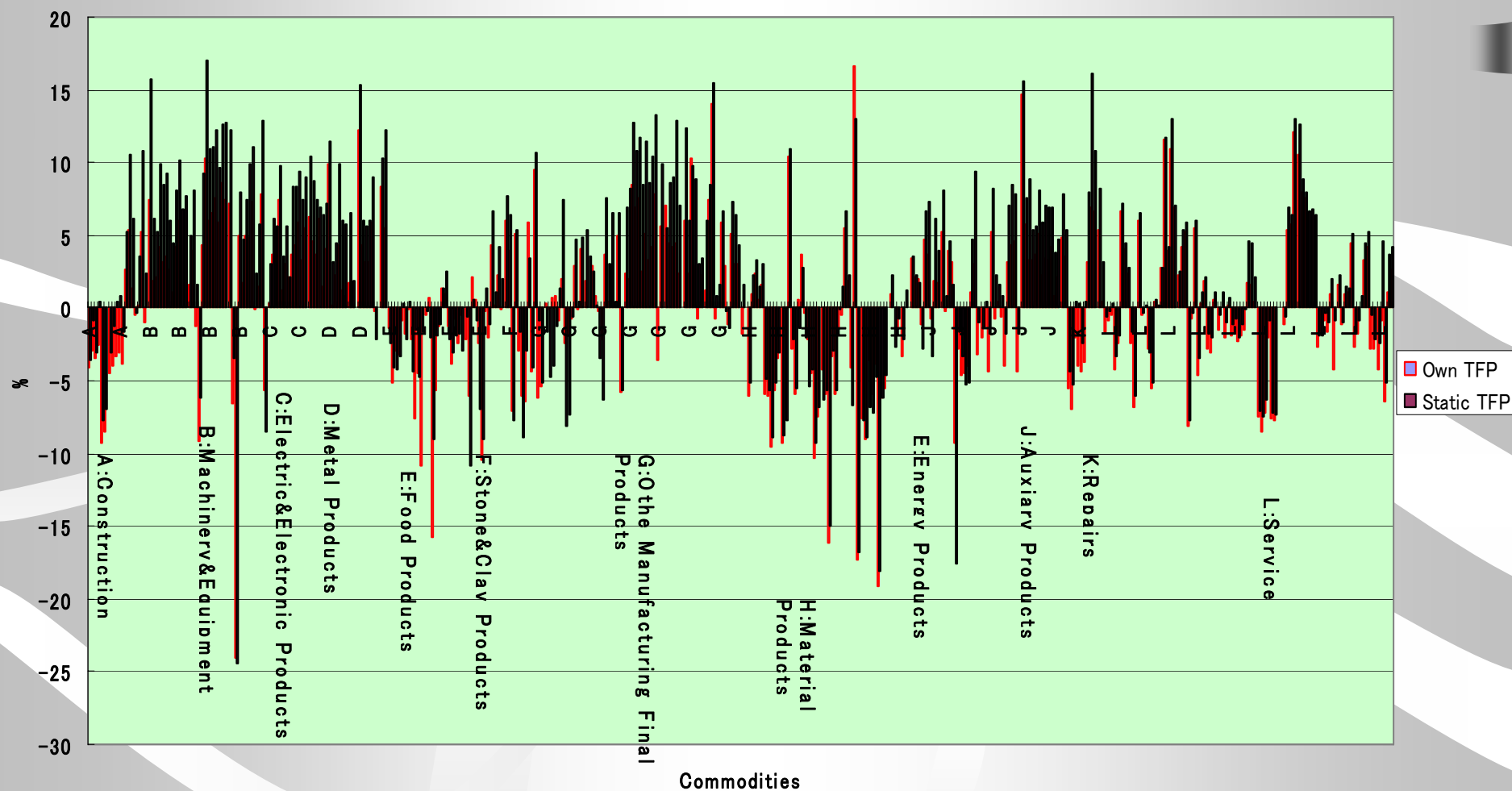· **Aggregation of commodity-based TFP**
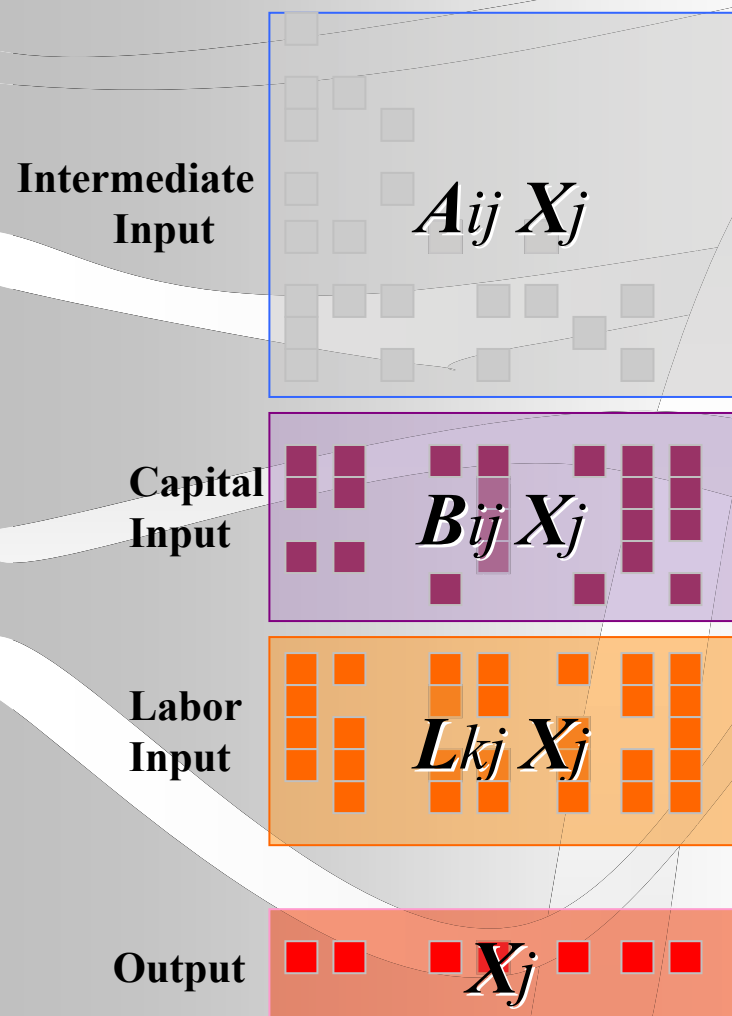
Annual Rate of Own and Static TFP by Commodities during the period 60-65

Difference between Static Unit and Own TFP : 1960-1965

Commodities

Annual Growth Rate of Own and Static TFP by Commodities during the period 65-70

Legend: Own TFP, Static TFP

Y-axis: %

X-axis: Commodities

Categories:
A:Construction
B:Machinery&Equipment
C:Electric&Electronic Products
D:Metal Products
E:Food Products
F:Stone&Clay Products
G:Othe Manufacturing Final Products
H:Material Products
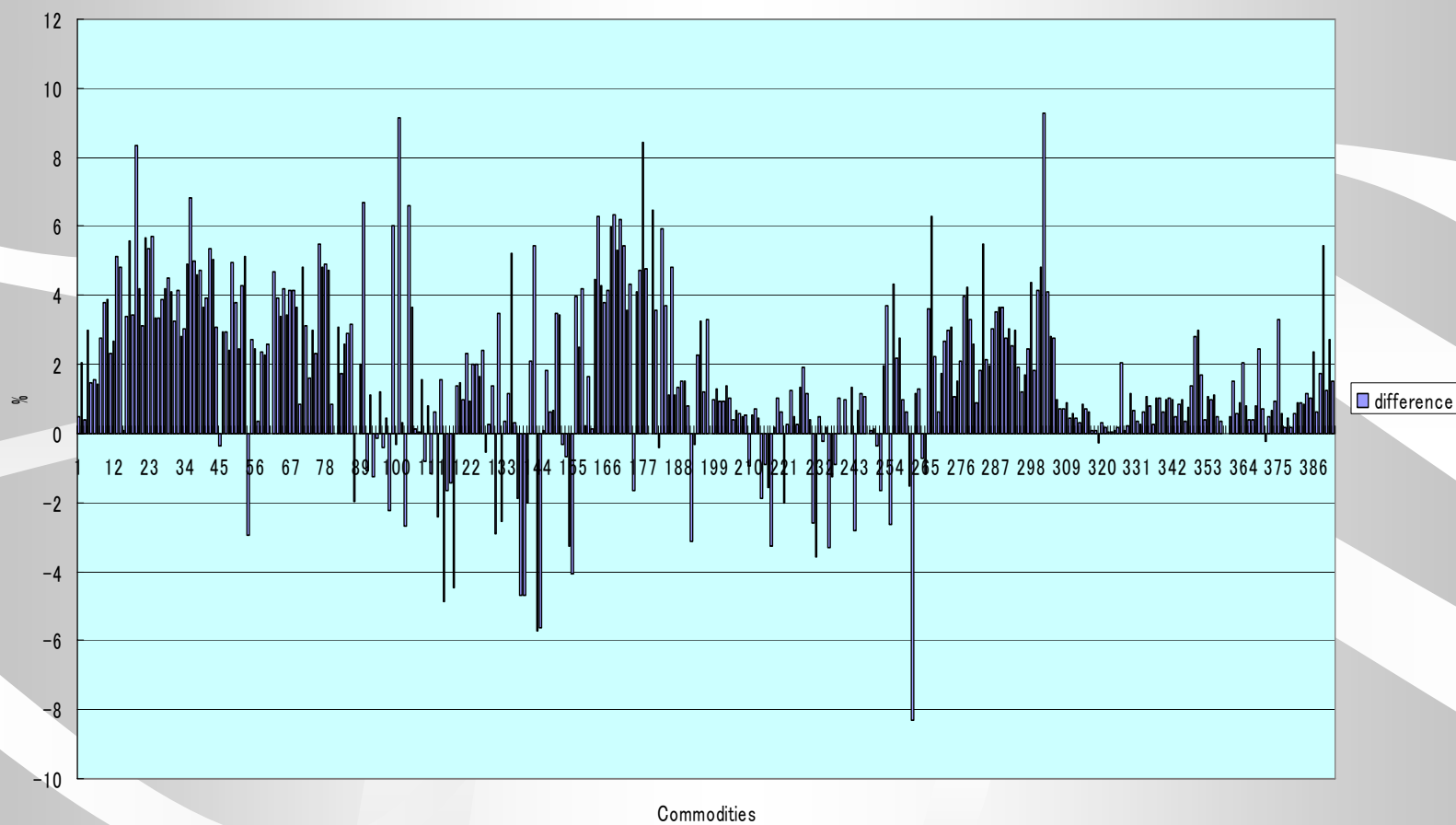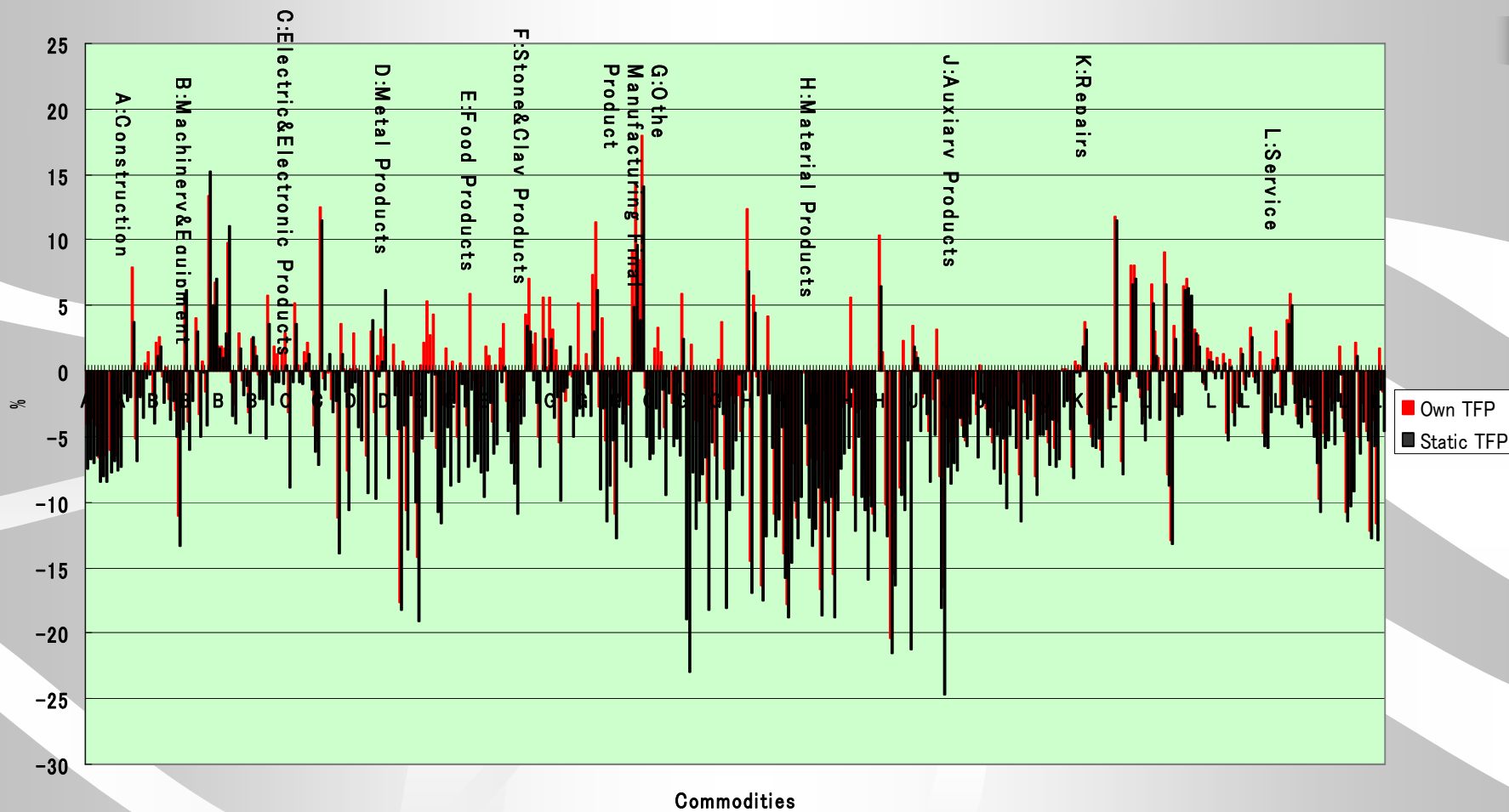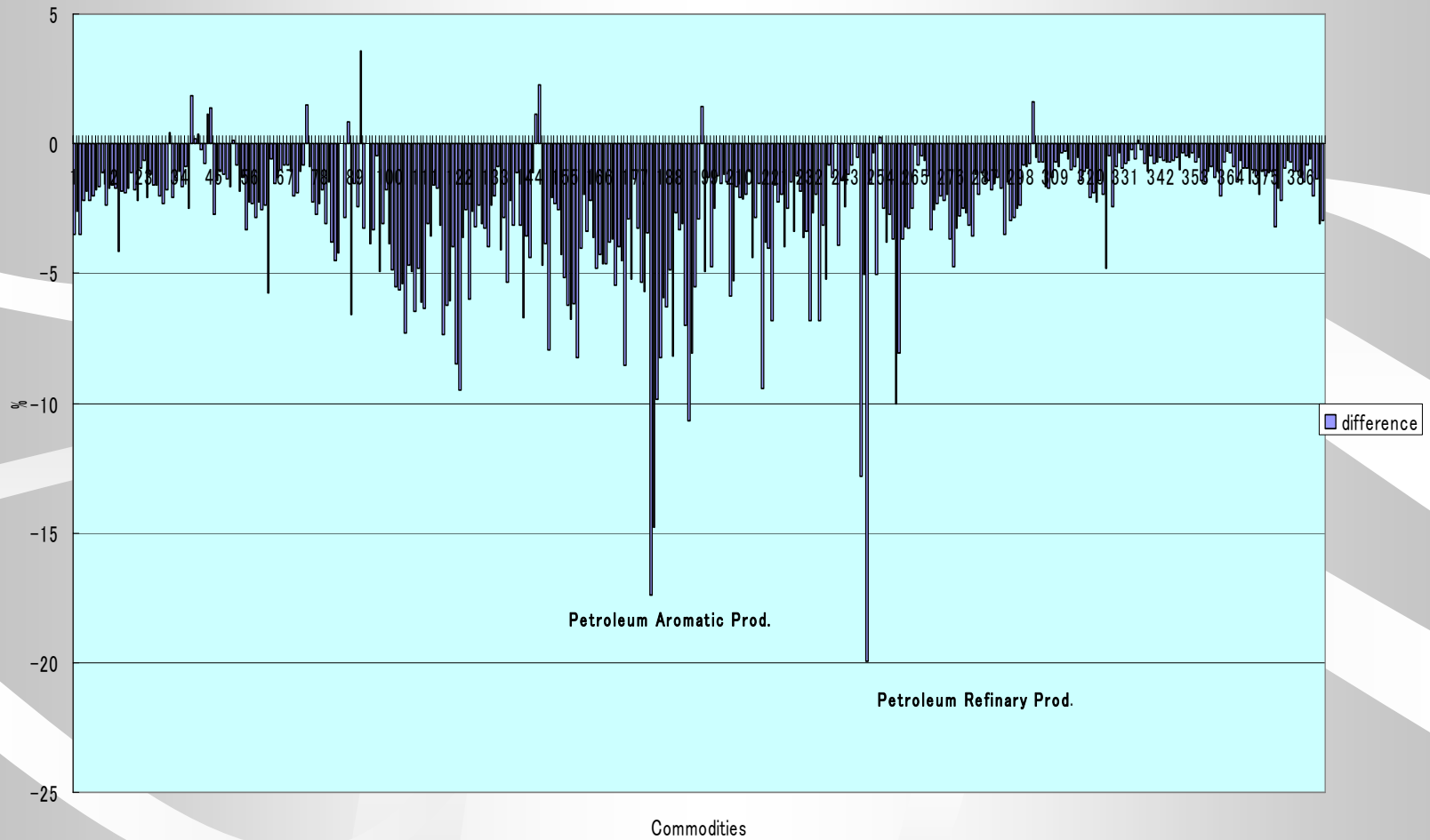E:Energy Products
J:Auxiary Products
K:Repairs
L:Service

Difference between Static Unit and Own TFP: 1965-1970

Annual Growth Rate of Own and Static TFP by Commodities during the period 70-75

Difference betwen Static Unit and Own TFP : 1970-1975

Petroleum Aromatic Prod.

Petroleum Refinary Prod.

Commodities

Annual Growth rate of Own and Static TFP by Commodities during the Period 75-80

%

Commodities

Own TFP
Static TFP

A:Construction
B:Machinery&Equipment
C:Electric&Electronic Products
D:Metal Products
E:Food Products
F:Stone&Clay Products
G:Other Manufacturing Final Product
H:Material Product
J:Auxiary Product
K:Repairs
L:Service

Difference between Static Unit and Own TFP: 1975-1980

starch

Commidities

difference

Annual Growth Rate of Own and Static TFP bt Commodities during the Period 80-85

Differences between Static Unit and Own TFP: 1980-85

Non-ferrous metal Prod.

difference

Commodities

Annual Growth Rate of Own and Static TFP by Commodities during the Period 85-90
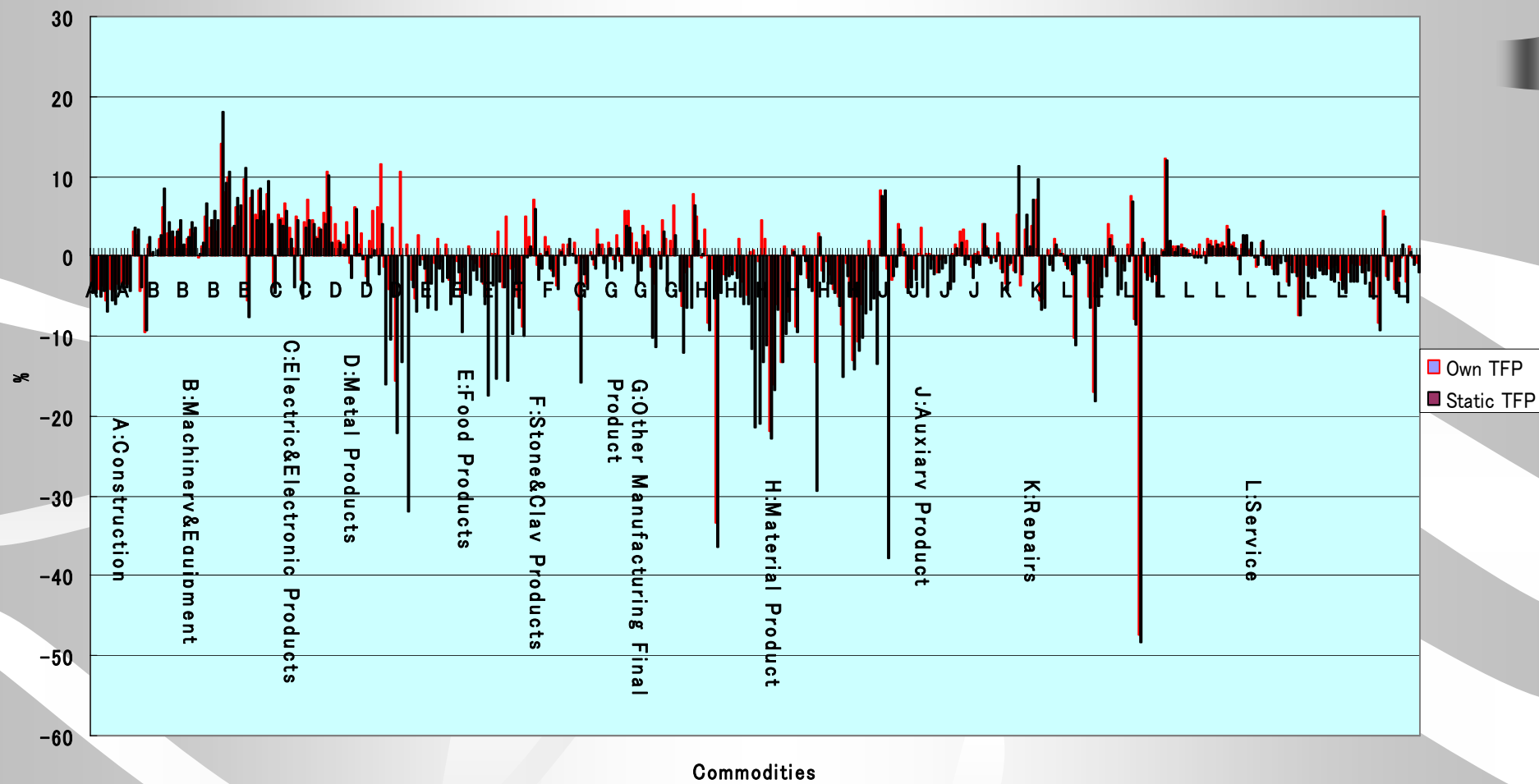
Defference between Static Unit and Own TFP: 1985-1990

Annual Growth Rate of Own and Static TFP by Commodities
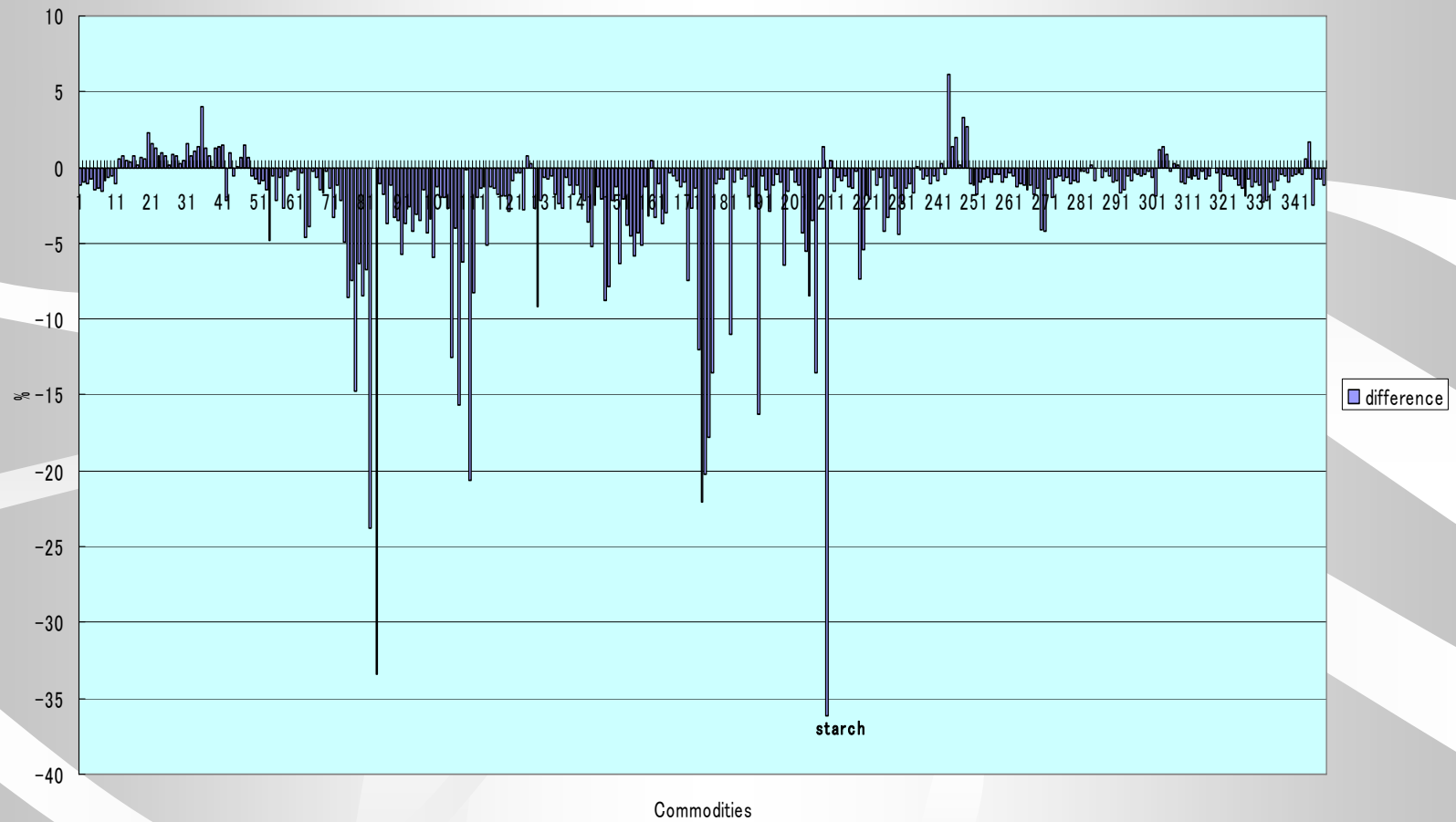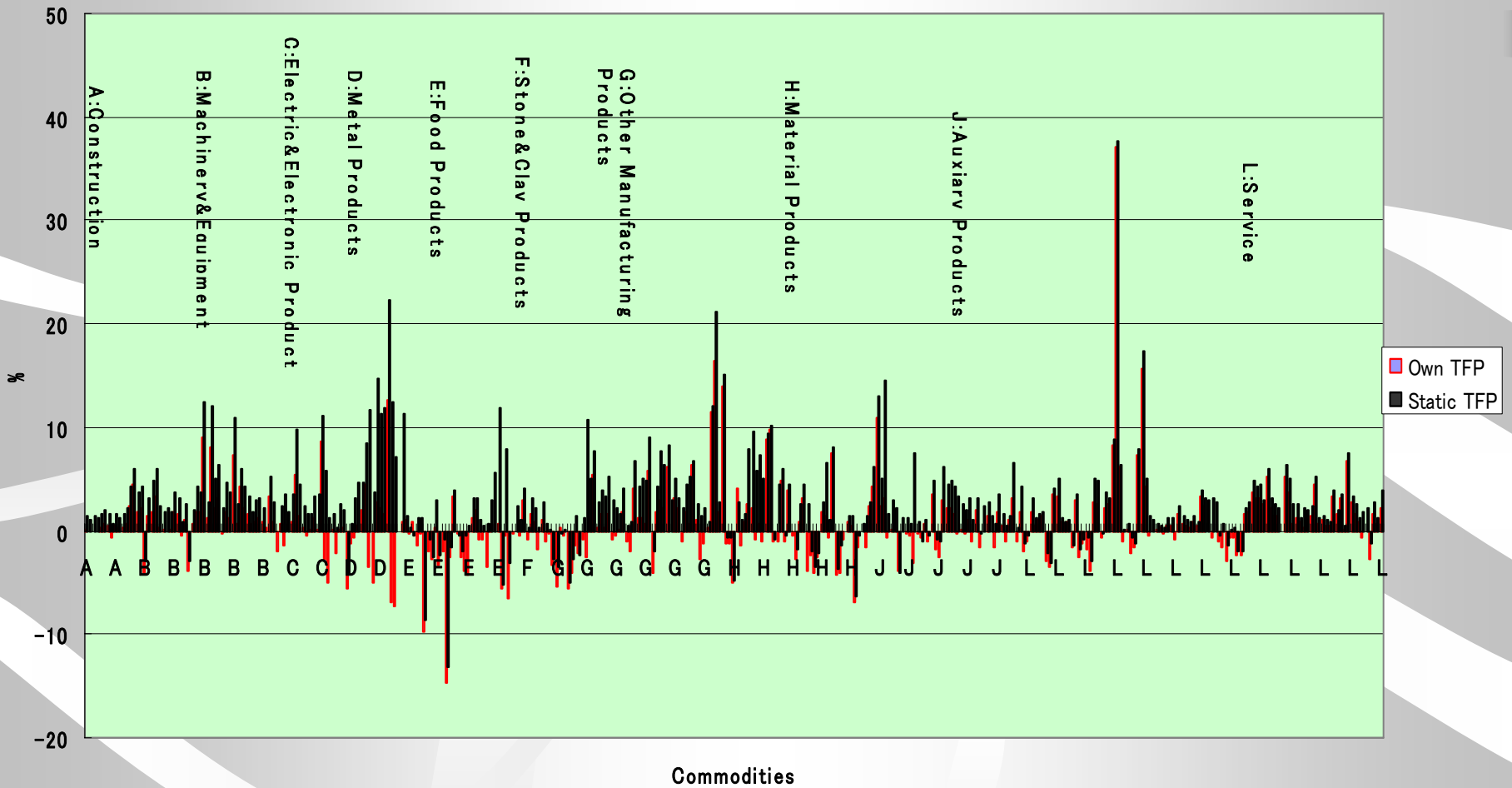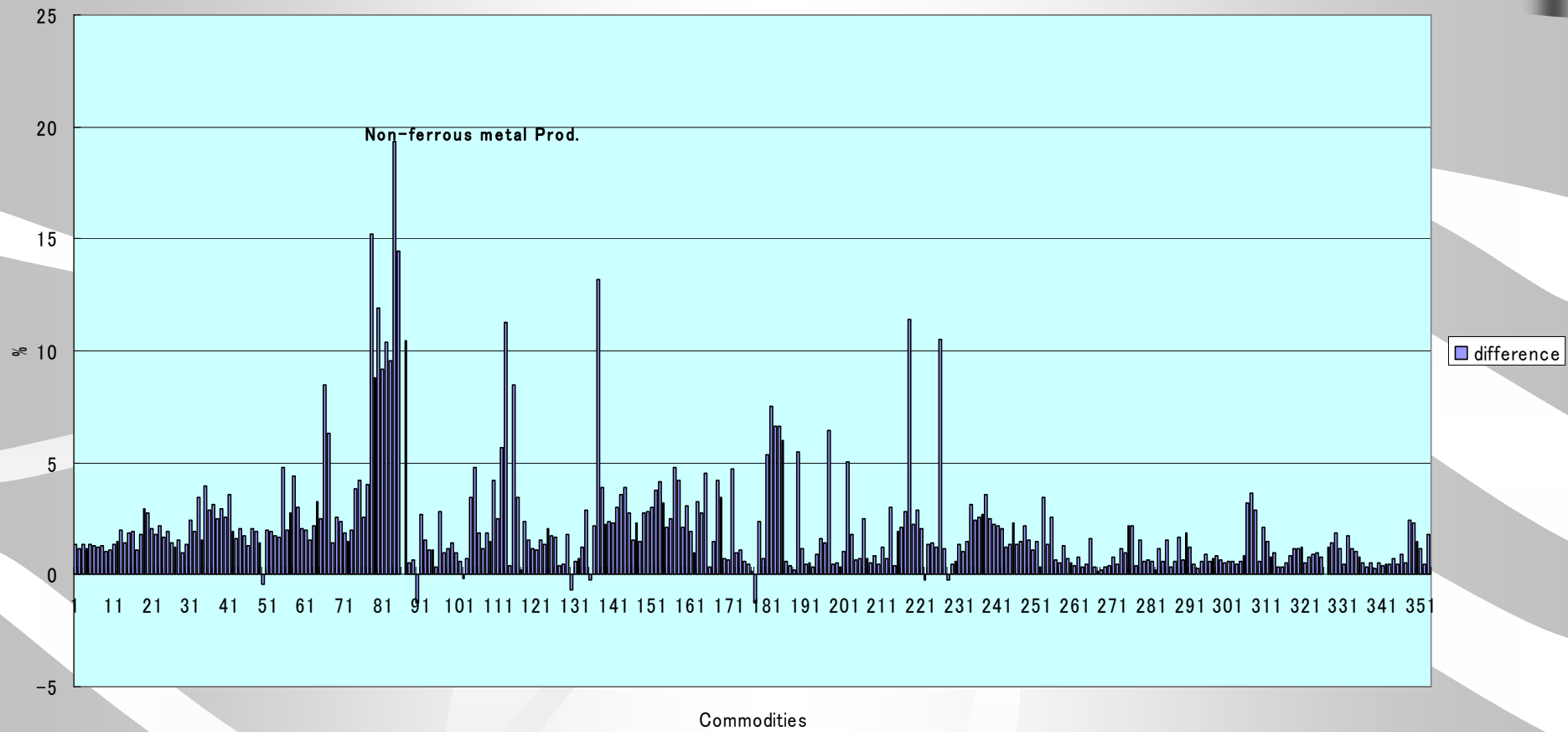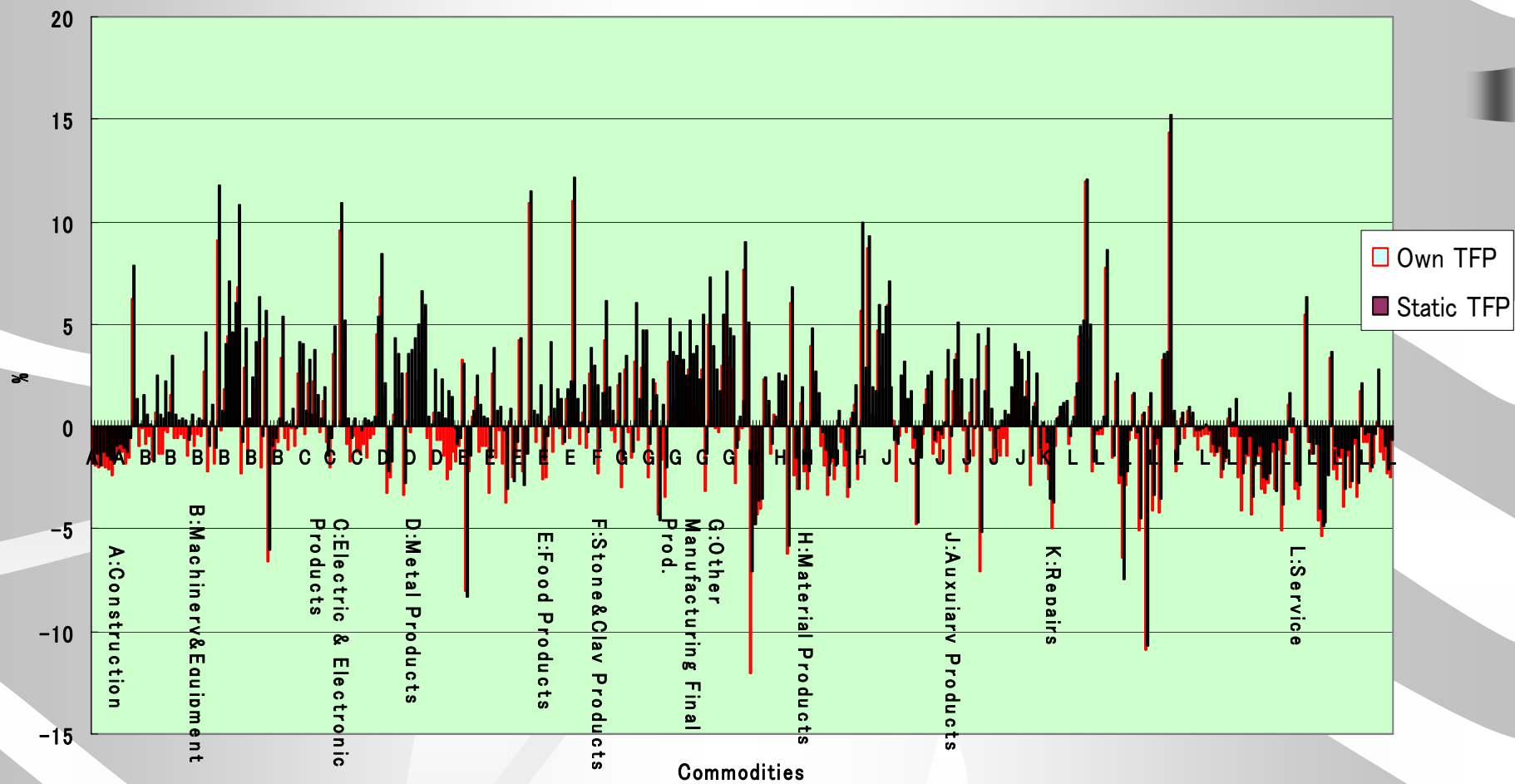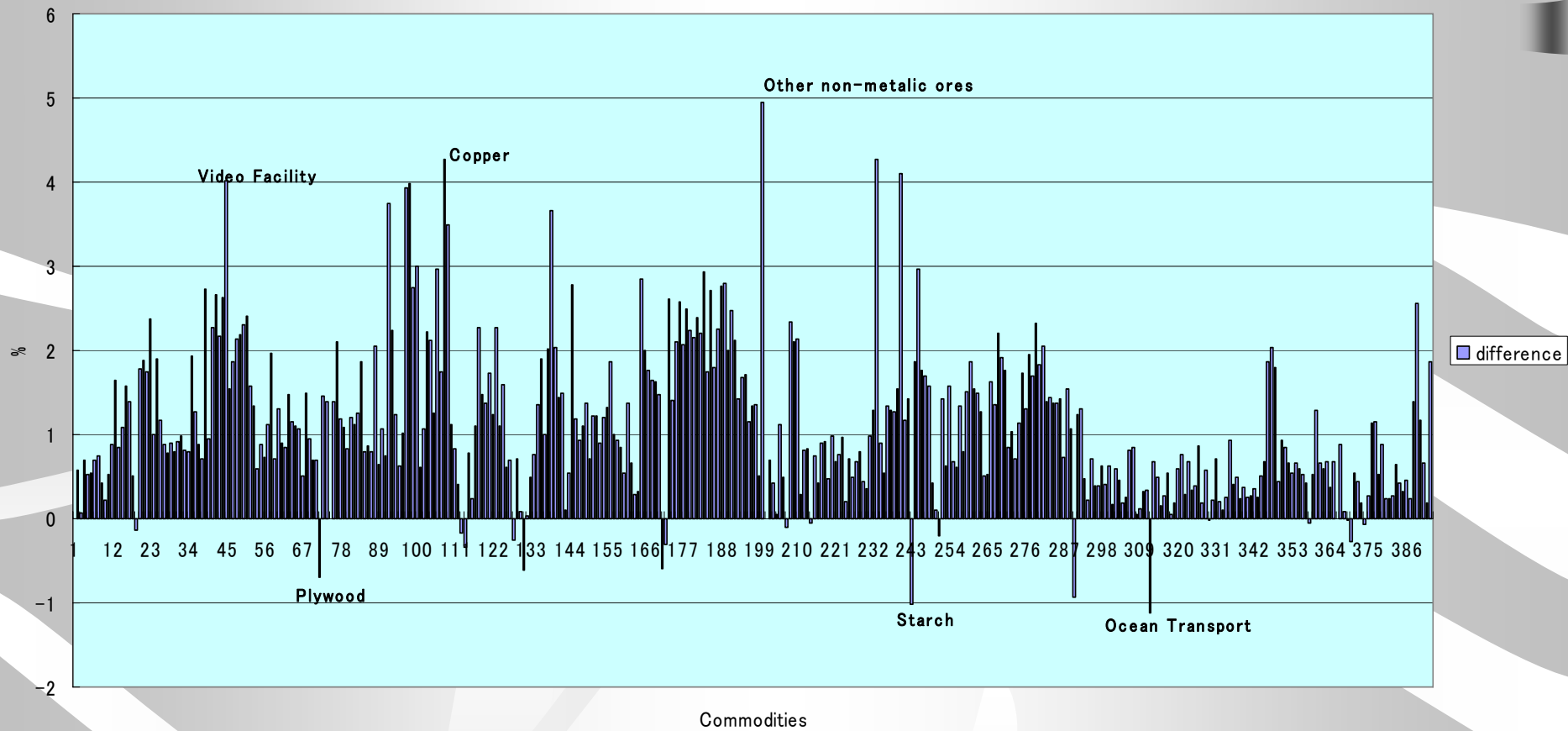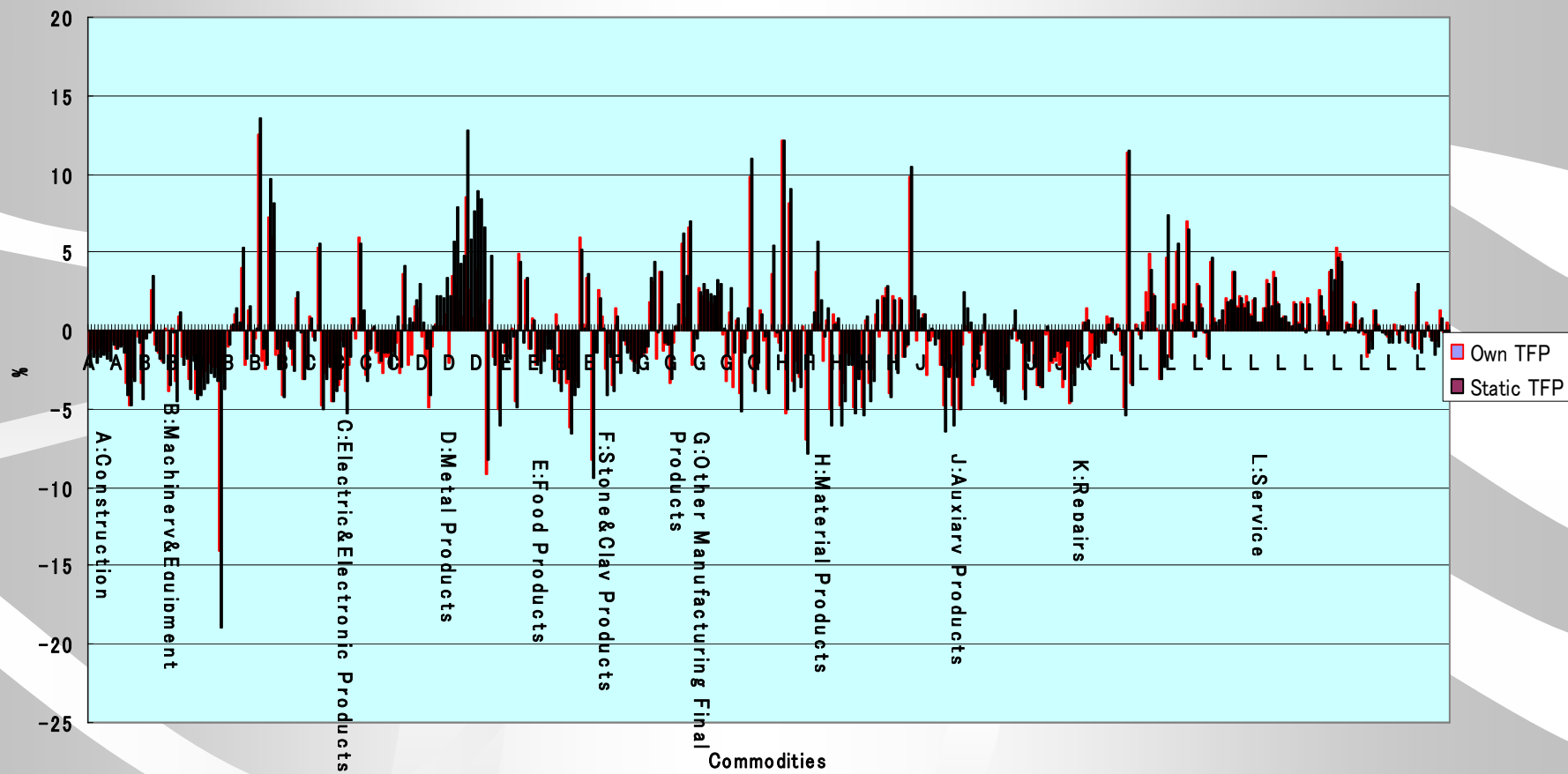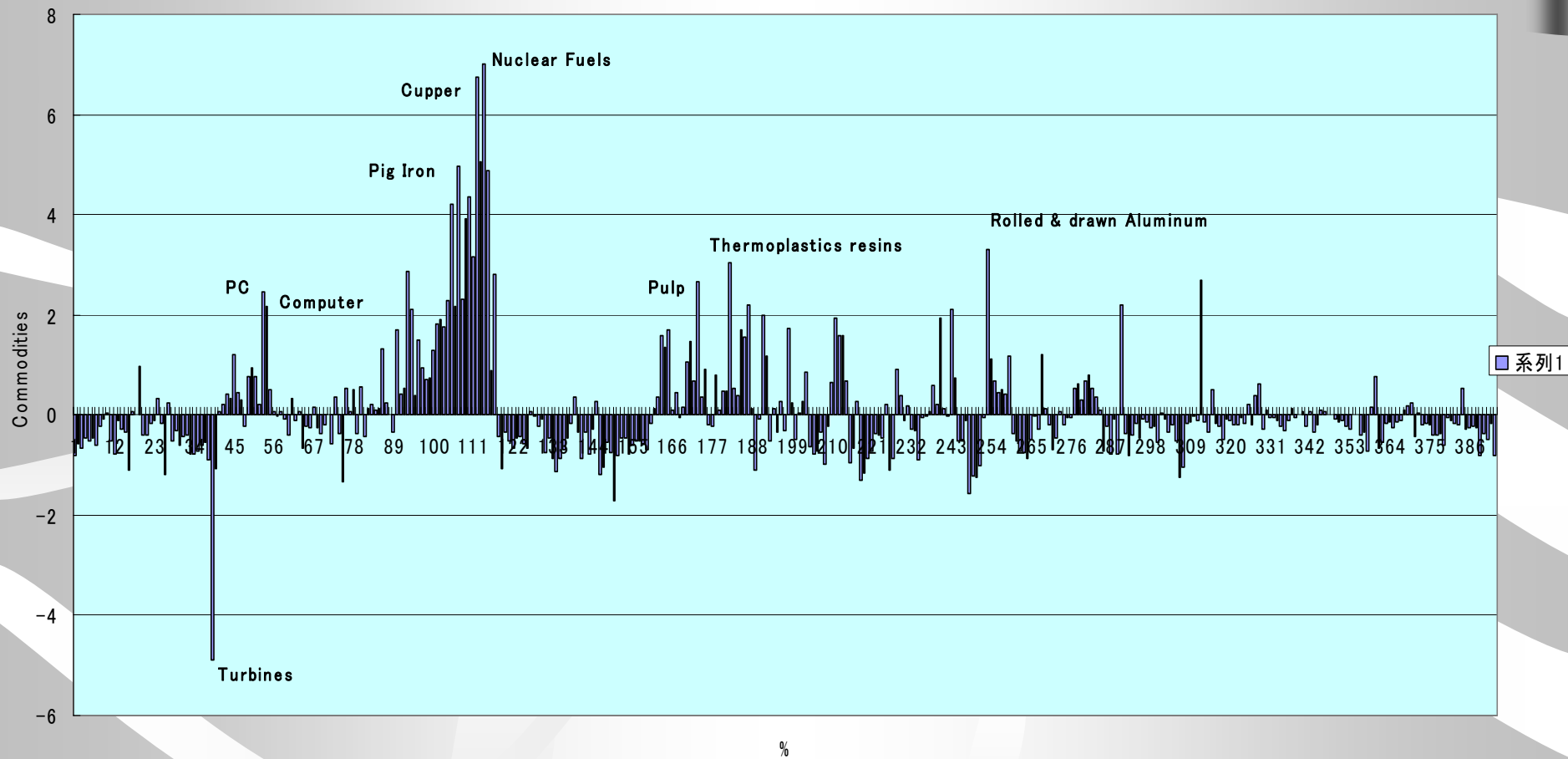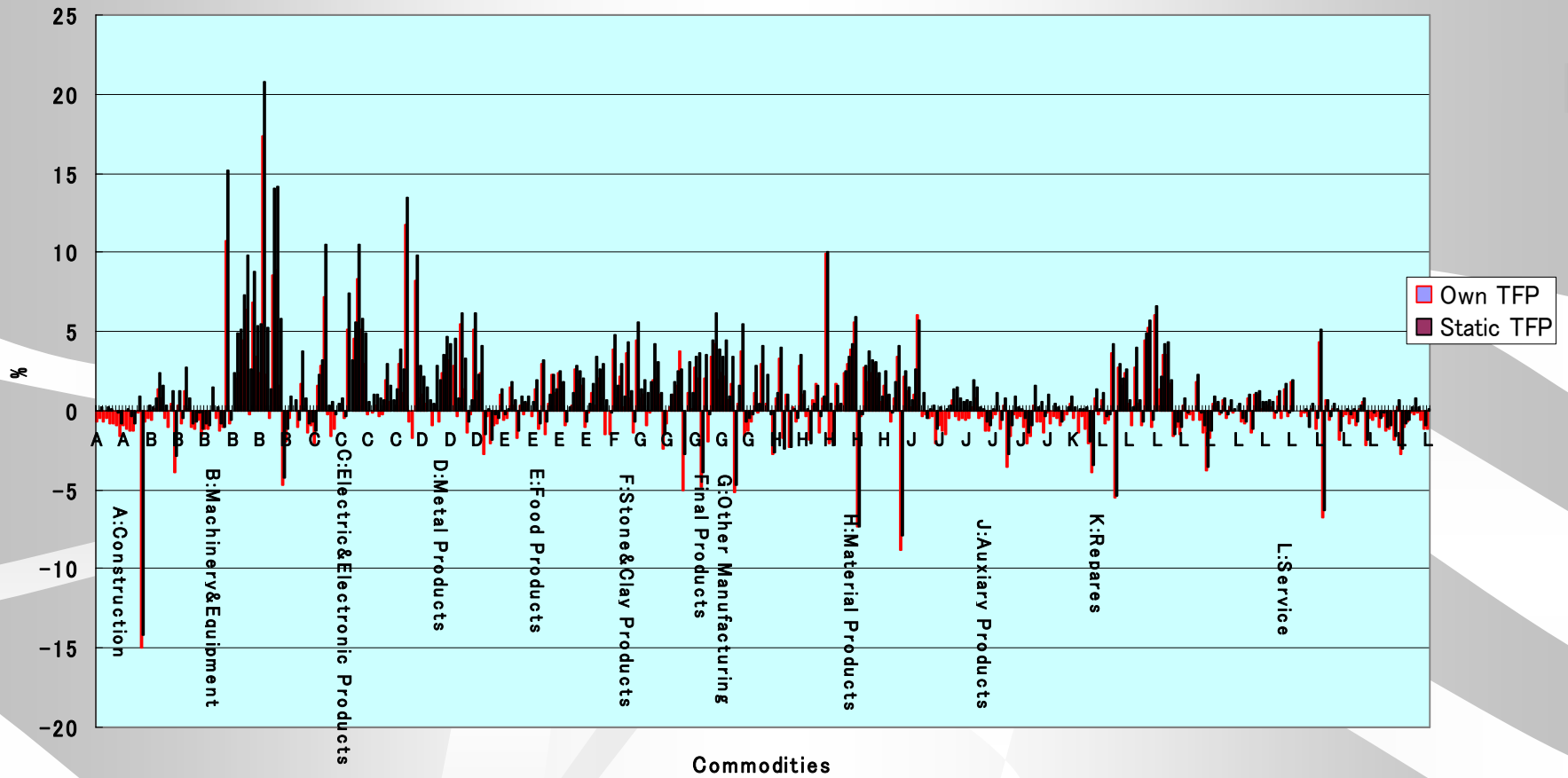during the Period 90-95

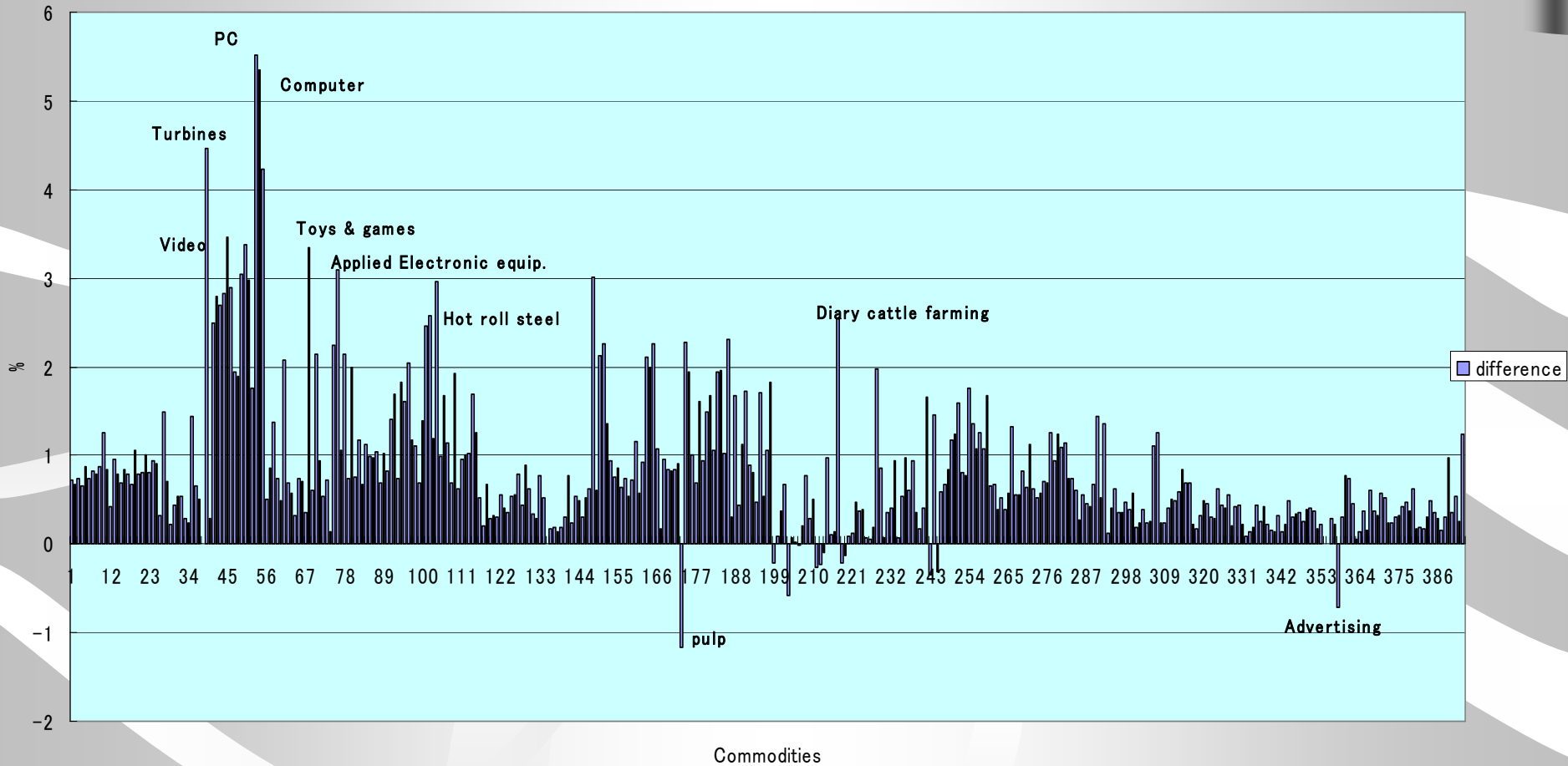# Differences between Statric Unit and Own TFP 1990-1995

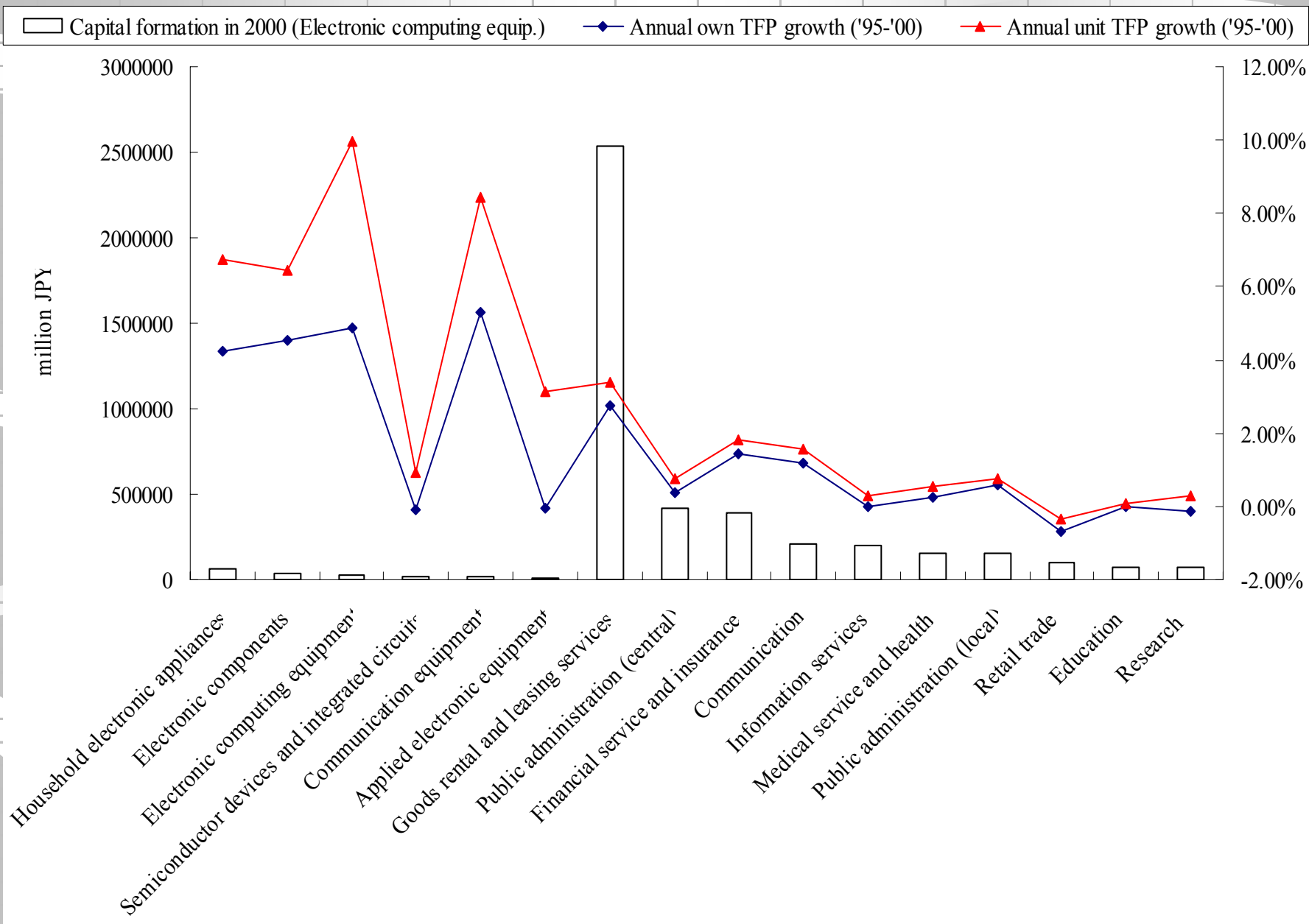Annual Growth Rate of Own and Static TFP by Commodities during the Period 95-00
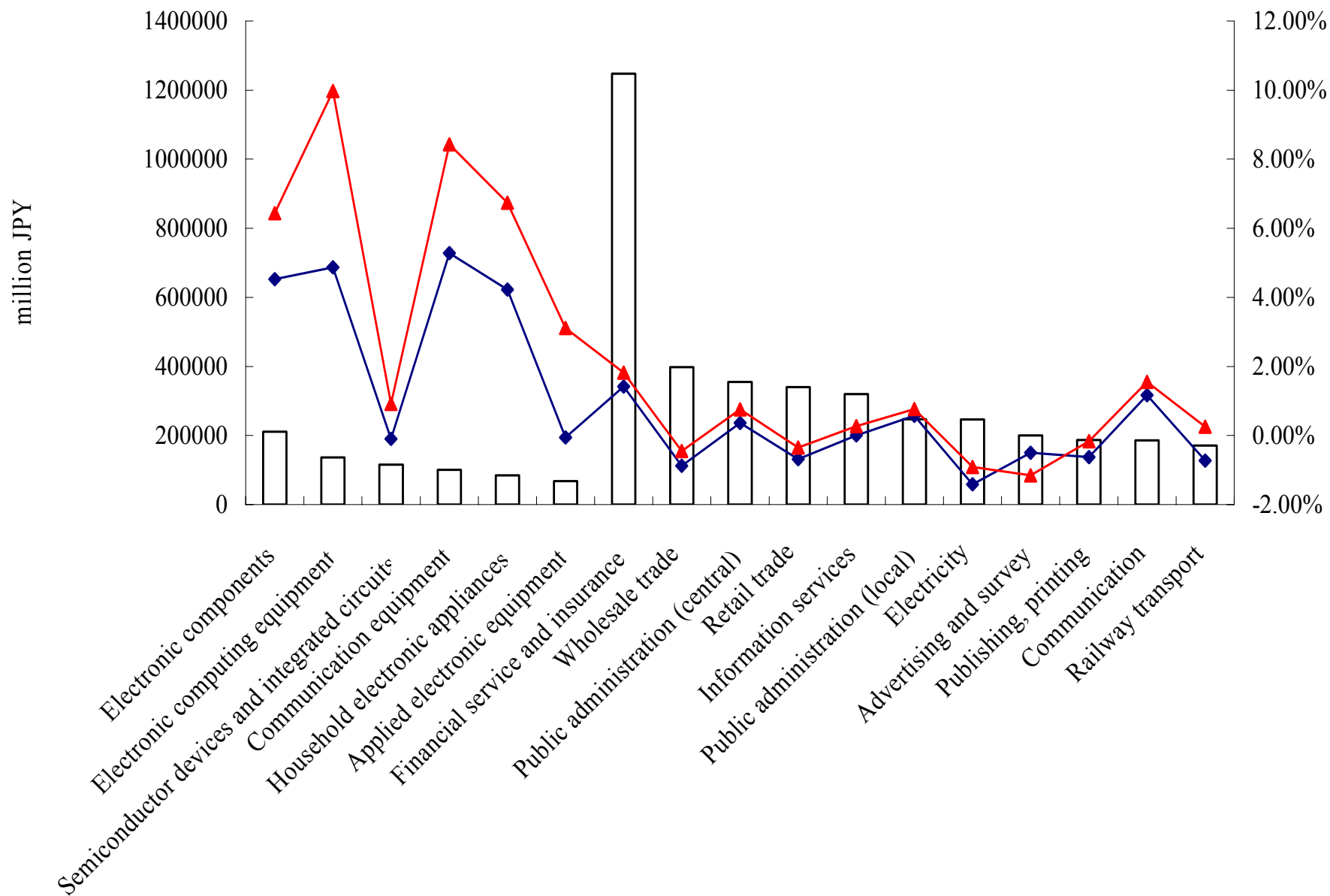
Differences between Static Unit and Own TFP 1995-2000

Changes of TFP Paterns During 1990-95 and 1995-2000

(Price) Own & Unit TFP : 95–00 年Domar Weight	(1)Both Own (b) & Unit (a) TFPs are negative and differences (a–b) is negative.	(2) Own (b) is positive, but Unit (a) TFP is negative and differences (a–b) is also negative.	(3)Both Own (b) & Unit(a) TFPs are positive,and differences (a–b) is negative.	(4) Both Own(b) & Unit(a) TFPs are negative, but differences (a–b) is positive.	(5) Own (b) is negative, but Unit(a) TFP is positive, and differences (a–b) is positive.	(6) Both Own(b) & Unit(a) TFP are positive, and differences (a–b) is positive.
90–95	(b) (a) (a–b)	(b) (a) (a–b)	(b) (a) (a–b)	(b) (a) (a–b)	(b) (a) (a–b)	(b) (a) (a–b)
(1)	0311–04 Marine Culture 1711–01 Wooden Funiture and Fixtures	0213–01Special Forest Products 0312–01 Inland Water Fisheries		1521–01 Woven Fabric Apparel 4132–09 Other Civil Engineering 6112–01Reatl Trade 8519–09 Other Business Service 8612–01 General eating Places 8613–01 Hotel and Lodging Places 0112–02,0822–02,1113–03, 1119–02,1129–02,1141–01,1519–02,1613–01,1611–02,1911–03,2039–01,2039–02,2071–01,2071–02,2074–01,2079–02,2319–02,2411–01,2523–01,2599–02,3011–01,3011–03,3013–01,3019–01,3019–09,3021–01,3022–01,3024–02,3029–01,3029–02,3029–03,3029–04,3029–09,3031–01,3031–02,3031–09,3510–01,3611–02,3611–03,3719–01,4131–02,4131–03,4132–01,4132–02,6210–01,6211–02,7189–04,7189–09,8611–01,8619–02,8619–03,8619–04,8619–09,8619–07,8619–08	2211–01 Plastic Poducts 3521–01 Trucks and Buses 4111–01 Residential Const.(wooden) 4112–02 Residential Const.(non-wooden) 4121–01 Repair of Construction 4131–01 Public Const. of Road 8515–01Repair of Car 8516–01 Repari of Machine 8611–04 Amusement and recreation Facilities 0131–01,0131–02,1117–05,1119–03,1121–02,1519–09,1521–02,1522–09,1619–09,2319–01,2319–09,2412–02,2522–01,2599–09,3012–01,3112–01,3241–01,3611–01,3621–01,3719–01,3911–02,3919–01,3919–03,3919–09,4112–01,7311–01,9900–00	1114–01 Grain milling 6211–01 Financial Service 6411–02 Real Estate Rental 7122–01 Bus Transp. Service 0111–01,0116–01,0116–02,0121–02,0121–04,0212–01,0311–00,0822–01,0711–01,1111–01,1112–02,1112–03,1113–04,1113–09,1116–03,1116–02,1119–01,1119–05,1121–01,1121–03,1129–01,1129–02,1611–02,1629–01,2029–03,2039–09,2072–02,2121–02,2311–01,2612–01,2619–09,2631–01,2699–01,2699–03,3011–02,3024–01,3212–02,3421–03,3629–01,3711–09,3911–01,6212–02,6212–02,7142–01,7161–01
(2)				6111–01 Wholesale Trade 8211–01 School Education(Public) 8612–03 Eating and Drinking Places for Pleasure 0116–03,1119–09,1519–03,7121–02,7161–01,7189–02,7189–03,7189–09,7319–09,7321–03,8213–01,8221–01,8221–02,8313–01,8411–01,8514–01,8519–02,8619–01,8919–09	7111–01 Railway Transport (Passengers) 1115–01,3621–01,5212–01,8213–03,8411–02	2061–01 Medicaments 3541–02 Internal Combustion engines for Motor Vehicles and Parts 6421–01 House Rent 8112–01 Public Adminm.(local) 8211–02 School Education (Private) 8222–01 R&D (intra-enterprises) 8519–03 Civil Engineering and Construction Service 0113–00,0115–02,0121–09,1113–02,1114–02,1117–03,1121–09,1514–01,2029–02,2521–01,3359–03,3611–01,5211–03,6411–01,7112–01,7121–01,7143–01,7171–01,7189–01,7189–05,8213–02,8221–05,8312–02,8313–03,8313–04,8519–04,8611–06
(3)	8511–01 Advertising Saervices			0211–01,5313–03	9000–00 Activities not classified 1711–02	3541–03 Parts of Motor Vehicles 1115–01,1119–04,8519–01,8611–07
(4)	2021–01	1117–02,1519–01		1112–01,2011–01,2079–01,2599–01,2599–03,3019–02,3541–01,3919–02,3919–08,8611–03	1131–02,1711–03,1813–02,1829–09,1911–01,2029–09,2599–04,2631–02,2812–01,2891–01,2899–02,2899–09,3111–01,3321–09,3332–01,3341–02,3411–02,3411–03,3421–02,3622–10,3629–09,3712–01,3719–02,4132–03,8611–02	3311–03 Electric Computing Equipment(accessory equipt.) 0629–09,1512–03,1529–01,1529–09,1611–01,2032–01,2039–01,2412–01,2635–01,3321–03,3331–01,3411–01,3411–09,3421–05,3919–04,5122–21
(5)					1521–09,2631–01,2721–01,2722–03,3919–05	0112–01,1513–01,1812–02,2031–02,2041–09,2611–03,2649–09,2722–02,2811–01,3321–01,3421–04,5121–01
(6)	0115–01,0621–01	0721–01,1811–01		5111–00 Electricity 6212–01 Life Insurance 0115–09,0121–05,1117–04,1131–01,1611–02,3031–01,2041–01,2072–01,2711–02,2722–09,7141–01,7321–01,7321–02,6221–02,6312–01,6512–02,6611–01,8611–05	0114–01,1115–02,1117–01,1512–01,1512–02,1521–01,2611–01,2623–01,2711–03	2111–01 Petroleun Refinery Produovts 2621–01 Hot Rolled Steel 3359–09 Other Electronic Components 7312–01 Telecommunication 8111–01 Public Admim.(central) 8311–01Medical Service(Public) 8311–02 Medical Service(NGO) 8311–03 Medical Service(Corporations) 8512–01 Information Services 0111–02,0121–01,0611–01,1611–01,1812–01,2029–01,2032–02,2039–03,2039–04,2041–02,2041–03,2051–01,2051–02,2073–01,2121–01, 2811–02,2811–04,2822–01,2623–02,2649–01,2711–01,2711–09,2721–02,2722–01,2722–04,3023–01,3111–09,3211–01,3311–02,3211–03,3212–01,3311–01,3311–02,3321–02,3359–01,3421–01,3421–09,3622–01,3711–01,5111–04,7161–01,5213–04, 8221–03,8221–04,8619–05

Note: Rank of the Size in Domor Weight for Macro TFP Measures
(1) Rank 1–10
(2) Rank 11–20
(3) Rank 21–30
(4) Rank 31–40
(5) Rank 41–50
(6) Rank 51–

Legend: Capital formation in 2000 (Electronic computing equip.) · Annual own TFP growth ('95-'00) · Annual unit TFP growth ('95-'00)

Y-axis (left): million JPY — 0, 500000, 1000000, 1500000, 2000000, 2500000, 3000000

Y-axis (right): -2.00%, 0.00%, 2.00%, 4.00%, 6.00%, 8.00%, 10.00%, 12.00%

X-axis categories: Household electronic appliances; Electronic components; Electronic computing equipment; Semiconductor devices and integrated circuits; Communication equipment; Applied electronic equipment; Goods rental and leasing services; Public administration (central); Financial service and insurance; Communication; Information services; Medical service and health; Public administration (local); Retail trade; Education; Research

Legend		
☐ Capital formation in 2000 (Software)	◆ Annual own TFP growth ('95-'00)	▲ Annual unit TFP growth ('95-'00)

Y-axis (left): million JPY — 0, 200000, 400000, 600000, 800000, 1000000, 1200000, 1400000

Y-axis (right): -2.00%, 0.00%, 2.00%, 4.00%, 6.00%, 8.00%, 10.00%, 12.00%

Categories:
Electronic components
Electronic computing equipment
Semiconductor devices and integrated circuits
Communication equipment
Household electronic appliances
Applied electronic equipment
Financial service and insurance
Wholesale trade
Public administration (central)
Retail trade
Information services
Public administration (local)
Electricity
Advertising and survey
Publishing, printing
Communication
Railway transport

Classification of Intangible Assets defined by CHS

(1)Computerized information
    1-1) Custom software
    1-2) Packaged software
    1-3) In-house software
    1-4) Data base

(2)Innovative property
    2-1) Science and engineering R&D
    2-1) Mineral exploration
    2-3) Copyright and license costs
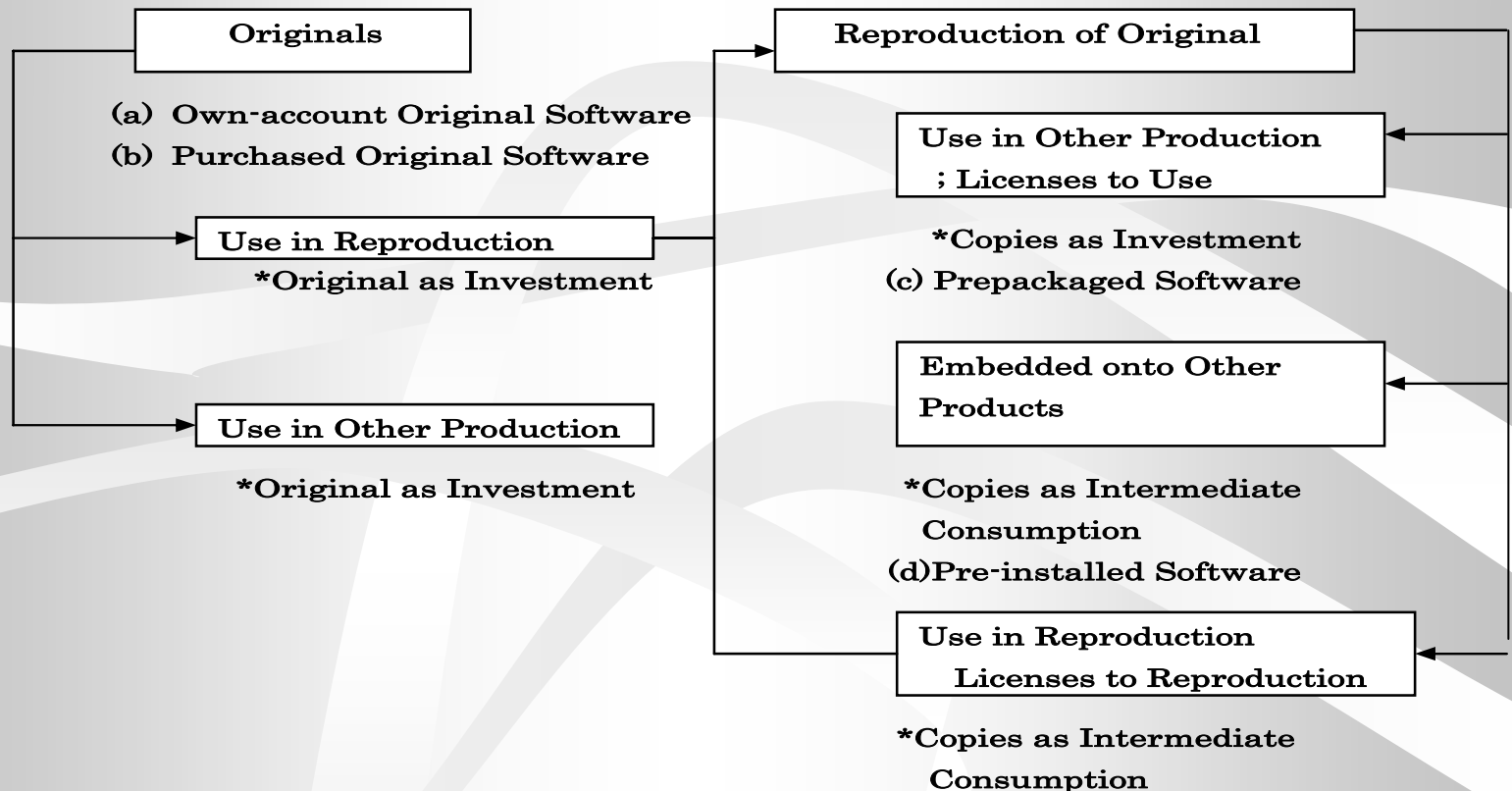   2-4) Other product development design and
        research expenses

(3) Economic Competencies
    3-1) Brand equity
    3-2) Firm-specific human capital
    3-3) Organizational structure

Note: c.corrado, C.R.Hulten and D.E.Sichel, (2006) ,"Intangible Capital and Economic Growth", Working Paper 11948, NBER

Measurement of Software

Figure 1 Production Process and Use of Software [1]

Originals	Reproduction of Original

(a) Own-account Original Software
(b) Purchased Original Software

Use in Other Production
; Licenses to Use

Use in Reproduction
  *Original as Investment

*Copies as Investment
(c) Prepackaged Software

Embedded onto Other Products

Use in Other Production

*Original as Investment

*Copies as Intermediate Consumption
(d)Pre-installed Software

Use in Reproduction
  Licenses to Reproduction

*Copies as Intermediate Consumption

Note: (1) This figure is referred from Nomura(2004).
K. Nomura (2004) ,"Capitalizing Own Account Software in Japan"
Keio Economic Observatory, Discussion Paper

Software Measurement
# in the Japanese IO and SNA

- IO framework: a) Customized software has been measured since 1980 as a commodity of information service industry. But it has not been capitalized. They were treated to be allocated into intermediates and consumption. b) Since 1995, customized software are capitalized and since 2000, package software was added into intangible assets.

- SNA framework: Since 1995 customized software, Mineral exploration and plant engineering were treated as intangible assets. Since 2000 package software was added.

- Pre-installed software is treated as intermediate input.

- Own-account software has not been capitalized so far.

Capitalizing Own-accounts Software

In the Japanese IO and SNA, so far the own-account software has not been treated **explicitly not only as an intermediate input, but also as an intangible asset**.
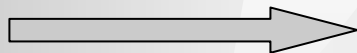
We could understand the current treatment as the following alternative explanations.

1) Hypothesis 1: Own-accounts software seems to be included in the in-house R&D activities and allocated as intermediate inputs.
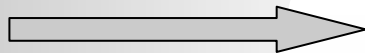
⟶ **R&D Hypothesis**

2) Hypothesis 2: Own-accounts software seems to be included in every industry activities implicitly.

⟶ **Industry Activity Hypothesis**

R&D Activity Hypothesis

R&D Activity Hypothesis:

· **Intra-enterprise R&D activities by industry has been identified in IO and its outcome including own-account software development is assumed to allocate to industries as intermediate inputs. Therefore in order to capitalize own-accounts software,   firstly, we have to separate it from intra-enterprise R&D activity and secondly capitalize it.**

·**GDP measure is increased by capital formation, while GDI measure is increased by imputed rents + capital consumption allowance by own-account software as an intangible asset.**

Industry Activity Hypothesis

Industry Activity Hypothesis:

- Own-accounts software activity assumes to be included in the industry activity implicitly. Then, own-accounts software activity has to be identified from the industry activity.

- Because own-accounts activity has been already included implicitly in the industry activity, treatment we have to do is only to identify the own-accounts software accounts from each industry activity and capitalize it.

- GDP is increased by capital formation and GDI is increased by capital consumption allowance.

Alternative Methods on the Evaluation of R & D Activities by IO

· **Current Treatment of the R&D Activities in the Japanese Input-Output Table**

  1) **Classification**

  Research Institutes for National Science (Public)

  Research Institutes for Cultural & Social Science (Public)

  Research Institutes for Natural Sciences

  (Private & non- profit)

  Research Institutes for Cultural & Social Science

  Private & non-profit)

  Research Institutes for Natural Sciences (Profit making)

  Research Institutes for Cultural & Social Sciences

  (Profit making)

  Research and Development (intra-enterprise)

Current Treatment of R&D in JIO

2. Gross Output evaluated by Cost structure

    Gross Output = Total Intermediate Cost

      + Labor Compensation

      + Capital Consumption allowance

where gross output in R&D sectors except profit making activities is evaluated by the total amount of cost, and that in the profit making R&D institute is added certain of profit to above cost.

The deflator of gross output of the R&D activities in the institutes except the profit making institute is estimated by the cost structure. That means that TFP growth in R&D sector assumed to be zero by definition.

Current Treatments of R&D in JIO

3. Outputs of the R&D activities, which are estimated by the information of expenditure side, are allocated into the using sectors as the intermediate inputs, but not into the final demand.

It implies that R&D activities do not have any accumulation of the knowledge stock in the society.

Alternative Treatments of R&D Activities

1. R&D activities assume to accumulate the knowledge stock to create new innovative action in the society. Some parts of the knowledge are freely distributed and the other are distributed with some charge. Whatever freely or non-freely available, we have to evaluate R&D activities by the cost.

2. The R&D activities will accumulate the knowledge stock in the society. We have to evaluate the R&D activities not only in the current transaction, but also in the capital investment for the knowledge stock as intangible assets. We need information to allocate the output into intermediate demands as well as final demand by the using sectors.

3. The knowledge stocks which are accumulated by the R&D activities is going to create new capital service dynamically. In the using sectors, they will capitalize the innovative capital service as capital input from the knowledge stock.

Treatment of Activities though Intangible Assets

1. Activities though investment for intangible assets are assumed to create the knowledge stock dynamically though intangible assets as well as the static changes in flow of intermediate transaction.

2. We have to estimate the knowledge stock as intangible assets by sectors and capitalize the service input dynamically.

Static Structure

A_{ij}

I_i

Dynamic Structure

B_{ij}