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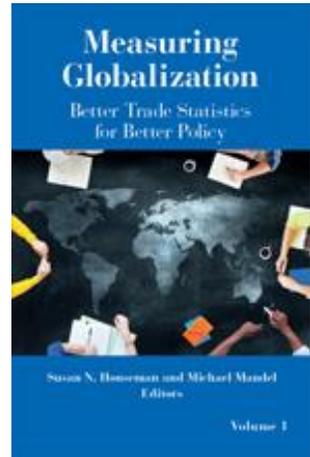
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## Biases to Manufacturing Statistics from Offshoring: Evidence from Japan

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# 7

## **Biases to Manufacturing Statistics from Offshoring**

### **Evidence from Japan**

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As manufacturing sectors of developed economies outsource more and more to developing economies, this may give rise to a serious measurement problem. If a manufacturing industry (or firm) procures a lot of parts and components from developing economies at exceptionally low prices and we do not correctly take account of these low prices, we will overestimate the productivity of this industry (or firm).

In this chapter, we investigate two types of biases to manufacturing statistics from the growth in manufacturers' use of imported intermediates—commonly known as offshoring.

The first type of bias concerns measuring the use of imported products in the economy. Most countries, including the United States, do not track whether imports are destined for final demand or intermediate uses but instead assume that industries use imports in proportion to their overall use of these products in the economy—this is the so-called import proportionality assumption. Measures using the import proportionality assumption will differ from measures based on actual input use if two conditions occur: 1) industries' use of imports differs significantly from that assumed under the import proportionality assumption, and 2) the price movements of imported and domestic intermediates within commodity classes differ significantly.<sup>1</sup> In this study, we call these types of biases the bias caused by the import proportionality assumption.

The second type of bias concerns the price gap between domestically produced inputs and imported inputs. If manufacturers shift sourcing from a high-cost domestic supplier to a low-cost foreign supplier and statisticians do not take account of this price gap, statisticians' estimates of the inputs of these manufacturers will be downwardly biased, and estimates of the total factor productivity (TFP) will be upwardly biased. This has been referred to as "offshoring bias" in the literature (Diewert and Nakamura 2011; Houseman et al. 2011).

Japan presents an ideal case study to examine both the bias caused by the import proportionality assumption and the bias caused by offshoring. The reason is that 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 survey, implemented by the Ministry of Economy, Trade, and Industry (METI), on the sources of each industry's procurements. Moreover, because of Japan's location, imports of intermediate inputs from China and other developing economies in East Asia have increased rapidly in recent decades. Against this background, using Japan's I-O tables and price indices for imported and domestic products, one of the major aims of this study is to estimate the bias from the import proportionality assumption by examining differences in estimates of import use in the I-O tables based on actual data and estimates based on the import proportionality assumption.

In order to estimate offshoring bias, we need—in addition to data on import use in the economy and price indices for imported and domestic products—data on the price gap between domestically produced inputs and imported inputs. In Japan, such data are available from the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input*, conducted by METI 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. Using these data, we estimate the price gap between domestically produced inputs and imported inputs by country of origin.

The structure of the article is as follows. In Section Two, "Approach to Measuring the Two Types of Biases," we explain our methodology to

estimate the two types of biases using data on Japan. We then explain our data in Section Three, “Data Used.” We also detail what data METI collects and how it collects these data. In Section Four, “Estimation of Bias Caused by the Import Proportionality Assumption,” we report our results on bias created by the import proportionality assumption. In Section Five, “Estimation of Offshoring Bias,” we report our results on the second type of bias. Section Six concludes.

## APPROACH TO MEASURING THE TWO TYPES OF BIASES

This section presents the approach we use to measure the two types of bias: 1) bias caused by the import proportionality assumption and 2) offshoring bias.

We start by explaining our approach to measuring the bias caused by the import proportionality assumption.

In Japan, 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  $j$ ,  $X_{i,j}^H(t)$ , are available separately. Here, superscript  $M$  stands for imported intermediate inputs and superscript  $H$  stands for domestically produced intermediate inputs. In the United States, only data on the total value of intermediate inputs from sector  $i$  to sector  $j$ ,  $X_{i,j}^M(t) + X_{i,j}^H(t)$ , are available to construct input-output tables; the extent to which the intermediate inputs used in sector  $j$  are imported or domestically produced is unknown.

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

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, as 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 indexes 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  $P_i^H(t) / P_i^H(0)$  denote the price change of domestically produced product  $i$  from year 0 to year  $t$ .<sup>2</sup>

For our estimation of the bias, which would be caused by a lack of information on imports, we first prepared nominal and real import input-output tables for 1995, 2000, 2005, and 2008 in Japan using data on import use in the economy. As we will explain in detail in the next section, the main sources of our I-O tables are the 1995-2000-2005 Linked Input-Output Tables, published by the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIAC), and the 2008 Updated Input-Output Tables, published by METI. Both of the statistics set 2005 as their benchmark year.

The key variables we would like to estimate are the real input indexes for each sector. For the calculation of these quantity indexes, we use 2005 as the base year. That is, we weight input quantity changes by the nominal input values of 2005. Using Japan's I-O tables, which incorporate information on the use of imports in the economy, we derive the real input index for sector  $j$  for year  $t$  ( $t = 1995, 2000, 2005, 2008$ ),  $x_j^J(t)$ , as follows:

$$(7.1) \quad x_j^J(t) = \frac{\sum_i \left( X_{i,j}^M(t) \frac{X_{i,j}^M(t)}{P_i^M(t)} + X_{i,j}^H(t) \frac{X_{i,j}^H(t)}{P_i^H(t)} \right)}{\sum_i \left( X_{i,j}^M(T) \frac{X_{i,j}^M(T)}{P_i^M(T)} + X_{i,j}^H(T) \frac{X_{i,j}^H(T)}{P_i^H(T)} \right)}$$

$$= \frac{\sum_i \left( X_{i,j}^M(t) \frac{P_i^M(T)}{P_i^M(t)} + X_{i,j}^H(t) \frac{P_i^H(T)}{P_i^H(t)} \right)}{\sum_i \left( X_{i,j}^M(T) + X_{i,j}^H(T) \right)},$$

where the superscript  $J$  means that this index is based on noncompetitive import-type I-O tables like Japan's.  $T$  denotes the base year, 2005.<sup>3</sup>

In most countries, data on the destination of imports in the economy are not regularly available, and the ordinary approach is to assume

that a sector'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)—the so-called import proportionality assumption.

That is, an industry's imports are calculated as follows: let  $m_i(t)$  denote the economy-wide imports of product  $i$  relative to total demand for product  $i$ :

$$(7.2) \quad m_i(t) = \frac{\sum_j X_{i,j}^M(t) + \sum_k F_{i,k}^M(t)}{\sum_j (X_{i,j}^M(t) + X_{i,j}^H(t)) + \sum_k (F_{i,k}^M(t) + F_{i,k}^H(t))},$$

where  $F_{i,k}^M(t)$  and  $F_{i,k}^H(t)$  denote the value of imports of product  $i$  used to satisfy final demand  $k$  and the value of domestic output of product  $i$  used to satisfy final demand  $k$ .

In this shortcut approach, growth of real inputs from sector  $i$  to sector  $j$  is estimated by

$$m_i(t) \frac{\frac{X_{i,j}^M(t) + X_{i,j}^H(t)}{P_i^M(t)}}{\frac{X_{i,j}^M(T) + X_{i,j}^H(T)}{P_i^M(T)}} + (1 - m_i(t)) \frac{\frac{X_{i,j}^M(t) + X_{i,j}^H(t)}{P_i^H(t)}}{\frac{X_{i,j}^M(T) + X_{i,j}^H(T)}{P_i^H(T)}}.$$

Moreover, the real input index for sector  $j$  for year  $t$ ,  $x_j^U(t)$ , is defined by

$$(7.3)$$

$$\begin{aligned} & x_j^U(t) \\ &= \frac{\sum_i (X_{i,j}^M(T) + X_{i,j}^H(T)) \left( m_i(t) \frac{\frac{X_{i,j}^M(t) + X_{i,j}^H(t)}{P_i^M(t)}}{\frac{X_{i,j}^M(T) + X_{i,j}^H(T)}{P_i^M(T)}} + (1 - m_i(t)) \frac{\frac{X_{i,j}^M(t) + X_{i,j}^H(t)}{P_i^H(t)}}{\frac{X_{i,j}^M(T) + X_{i,j}^H(T)}{P_i^H(T)}} \right)}{\sum_i (X_{i,j}^M(T) + X_{i,j}^H(T))} \\ &= \frac{\sum_i (X_{i,j}^M(t) + X_{i,j}^H(t)) \left( m_i(t) \frac{P_i^M(T)}{P_i^M(t)} + (1 - m_i(t)) \frac{P_i^H(T)}{P_i^H(t)} \right)}{\sum_i (X_{i,j}^M(T) + X_{i,j}^H(T))}, \end{aligned}$$

where the superscript  $U$  means that this index is drawn from U.S.-type input-output tables based on the import proportionality assumption.

Equation (7.3) shows that when the price of imports relative to that of domestic output declines ( $P_i^M(T) / P_i^H(T) > P_i^M(t) / P_i^H(t)$ ) from  $T$  to  $t$  for most inputs  $i$ , we will underestimate the increase in intermediate inputs in sectors where imports of product  $i$  relative to the sector's total demand is higher than the economy-wide imports/domestic output ratio ( $(X_{ij}^M(t) / (X_{ij}^M(t) + X_{ij}^H(t))) > m_i(t)$ ) for these inputs. As a result, we will overestimate the TFP growth of such sectors.

This type of bias is 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. This bias will be large if imports of each input, relative to the total demand for that input, are quite different across sectors, and if changes in the relative prices of imports and domestic products are large.

Biases caused by the import proportionality assumption have zero-sum characteristics. 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 macroeconomy when the prices of imports relative to those of domestic output decline.

Using Japan's I-O data from 1995 to 2008, we will analyze how the intermediate input index based on Equation (7.1) moves differently from the intermediate input index based on Equation (7.3).

Next, let us explain our methodology for measuring offshoring bias. The offshoring bias concerns an important caveat regarding our real input index  $x_i^U(t)$ , which is defined by Equation (7.1) and is based on import I-O tables like Japan's. If quality-adjusted prices of imports  $i$  and that of domestic output  $i$  are different, then our intermediate input index defined by Equation (7.1) is not appropriate for measuring true intermediate input growth. This issue was first pointed out by Diewert and Nakamura (2011) and empirically examined by Houseman et al. (2011).

If we express the (quality-adjusted) absolute price level of imported products by  $P_i^M(t)$  and the (quality-adjusted) absolute price level of

domestically produced products by  $P_i^H(t)$ , then the appropriate input index of sector  $j$  for year  $t$  is defined by

$$(7.4) \quad x_j^o(t) = \frac{\sum_i \left\{ (X_{i,j}^M(T) + X_{i,j}^H(T)) \frac{\frac{X_{i,j}^M(t)}{P_i^M(t)} + \frac{X_{i,j}^H(t)}{P_i^H(t)}}{\frac{X_{i,j}^M(T)}{P_i^M(T)} + \frac{X_{i,j}^H(T)}{P_i^H(T)}} \right\}}{\sum_i (X_{i,j}^M(T) + X_{i,j}^H(T))},$$

where the superscript  $o$  means that this index is based on information on price gaps between domestically produced inputs and imported inputs and is free from offshoring bias.

Assume that imports are cheaper than domestically produced inputs and that both prices,  $P_i^M(t)$  and  $P_i^H(t)$ , are constant over time. Also assume that firms in sector  $j$  substitute imports for domestically produced inputs by the same amount, and that imports and domestically produced inputs make the same marginal contribution to production. Then the true intermediate input index must remain constant. Input index  $x_j^o(t)$ , which is defined by Equation (7.4), satisfies this condition. But both the input index  $x_j^j(t)$ , which is defined by Equation (7.1), and the input index  $x_j^u(t)$ , which is defined by Equation (7.3), decline. When we use  $x_j^j(t)$  or  $x_j^u(t)$ , we will judge incorrectly that the intermediate input in sector  $i$  has decreased. Thus, we will overestimate the TFP growth of sector  $i$ .

Using METI's *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI 1999) and Japan's I-O data, we will evaluate offshoring bias by comparing the intermediate input index  $x_j^u(t)$  defined by Equation (7.3) and the intermediate input index  $x_j^o(t)$  defined by Equation (7.4).

## DATA USED

In this section we explain the data we use for our analysis. For information on the nominal use of imports in the Japanese economy

in 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  $j$ ,  $X_{ij}^M(t)$ , and the nominal value of imports used to satisfy final demand  $k$ ,  $F_{ik}^M(t)$ , for each product  $i$  are available.

In order to construct these tables on imports, METI, which collaborates with MIAC to compile the I-O tables, conducts its survey on the use of major imports at the HS nine-digit level.<sup>4</sup> Online Appendix Table 7A.1 provides an outline of the questionnaire form, which has been partially filled out by the authors with made-up industry names to illustrate the conceptual framework of the METI survey.<sup>5</sup> About 200 trading companies and producer associations are interviewed; the latter, such as the association of electronics parts producers and the association of automobile parts producers, make up the majority. This means that METI mainly asks the Japanese producers of each commodity about the destination industries for 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.)

To extend our analysis to more recent years, we estimate import input-output tables for 2008 using the 2008 Updated Input-Output Tables and the 2005 Input-Output Tables for Japan. The updated I-O Tables do not contain tables on imports, so we therefore estimate tables on imports by extrapolating data in import tables for 2005 using import data for 2008.

We obtain deflators for imports and domestic output separately for each sector  $i$  from the 1995-2000-2005 Linked Input-Output Tables, published by the Statistics Bureau of MIAC, and the 2008 Updated Input-Output Tables. In these I-O 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 import 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 for our calculation of the quantity and the price index before and after 2005.

Moreover, for data on price gaps necessary for our analysis we use the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI 1999). This survey has been conducted every year since 1993 and reports differences in the customer delivery price for about 150 intermediate goods and 30 services between Japan on the one hand and the United States, China, Germany, and the newly industrializing economies (NIEs, consisting of South Korea, Hong Kong, Taiwan, and Singapore) on the other. The survey specifies each commodity and service in great detail. In the case of commodities, the survey in principle follows the commodity specification of the Corporate Goods Price Index.

As we will report in detail in Section Five, “Estimation of Offshoring Bias,” unit prices in the developing economies included in the survey (i.e., China and the NIEs) for many products tend to be much lower than unit prices in the developed economies (i.e., Japan, the United States, and Germany). This implies that it would be inappropriate to assume, as is done in Equation (7.4), that the unit prices of Japanese imports are identical regardless of the country of origin. We therefore distinguish between imports from developed and from developing economies.

The number of goods and services covered by the survey differs across countries and across years. Data are relatively abundant for U.S.-Japan and China-Japan price differences from 2000, and we therefore use data for the two pairs for 2000 and 2008.<sup>6</sup>

We grouped Japan’s trade partners into two groups: 1) developed economies, consisting of the United States and countries that were members of the European Union in 2000, and 2) developing economies, consisting of China and the rest of the world. We assume that price differentials between Japan and the developed economies are the same as the U.S.-Japan price differentials, and that price differentials between Japan and the developing economies are the same as the China-Japan price differentials.

A potential problem is that customer delivery prices in the United States and China reported in METI’s survey may include prices of goods imported into the United States and China, but what we would like to know is the price gaps between domestically produced goods and imported goods from China and the United States in Japan. However, because we have no way of knowing whether the customer delivery prices in the United States and China reported in the METI survey

include imported goods, we assume that the price gaps reported in the survey are good indicators of the price gaps between domestically produced goods and imported goods in Japan.

Another, related issue is that in Japan's I-O tables, the value of domestic products is given on a producer price basis, while the value of imported products is on a CIF (cost, insurance, and freight) basis. On the other hand, METI's survey reports price gaps between customer delivery prices in Japan and customer delivery prices in other countries. Because of trade costs, it is likely that the ratio of the price of imported products on a CIF basis over the price of domestic products will tend to be higher than the ratio of customer delivery prices in other countries over customer delivery prices in Japan. In order to adjust for this factor, we assume for each commodity that the ratio of the price of imported products on a CIF basis over the price of domestic products is 10 percent higher than the ratio of customer delivery prices in other countries over customer delivery prices in Japan.

In our analysis of offshoring bias, we use 2000 as the base year and set the producer prices of domestic product  $i$  in year 2000,  $P_i^H(2000)$ , equal to one for all  $i$ . We derive the CIF price of product  $i$  in year 2000 imported from developed economies,  $P_i^D(2000)$ , and the CIF price of product  $i$  in year 2000 imported from developing economies,  $P_i^L(2000)$ , for each  $i$  using the following equations:

$$(7.5) \quad P_i^D(2000) = 1.1 \frac{\Pi_i^D(2000)}{\Pi_i^H(2000)} P_i^H(2000)$$

and

$$(7.6) \quad P_i^L(2000) = 1.1 \frac{\Pi_i^L(2000)}{\Pi_i^H(2000)} P_i^H(2000),$$

where  $\Pi_i^H(2000)$ ,  $\Pi_i^D(2000)$ , and  $\Pi_i^L(2000)$  respectively denote the customer delivery price of product  $i$  in year 2000 in Japan, the United States, and China, which we take from the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI 1999).

As for the CIF prices of product  $i$  in Year 2008 imported from developed and developing economies (both developed and developing mea-

sured in terms of the producer price of domestic product  $i$  in Year 2000 in Japan), one way to estimate this is to use the customer delivery price in Year 2008 in Japan, the United States, and China and sectoral deflators in the I-O tables. That is, we can derive the CIF price of product  $i$  in Year 2008 imported from developed economies,  $P_i^D(2008)$ , and the CIF price of product  $i$  in Year 2008 imported from developing economies,  $P_i^L(2008)$ , for each  $i$ , as well as the producer price of domestic product  $i$  in year 2008,  $P_i^H(2008)$ , for each  $i$ , using the following equations:

$$(7.7) \quad P_i^D(2008) = 1.1 \frac{\Pi_i^D(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)} P_i^H(2000),$$

$$(7.8) \quad P_i^L(2008) = 1.1 \frac{\Pi_i^L(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)} P_i^H(2000), \text{ and}$$

$$(7.9) \quad P_i^H(2008) = \frac{P_i^H(2008)}{P_i^H(2000)} P_i^H(2000),$$

where  $\Pi_i^H(2008)$ ,  $\Pi_i^D(2008)$ , and  $\Pi_i^L(2008)$  denote the customer delivery price of product  $i$  in Year 2008 in Japan, the United States, and China, respectively. We obtain  $P_i^H(2008) / P_i^H(2000)$  from the sectoral deflators in the 1995-2000-2005 Linked Input-Output Tables and the 2008 Updated Input-Output Tables.

We should note that there is another important source of import price change in addition to the combined data of the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI 1999) and the sectoral deflators in the 1995-2000-2005 Linked Input-Output Tables and the 2008 Updated Input-Output Tables—namely, the import deflators in the I-O tables. The import deflators in the I-O tables are mainly based on the Bank of Japan—published Corporate Goods Price Index, which covers many more commodities and countries of origin than METI’s survey. The import deflators in the I-O tables therefore likely are more reliable than our estimates using Equations (7.7), (7.8), and (7.9), but the I-O tables do not contain data on import prices by country of origin or on absolute price gaps. Taking these advantages and disadvantages of the import deflator in the I-O

tables into account, we use these deflators as a kind of a control total, as we shall explain below.

The CIF price of product  $i$  in year 2008 imported from developed economies,  $P_i^D(2008)$ , and the CIF price of product  $i$  in year 2008 imported from developing economies,  $P_i^L(2008)$ , are expected to satisfy the following equation:

$$(7.10) \quad \frac{P_i^M(2008)}{P_i^M(2000)} = m_i^D(2008) \frac{P_i^D(2008)}{P_i^D(2000)} + (1 - m_i^D(2008)) \frac{P_i^L(2008)}{P_i^L(2000)},$$

where  $P_i^M(t)$  denotes Japan's import price of product  $i$  from the rest of the world in year  $t$ , and  $m_i^D(t)$  denotes the percentage of Japan's imports of product  $i$  from developed economies in Japan's total imports in 2008. We obtain these data from the Trade Statistics of Japan, published by the Ministry of Finance.

Because of the differences in data sources and other factors (such as the fact that we use price difference data only for the U.S.-Japan and China-Japan pairs, whereas the import deflators in the I-O tables cover all of Japan's imports from the world),  $P_i^D(2008)$  and  $P_i^L(2008)$ , derived from Equations (7.8) and (7.9), do not necessarily satisfy Equation (7.10). To make  $P_i^D(2008)$  and  $P_i^L(2008)$  consistent with Equation (7.10), we add an adjustment term  $\gamma$  on the right-hand side of Equations (7.8) and (7.9) and redefine  $P_i^D(2008)$  and  $P_i^L(2008)$  as follows:

$$(7.11) \quad P_i^D(2008) = 1.1\gamma \frac{\Pi_i^D(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)} P_i^H(2000)$$

and

$$(7.12) \quad P_i^L(2008) = 1.1\gamma \frac{\Pi_i^L(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)} P_i^H(2000),$$

where  $\gamma$  is defined by

$$\gamma = \frac{\frac{P_i^M(2008)}{P_i^M(2000)}}{m_i^D(2008) \frac{\frac{\Pi_i^D(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)}}{\frac{\Pi_i^D(2000)}{\Pi_i^H(2000)}} + (1 - m_i^D(2008)) \frac{\frac{\Pi_i^L(2008)}{\Pi_i^H(2008)} \frac{P_i^H(2008)}{P_i^H(2000)}}{\frac{\Pi_i^L(2000)}{\Pi_i^H(2000)}}}.$$

It can be easily confirmed that  $P_i^D(2008)$  and  $P_i^L(2008)$ , defined by Equations (7.11) and (7.12), satisfy Equation (7.10).

Our input index for sector  $j$  for year  $t$ , which is based on information on price gaps between domestically produced inputs and imported inputs and is free from offshoring bias, is defined by the following equation:

(7.13)

$$x_j^o(t) = \frac{\sum_i \left\{ (X_{i,j}^M(t) + X_{i,j}^H(t)) \frac{\frac{m_i^D(t)X_{i,j}^M(t)}{P_i^D(t)} + \frac{(1-m_i^D(t))X_{i,j}^M(t)}{P_i^L(t)} + \frac{X_{i,j}^H(t)}{P_i^H(t)}}{\frac{m_i^D(T)X_{i,j}^M(T)}{P_i^D(T)} + \frac{(1-m_i^D(T))X_{i,j}^M(T)}{P_i^L(T)} + \frac{X_{i,j}^H(T)}{P_i^H(T)}} \right\}}{\sum_i (X_{i,j}^M(T) + X_{i,j}^H(T))}$$

for  $t = 2000, 2008$ , and  $T = 2000$ . This is a modified version of Equation (7.4).

Two additional caveats with regard to our data should be pointed out. First, METI's survey on price differentials does not cover food processing and agricultural, fishery, and forestry output, while the coverage of service output is very limited. Therefore, we calculate price gaps only for the output of the mining and manufacturing sectors other than processed food, and we assume that there are no price differentials in the case of agricultural, forestry, and fishery products; food processing; and services. Moreover, because of this limitation in the data, we excluded the food processing sector from our analysis of the offshoring bias.

Second, even in the case of nonfood commodities, the number of commodities reported in the survey (about 180) is not sufficient for the estimation of price gaps for our disaggregated three-digit-level I-O tables in which we have 285 rows, consisting of the mining sector and of manufacturing sectors other than processed food. Therefore, for industries in the I-O tables that we could not match at the three-digit level, we assumed that the price gap was the same as at the more aggregated two-digit industry level. Moreover, when the METI survey provides price gap data on multiple commodities that correspond to one of the 285 industry rows, we calculate the industry average price gap

for that industry by employing the weights used in the METI survey. The original source of the weights is the Corporate Goods Price Index.

### **ESTIMATION OF BIAS CAUSED BY THE IMPORT PROPORTIONALITY ASSUMPTION**

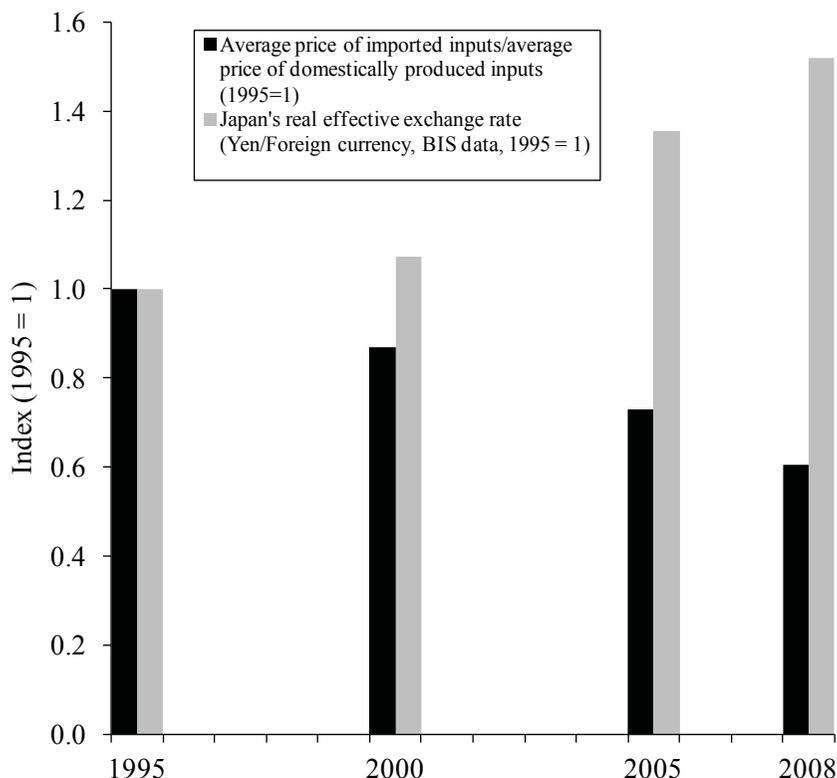
Using our data, we analyze how the prices of imported inputs relative to domestically produced inputs changed between 1995 and 2005, as well as how much the share of imported inputs in total inputs differs across sectors and how this share changed between 1995 and 2005. In addition, we estimate the bias from the import proportionality assumption by comparing the intermediate input index based on information from the tables on imports. We estimate 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 Two, "Approach to Measuring the Two Types of Biases," the 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 be large if changes in the relative prices of imports and domestic products are large and if imports of each input, relative to the total demand for that input, are quite different across sectors.

Figure 7.1 shows how the ratio of the average price index of imported inputs over the average price index 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 7.1 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 and the decline of output price in countries of origin.<sup>7</sup>

Figure 7.2 shows the regional composition of Japan's imports of manufactured products for 2000, 2005, and 2008. Similarly, Figure 7.3 shows the regional composition of Japan's imports of machinery for

**Figure 7.1 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**



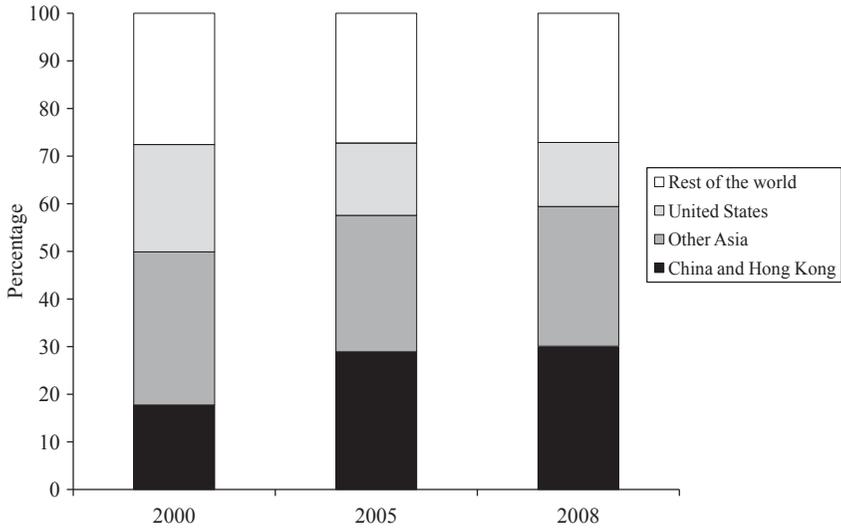
NOTE: “BIS” stands for Bank for International Settlements.

SOURCE: 1995-2000-2005 Linked Input-Output Tables, published by the Statistics Bureau of the Ministry of Internal Affairs and Communications (MIAC); 2008 Updated Input-Output Tables, published by the Ministry of Economy, Trade, and Industry (METI); and effective exchange rate, Bank of Japan.

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.

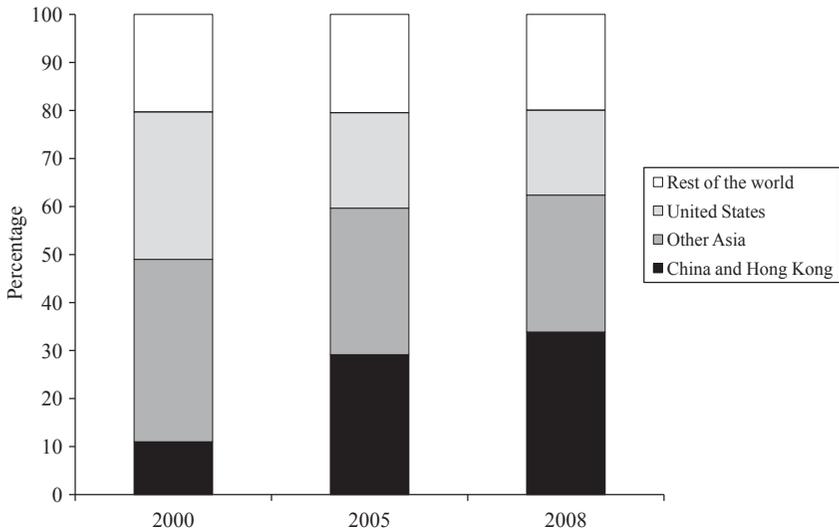
Next, Online Appendix Table 7A.2 provides a list of commodities for which the ratio of the price of imports over the price of domestic

**Figure 7.2 Regional Composition of Japan's Imports of Manufactured Products: 2000, 2005, and 2008**



SOURCE: Trade Statistics of Japan, published by the Ministry of Finance.

**Figure 7.3 Regional Composition of Japan's Imports of Machinery: 2000, 2005, and 2008**



SOURCE: Trade Statistics of Japan, published by the Ministry of Finance.

products declined by more than 25 percent from 1995 to 2008. 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.

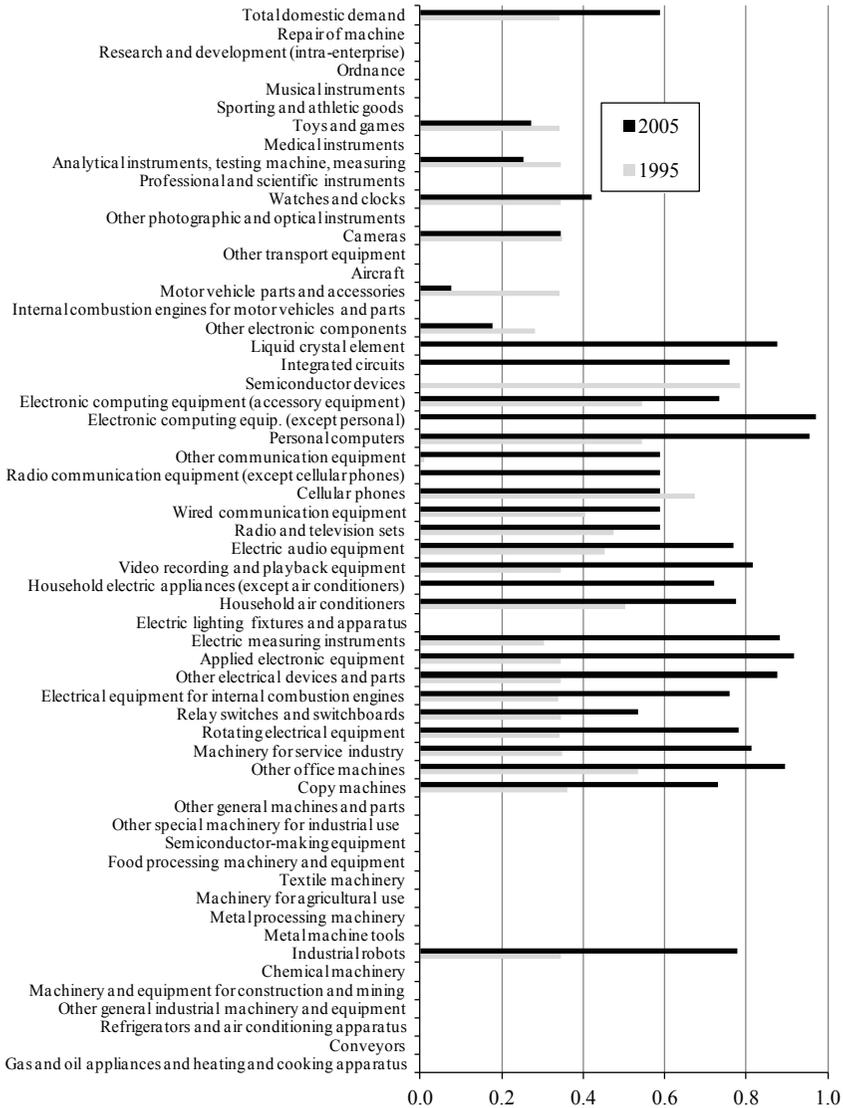
The next issue we examine is how much the share of imported inputs in total inputs differs across sectors, and how this share has changed over time. We do so by two illustrations, Figures 7.4 and 7.5, that use the examples of integrated circuits and semiconductor devices, which are important inputs in manufactured products.

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.<sup>8</sup> 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 total nominal input increased from 34 percent to 58 percent. The increase in the share of the total 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 7.4 and 7.5, the share of imports in total demand differs considerably across sectors. In the case of both figures, 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.

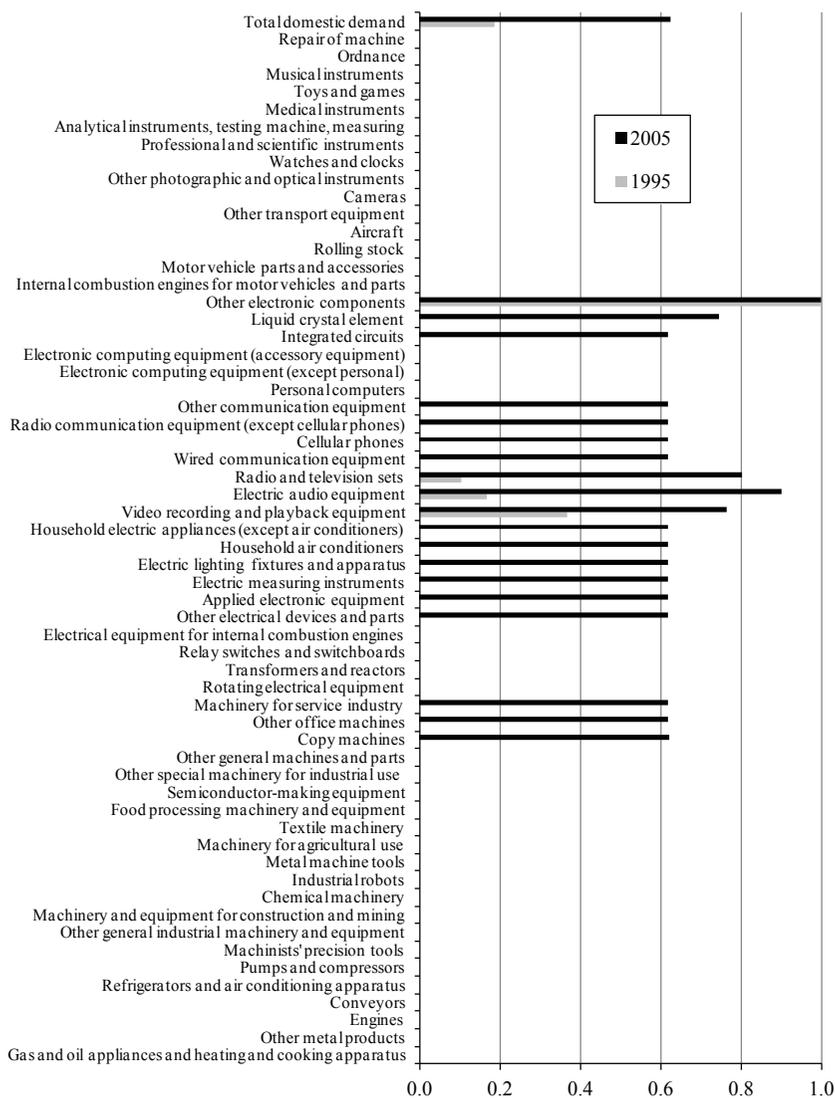
We calculate the extent of underestimation,  $\ln(x_j^U(2008) / x_j^I(2008)) - \ln(x_j^U(1995) / x_j^I(1995))$ , for all of the 202 manufacturing sectors, other than processing food, and all of the six mining sectors, using our data. Table 7.1 shows the 25 sectors in which the underestimation of intermediate input growth is largest among these 208 mining and manufacturing sectors.<sup>9</sup> By multiplying this value with two values—that is, with  $-1$  and with the average of the nominal intermediate input–nominal gross output ratio of a particular sector for 1995 and 2008, we also calculate the extent of the overestimation of TFP growth for the period 1995–2008.

**Figure 7.4 Share of Imported Inputs in Total Inputs: Integrated Circuits, 1995–2005**



SOURCE: 1995 and 2005 Input-Output Tables, published by the Statistics Bureau of MIAC.

**Figure 7.5 Share of Imported Inputs in Total Inputs: Semiconductor Devices, 1995–2005**



SOURCE: 1995 and 2005 Input-Output Tables, published by the Statistics Bureau of MIAC.

**Table 7.1 Underestimation of Intermediate Input Growth as a Result of the Import Proportionality Assumption: Top 25 Sectors, 1995–2008**

Sector	Underestimation of intermediate input growth, $\ln(x^U/x^I)$ (%), 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
Nonferrous 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

SOURCE: Authors' calculations.

In the top 14 sectors in which the underestimation of intermediate input growth caused by the import proportionality assumption is largest (namely, animal oils and fats, ordnance, aircraft, liquid crystal elements, methane derivatives, organic fertilizers not elsewhere classified, video recording and playback equipment, thermo-setting resins, salt, bicycles, turbines, glass fiber and glass fiber products not elsewhere classified, integrated circuits, and processed meat products), the negative bias of intermediate input growth caused by the import proportionality assumption is more than 2.6 percent, and the positive bias of TFP growth is more than 1.7 percent. These sectors include important high-tech machinery sectors, such as aircraft and integrated circuits.

Next, Table 7.2 shows the 27 sectors in which the overestimation of intermediate input growth is largest among all the manufacturing sectors. These include six sectors—cellular phones, radio and television sets, coal products, other nonferrous metal products, repair of aircraft, and other photographic and optical instruments—where the positive bias of intermediate input growth is at least 3.25 percent, and the negative bias of TFP growth is more than 1.9 percent.

## **ESTIMATION OF OFFSHORING BIAS**

Using our data, we estimate offshoring bias by comparing the real input index based on information on the price gaps between domestically produced and imported intermediate inputs. That is, we estimate Equation (7.13) in Section Three (“Data Used”), which is a modified version of Equation (7.4) in Section Two (“Approach to Measuring the Two Types of Biases”). We also estimate the real input index, based on the assumption that an industry’s imports of each input, relative to the total demand for that input, are the same as the economy-wide imports relative to total demand (as is assumed in the I-O tables for the United States)—i.e., Equation (7.3) in Section Two. For the estimation, we use the year 2000 as our base year and calculate how the two types of intermediate input indexes for each sector changed from 2000 to 2008. In addition, we analyze how much of a price gap there exists between domestically produced intermediate inputs, inputs imported from devel-

**Table 7.2 Overestimation of Intermediate Input Growth as a Result of the Import Proportionality Assumption: Top 27 Sectors, 1995–2008**

Sector	Overestimation of intermediate input growth, $\ln(x^u/x^l)$ (%), 1995–2008)	Intermediate input/gross output (average value of 1995 and 2008)	Underestimation of TFP growth on a gross output basis (%), 1995–2008)
Sector	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 nonferrous metal products	3.70	0.715	−2.64
Repair of aircraft	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

SOURCE: Authors' calculations.

oped economies, and inputs imported from developing economies, as well as how these price gaps changed from 2000 to 2008.

As Diewert and Nakamura (2011) and Houseman et al. (2011) explain, offshoring bias tends to be greater when there are large price gaps between domestically produced intermediate inputs and imported inputs and when firms substitute imports for domestically produced inputs to a substantial extent.

Online Appendix Figures 7A.1 and 7A.2 show our results for estimating the price gaps between domestically produced intermediate inputs, inputs imported from developed economies, and inputs imported from developing economies for 2000 and 2008, respectively. For the calculation, we use Equations (7.5), (7.6), (7.9), (7.11), and (7.12). In the two figures, the price levels of domestically produced products are set to 1 for both 2000 and 2008. Moreover, for the figures, we aggregate the estimated price gaps for the 285 sectors into 53 sectors. As explained in Section Three, titled “Data Used,” our estimation of the price gaps between developed economies and Japan is based on U.S.-Japan price differentials, and our estimation of the price gaps between developing economies and Japan is based on China-Japan price differentials.

The two figures show that in the case of price gaps between domestically produced inputs and inputs imported from developed economies, domestically produced inputs are not always more expensive than imported inputs. On the contrary, in many sectors, including most of the machinery sectors, the price level of domestically produced inputs was lower than the price level of inputs imported from developed economies, both in 2000 and in 2008.

In the case of price gaps between domestically produced inputs and inputs imported from developing economies, imported inputs are cheaper than domestically produced inputs in most of the sectors. Moreover, in both 2000 and 2008, the price gap is considerable, not only in the case of most of the light-industry products (such as apparel and other textile products, timber and wooden products, and fur skins and miscellaneous leather products), but also in the case of most machinery products.

In comparing the price gaps between domestically produced inputs and inputs imported from developing economies in 2000 and 2008, the gaps do not seem to have widened in most sectors, although there are some exceptions such as electronic computing equipment and acces-

sories as well as semiconductor devices and integrated circuits. In fact, price gaps narrowed slightly in some sectors, probably because of rapid increases in wages in China (as well as appreciation of the Chinese exchange rates).

These results suggest that during this period there was no large offshoring bias caused by a sharp decline in the prices of inputs imported from developing economies, except in the case of the electrical machinery industry. However, even though prices of imported inputs generally may not have fallen, it is still possible that there was substantial offshoring bias as a result of the rapid increase of imported inputs at prevailing price gaps. As seen in Figures 7.2 and 7.3, the share of imports of manufactured products from China, Hong Kong, and other Asian economies in Japan's total imports increased considerably between 2000 and 2008. Moreover, Figure 7.6 shows that Japan's imports of machinery increased not only in the case of final goods but also in the case of many types of parts and components.

To examine whether the rapid rise in imported inputs from developing countries gave rise to offshoring bias, we calculate the extent of underestimation of intermediate input growth,  $\ln(x_j^U(2008) / x_j^O(2008)) - \ln(x_j^U(2000) / x_j^O(2000))$ , using our data. By multiplying this value with  $-1$  and with the average value of the nominal intermediate input–nominal gross output ratio of a particular sector for 2000 and 2008, we also calculate the extent of the overestimation of TFP growth for the period 2000–2008.

Table 7.3 shows the 27 sectors in which the underestimation of intermediate input growth is largest among all of the 208 mining and manufacturing sectors other than food processing. Probably reflecting the fact that Japan's imports of cheap electrical parts and components from developing economies have increased substantially, the 27 sectors include many electrical machinery sectors such as liquid crystal elements, personal computers, electronic computing equipment (except personal computers), and electric measuring instruments. Among the 27 sectors, about half produce machinery.

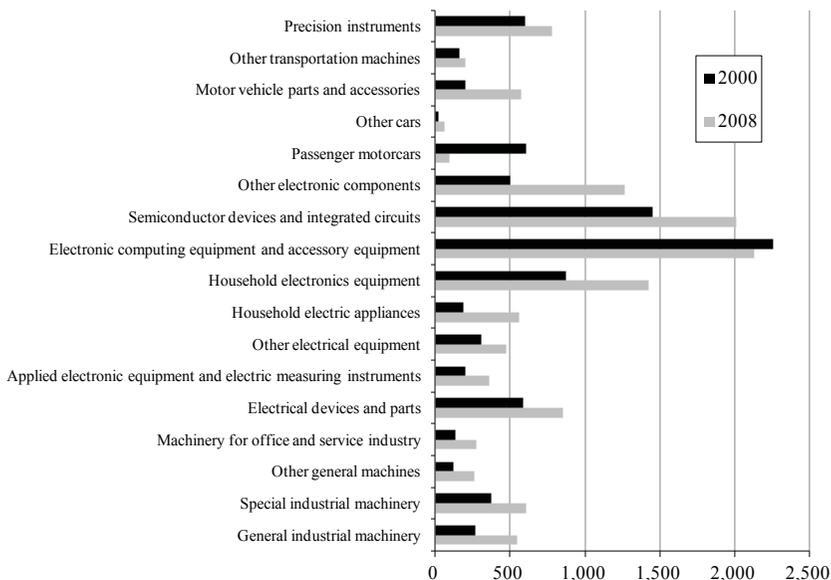
In many sectors, especially in machinery sectors, offshoring bias is of a substantial size that cannot be ignored. For example, Table 7.3 shows that the TFP growth rate in liquid crystal elements and in personal computers is overestimated by 5.92 percent and 5.34 percent,

**Table 7.3 Underestimation of Intermediate Input Growth and Total Factor Productivity Growth from Offshoring Bias: Top 27 Sectors, 2000–2008**

Sector	Underestimation of intermediate input growth, $\ln(x^I/x^O)$ (%), 2000–2008)	Intermediate input/gross output (average value of 2000 and 2008)	Overestimation of TFP growth on a gross output basis (%), 2000–2008)
	A	B	A×B
Tatami (straw matting) and straw products	-15.47	0.738	11.41
Nuclear fuels	-13.14	0.551	7.24
Toys and games	-9.92	0.700	6.95
Pumps and compressors	-8.90	0.644	5.73
Rayon and acetate	-8.84	0.678	6.00
Other nonmetallic ores	-8.55	0.578	4.94
Liquid crystal element	-8.21	0.721	5.92
Metallic ores	-7.78	0.465	3.62
Salt	-7.10	0.535	3.80
Repair of aircraft	-6.87	0.674	4.63
Pulp	-6.87	0.858	5.90
Food processing machinery and equipment	-6.85	0.582	3.98
Sheet glass and safety glass	-6.72	0.582	3.91
Personal computers	-6.56	0.814	5.34
Paperboard	-6.36	0.722	4.59
Other nonferrous metal products	-6.29	0.706	4.44
Electronic computing equipment (except personal computers)	-6.25	0.748	4.68
Electric measuring instruments	-6.24	0.660	4.12
Other office machines	-6.13	0.737	4.52
Coal mining, crude petroleum, and natural gas	-5.84	0.428	2.50
Boilers	-5.66	0.575	3.25
Textile machinery	-5.46	0.594	3.24
Machinists' precision tools	-5.44	0.540	2.93
Bearings	-5.40	0.596	3.22
Other structural clay products	-4.87	0.537	2.62
Chemical machinery	-4.77	0.574	2.74
Other wooden products	-4.75	0.547	2.60

SOURCE: Authors' calculations.

**Figure 7.6 Japan's Imports of Machinery from Developing Economies: 2000 and 2008 (billions of yen)**



SOURCE: Trade Statistics of Japan, published by the Ministry of Finance.

respectively (the annual rate in log value is 0.74 percent and 0.67 percent, respectively).

We should note that the biases shown in Table 7.3 contain both biases caused by the import proportionality assumption and biases caused by gaps in the absolute price levels between imported products and domestically produced products. It is probably for this reason that many electrical machinery sectors such as liquid crystal elements, personal computers, electronic computing equipment (except personal computers), and electric measuring instruments appear in both Tables 7.1 and 7.3.

Comparing Tables 7.1 and 7.3, we also find that the biases in Table 7.3 tend to be much larger than those in Table 7.1, although the period covered by Table 7.3 is five years shorter than the period covered by Table 7.1. The minimum value of the bias in TFP growth in Table 7.3 is 3.04 percent (for leather and fur skins), which is much larger than the

minimum value of the bias in TFP growth in Table 7.1, 0.70 percent (for cameras). It seems that biases caused by gaps in the absolute price levels between imported products and domestically produced products are a more serious problem than biases caused by the import proportionality assumptions.

In the case of the overestimation of intermediate input growth, such overestimation occurred in only 29 out of the 208 mining and manufacturing sectors other than food processing. In other words, in 179 sectors, intermediate inputs were underestimated. Among the 29 overestimated sectors, only five sectors produce machinery. We also find that in many sectors the magnitude (absolute value) of the underestimation of TFP growth caused by offshoring bias is smaller than the magnitude (absolute value) of the overestimation of TFP growth caused by offshoring bias, which is reported in Online Appendix Table 7A.3.

As pointed out in Section Two, biases caused by the import proportionality assumption have zero-sum characteristics. 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, offshoring biases do not have such zero-sum characteristics. If a majority of sectors shift their sourcing from high-cost domestic suppliers to low-cost foreign suppliers, then the TFP growth of all these sectors will be overestimated, and the TFP growth of the economy as a whole will also be overestimated. Table 7.3 and Online Appendix Table 7A.3 show that TFP growth was overestimated in 179 out of the 208 mining and manufacturing sectors during the period 2000–2008. It therefore seems likely that the TFP growth of Japan's economy as a whole during this period may also have been overestimated.

## CONCLUSION

Using import tables and other data from Japan's input-output tables 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 the total demand for the input, are the same as the economy-wide imports

relative to total demand. We also examined offshoring bias, which concerns the price gap between domestically produced inputs and imported inputs. For this analysis, we used the *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* (METI 1999) in addition to I-O tables.

Our main findings are listed in the following 10 points:

- 1) Our theoretical analysis shows that the bias caused by the import proportionality assumption will be large if imports of each input, relative to the total demand for it, 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 1995–2008.
- 4) We examined how the share of imported inputs in total inputs differs across sectors, focusing on the cases of integrated circuits and semiconductor devices. We found that for both types of input, the import ratio tends to be high in the electrical machinery sectors. Moreover, the ratio is relatively low in other sectors such as automobiles and precision machinery.
- 5) We found that the bias caused by the import proportionality assumption is quite large in some sectors. For example, in animal oils and fats, ordnance, aircraft, liquid crystal elements, methane derivatives, organic fertilizers not elsewhere classified, video recording and playback equipment, thermo-setting resins, salt, bicycles, turbines, glass fiber and glass fiber products not elsewhere classified, integrated circuits, and processed meat products, the negative bias of intermediate input growth

caused by the import proportionality assumption is more than 2.6 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 nonferrous metal products, repair of aircraft, and photographic and optical instruments, the positive offshoring bias of intermediate input growth is more than 3.2 percent, and the negative offshoring bias of TFP growth is more than 1.9 percent.
- 7) Next, we estimated offshoring biases caused by the price gap between domestically produced inputs and imported inputs and the substitution of intermediate inputs from expensive domestic products to cheap foreign products. In the case of price gaps between domestically produced inputs and inputs imported from developing economies, imported inputs are cheaper than domestically produced inputs in most sectors. Moreover, in both 2000 and 2008, the price gap was relatively large not only in the case of most light industry products, such as apparel and other textile products, timber and wooden products, and fur skins and miscellaneous leather products, but also in the case of most machinery products.
- 8) In the 2000s, Japan's imports of machinery from developing economies increased not only in the case of final goods but also in the case of many types of parts and components. As a result of the rapid increase of imported inputs at prevailing price gaps, in many sectors, especially in machinery sectors, a substantial offshoring bias arose that cannot be ignored. For example, the TFP growth rates for the liquid crystal elements and personal computers sectors are overestimated by 5.92 percent and 5.34 percent, respectively. (The annual rates in log value were 0.74 percent and 0.67 percent.)
- 9) Reflecting the fact that Japan's imports of cheap electrical parts and components from developing economies increased substantially, the 50 sectors in which the underestimation of intermediate input growth is largest include many electrical machinery sectors such as liquid crystal elements, personal computers,

electronic computing equipment (except personal computers), and electric measuring instruments.

- 10) Biases caused by the import proportionality assumption have zero-sum characteristics. 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. In contrast, offshoring biases do not have such zero-sum characteristics. If most sectors shifted their sourcing from high-cost domestic suppliers to low-cost foreign suppliers, then the TFP growth of these sectors would be overestimated. In this case, the TFP growth of the economy as a whole would also be overestimated. We found that during the period 2000–2008 TFP growth was overestimated as a result of offshoring bias in 179 out of the 208 mining and manufacturing sectors we examined. Consequently, Japan's TFP growth at macro-level during this period may also be overestimated.

One of the key findings is that there are relatively large biases due to offshoring in a substantial number of manufacturing sectors, including important machinery sectors. This means that the issue of biases from offshoring should be taken into account in future productivity analyses at the sectoral and firm levels. Moreover, since offshoring activities are likely to continue increasing, data collection by statistical offices to grapple with such offshoring biases will be of growing importance.

## Notes

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

1. A good discussion of these types of biases is provided in the next chapter, Chapter 8.
2. For ease of presentation, it is assumed here that each sector produces one product, so subscript  $i$  is used to refer to both sectors and products.
3. Our quantity indexes are based on the Laspeyres formula for years after the base year  $T$  and on the Paasche formula for years before  $T$ .

4. In 2013, this survey became one of Japan's General Statistics and is now called the Survey on Input-Output Structure (Survey on Sale Destination of Import Goods).
5. The online appendix, containing Appendix Tables 7A.1, 7A.2, and 7A.3 and Appendix Figures 7A.1 and 7A.2, can be found at <http://www.upjohn.org/MEG/Ch7appendix.pdf>.
6. In the case of the 2000 survey, the survey investigates absolute price levels in each country's currency during the period September–November 2000 and converts these prices into prices in Japanese yen using average market exchange rates during the survey period. The exchange rates were 108.00 yen to the U.S. dollar and 13.05 yen to the Chinese yuan. In the case of the 2008 survey, the survey period was July–September 2008, and the exchange rates were 107.60 yen to the U.S. dollar and 15.74 yen to the Chinese yuan.
7. As already explained, we obtain deflators for imports and domestic output separately for each sector  $i$  from the 1995-2000-2005 Linked Input-Output Tables published by the Statistics Bureau, MIAC, and the 2008 Updated Input-Output Tables. In these I-O tables, the major original sources for deflators for commodities are the Domestic Corporate Goods Price Index (DCGPI) and the Import Price Index (IPI), both taken from the Corporate Goods Price Index, published by the Bank of Japan. When the Bank of Japan compiles the IPI, it specifies each commodity in great detail and tracks price changes of the same commodity from the same country of origin. Therefore, a shift of imports from high-price countries to low-price countries will not affect the IPI and the deflators of the I-O tables. However, in the case of some imported raw materials and manufactured products, for which IPI data are not available, the I-O tables use the unit price of imports as deflators. In the case of these products, a shift of imports from high-price countries to low-price countries will reduce the deflators in the I-O tables. Therefore, the decline in relative import prices in Figure 7.1 reflects not only the decline of output prices in countries of origin but also the increase in Japan's imports of low-priced products from Asian countries. We should also note that in the case of these products, for which unit prices from the trade statistics are used as import deflators, Equation (7.10) does not strictly hold. When the unit prices of imports decline because of a shift from high-cost exporters to low-cost exporters, there is a risk that Equations (7.11) and (7.12) will overestimate the price decline in exporting countries.
8. 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; we therefore think that the table on imports for 2005 is more reliable.
9. The reason that we are focusing only on 208 and not 285 industries is as follows: As explained in Section Three, titled "Data Used," the endogenous table we use is not symmetric. The table for each year has 514 rows and 401 columns. Out of the 514 rows, 285 are for mining and manufacturing sectors other than food processing. We prepared our special data on prices and imported intermediate inputs by country of origin and other categories for these 285 row sectors. Out of the 401 columns, 208 are for mining and the manufacturing sectors other than food processing. We calculated biases of intermediate inputs and TFP growth for these 208 column sectors.

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# **Measuring Globalization**

## **Better Trade Statistics for Better Policy**

### **Volume 1**

## **Biases to Price, Output, and Productivity Statistics from Trade**

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and  
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