RIETI Discussion Paper Series 13-E-002

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The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 13-E-002
January 2013

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Abstract

As the manufacturing sectors of developed economies increasingly outsource to developing economies, a serious measurement problem, or "offshoring bias" (Houseman et al. 2011), may arise. If a manufacturing industry or firm procures many parts and components from developing economies at exceptionally low prices, taking advantage of special supplier networks or efficient foreign affiliates as an example, and if these low prices are not correctly accounted, the productivity of this industry will be overestimated.

Using Japan's I-O tables and price data for imported and domestic products, we estimate the offshoring bias by examining the differences in estimates of import use in the I-O tables based on direct data and estimates derived from the assumption that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand (as is assumed in the I-O tables for the United States). We also detail the types of data used and their collection method by METI.

Our main findings are as follows. 1) In the period 1995-2008, the import price-domestic price ratio of many commodities, including important parts and components, declined sharply. For instance, in the case of integrated circuits and semiconductor devices, the relative prices declined by 33 % and 28 %, respectively. 2) Since the share of imported inputs in total inputs differs across sectors, we found quite large negative or positive offshoring biases in some sectors. For example, in sectors such as aircrafts, liquid crystal elements, and integrated circuits, the negative offshoring bias of intermediate input growth is more than 2.5 % and the positive offshoring bias of total factor productivity (TFP) growth is more than 1.7 %. On the other hand, in sectors such as cellular phones, radio and television sets, and other photographic and optical instruments, the positive offshoring bias of intermediate input growth is more than 3.3 % and the negative offshoring bias of TFP growth is more than 1.9 %.

Keywords: Offshoring bias, Input-output tables, Total factor productivity, Imported inputs
JEL classification: D24, F60, D57

† This research was conducted as part of RIETI's East Asian Industrial Productivity Project. We would also like to express our gratitude for the financial support provided by the Global Centers of Excellence (COE) program "Research Unit for Statistical and Empirical Analysis in Social Sciences" (G-COE Hi-Stat), Hitotsubashi University.

1. Introduction

As manufacturing sectors of developed economies outsource more and more to developing economies, this may give rise to a serious measurement problem, or an "offshoring bias" (Houseman et al. 2011). If a manufacturing industry (or firm) procures a lot of parts and components from developing economies at exceptionally low prices taking advantage of, say, special supplier networks or efficient foreign affiliates and we do not correctly take account of these low prices, we will overestimate the productivity of this industry (or firm). Japan presents an ideal case to study this issue. Every five years, the Ministry of Internal Affairs and Communications publishes the *Input-Output Tables for Japan* (I-O tables), in which domestically produced intermediate inputs and imported intermediate inputs are treated separately. The Japanese government estimates the input structure by conducting a special Ministry of Economy, Trade and Industry (METI) survey on the sources of each industry's procurement. And because of its proximity to East Asia, Japan's imports of intermediate inputs from China and other developing economies in East Asia have increased rapidly in recent decades.

Using Japan's I-O tables and price data for imported and domestic products, we estimate the outsourcing bias by examining differences in estimates of import use in the I-O tables based on direct data and estimates based on the assumption that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand (as is assumed in the I-O tables for the United States). We also detail what data METI collects and how it collects these data.

The structure of the paper is as follows. In the next section we explain our methodology to evaluate offshoring bias using data on Japan. In Section 3, we then explain our data, while in Section 4, we report our results on offshoring bias. Section 5 concludes.

2. Methodology to Evaluate Offshoring Bias

In this section we explain our methodology to evaluate offshoring bias.

In Japan, non-competitive import type input-output tables, in which domestically produced intermediate inputs and imported intermediate inputs are treated separately, are constructed every five years. Therefore, data on the nominal value of imported intermediate inputs from sector i to sector j, $X_{i,j}^{M}(t)$, and data on the nominal value of domestically produced intermediate inputs from sector i to sector j, $X_{i,j}^{D}(t)$, are separately available. In the United States, it is usually competitive import type input-output tables that are estimated, and therefore only data on the total value of intermediate inputs from sector i to sector j, $X_{i,j}^{M}(t)+X_{i,j}^{D}(t)$, are available.

Let us theoretically examine biases caused by this shortcoming of U.S.-type input-output tables based on the assumption of competitive imports.

Assume that imported intermediate inputs from sector *i* to sector *j* and domestically produced intermediate inputs from sector *i* to sector *j* are different products and the cost share of each product reveals its marginal contribution to production in sector *j*.

In Japan, like in the United States, data on the absolute price levels of imported products and domestic products are not available. In both countries, only the price indices of imported products and domestic products are available. Let $P_i^M(t)/\ P_i^M(0)$ denote the price change of imported product *i* from year 0 to year *t* and $P_i^D(t)/\ P_i^D(0)$ denote the price change of domestically produced product *i* from year 0 to year *t*.

The appropriate Laspeyres real input index of sector *j* for year *t*, $x_j^J(t)$, where the base year is 0, is defined by

$$x_j^J(t) = \frac{\sum_i \left(X_{i,j}{}^M(0) \frac{\frac{X_{i,j}{}^M(t)}{X_{i,j}{}^M(0)}}{\frac{P_i^M(t)}{P_i^M(0)}} + X_{i,j}{}^D(0) \frac{\frac{X_{i,j}{}^D(t)}{X_{i,j}{}^D(0)}}{\frac{P_i^D(t)}{P_i^D(0)}} \right)}{\sum_i \left(X_{i,j}{}^M(0) + X_{i,j}{}^D(0) \right)}$$

$$= \frac{\sum_i \left(X_{i,j}{}^M(t) \frac{P_i^M(0)}{P_i^M(t)} + X_{i,j}{}^D(t) \frac{P_i^D(0)}{P_i^D(t)} \right)}{\sum_i \left(X_{i,j}{}^M(0) + X_{i,j}{}^D(0) \right)} \qquad (1)$$

And the corresponding Paasche price index of intermediate inputs in sector *j* for year *t*, $p_j^J(t)$, is defined by

$$p_j^J(t) = \frac{\sum_i \left(X_{i,j}{}^M(t) + X_{i,j}{}^D(t) \right)}{\sum_i \left(X_{i,j}{}^M(t) \frac{P_i^M(0)}{P_i^M(t)} + X_{i,j}{}^D(t) \frac{P_i^D(0)}{P_i^D(t)} \right)} \qquad (2)$$

In countries where non-competitive import type input-output tables are not regularly available, the ordinary approach is to assume that an industry’s imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand (as is assumed in the I-O tables for the United States).

Let $m_i(t)$ denote the economy-wide imports of product i relative to total demand for product i:

$$m_i(t) = \frac{\sum_j X_{i,j}{}^M(t) + \sum_k F_{i,k}{}^M(t)}{\sum_j \left(X_{i,j}{}^M(t) + X_{i,j}{}^D(t)\right) + \sum_k \left(F_{i,k}{}^M(t) + F_{i,k}{}^D(t)\right)} \qquad (3)$$

where $F_{i,k}{}^M(t)$ and $F_{i,k}{}^D(t)$ denote value of imports i used to satisfy final demand k and the value of domestic output i used to satisfy final demand k. In this shortcut approach, the Paasche price index of intermediate inputs in sector j for year t, $p_j{}^U(t)$, is expressed by

$$p_j{}^U(t) = \frac{\sum_i \left(X_{i,j}{}^M(t) + X_{i,j}{}^D(t)\right)}{\sum_i \left(X_{i,j}{}^M(t) + X_{i,j}{}^D(t)\right)\left(m_i(t)\frac{P_i^M(0)}{P_i^M(t)} + (1 - m_i(t))\frac{P_i^D(0)}{P_i^D(t)}\right)} \qquad (4)$$

and the Laspeyres eal input index of sector j for year t, $x_j{}^U(t)$, is defined by

$$x_j{}^U(t) = \frac{\sum_i \left(X_{i,j}{}^M(t) + X_{i,j}{}^D(t)\right)\left(m_i(t)\frac{P_i^M(0)}{P_i^M(t)} + (1 - m_i(t))\frac{P_i^D(0)}{P_i^D(t)}\right)}{\sum_i \left(X_{i,j}{}^M(0) + X_{i,j}{}^D(0)\right)} \qquad (5)$$

Equations (3) and (5) show that when the price of imports relative to that of domestic output declines ($P_i^M(t)/ P_i^D(t) < P_i^M(0)/ P_i^D(0)$) for most inputs i, we will underestimate the increase in intermediate inputs in sectors where industry's imports relative to its total demand is higher than the economy-wide imports-domestic output ratio ($(X_{i,j}{}^M(t)/(X_{i,j}{}^M(t) + X_{i,j}{}^D(t)) > m_i(t)$) for these inputs. As a result, we will overestimate the TFP growth of such sectors.

The offshoring bias caused by the assumption that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand, will become large if imports of each input, relative to its total demand, are quite different across sectors and changes in the relative prices of imports and domestic products are large.

In some sectors, the imports-total demand ratio is higher than the economy-wide average, while in others, the ratio is lower. Therefore, these biases will tend to cancel each other out when we calculate macro-level TFP growth. However, if imports tend to be used more as intermediate inputs and domestic output tends to be used more for satisfying final demand, we will overestimate TFP growth of the macro economy when the prices of imports relative to those of domestic output decline.

Using Japan's IO data from 1995 to 2008, we will analyze how the intermediate input index based on equation (1) moves differently from the intermediate input index based on equation (5).

There is an important caveat regarding our theoretical framework. If imports *i* and domestic output *i* are the same good (or service) even when the absolute price level of imports and that of domestic output are different, then our Laspeyres intermediate input index defined by equation (1) is not appropriate for measuring true intermediate input growth. This issue was pointed out by Diewert and Nakamura (2011) and empirically analyzed by Houseman et al. (2011).

If we express the absolute price level of imported products by $P_i^M(t)$ and the absolute price level of domestically produced products by $P_i^D(t)$, the appropriate Laspeyres input index of sector *j* for year *t* is defined by

$$x_j^I(t) = \frac{\sum_i \left\{ \left(X_{i,j}^M(0) + X_{i,j}^D(0) \right) \dfrac{\dfrac{X_{i,j}^M(t)}{P_i^M(t)} + \dfrac{X_{i,j}^D(t)}{P_i^D(t)}}{\dfrac{X_{i,j}^M(0)}{P_i^M(0)} + \dfrac{X_{i,j}^D(0)}{P_i^D(0)}} \right\}}{\sum_i \left(X_{i,j}^M(0) + X_{i,j}^D(0) \right)} \qquad (6)$$

And the corresponding Paasche price index of intermediate inputs in sector *j* for year *t* is expressed by

$$p_j^I(t)=\frac{\sum_i \left(X_{i,j}{}^M(1)+X_{i,j}{}^D(1)\right)}{\sum_i \left\{ \left(X_{i,j}{}^M(1)+X_{i,j}{}^D(1)\right) \frac{\dfrac{X_{i,j}{}^M(0)+X_{i,j}{}^D(0)}{\dfrac{X_{i,j}{}^M(0)}{P_i^M(0)}+\dfrac{X_{i,j}{}^D(0)}{P_i^D(0)}}}{\dfrac{X_{i,j}{}^M(1)+X_{i,j}{}^D(1)}{\dfrac{X_{i,j}{}^M(1)}{P_i^M(1)}+\dfrac{X_{i,j}{}^D(1)}{P_i^D(1)}}} \right\}} \quad (7)$$

Assume that imports are cheaper than domestically produced inputs and both prices, $P_i^M(t)$ and $P_i^D(t)$, are constant over time. Also assume that firms in sector j substitute imports for domestically produced inputs by the same amount, and imports and domestically produced inputs make the same marginal contribution to production. Then the true price index of intermediate inputs must decline. Price index, $p_j^I(t)$, which is defined by equation (7), satisfies this condition. But price index, $p_j^J(t)$, which is defined by equation (2) does not decline. When we use $p_j^J(t)$, we will judge incorrectly that the intermediate input in sector i has decreased. Thus, we will overestimate the TFP growth of sector i.

In Japan, METI conducts the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* every year. This survey provides information on differentials in customer delivery prices among Japan, China, the United States, Germany, South Korea, Taiwan, and Hong Kong for about 180 commodities and 40 services. In the future, we would like to evaluate the type of offshoring bias pointed out by Diewert and Nakamura (2012) using the results of this survey. However, in this paper, we focus on the issue how the intermediate input index based on equation (1), which uses information of non-competitive import type input-output tables, moves differently from the intermediate input index based on equation (5), which does not use such information.

3. Data Used

In this section we explain the data we use for our analysis.

As nominal non-competitive import type input-output tables for 1995, 2000 and 2005, we use the *Input-Output Tables for Japan* for each of these years, published by the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIAC). For these years, tables of imports reporting the nominal value of imports used as inputs in sector j, $X_{i,j}^M(t)$, and the nominal value of imports used to satisfy final demand k,

$F_{i,k}{}^{M}(t)$, for each product *i* are available.

In order to construct these tables on imports, METI, which collaborates with MIAC to compile the IO tables, conducts its survey on the use of major imports at the HS 9-digit level. About 200 trading companies and producer associations are interviewed, with the latter, such as the association of electronics-parts producers, the association of automobile-parts producers, etc., making up the majority. This means that METI mainly asks the Japanese producers of each commodity about the destination industries of imports of these commodities, most of which are produced by their rivals abroad (of course, some Japanese producers are now multinationals and import from their own affiliates abroad). Table 1 provides an outline of the questionnaire form.

To extend our analysis to more recent years, we estimated non-competitive import type input-output tables for 2008 using the *2008 Extended Input-Output Tables* and the *2005 Input-Output Tables for Japan*. The extended IO Tables do not contain tables on imports and we therefore estimated tables on imports by extrapolating tables on imports of 2005 using import data of 2008.

We obtain deflators for imports and domestic outputs separately for each sector *i* from the *1995-2000-2005 Linked Input-Output Tables* published by the Statistics Bureau, MIAC, and the *2008 Extended Input-Output Tables*. In these IO tables, the major original sources of deflators for commodities are the domestic corporate goods price index (DCGPI) and the import price index (IPI) taken from the *Corporate Goods Price Index* published by the Bank of Japan.

Using these various sources, we prepared nominal and real non-competitive import type input-output tables for 1995, 2000, 2005 and 2008. The endogenous sector table for each year has 514 rows and 401 columns. In our analysis, we set 2005 as our benchmark year and calculate the Laspeyres quantity index and the Paasche price index for years after 2005 and the Paasche quantity index and the Laspeyres price index for years before 2005.

Table 1. Outline of the Questionnaire Form for *the Survey on Demand for Imported Commodities*

Survey on Demand for Imported Commodities for the Year 2010

Note: Please enter the percentage share of each final consumer of each commodity.

Form A	
HS Code (9 digit)	
(Japan's HS code 9 digit classification contains 2,784 commodities)	
HS Commodity Name	
Interviewed at	
	Sectoral distribution of imported commodity (nominal value of imported commodity demanded by that sector/nominal value of total imports)
Intermediate input by 32 sectors	%
Agriculture, forestry and fishery	4
Mining	3
….	
….	
Electrical machinery	25
….	
….	
Household services	
Business services	30
….	
Final demand	
Household consumption	2
Government consumption	10
Private investment	4
Government investment	3
…..	
Total	100

Form B	
Please provide the final destination of the commodity by 4 digit and 6 digit industry classification for the two sectors that make up the highest shares in Form A.	
4 digit table	
Electrical machinery	
Electronics parts	
Household electric appliances	
Sub-total	25
Business services	
…..	
Sub-total	30
6 digit table	
Electrical machinery	
…..	
Electronics parts	
Semiconductors	
Condensers	
Sub-total	25
Business services	
…..	
Sub-total	30

4. Estimation of Offshoring Bias

Using our data, we analyze how the prices of imported inputs relative to domestically produced inputs changed as well as how much the share of imported inputs in total inputs differs across sectors and how this share changed between 1995 and 2005. In addition, we estimate offshoring bias by comparing the intermediate input index based on information from the tables on imports and the index based on the assumption that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand (as is assumed in the I-O tables for the United States).

As we explained in Section 2, the offshoring bias caused by the assumption that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand, will become large if changes in the relative prices of imports and domestic products are large and if imports of each input, relative to its total demand, are quite different across sectors.

Figure 1 shows how the ratio of the average price of imported inputs over the average price of domestically produced inputs has changed over time. As can be seen, the ratio declined by 40 percent in the period 1995-2008. This decline was not caused by yen appreciation, since, as Figure 1 also shows, the value of the yen as measured by the real effective exchange rate, fell by more than 50 percent during the same period. Rather, a likely reason for the decline in relative import prices is the increase in Japan's imports of low-priced products from Asian countries.

Figure 1. Average Price of Imported Inputs over Average Price of Domestically Produced Inputs (1995=1) and Japan's Real Effective Exchange Rate (Yen/Foreign Currency): 1995-2008

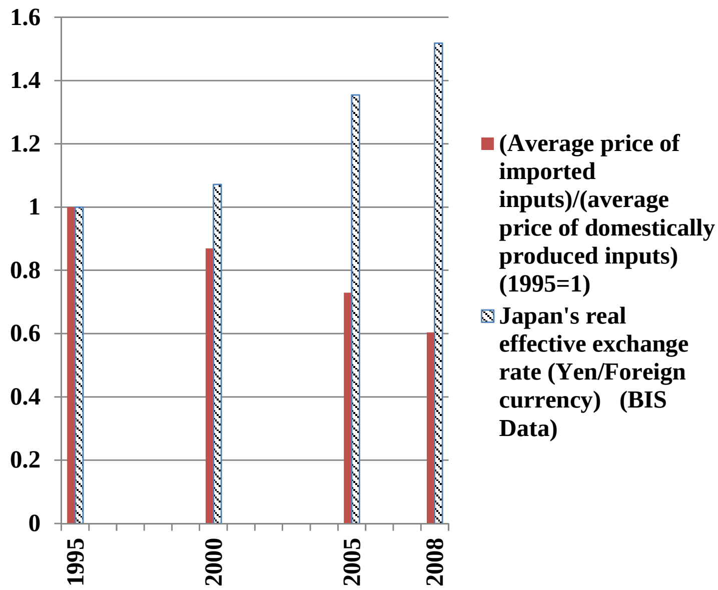


Figure 2 shows the regional composition of Japan's imports of manufactured products for 2000, 2005 and 2008. Similarly, Figure 3 shows the regional composition of Japan's imports of machinery imports for 2000, 2005 and 2008. The figures show that the share of imports from China and other Asian countries in Japan's total manufacturing and machinery imports increased rapidly in the 2000s.

Figure 2. Regional Composition of Japan's Imports of Manufactured Products: 2000, 2005 and 2008

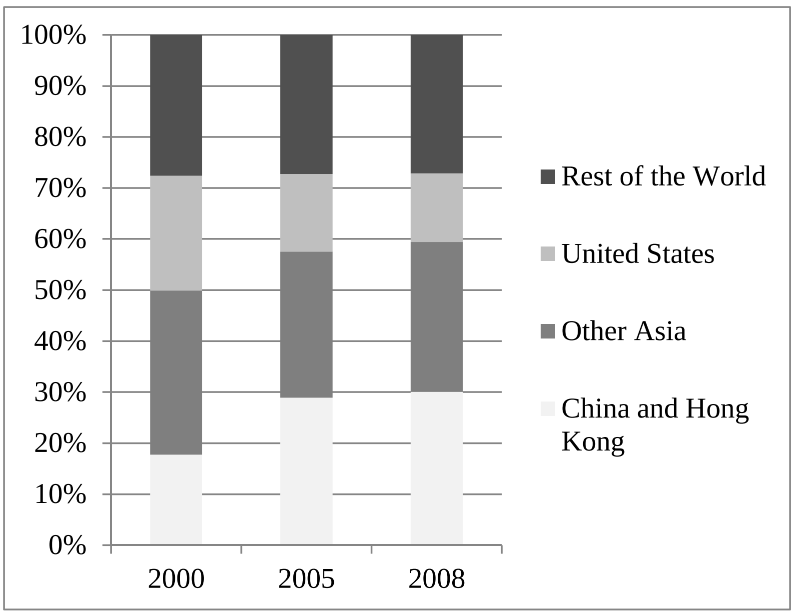
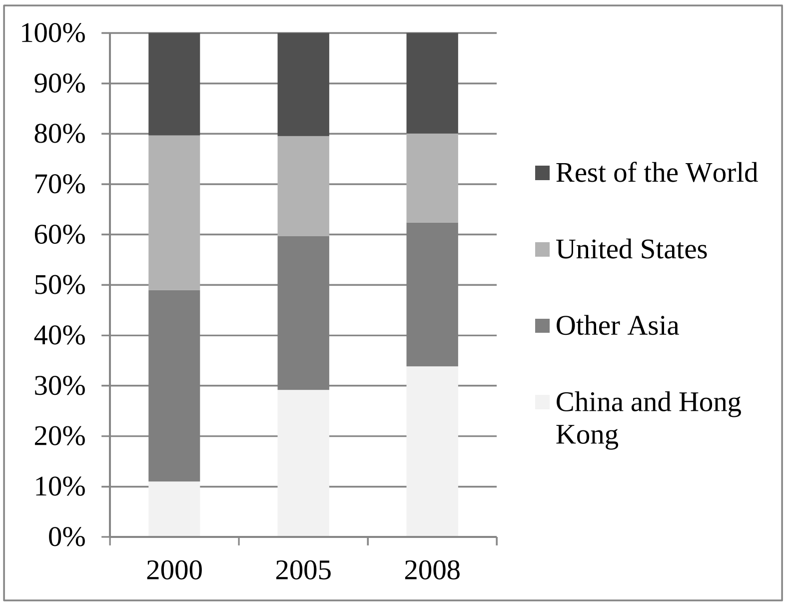


Figure 3. Regional Composition of Japan’s Imports of Machinery: 2000, 2005 and 2008



Next, Table 2 provides a list of commodities for which the ratio of the price of imports over the price of domestic products declined by more than 25 percent from 1995 to 2008. Cells showing machinery products are highlighted. The table confirms that the import price-domestic price ratio of many commodities, including important parts and components, sharply declined during the period. For instance, in the case of integrated circuits and semiconductor devices, the relative price declined by 33 percent and 28 percent, respectively.

The next issue we examine is how much the share of imported inputs in total inputs differs across sectors and how this share has changed over time. We do so by focusing on integrated circuits and semiconductor devices. The results are shown in Figures 4 and 5.

Starting with integrated circuits, the nominal value of total intermediate inputs increased from 3.0 trillion yen in 1995 to 3.6 trillion yen in 2005.[1] While this increase in the nominal value is not particularly large, intermediate input in real terms in fact increased threefold. The share of the total nominal input of imports in the total nominal input increased from 34 percent to 58 percent. The increase in the share of the total

[1] The reason that we focus on the period up to 2005 and not up to 2008 here is that we had to estimate the table on imports for 2008 and therefore think that the table on imports for 2005 is more reliable.

nominal input of imports was even more pronounced in the case of semiconductor devices, where it jumped from 18 percent to 61 percent.

However, as can be seen in Figures 4 and 5, the share of imports in total demand differs considerably across sectors. In both cases, the import ratio tends to be high in electrical machinery sectors, but relatively low in other sectors such as automobiles and precision machinery. This means that we will underestimate the growth of these electronics parts inputs in electrical machinery sectors and overestimate it in other machinery sectors, if we assume that an industry's imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand.

Table 3 shows the 50 sectors in which the underestimation of intermediate input growth is largest among all the 240 manufacturing sectors. We calculate the extent of underestimation, $\ln(x_j^U(2008)/\ x_j^I(2008))$- $\ln(x_j^U(1995)/\ x_j^I(1995))$, using our data. By multiplying this value with the average value of the nominal intermediate input-nominal gross output ratio of a particular sector for 1995 and that for 2008 and with minus one, we also calculate the extent of the overestimation of TFP growth for the period 1995-2008.

In the top 15 sectors in which the underestimation of intermediate input growth is largest, that is, animal oils and fats, ordnance, aircrafts, liquid crystal elements, methane derivatives, organic fertilizers, n.e.c., video recording and playback equipment, thermo-setting resins, salt, bicycles, turbines, glass fiber and glass fiber products, n.e.c., and integrated circuits, the negative offshoring bias of intermediate input growth is more than 0.025 percent and the positive offshoring bias of TFP growth is more than 1.7 percent. These sectors include important "high tech" machinery sectors, such as aircrafts and integrated circuits.

Next, Table 4 shows the 50 sectors in which the overestimation of intermediate input growth is largest among all the manufacturing sectors. These include cellular phones, radio and television sets, coal products, other non-ferrous metal products, repair of aircrafts, and other photographic and optical instruments, where the positive offshoring bias of intermediate input growth is more than 0.033 [percent] and the negative offshoring bias of TFP growth is more than 1.9 percent.

Table 2. Commodities for Which the Import Price-Domestic Price Ratio Declined by More than 25% from 1995 to 2008

Sector	Import price /domestic price of 2008 (1995=1)	Sector	Import price /domestic price of 2008 (1995=1)	Sector	Import price /domestic price of 2008 (1995=1)
Other petroleum refinery products	0.174	Printing, plate making and book binding	0.539	Condiments and seasonings	0.673
Natural gas	0.215	Rolling stock	0.547	Integrated circuits	0.674
Video recording and playback equipment	0.230	Polyethylene (low density)	0.551	Engines	0.675
Miscellaneous cereals	0.239	Bread	0.552	Other livestock	0.686
Coal mining	0.245	Other non-metallic ores	0.554	Processed meat products	0.686
Forged steel	0.279	Tea and roasted coffee	0.555	Other hot rolled steel (ordinary steel)	0.687
Iron ores	0.291	Soft drinks	0.556	Other electrical devices and parts	0.689
Other coal products	0.316	Heavy oil B and C	0.557	Cooking oil	0.693
Electric audio equipment	0.324	Steel pipes and tubes (ordinary steel)	0.558	Methane derivatives	0.694
Crude steel (electric furnaces)	0.331	Synthetic rubber	0.560	Other aliphatic intermediates	0.697
Gasoline	0.351	Internal combustion engines for motor vehicles and parts	0.560	Other office machines	0.699
Personal Computers	0.356	Cast materials (iron)	0.565	Rice	0.699
Ethylene glycol	0.361	Gas and oil appliances and heating and cooking	0.567	Dextrose, syrup and isomerized sugar	0.699
Crops for inedible agricultural products, n.e.c.	0.367	Hen eggs	0.572	Polyethylene (high density)	0.700
Preserved agricultural foodstuffs (other than bottled or	0.367	Other liquors	0.577	Crops for feed and forage	0.702
Industrial plastic products	0.367	Gravel and quarrying	0.581	Other non-ferrous metal products	0.703
Optical fiber cables	0.376	Cast iron pipes and tubes	0.598	Electrical equipment for internal combustion engines	0.705
Vending machines	0.379	Noodles	0.600	Cement	0.706
Steel ships	0.385	Other resins	0.600	Hot rolled steel (special steel)	0.710
Photographic sensitive materials	0.385	Total of intermediate sectors	0.604	High function resins	0.712
Coke	0.400	Tobacco	0.609	Synthetic phenol	0.712
Magnetic tapes and discs	0.407	Metal containers, fabricated plate and sheet metal	0.609	Miscellaneous leather products	0.712
Acetic acid	0.429	Electron tubes	0.617	Steel bar (ordinary steel)	0.715
Glass processing materials	0.433	Other fruits	0.620	Timber	0.715
Agricultural chemicals	0.434	Steep plate (ordinary steel)	0.624	Bottled or canned meat products	0.717
Other cyclic intermediates	0.452	Other pulses	0.625	Bicycles	0.719
Dairy products	0.459	Pure toluene	0.628	Semiconductor devices	0.720
Oil seeds	0.465	Pig iron	0.632	Nuclear fuels	0.722
Non-ferrous metal castings and forgings	0.466	Ships (except steel ships)	0.635	Batteries	0.726
Printing ink	0.468	Other glass products, n.e.c.	0.635	Starch	0.726
Electronic computing equipment (except personal	0.468	Clay refractories	0.637	Woolen fabrics, hemp fabrics and other fabrics	0.728
Chemical fertilizer	0.481	Medicaments	0.638	Sawmill, wood working, veneer and plywood	0.728
Plywood	0.484	Other meat (bone meat)	0.644	Citrus fruits	0.730
Radio and television sets	0.485	By-products of slaughtering and meat processing	0.644	Other foods	0.732
Pure benzene	0.487	Catalyzer	0.648	Bottled or canned seafood	0.737
Fowls and broilers	0.493	Other inorganic pigments	0.648	Surface active agents	0.742
Other materials for ceramics	0.502	Pulp equipment and paper machinery	0.651	Rolled and drawn aluminum	0.743
Household air-conditioners	0.508	Metal products for construction	0.651	Watches and clocks	0.743
Carpets and floor mats	0.515	Milled rice	0.658	Other grain milling	0.745
Toys and games	0.518	Titanium oxide	0.660	LPG (liquefied petroleum gas)	0.745
Wheat flour	0.525	Synthetic alcohol	0.664	Other machinery for service industry	0.746
Limestone	0.527	Household electric appliances (except air-conditioners)	0.668	Passenger motor cars	0.746
Other industrial inorganic chemicals	0.529	Soda ash	0.672	Oil and fat industrial chemicals	0.747
Beer	0.530	Apples	0.673	Acrylonitrile	0.748
Rice straw	0.533	Other photographic and optical instruments	0.673	Metal products for architecture	0.754

Figure 4. Share of Imported Inputs in Total Inputs: Integrated Circuits, 1995-2005

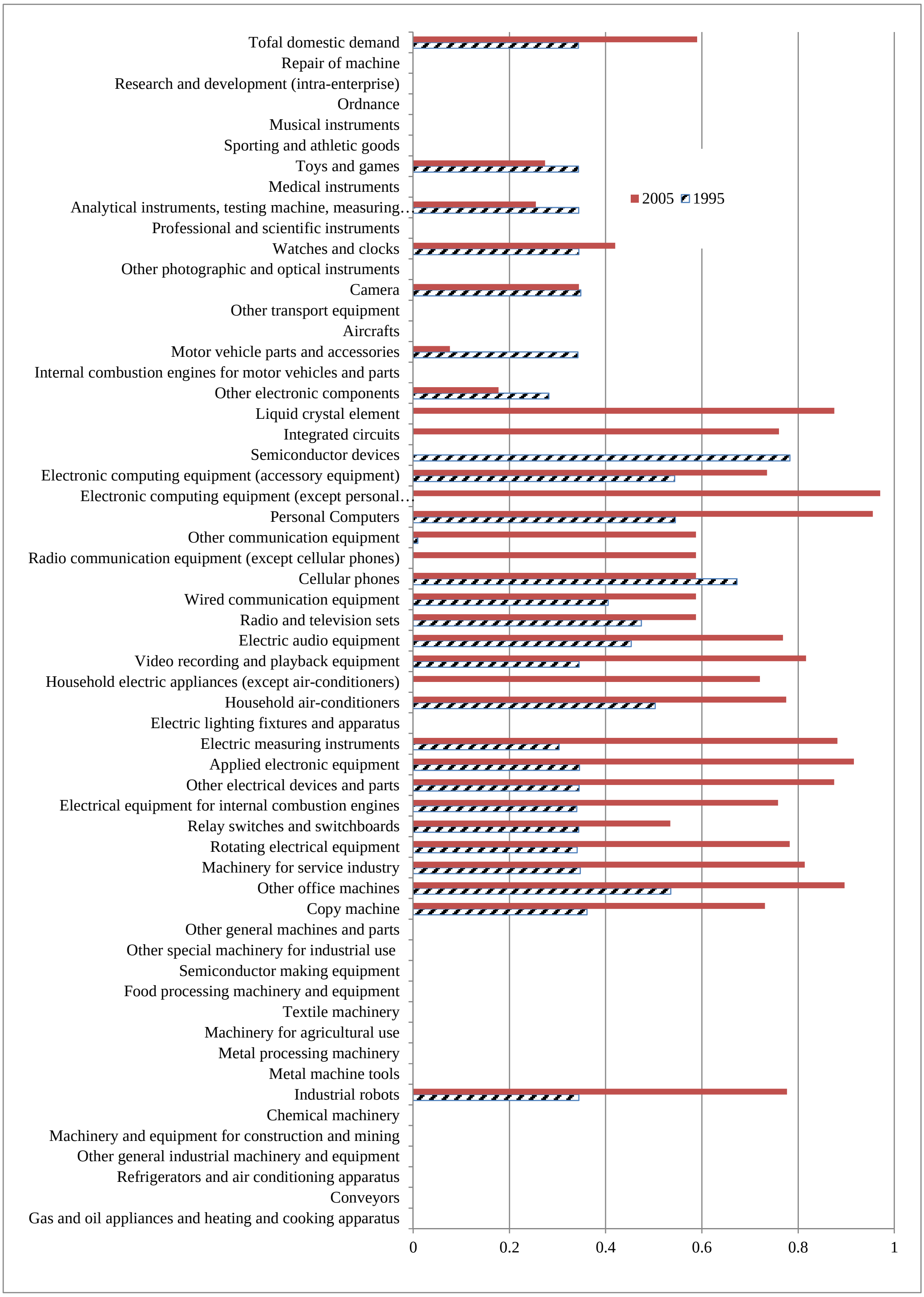


Figure 5. Share of Imported Inputs in Total Inputs: Semiconductor Devices, 1995-2005

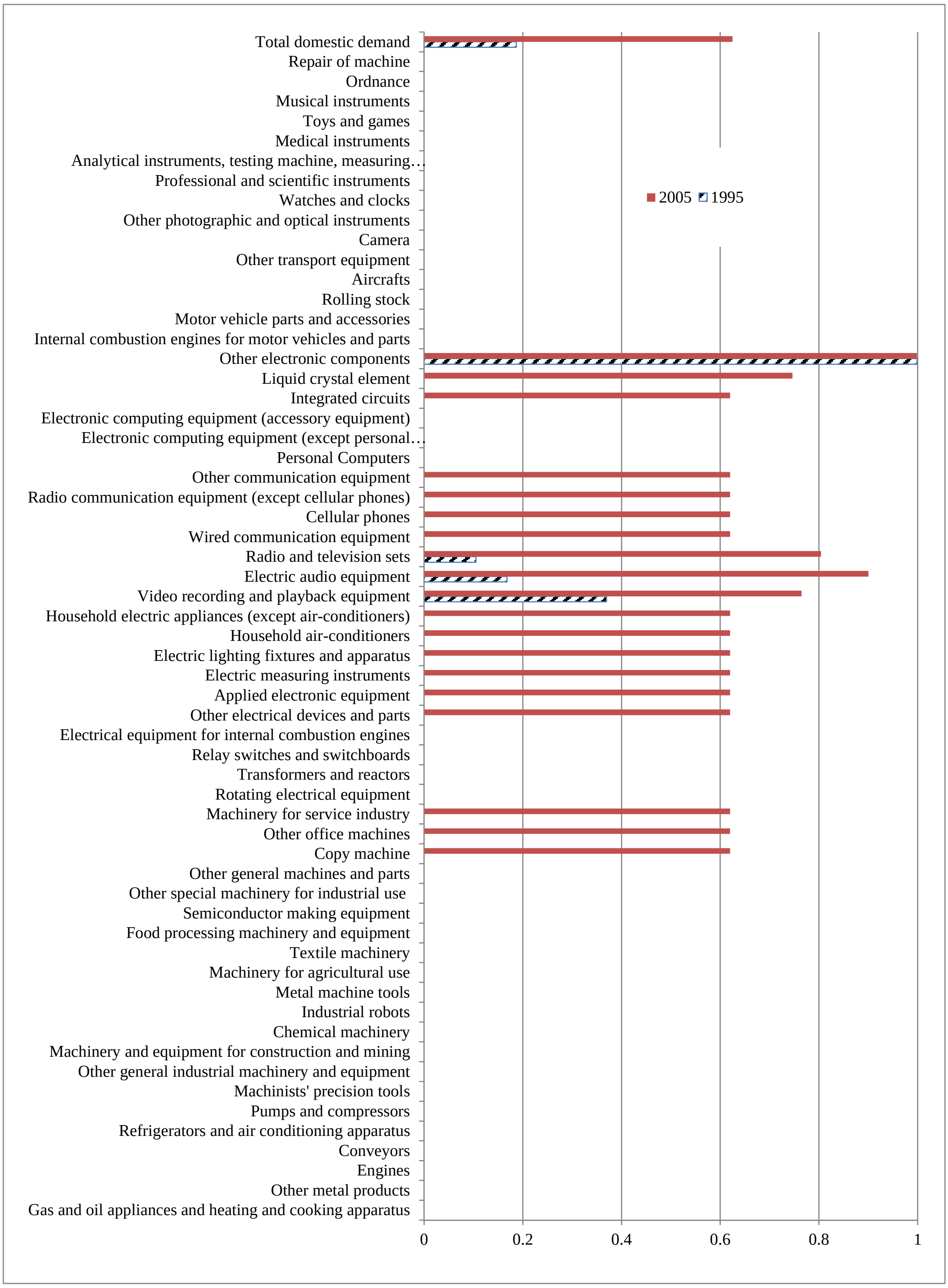


Table 3. Underestimation of Intermediate Input Growth: Top 50 Sectors, 1995-2008

Sector	Underestimation of intermediate input growth, $\ln(x^U/x^J)$ (1995-2008)	Intermediate input/gross output (average value of 1995 and 2008)	Overestimation of TFP growth on a gross output basis (1995-2008)
	A	B	A*B
Animal oils and fats	-14.04%	0.715	10.04%
Ordnance	-12.62%	0.619	7.81%
Aircrafts	-9.85%	0.538	5.29%
Liquid crystal elements	-8.13%	0.727	5.91%
Methane derivatives	-6.90%	0.742	5.12%
Organic fertilizers, n.e.c.	-4.49%	0.657	2.95%
Video recording and playback equipment	-4.25%	0.722	3.07%
Thermo-setting resins	-4.13%	0.733	3.03%
Salt	-4.13%	0.546	2.25%
Bicycles	-3.73%	0.720	2.68%
Turbines	-3.38%	0.643	2.17%
Glass fiber and glass fiber products, n.e.c.	-3.20%	0.604	1.93%
Integrated circuits	-2.62%	0.650	1.70%
Processed meat products	-2.62%	0.710	1.86%
"Tatami" (straw matting) and straw products	-2.47%	0.703	1.74%
Wooden chips	-2.39%	0.733	1.75%
Other resins	-2.34%	0.749	1.75%
Other glass products	-1.94%	0.537	1.04%
Non-ferrous metal castings and forgings	-1.85%	0.703	1.30%
Dextrose, syrup and isomerized sugar	-1.72%	0.820	1.41%
High function resins	-1.49%	0.778	1.16%
Electronic computing equipment (except personal computers)	-1.45%	0.716	1.04%
Optical fiber cables	-1.28%	0.740	0.95%
Applied electronic equipment	-1.22%	0.716	0.88%
Watches and clocks	-1.21%	0.630	0.76%
Machinery for service industry	-1.10%	0.725	0.79%
Plywood	-1.07%	0.690	0.74%
Rolling stock	-1.03%	0.745	0.77%
Electric measuring instruments	-1.03%	0.652	0.67%
Cameras	-1.02%	0.689	0.70%
Cement	-1.00%	0.697	0.69%
Food processing machinery and equipment	-0.97%	0.587	0.57%
Sporting and athletic goods	-0.96%	0.676	0.65%
Rotating electrical equipment	-0.88%	0.649	0.57%
Cast and forged steel	-0.78%	0.517	0.41%
Internal combustion engines for vessels	-0.77%	0.691	0.53%
Other electrical devices and parts	-0.75%	0.642	0.48%
Repair of rolling stock	-0.73%	0.636	0.46%
Relay switches and switchboards	-0.71%	0.634	0.45%
Other foods	-0.70%	0.595	0.41%
Bottled or canned meat products	-0.69%	0.726	0.50%
Iron and steel shearing and slitting	-0.69%	0.788	0.54%
School lunchs (public)	-0.69%	0.567	0.39%
Musical instruments	-0.67%	0.609	0.41%
Copy machines	-0.67%	0.800	0.53%
Personal Computers	-0.66%	0.804	0.53%
Motor vehicle bodies	-0.65%	0.757	0.49%
Professional and scientific instruments	-0.62%	0.569	0.35%
Transformers and reactors	-0.61%	0.597	0.36%
Passenger motor cars	-0.58%	0.858	0.50%

Table 4. Overestimation of Intermediate Input Growth: Top 50 Sectors, 1995-2008

Sector	Overestimation of intermediate input growth, $\ln(x^U/x^J)$ (1995-2008)	Intermediate input/gross output (average value of 1995 and 2008)	Underestimation of TFP growth on a gross output basis (1995-2008)
	A	B	A*B
Cellular phones	5.49%	0.782	-4.30%
Radio and television sets	5.47%	0.780	-4.27%
Coal products	4.04%	0.825	-3.33%
Other non-ferrous metal products	3.70%	0.715	-2.64%
Repair of aircrafts	3.49%	0.656	-2.29%
Other photographic and optical instruments	3.25%	0.592	-1.92%
Confectionery	3.04%	0.580	-1.76%
Electric audio equipment	2.96%	0.742	-2.20%
Leather and fur skins	2.87%	0.692	-1.98%
Bottled or canned vegetables and fruits	2.69%	0.770	-2.07%
Chemical fertilizer	2.54%	0.685	-1.74%
Other electrical devices and parts	2.41%	0.630	-1.52%
Retort foods	2.40%	0.704	-1.69%
Dishes, sushi and lunch boxes	2.16%	0.697	-1.50%
Synthetic dyes	2.12%	0.649	-1.38%
Other metal products	1.88%	0.463	-0.87%
Batteries	1.80%	0.733	-1.32%
Other electronic components	1.78%	0.690	-1.23%
Medicaments	1.67%	0.608	-1.01%
Dairy farm products	1.49%	0.779	-1.16%
Steel pipes and tubes	1.42%	0.759	-1.08%
Other industrial organic chemicals	1.26%	0.672	-0.84%
Soap, synthetic detergents and surface active agents	1.21%	0.715	-0.86%
Synthetic fibers	1.21%	0.633	-0.77%
Preserved agricultural foodstuffs (other than bottled or canned)	1.21%	0.631	-0.76%
Nuclear fuels	1.21%	0.541	-0.65%
Inorganic pigment	1.18%	0.687	-0.81%
Other liquors	1.16%	0.483	-0.56%
Oil and fat industrial chemicals	1.15%	0.650	-0.74%
Bread	1.11%	0.561	-0.62%
Petrochemical basic products	1.09%	0.920	-1.01%
Compressed gas and liquefied gas	1.07%	0.685	-0.74%
Other industrial inorganic chemicals	1.02%	0.629	-0.64%
Clay refractories	0.96%	0.603	-0.58%
Carpets and floor mats	0.90%	0.754	-0.68%
School lunches (private)	0.90%	0.561	-0.50%
Electric bulbs	0.86%	0.605	-0.52%
Feeds	0.84%	0.873	-0.74%
Prepared frozen foods	0.84%	0.659	-0.56%
Engines	0.82%	0.727	-0.60%
Sheet glass and safety glass	0.81%	0.562	-0.46%
Bolts, nuts, rivets and springs	0.81%	0.544	-0.44%
Petroleum refinery products (inc. greases)	0.77%	0.634	-0.49%
Noodles	0.76%	0.630	-0.48%
Jewelry and adornments	0.71%	0.680	-0.48%
Machinery and equipment for construction and mining	0.70%	0.673	-0.47%
Bedding	0.58%	0.668	-0.38%
Starch	0.58%	0.775	-0.45%
Tires and inner tubes	0.57%	0.688	-0.39%
Carbon and graphite products	0.50%	0.589	-0.30%

5. Conclusion

Using Japan’s tables of imports and other IO statistics for 1995, 2000, 2005, and 2008, we estimated how much and in what direction the intermediate input index and TFP growth will be biased if we assume that an industry’s imports of each input, relative to its total demand, are the same as the economy-wide imports relative to total demand. We also examined how the prices of imported inputs relative to domestically produced inputs changed as well as how much the share of imported inputs in total inputs differs across sectors and how this share changed between 1995 and 2005.

Our main findings are as follows.

1. Through theoretical analysis, we found that the offshoring bias will become large if imports of each input, relative to its total demand, are quite different across sectors and changes in the relative prices of imports and domestic products are large.

2. Japan experienced a 40 percent decline in the ratio of the average price of imported inputs over the average price of domestically produced inputs in the period 1995-2008. This decline was not caused by yen appreciation, since the value of the yen as measured by the real effective exchange rate in fact fell by more than 50 percent during the same period. Rather, a likely reason for the decline in relative import prices is the increase in Japan’s imports of low-priced products from Asian countries.

3. The import price-domestic price ratio of many commodities, including important parts and components, declined sharply during the period. For instance, in the case of integrated circuits and semiconductor devices, the relative price declined 33 percent and 28 percent, respectively.

4. We examined how the share of imported inputs in total inputs differs across sectors, focusing again on the case of integrated circuits and semiconductor devices. We found that in both cases, the import ratio tends to be high in electrical machinery sectors. And the ratio is relatively low in other sectors, such as automobile and precision machinery.

5. We found that offshoring bias is quite large in some sectors. For example, in animal oils and fats, ordnance, aircrafts, liquid crystal elements, methane derivatives, organic fertilizers, n.e.c., video recording and playback equipment, thermo-setting

resins, salt, bicycles, turbines, glass fiber and glass fiber products, n.e.c., and integrated circuits, the negative offshoring bias of intermediate input growth is more than 2.5 percent and the positive offshoring bias of TFP growth is more than 1.7 percent.

6. On the other hand, in cellular phones, radio and television sets, coal products, other non-ferrous metal products, repair of aircrafts, and other photographic and optical instruments, the positive offshoring bias of intermediate input growth is more than 3.3 percent and the negative offshoring bias of TFP growth is more than 1.9 percent.

Since a relatively large offshoring bias exists in a substantial number of manufacturing sectors, including important machinery sectors, it is desirable to take account of the offshoring bias issue in future productivity analyses at the sectoral and firm levels. And since offshoring activities are likely to continue increasing, data collection on this issue by statistical offices will be of growing importance.

Let us conclude the paper by discussing our agenda for the future. Our analysis is based on the assumption that imported intermediate inputs from sector *i* to sector *j* and domestically produced intermediate inputs from sector *i* to sector *j* are different products and that the cost share of each product reveals its marginal contribution to production in sector *j*. If imports *i* and domestic output *i* are same good (or service) even when the absolute price level of imports and that of domestic output are different, then our intermediate input index is not appropriate for measuring true intermediate input growth. In this case, we need absolute price level data for imported inputs and domestically produced inputs. We hope to tackle this issue in the future by matching data from the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI) with our IO data.

Another issue we would like to examine in more detail is why the prices of imported inputs have declined so sharply in comparison with domestic input prices. Our present hypothesis is that Asian countries, including China, have succeeded in becoming efficient producers of manufacturing goods and that Japan has increased her imports from these countries. We can test this hypothesis by checking what the most important countries of origin are of commodities whose import prices have declined sharply, using Japan’s import data and by checking in what countries the prices of these products are lowest using data from the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input*.

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