Final Demand-Intermediate Demand Aggregation System of Japan’s Producer Price Index

Moegi Inoue, Atsushi Kawakami, Ayako Masujima, Ichiro Muto, Shogo Nakano, and Izumi Takagawa

One of the main objectives of the producer price index (PPI) is to serve as an aggregation price index that appropriately represents the overall supply-demand condition regarding goods and services in an economy as a whole. In this respect, the current system of Japan’s PPI system is confronted with the following two challenges: (i) overall inflationary pressures in the entire economy cannot be tracked because the indexes for goods and services are separately constructed and published; and (ii) the effects of price changes in upstream stages in the production flow are exaggerated because the PPI is aggregated as the “all commodities index” in which prices of commodities in different demand stages are aggregated through weight-averaging by gross trade value. In order to overcome those challenges, we construct a price index of Final Demand-Intermediate Demand aggregation system of Japan’s PPI (the FD-ID price index) by assigning commodity-level Japanese PPI indexes for goods and services to the stage of final demand and the four stages of intermediate demand, in an optimal manner in accordance with the production flow in the Input-Output table and by aggregating the indexes in a way that eliminates multiple counting. The use of the FD-ID price index makes it possible to measure inflationary pressures in the entire Japanese economy, including both goods and services sectors. It also becomes possible to track the process of price changes being transmitted from upstream to downstream stages in the production flow across the sectors of goods and services. This study provides detailed explanations of the methodology for constructing the Japanese FD-ID price index and the characteristics of the constructed index.

Keywords: Producer price index; FD-ID aggregation system; Input-Output table; Multiple counting problem
JEL Classification: C82, E31

Moegi Inoue: Associate Director, Research and Statistics Department, Bank of Japan (E-mail: moegi.inoue@boj.or.jp)

Atsushi Kawakami: Director, Research and Statistics Department (currently, International Department), Bank of Japan (E-mail: atsushi.kawakami@boj.or.jp)

Ayako Masujima: Research and Statistics Department, Bank of Japan (E-mail: ayako.masujima@boj.or.jp)

Ichiro Muto: Head of Price Statistics Division, Research and Statistics Department (currently, Head of Economic and Financial Studies Division, the Institute for Monetary and Economic Studies), Bank of Japan (E-mail: ichirou.mutou@boj.or.jp)

Shogo Nakano: Research and Statistics Department, Bank of Japan. Currently in the Personnel and Corporate Affairs Department (studying at the University of Chicago) (E-mail: shougo.nakano@boj.or.jp)

Izumi Takagawa: Deputy Director, Research and Statistics Department (currently, Financial System and Bank Examination Department), Bank of Japan (E-mail: izumi.takagawa@boj.or.jp)

The authors thank Kosuke Aoki, Yukinobu Kitamura, Shigenori Shiratsuka, and the staff of the Bank of Japan for their valuable comments. We also thank Kotaro Suita for his co-operation in data calculations. We express our appreciation to many staff members of the U.S. Bureau of Labor Statistics, including Bill Thompson, Bonnie Murphy, Greg Kelly, Jeffrey Hill, Jonathan Weinhagen and Tim Wu for having provided detailed, wide-ranging information under an international cooperation program of the bureau. All remaining errors are our own. The views expressed in this study are those of the authors and do not necessarily reflect the official views of the Bank of Japan.

I. Introduction

The Producer Price Index (PPI) is an index of price statistics compiled by surveying and aggregating producer prices of goods and services provided by businesses. The PPI serves as one of the main price indexes along with the Consumer Price Index (CPI), and it is constructed and published in many countries, including both developed and emerging countries.[1] In Japan, the Research and Statistics Department of the Bank of Japan constructs the PPI for goods as the Corporate Goods Price Index (CGPI) and the PPI for services as the Services Producer Price Index (SPPI).[2]

The main objectives of the PPI include: (i) tracking the overall supply-demand condition regarding goods and services in the economy as a whole by aggregating prices set by businesses in order to provide information useful for judging economic conditions; (ii) providing the deflator function of calculating real values by removing price factors from nominal values; and (iii) providing reference indicators for price settings in commercial transactions in individual industries. The PPI is constructed by compiling commodity-level price indexes and aggregating them into a macro-level price index. If the objectives of the PPI are limited to (ii) and (iii) above, appropriate measurement of commodity-level price indexes would be sufficient, and macro-level aggregation would not necessarily have to be conducted. That is because only commodity-level deflators are used for calculating gross domestic product (GDP) and other economic data in real values and also because commodity-level price indexes are sufficient to serve as reference indicators for price determination in commercial transactions. However, if the PPI is to serve the purpose (i) above, it is necessary not only to compile commodity-level price indexes but also to aggregate those indexes in order to appropriately track the overall supply-demand condition regarding goods and services in the entire country.

When we consider the role of the PPI as an aggregate price index, broadly speaking, the Japanese PPI system is confronted with two challenges. First, overall inflationary pressures in an economy as a whole cannot be tracked because the price indexes for goods and services under the current Japanese PPI system are separately constructed and published. In order to track overall inflationary pressures in the entire economy at a time when the shift to a services-oriented economy has become a trend, it is important to take into consideration the relative balance between goods and services. In particular, against the backdrop of the progress in digitalization, commodities classified on the border between goods and services (e.g., mobile phones and products related to internet of things [IoT]) have been increasing in recent years, and as a result, it has become more important than before to track price trends for goods and services in an integrated manner, rather than individually.

Second, the current Japanese PPI system is afflicted with the so-called "multiple counting problem," which occurs when the effects of price changes in an upstream stage of the production flow are exaggerated as a result of aggregating prices of commodities

1. For information on the status of construction of CPIs and PPIs in other countries, see Berry *et al*. (2019), for example.
2. Under the CGPI system, there are three separate indexes, i.e., the Producer Price Index for domestic transactions, the Export Price Index, and the Import Price Index, and an all commodities index is constructed for each of the three. Below, the all commodities index of the CGPI refers to that of domestic commodities unless otherwise stated.

in different demand stages into the "all commodities index" through weight-averaging by gross trade value. Typically, this problem occurs with respect to the PPI for goods. For example, when prices of raw materials, such as crude petroleum, affect prices of intermediate goods in respective stages of intermediate demand and final goods, the effects of price changes for commodities in upstream stages inevitably become predominant if the prices of those goods are aggregated through weight-averaging by gross trade value. As a result, the supply-demand condition for commodities in downstream stages may fail to be grasped in the aggregate price index. Given this problem, when constructing an aggregate price index, it is highly necessary to appropriately classify prices of commodities into different demand stages and appropriately resolve the multiple counting problem.

In this study, in order to overcome the challenges for the Japanese PPI as an aggregate price index, we attempt to construct new price indexes by demand stages in accordance with the production flow in the Input-Output table (hereinafter referred to as the "IO table"). To be more specific, we assign commodity-level indexes of the PPIs for goods and services to the stage of final demand (FD) and the four stages of intermediate demand (ID) in an optimal manner in accordance with the production flow in the IO table and construct a price index of FD-ID aggregation system (the "FD-ID price index") by aggregating commodity-level indexes in a way that eliminates multiple counting. The FD-ID price index is a type of aggregate price index that the Bureau of Labor Statistics (BLS), which is the U.S. agency responsible for constructing the PPI, started constructing on an experimental basis in 2011. Since 2014, the BLS has constructed and published the FD-ID price index as the headline aggregate index of the PPI. In the past, the "all commodities index" was used as the headline index for goods in the United States as well. However, the BLS has shifted to an FD-ID aggregation system because the need for resolving the multiple counting problem grew after the petroleum price upsurges in the 1970s and also because in recent years, the PPI's coverage of services has surpassed 70%, a level comparable to the coverage of goods. The Japanese PPI's coverage of services also rose from 50.5% to 71.3% (including wholesale service prices) as a result of the revision of the 2015 base for the SPPI conducted in 2019, so it may be said that the prerequisite for integrating prices of goods and services has been met in this respect. In other words, efforts to improve the SPPI in recent years have made it possible to integrate prices of goods and services, a challenge that has until now been difficult to achieve from the viewpoint of coverage.

This study is structured as follows. Section II provides concrete explanations of the current status of and challenges for the Japan's PPI as an aggregate price index. Section III explains the overview of the FD-ID price index based on the construction methodology used in the United States. Section IV explains the construction methodology for the Japanese FD-ID price index. Section V shows the calculation results of the Japanese FD-ID price index. Section VI compares the FD-ID price index with existing price indexes. Section VII shows an example of analysis of the transmission process of price changes using the FD-ID price index. Section VIII provides a summary of this study.

II. Current Status of Japan's PPI: Challenges for the PPI as an Aggregate Price Index

This section explains the current status of and challenges for Japan's PPI as an aggregate price index to track the supply-demand condition for goods and services.

A. PPI's Scope and the All Commodities Index

First, let us look at the PPI's scope of goods and services. According to the PPI Manual (International Labour Organization *et al*. [2004]), which describes an international standard methodology for constructing the PPI, the PPI is a price index that comprehensively covers goods and services transactions at the level of producers (businesses), so it is distinctive for its very broad scope. First, from the viewpoint of production side, conceptually, the PPI covers the whole of domestically produced goods and services, and this means that the scope includes all production sectors (row sectors) in the IO table (Figure 1).[3] From the viewpoint of the demand side (purchasers), all transactions are covered regardless of whether the goods and services are consumed in intermediate stages or in the stage of final demand, which means that the scope includes all demand sectors (column sectors) of the IO table. This provides a contrast to the scope of the CPI, which focuses exclusively on the household consumption expenditure in final demand and which excludes intermediate demand and non-household expenditure in final demand.

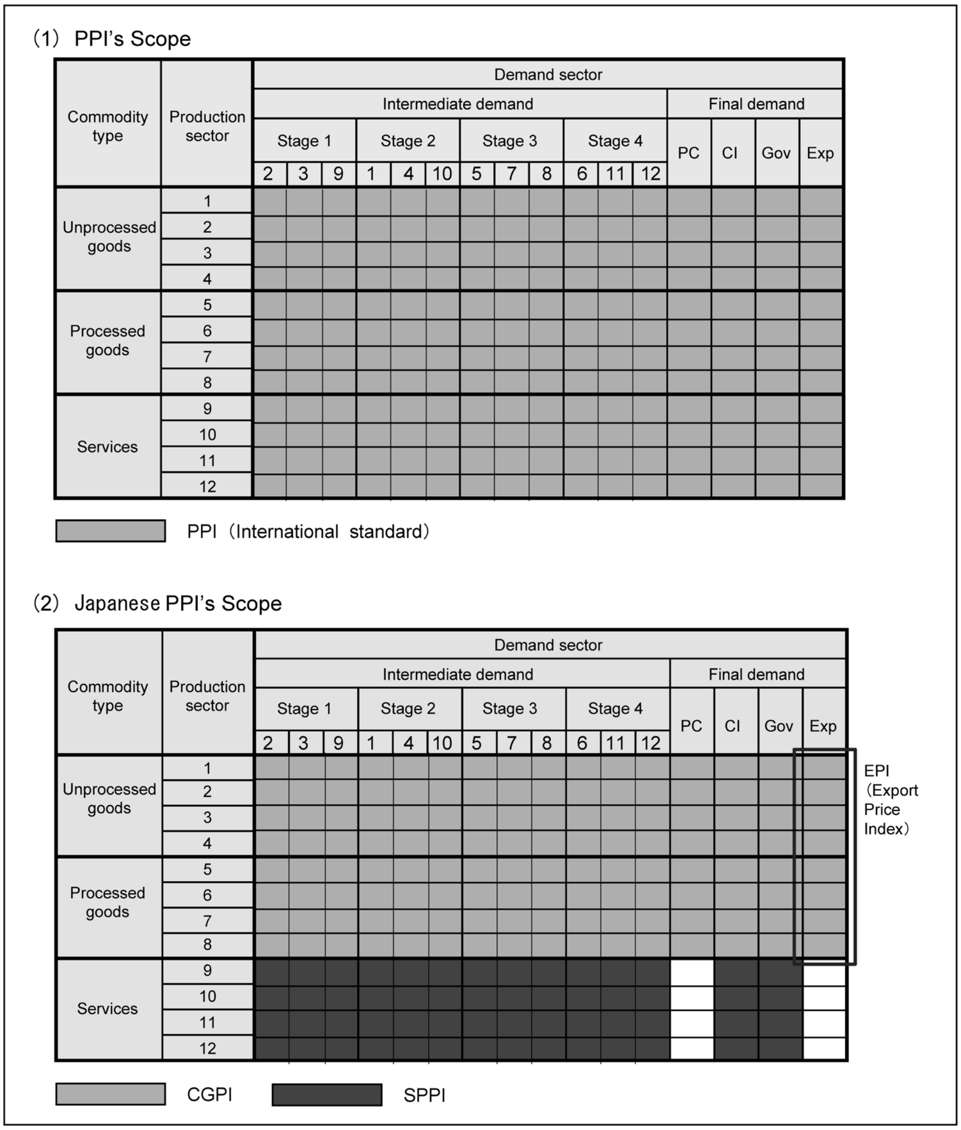
The Japanese PPI system also has a broad scope. Namely, Japan's CGPI and SPPI, which correspond to the PPIs for goods and services, respectively, together have a scope roughly equal to the scope of the abovementioned international standard PPI. With respect to goods in particular, the CGPI covers almost all goods, including those traded mainly in the stages of intermediate demand but also those traded in the stage of final demand for use by households and the government and for corporate capital investment and other purposes. However, regarding services, many services for households are not covered by the SPPI.[4]

For each of the CGPI and the SPPI, the all commodities index, which is constructed by weight-averaging the component indexes for all commodities covered, serves as the headline index.[5] The all commodities index of the CGPI covers all goods traded in the stages of intermediate demand and all goods traded in the stage of final demand minus exports, i.e., goods traded in the stage of final demand for domestic consumption

....

3. However, when a PPI is constructed, some goods and services are excluded from its scope in some cases depending on the purpose. For example, the PPI Manual points out that nonmarket services, such as "government services," whose prices are determined with no regard for the supply-demand balance in most cases, and "imputed rent of owner-occupied dwellings," which is consumed by producers themselves, may be excluded from the PPI's scope because they are not suited to be used for tracking inflationary pressures.
4. The CGPI covers a broad range of goods traded between companies, including those intended for personal consumption. In other words, even prices of goods that are ultimately consumed by households may be covered by the CGPI survey when the goods are sold by producers to other companies (e.g., distributors), rather than being sold by producers directly to households. On the other hand, services intended for personal consumption are excluded from the SPPI's scope because direct transactions between producers (companies) and households account for most of the transactions for those services.
5. As for the SPPI, the all commodities index is called the "index of all items" in the official statistics. In this study, the "all commodities index" and the "index of all items" are used interchangeably.

Figure 1 Scope of PPI and the Japanese PPI

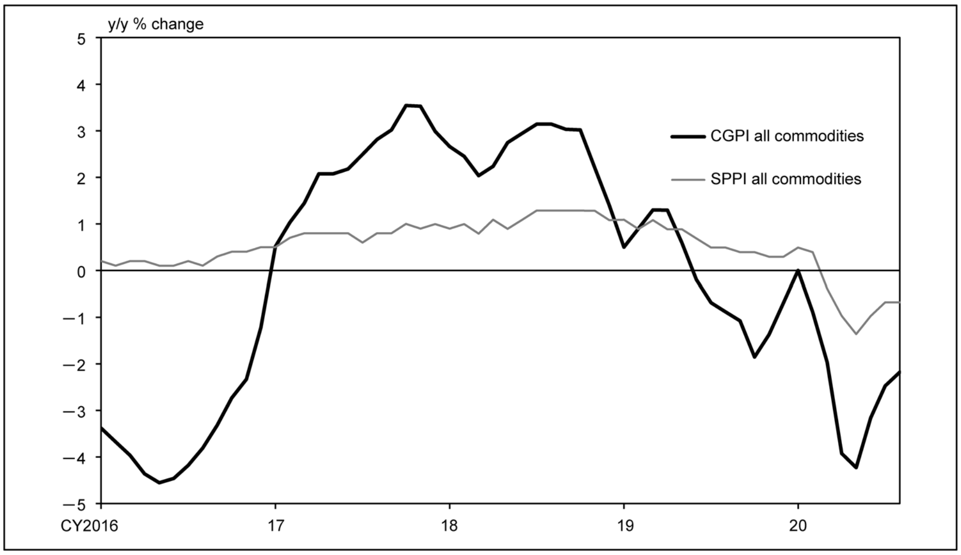


Note: PC, CI, Gov, and Exp stand respectively for personal consumption, capital investment, government expenditure, and exports.

(personal consumption, capital investment, and government expenditure). On the other hand, the all commodities index of the SPPI covers all services traded in the stages of intermediate demand and all services traded in the stage of final demand minus personal consumption and exports, i.e., services traded in the stage of final demand for capital investment and government expenditure.[6] The all commodities indexes constructed

6. Under the SPPI system, the price indexes concerning services exports and imports are treated merely as reference indexes that should not be used as components of the all commodities index. As a result, the all commodities index of the SPPI covers only the domestic demand portion of inter-company services transactions.

Figure 2 CGPI and SPPI: All Commodities Indexes



Note: CGPI and SPPI exclude consumption tax.
Source: Bank of Japan

by aggregating all commodity-level indexes through weight-averaging by gross trade value without distinguishing between different stages of processing or demand.

B. Challenges for Japan's PPI (i): Integrating Prices of Goods and Services

When we consider the role of the PPI as an aggregate price index, one challenge for the Japanese PPI system is that the indexes for goods and services are separately constructed and published as the CGPI and the SPPI, respectively, which means that there is not a single index that can track inflationary pressures in the entire economy, including both goods and services sectors. In fact, a comparison between the all commodities indexes of the CGPI and the SPPI shows that the two indexes have followed clearly different trend, with the index of the CGPI showing more volatile movements than the index of SPPI (Figure 2). Given the different trends in these two indexes, it is natural that the question of how much weight should be assigned to prices of goods and services, respectively, in order to track the supply-demand condition for the entire economy comes to the mind of many users of price statistics.

However, if the challenge for the PPI as an aggregate price index is nothing more than how to set the balance of weight between prices of goods and services, it is relatively easy to resolve it. One solution is to weight-average the all commodities indexes of the CGPI and of the SPPI based on the relative ratio of the transaction values of goods and services. Indeed, among Japanese price statistics, the CPI is constructed as an aggregate price index integrating prices of goods and services by assigning weights to prices of goods and services based on commodity-by-commodity purchase values in the Family Income and Expenditure Survey. It is easy to adopt a similar approach and aggregate the all commodities indexes of the CGPI and of the SPPI into a single index by weight-averaging them by gross trade value.

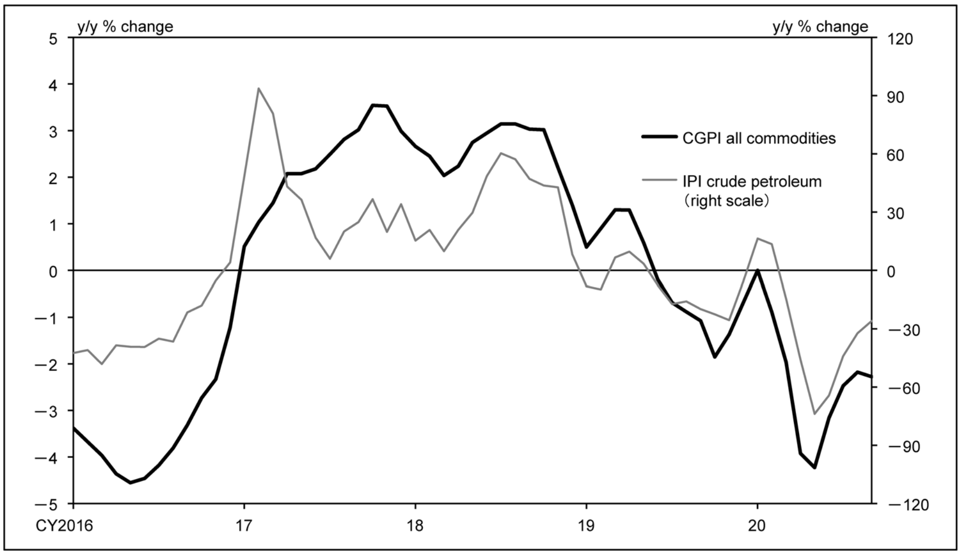
However, unlike in the case of the CPI, it is impossible to construct a conceptually meaningful aggregate price index through a simple approach like this in the case of the PPI. The reason for that is as follows. In the case of the CPI, which covers only the household portion of final demand, an aggregate price index has clear economic significance as a cost of living index, i.e. an average price index for a consumption basket of goods and services purchased by the representative household. On the other hand, in the case of the PPI, when a price index is constructed by merely aggregating commodity-level prices, it is not clear for which economic agent the index serves as a price reference given the presence of a multitude of businesses classified into each of the different demand stages. In other words, in order to construct a meaningful PPI aggregate price index, it is necessary to first organize commodities into groups by demand stages along the production flow and then aggregate prices of commodities in each group. In light of this point, as the prerequisite for integrating the PPIs for goods and services, it is essential to appropriately divide demand into stages and classify goods and services by demand stages.

C. Challenges for Japan's PPI (ii): Multiple Counting Problem

Another challenge that Japan faces in tracking the supply-demand condition for goods and services in the entire economy is the so-called "multiple counting problem." The multiple counting problem occurs when the effects of price changes in an upstream stage of the production flow are exaggerated as a result of aggregating prices of commodities in different demand stages into an "all commodities index" through weigh-averaging by gross trade value. Typically, this problem occurs with respect to the PPI for the goods. For example, when changes in the crude petroleum price affect prices of intermediate goods in the stages of intermediate demand and final goods, including polyethylene, plastic products, auto parts, and motor vehicles, the effects of price changes for commodities in upstream stages inevitably become predominant if prices of those goods are aggregated through weight-averaging by gross trade value. As a result, the supply-demand condition for commodities in downstream stages may fail to be grasped in the aggregate price index. In fact, reflecting the multiple counting problem, the developments of Japan's CGPI all commodities index are explained in most part by changes in the crude petroleum price. Therefore, it cannot be said that this index appropriately represents the supply-demand condition for a broad range of goods traded in Japan (Figure 3).

The BLS, which is the U.S. agency responsible for constructing the PPI, also has strong awareness of the multiple counting problem (see Weinhagen [2011], for example). In the past, the all commodities index was used as the headline index for goods in the United States as well. However, at the time of petroleum price upsurges in the 1970s, the all commodities index came under serious criticism for exaggerating the effects of changes in the crude petroleum price because of its inclusion of prices of both gasoline, which is a final demand item, and crude petroleum, which is used as an input for the production of gasoline. Against this background, although the BLS still continues to publish an all commodities index exclusively for goods, it has made clear its position that it "does not recommend using this index for the purpose of contract escalation or data analysis." Given the seriousness of the multiple counting problem, it

Figure 3 CGPI All Commodities Index and IPI Crude Petroleum



Notes: 1. CGPI excludes consumption tax.
2. IPI is on the yen basis.
Source: Bank of Japan

is essential to implement appropriate procedures that prevent the problem at the same time as appropriately dividing demand into stages and classifying goods and services by demand stages.

III. The FD-ID Price Index: Overview

The FD-ID price index serves as the headline index of the PPI that is constructed and published by the U.S. BLS. In the past, the PPI all commodities index was used as the headline index in the United States, but the FD-ID price index has now become the main price index system of the PPI because of the need to deal with the multiple counting problem and the expansion of coverage of services. In light of these circumstances, if Japan constructs an FD-ID price index of its own, it will become possible to respond to the challenges for Japan's PPI ((i) integrating prices of goods and services, and (ii) resolving the multiple counting problem) that were explained in the previous section. Below, we will explain the FD-ID aggregation system of PPI.

A. Characteristics of the FD-ID Price Index

The FD-ID price index is an aggregate price index based on prices classified by demand stages that includes the whole of the PPIs for goods and services. Since 2014, the U.S. BLS has treated the FD-ID price index as the headline index of the PPI, after starting to construct and publish it on an experimental basis in 2011.[7]

....

7. Before developing the FD-ID price index, the BLS was using the stage of processing (SOP) system, which classified goods by their type from the late 1970s onward. Under the SOP system, transactions were classified into "crude goods," "intermediate goods," and "finished goods." In other words, the SOP system dealt with

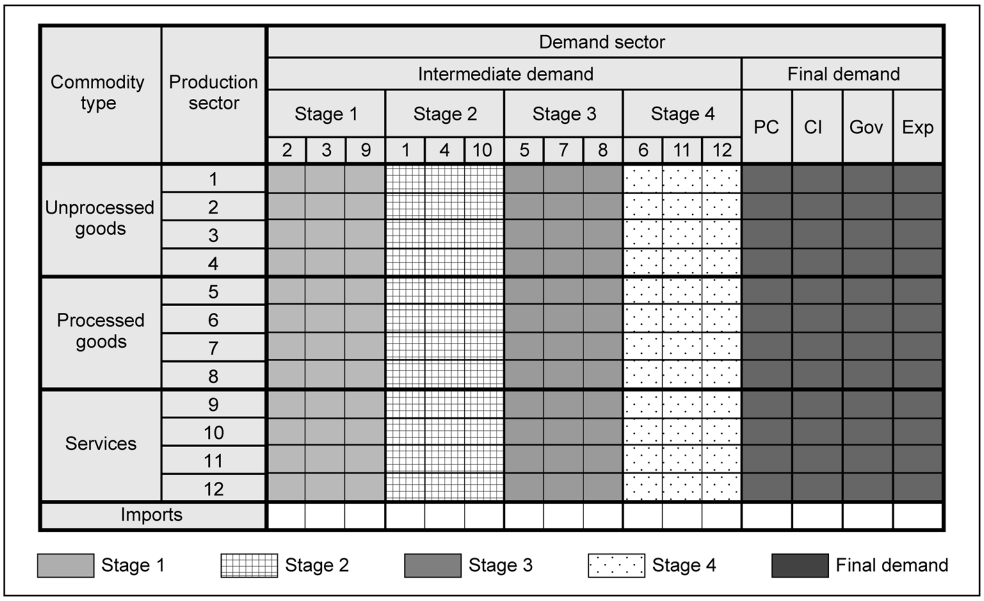
The FD-ID price index is characterized by the following four points: (i) aggregating prices of goods and services in an integrated manner; (ii) dividing demand into the stage of final demand and the stages of intermediate demand, and constructing the Final Demand Index (FD index) and the Intermediate Demand Indexes (ID indexes); (iii) dividing the intermediate demand category into four stages, from upstream to downstream stages in the production flow, and constructing ID indexes for Stage 1 (the most upstream stage) to Stage 4 (the most downstream stage); and (iv) excluding transactions conducted within stages (internal flow) from the calculation of weights for the ID indexes.

Looking at the IO table, we can see that the FD-ID aggregation system is characteristic in that it classifies sectors of goods and services by demand stages along the production flow (the column sectors of the IO table), rather than by type of goods and services (the row sectors of the IO table) (Figure 4).[8, 9] In other words, sectors are divided into groups by demand stages, and prices of goods and services in each group are weight-averaged by trade value. In this process, while demand is naturally divided into intermediate demand (ID indexes) and final demand (FD index), it is noteworthy that the intermediate demand category is divided into multiple stages (four stages in the case of the United States). This represents a significant difference from the all commodities index, which aggregates prices in all sectors as a whole without stage-by-stage division of demand. The FD-ID aggregation system's objective in dividing the intermediate demand category into multiple stages is to resolve the multiple counting problem and to track the process of inflationary pressures being transmitted from upstream to downstream stages in the flow of intermediate demand.[10] Under this system, demand

the multiple counting problem, which became serious when the all commodities index was in use, by using classification by type of goods (the rows of the IO table), rather than by classifying goods by demand stages (the columns of the IO table). Later, the BLS continued to construct and publish the PPI under the SOP system for many years. However, the BLS has developed the FD-ID price index, which integrates prices of goods and services and which divides demand into stages from the viewpoint of the production flow, and has fully shifted away from the SOP system because in the 2010s, the PPI's coverage of sectors of services surpassed 70%, a level comparable to the coverage of goods. Another factor behind the shift is that even under the SOP system, the multiple counting problem continued in the absence of classification of intermediate goods by demand stages.

8. Attention should be paid to the point that the Index by Stage of Demand and Use (ISDU), which is constructed and published as a reference index concerning the CGPI, is a price index that aggregates prices of goods classified by type of goods (the rows of the IO table), as is the case with the SOP system, which was the predecessor to the U.S. FD-ID price index, rather than classified by demand stages (the columns of the IO table). This point will be explained once again in Section VI.
9. The PPI Manual defines the aggregate price index as a "stage of production"-based price index constructed by classifying the production flow into some demand stages based on the IO table and aggregating price indexes for the different stages, and describes it as useful particularly for tracking the process of transmission of inflationary pressures. Meanwhile, the Australian Bureau of Statistics started publishing a "stage of-production"-based aggregate price index earlier than the publication of the U.S. FD-ID price index. However, the Australian aggregate price index system is simple compared with the U.S. FD-ID price index system, as intermediate demand is divided into only two stages, "preliminary demand" and "intermediate demand," as opposed to the four-stage division under the U.S. system.
10. There is no clear solution to the question of how detailed the division of the intermediate demand category into stages should be. If the purpose is merely resolving the multiple counting problem, the division of intermediate demand into stages should be as detailed as possible. However, if the division is excessively detailed, it is difficult to intuitively track the transmission of price changes from upstream to downstream stages of intermediate demand. Taking into consideration the trade-off, this study divides the intermediate demand category into four stages in line with the U.S. approach and verifies the appropriateness of the classification of

Figure 4 Scope of the U.S. FD-ID Price Index



is divided into four stages of intermediate demand and one stage of final demand, and prices of all goods and services used as inputs necessary for production of goods and services classified into each intermediate stage are aggregated according to the input weight specified in the IO table. As a result, each of the ID indexes for the four stages of intermediate demand and FD index for the stage of final demand corresponds to the input price index in the relevant stage.

B. Assigning Sectors to Intermediate Demand Stages

The core process for constructing the FD-ID price index is assigning individual sectors of goods and services to demand stages in the production flow. Namely, first, intermediate demand is divided into four stages, and then, individual sectors of goods and services are assigned respectively to stages in an optimal manner so as to ensure consistency with the production flow specified in the IO table. The assignment is implemented through the following three procedures.[11]

1. Provisional assignment of sectors to stages

First, the four stages of intermediate demand are defined as follows.

demand into stages by examining the characteristics of sectors of goods and services assigned to each stage and the transmission of inflationary pressures between price indexes for the different stages. The details are described in Section IV.C.

11. The description of the method for assigning sectors to stages described in this subsection is made in reference to the case of the U.S. BLS. For detailed information, see Bureau of Labor Statistics (2011).

【Definitions of the stages of intermediate demand】

Stage 4:	Sectors in which X% or more of the value of output is sold to final demand.
Stage 3:	Sectors in which Y% or more of the value of output is sold to final demand or Stage 4 and which are not included in Stage 4.
Stage 2:	Sectors in which Z% or more of the value of output is sold to final demand, Stage 4 or Stage 3 and which are not included in Stage 3 or Stage 4.
Stage 1:	Sectors which do not meet either of the above definitions.

As can be seen from the above, Stage 4 is the closest to final demand, namely the most downstream stage of intermediate demand. Stage 4 is preceded by Stage 3, Stage, 2 and Stage 1 in that order, with Stage 1 as the most upstream stage of intermediate demand. The values "X," "Y," and "Z" in the above table are cut-off variables used to determine the boundaries between the stages. When actually assigning sectors to stages, it is necessary to preset tolerable ranges for the variables and vary their values in fixed increments as a grid search process. The grid search concerning the cut-off variables to determine the stage boundaries is intended to achieve optimal assignment of sectors to stages so that the greatest possible consistency with the production flow in the IO table can be obtained.[12]

2. Setting the criteria for evaluating the production flow

The PPI system covers a multitude of sectors of goods and services. When assigning those sectors to the four stages of intermediate demand and the one stage of final demand, it is necessary to use some criteria for conducting comprehensive evaluation as to whether the assignment of sectors to stages is consistent with the production flow specified in the IO table. With respect to the evaluation criteria, the "net forward flow" (NFF) concept is used under the U.S. FD-ID price index system. NFF is an indicator to evaluate how much of the trade between sectors of goods and services represented in the IO table is consistent with the demand stages to which the relevant sectors are assigned. More specifically, NFF is defined as the value obtained by subtracting the total value of transactions between sectors in the IO table that flow from downstream to upstream demand stages (back flow) from the total value of transactions between those sectors that flow from upstream to downstream demand stages (forward flow) (Figure 5).[13]

12. The concreate method for setting the values X, Y, and Z in this study is described in Section IV.
13. Practically, in calculating NFF, both of outputs and inputs of goods and services are explicitly taken into account by respectively counting the value of outputs from each sector and the value of inputs to each sector for each of forward flow and back flow. For details about the calculation, see Figure 5.

Figure 5 Concept of Net Forward Flow

		Demand sector				
		Stage 1	Stege 2	Stage 3	Stage 4	FD
Production sector	Stage 1	A	B	C	D	E
	Stege 2	F	G	H	I	J
	Stage 3	K	L	M	N	O
	Stage 4	P	Q	R	S	T

Net forward flow ＝ total value of inter-sector transactions that flow from upstream to downstream demand stages

－ total value of inter-sector transactions that flow from downstream to upstream demand stages

＝ (the value of output upstream sector provides to downstream ＋ the value of input downstream sector receives from upstream)

－ (the value of output downstream sector provides to upstream ＋ the value of input upstream sector receives from downstream)

＝ {(B＋C＋D＋E＋H＋I＋J＋N＋O＋T)＋(B＋C＋H＋D＋I＋N)}

－ {(F＋K＋L＋P＋Q＋R)＋(F＋K＋P＋L＋Q＋R)}

【Definition of net forward flow】

Net forward flow (NFF)
= total value of inter-sector transactions that flow from upstream to downstream demand stages (forward flow)
– total value of inter-sector transactions that flow from downstream to upstream demand stages (back flow)

As mentioned earlier, the combination of the values of X, Y, Z that maximizes NFF is explored through a grid search, and based on the search results, the assignment of sectors to stages to be used for the FD-ID price system is determined.

C. Calculating Weights and Matching Price Indexes with Sectors

After the assignment of sectors of goods and services to stages, the next step is to calculate weights used for aggregation to construct the FD-ID price index. The calculation of weights used for aggregation to construct the FD index is relatively simple. The share of the value of inputs from each sector in the overall value of inputs for final demand in the IO table is used as the weight of the sector.

On the other hand, the calculation of weights for aggregation to construct the ID indexes must be implemented stage by stage. All the same, in principle, the share of the value of inputs from each sector in the overall value of inputs in the sectors of goods and services assigned to the stage is used for the weight calculation. However, in the case of the ID indexes, in order to avoid the multiple counting problem, the value of transactions within the same stage (internal flow) is excluded from the weight calculation. This means that internal flow, which represents the trade of inputs within the same stage, is nothing more than intra-stage horizontal trade, and therefore, it is not regarded as the flow that may cause price pass-through from upstream to downstream stages of demand. Through the above procedure, the FD-ID aggregation system overcomes the multiple counting problem that afflicts the all commodities index.

Following the calculation of sector-by-sector weights with respect to the FD and ID indexes, the FD-ID price index can be calculated by matching sectors with price indexes. In principle, PPI sector-by-sector indexes, which comprehensively cover transactions in the IO table, may be used as price indexes for the calculation.

IV. Constructing the Japanese FD-ID Price Index

In this study, we construct the Japanese FD-ID price index by following the U.S. BLS's methodology explained in the previous section. In constructing the index, even though we follow the U.S. methodology in principle, we adopt approaches different from those used by the BLS in some respects. This section explains how the Japanese FD-ID price index is constructed while mentioning the differences between the Japanese and U.S. methodologies.

A. Commodity-Level Classification of Sectors

In the process of constructing the Japanese FD-ID price index, the IO table (2015 base) is used for the assignment of sectors to demand stages and the calculation of aggregation weights. The IO table is a matrix of rows and columns that shows in which stages of intermediate demand or final demand (column sectors of the IO table) outputs of goods and services (row sectors of the IO table) are consumed. This study adopts the approach of classifying both production sectors and demand sectors in the greatest possible detail based on the IO table in order to precisely identify the input-output structure in Japan. Therefore, the classification of sectors used in this study is not at the industry-level but at the commodity-level.[14] That is because although this is different from the U.S. FD-ID aggregation system's approach of using an industry-level classification, identifying input factors at the commodity-level, rather than at the industry-level, is desirable for appropriately capturing the production flow. In this respect, the Japanese IO table can be used to assign sectors to demand stages at the commodity-level because its classification of sectors is implemented at a level close to the commodity-level. The commodity-level classification of sectors is presumed to make it easier to conduct a classification by demand stages that is consistent with the actual status of corporate production activity.

B. Incorporating Imports

As the U.S. FD-ID price index covers only domestically produced goods and services, it does not directly take into consideration the effects of imports. On the other hand,

14. As a result, the calculation of the value of inputs for "petroleum products" includes only input factors necessary for production of petroleum products (e.g., gasoline and naphtha) and excludes input factors related to goods and services produced as by-products in the petroleum refining industry (e.g., chemical products).

in Japan, industries depend on imports for most of the raw materials needed for their production, and imports also play an important role in each stage of demand. Therefore, in order to examine the inflationary trend and the transmission process of price changes, it is important to take into consideration the effects of not only domestic prices but also import prices on price changes in each stage of demand.

In light of this point, the FD-ID price index that we construct in this study covers imports (goods), as well as domestic commodities, as input factors (Figure 6).[15, 16] It should be noted that from the Japanese IO table, it is possible to identify the share of imports in the overall value of transactions between sectors of goods and services. As a result, when aggregation is conducted to construct the FD index and the ID indexes for the four stages of intermediate demand, the relative ratio of domestic and import commodities, which varies by input factor, can be taken into consideration. It is also possible to calculate an input price index exclusively covering either domestic or import commodities as a component of the aggregate price index.

C. Classification by Demand Stages

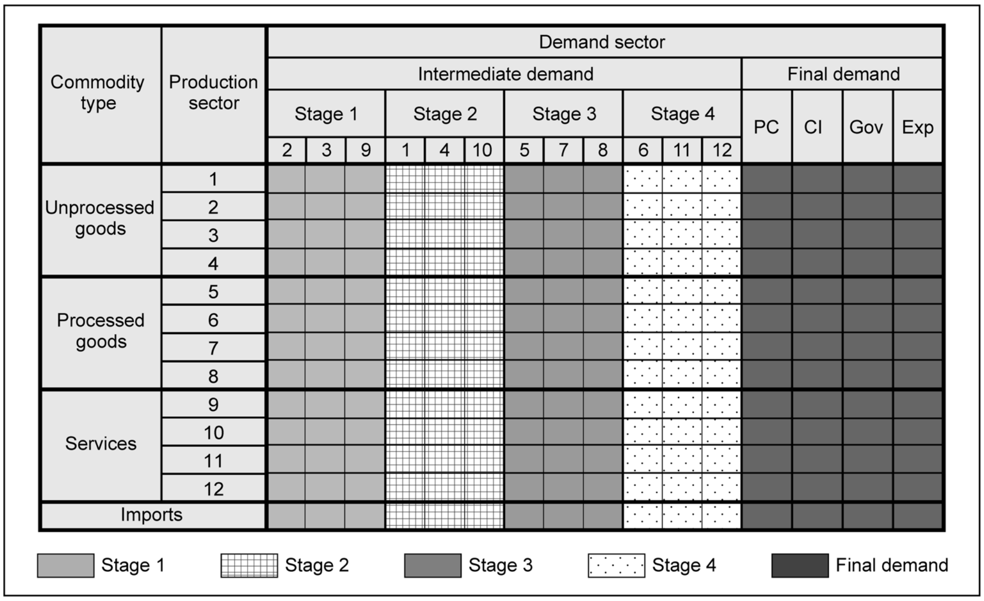
When sectors are classified at the commodity-level based on the Japanese IO table and import commodities are included in the coverage as described above, there are a total of 1,016 sectors (508 sectors each of domestic commodities and import commodities) on the production side and 390 sectors on the demand side (intermediate demand). In this respect, under the U.S. FD-ID aggregation system, there are 405 production sectors and the same number of demand sectors (intermediate demand). As mentioned above, while sectors are classified at the commodity-level in this study, the U.S. classification is at the industry-level. All the same, it can be said that there is not a significant difference in the total number of sectors covered by the FD-ID price index between Japan and the United States if import commodities are excluded.

In order to construct the FD-ID price index, it is necessary to assign 390 sectors on the demand side to four stages of intermediate demand. As explained in Section III.B, the assignment of those sectors to stages should be implemented in the manner of solving an optimization problem. Namely, the sectors should be assigned to either of the four stages of intermediate demand so as to maximize net forward flow (NFF), which represents the value of transactions that are consistent with the structure of production flow based on the classification of sectors by demand stage (forward flow) minus the value of transactions that are inconsistent with the structure (back flow). When implementing this process, the first step is to search for the optimal values of cut-off variables ("X," "Y," and "Z" in Section III.B), which determine the boundaries between the stages. To be more specific, a grid search is conducted in increments of 5 points within the preset search range of $50 \leqq X, Y, Z \leqq 90$, with 729 combinations of the values of cut-off variables (X, Y, and Z) set up. Sectors are assigned to stages on a provisional

....

15. In Figure 6, imports are represented as a single sector for the sake of simplification, but actually, the same number of import sectors as the number of domestic goods and services may be defined based on the IO table.
16. In Section III, it was explained that when aggregation weights for ID indexes are calculated, internal flow, which represents trade within the same stage, is excluded from aggregation. However, with respect to imports, the value of transaction is not excluded from aggregation when the trade is within the same stage because import goods are equivalent to input factors actually allocated from foreign sectors to domestic sectors and because the domestic and foreign sectors with the same heading may be different in substance.

Figure 6 Scope of the Japanese FD-ID Price Index



basis with respect to each combination. By obtaining the value of transactions between demand stages, the values of forward flow and back flow can be calculated with respect to each case of provisional assignment. As a result, it is possible to examine how NFF varies when the values of cut-off variables are changed. The details of the process for provisional stage assignment and NFF calculation are described in Appendix.

The next step is to select several candidates for the optimal assignment of sectors to stages from among provisional assignment cases and apply additional optimization procedures to the selected cases. Specifically, from among the 729 provisional assignment cases, around 10 cases, mainly those that rank high in terms of the value of NFF, are selected as candidates.[17] With respect to each candidate case, sectors of goods and services are moved, one by one, from their original stages under the provisional assignment to new stages and the impact on NFF is measured. By repeatedly implementing this procedure, assignment cases that achieve a marginal improvement of NFF below a certain threshold are identified. From among around 10 assignment cases selected through this additional optimization procedure, the one that maximizes NFF is adopted as the finalized assignment of sectors to stages.

As a result of the optimization of the assignment of sectors to stages, the values of the cut-off variables were fixed at: X=70, Y=65, and Z=60. Under the U.S. FD-ID

17. In the assignment of sectors to stages for the purpose of constructing the Japanese FD-ID price index, in addition to the top five cases in terms of the value of NFF, the top five cases in terms of the value of forward flow (ranked within the top 20 or so in terms of the value of NFF) were selected as candidates for optimizing the provisional assignment. Not only NFF but also forward flow is used as criteria for selecting candidates in order to prevent the risk that the range of options may be limited if emphasis is placed exclusively on NFF when conducting a grid search regarding the cut-off variables (X, Y, and Z). Indeed, as a result of classification by stage conducted at this time, the largest value of NFF is recorded for one of the cases which are ranked high in terms of the value of forward flow and which, therefore, go through the additional optimization procedure following the provisional assignment of sectors to stages, and that case is selected as the final choice.

aggregation system, the values of the cut-off variables were fixed at: X=75, Y=75, and Z=60. Although the U.S. and Japanese approaches are different in the classification level—the industry-level in the United States and the commodity-level in Japan—as mentioned above, we found that they are mostly similar in terms of the values of cut-off variables.

As for the breakdown of inter-stage transactions regarding the ID indexes, forward flow accounts for 84.5% of the overall output value, while the share of back flow is only 4.3%. On the whole, our assessment is that the Japanese FD-ID price index can capture net forward production flow accurately (Figure 7). The share of internal flow, which represents trade within the same stage, is 11.2%. As mentioned in Section III.C, internal flow is excluded from the calculation of aggregation weights in order to avoid the multiple counting problem. However, our findings show that even if internal flow is excluded, just under 90% of the overall value of transactions is covered, so it can be said that the FD-ID price index system constructed in this study covers most of the scope of the PPI.

Next, let us look at which representative sectors have actually been assigned to which stages (Figure 8).[18] Stage 1, the most upstream stage of intermediate demand, includes raw materials, such as crude petroleum, commodities directly using raw materials as input factors, such as petroleum products and crude steel, and, among services, worker dispatching services. Worker dispatching services are assigned to a relatively upstream stage presumably because they themselves do not require much input from other sectors while being used as an input factor in a broad range of industries. Stage 2, one level further downstream than Stage 1, includes plastic and steel products, which are manufactured by processing commodities included in Stage 1, such as petroleum products and crude steel. This captures the structure of production flow in manufacturing industries. As for services, Stage 2 includes those which are used in a relatively broad range of industries, such as advertising and internet-based services. Stage 3 includes motor vehicle parts, which are manufactured by processing plastic and steel products, integrated circuits and liquid crystal panels as well as services which are close to final demand, such as air transport and wholesale trade of machinery and equipment. Stage 4 includes final demand goods, such as soft drinks, passenger motor cars, machine tools, and personal computers, and services for which sales to households have a large share, such as hotels.[19]

....

18. The stage assignment for goods and services is available at the following link; https://www.boj.or.jp/en/research/wps_rev/wps_2021/data/wp21e06a.xlsx

19. The Japanese IO table makes it possible to identify the respective sectors of goods and services in which wholesale services for the various types of goods are consumed. Therefore, for the purpose of classification by stages, the "wholesale trade" sector in the IO table is divided into five categories—namely "wholesale trade for textile and apparel," "wholesale trade for food and beverages," "wholesale trade for building materials, minerals, metals, etc.," "wholesale trade for machinery and equipment," and "wholesale trade for miscellaneous goods"—in line with the classification of the SPPI. As a result of this treatment, a classification taking into consideration differences in characteristics between the various categories of wholesale trade has become possible. For example, "wholesale trade for building materials, minerals, metals, etc.," which handles mainly raw materials and intermediate goods, is assigned to the relatively upstream Stage 1, whereas "wholesale trade for machinery and equipment" is assigned to Stage 3, which is closer to final demand. Consequently, the total number of sectors of intermediate demand used for the assignment of sectors to stages actually come to 394, including the 390 sectors of intermediate demand in the IO table and four sectors created as a result of additional classification.

Figure 7　Shares of Transactions by Demand Stages

(%)

		Demand sector				
		Stage 1	Stage 2	Stage 3	Stage 4	FD
Production sector	Stage 1	2.4	5.1	1.4	2.2	2.5
	Stage 2	1.5	4.3	4.6	6.4	6.0
	Stage 3	0.7	0.8	2.9	6.4	9.2
	Stage 4	0.3	0.5	0.4	1.6	40.6

(%)

Forward flow			Back flow	Internal flow
	Next stage	Skip		
84.5	56.8	27.7	4.3	11.2

Next stage: The percent of total shipments sold by sectors to sectors classified in the next forward stage of production

Skip: The percent of total shipments sold by sectors to sectors classified in forward stages of production other than to the next stage

Back flow: The percent of total shipments sold by sectors to sectors classified in earlier stages of production

Internal flow: The percent of total shipments sold by sectors to sectors classified within the same stage of production

Note: These are calculated based on domestic transactions.

Figure 8　Assignments of Representative Sectors to Stages

Stage 1	Stage 2	Stage 3	Stage 4
• Crude petroleum • Petroleum products • Crude steel • Worker dispatching services • Wholsale trade (Building materials, minerals & metals, etc.)	• Plastic products • Steel products • Financial service • Advertising services • Road transport • Internet-based services	• Motor vehicle parts and accessories • Integrated circuits • Liquid crystal panel • Air transport • Wholesale trade (Machinery and equipment)	• Soft drinks • Passenger motor cars • Machine tools • Personal Computers • Hotels

In addition to the stage assignments of representative sectors described above, the characteristics can be observed at a more detailed level. For example, dishes, sushi and lunch boxes are assigned to Stage 4 while retort foods are assigned to Stage 3 even though these are both foods. This reflects the fact that retort foods are consumed for so-called business use (e.g., restaurants) to some extent even though these are both foods mainly consumed for households. As for textile products, cotton fabrics are assigned to Stage 3 while silk fabrics are assigned to Stage 4. This is because silk fabrics are shipped overseas in many cases and then the rate of export in final demand is relatively high.[20] Similarly, for services, financial service mostly consumed for businesses is assigned to Stage 2, life insurance mostly consumed for households is assigned to Stage 4, and non-life insurance consumed for businesses and households in a similar proportion is assigned to Stage 3. Although some characteristics like the above seem difficult to understand, all of them are the consequences that the assignment of sectors by demand stage exactly reflects the input-output structure in the IO table.

Looking at the lineup of sectors thus assigned to the stages of demand, we can see that the classification of sectors by demand stages implemented for this study is presumed to appropriately capture the supply chain structure.

As mentioned in Section III.A, intermediate demand is divided into four stages by following the U.S. methodology. This stage assignment is considered desirable in the sense that it can prevent the stage assignment process from getting overcomplicated in addition to the fact that it can alleviate multiple counting problem without missing the important characteristics of input-output structure in the overall supply chain in Japan. In fact, when testing the case of dividing into three stages with the cut-off variable fixed at Z=0 in the above-mentioned process NFF deteriorated as a whole compared with the case of dividing into four stages. For example, when comparing the case of dividing into four stages with the cut-off variable fixed at: X=70, Y=65, and Z=60, which is finally adopted in this study, with the case of dividing into three stages with the cut-off variable fixed at: X=70, Y=65, and Z=0, NFF in the latter case decreased by 7 percent compared to that in the former case. This is mainly because decrease in the number of stages makes the rate of transaction within the same stage (internal flow) high. On the other hand, in the case of dividing into five stages or more, it can be more difficult to understand the characteristic of each ID index based on achieved stage assignments in addition to the fact that the calculation burden of the stage assignment process mentioned in this section would be extremely heavy.[21] In light of these points, we eventually divide intermediate demand into four stages in this study.

D. Matching Price Indexes with Sectors

For the construction of the Japanese FD-ID price index, commodity-level indexes of the CGPI (including import and export prices) and the SPPI are used as sector-by-sector price indexes in principle. However, in the IO table, there are transactions that are not covered by either the CGPI or the SPPI. For example, in addition to many services intended for households that were mentioned in Section II.A, electricity, gas and water supply are among such transactions. Therefore, commodity-level indexes of the CPI

....

20. The stage assignment is conducted including goods for exports as a part of final demand. Under this method, even goods generally consumed for intermediate demand can be assigned to Stage 4 in case where the rate of exports in the IO table is extremely high, which tends to treat these goods as if they were final goods. In order to deal with this problem, some goods assigned to Stage 4 with high rate of exports are assigned to another stage in case where NFF is improved by the reassignment.

21. Generally, in case where intermediate demand is divided into N stages based on the process mentioned in this section, 9^{N-1} stage assignments should be tested as a whole because each of N-1 cut-off variables needs to be moved in increments of 5 points within the range of $50 \leqq X, Y, Z \leqq 90$ (9 figures can be adopted for each cut-off variable). Therefore, even in the case of five stages, 9^4=6,561 patterns of NFF need to be calculated. In this manner, the calculation burden needed for optimization of stage assignments can explode exponentially with increase in the number of stages.

are used for these and some other sectors.[22] All commodity-level indexes of the CGPI, the SPPI and the CPI used for the aggregation purpose are 2015 base indexes. In this study, the FD-ID price index is calculated for the period from January 2015 to August 2020. As all commodity-level indexes used exclude consumption tax, the FD-ID price index constructed in this study is also on an ex-consumption tax basis.

Based on the abovementioned approach, commodity-level indexes of the CGPI, the SPPI and the CPI are matched with corresponding sectors among the 1,016 production sectors (508 sectors each of domestic commodities and imported commodities) with respect to each of the FD and ID indexes.[23] Individual commodity-level indexes are integrated through a fixed-base Laspeyres formula based on weights calculated through the method described in Section III.C. Sectors for which there is not a corresponding commodity-level index are excluded from the aggregation for the construction of the FD-ID price index.[24, 25] When there are multiple corresponding commodity-level indexes for a single sector, an index compiled by weight-averaging them based on their weight in the relevant price index (CGPI, SPPI, or CPI) through a fixed-base Laspeyres formula is used.[26]

Through the above aggregation process, the headline indexes of the FD index and the four ID indexes are calculated. As a result of matching a total of 1,483 commodity-level indexes of the CGPI, the SPPI and the CPI with corresponding sectors, the FD-ID price index's overall coverage ratio comes to around 70% (Figure 9). It can be said that the FD-ID price index has a mostly sufficient coverage as a producer price-based aggregate index integrating prices of goods and services.

V. Calculation Results of the Japanese FD-ID Price Index

This section shows the calculation results of the Japanese FD-ID price index and outlines the characteristics of this index through comparison with existing price indexes.

A. FD Index

First, let us look at the calculation results of the FD index, which represents prices of goods and services in the stage of final demand. As already explained, the FD index is calculated by aggregating price indexes for components of final demand in the IO table through weight-averaging. In other words, it is a price index integrating prices of goods

22. Fresh food is also excluded from the CGPI, and therefore, a commodity-level index of the CPI is used as a substitute.
23. Regarding the SPPI, it is relatively easy to match commodity-level indexes with corresponding sectors because commodities are organized into groups based on the classification of sectors in the IO table. On the other hand, regarding the CGPI and the CPI, the classification of commodities does not necessarily correspond to the classification of sectors in the IO table. Therefore, it is necessary to classify commodities in accordance with the classification of sectors in the IO table.
24. For example, construction, retail services, research and development, school education and public services, among other services, are excluded from aggregation because price indexes that appropriately capture their price trends are currently not available.
25. In order to improve the efficiency of the aggregation process, commodities whose weight is less than 0.001% with respect to each of the FD index and the ID indexes are excluded from aggregation.
26. The weights for components of each aggregated index is available at the following link; https://www.boj.or.jp/en/research/wps_rev/wps_2021/data/wp21e06b.xlsx

Figure 9 Coverage and Number of Commodities

(1) Coverage

	FD (including exports and imports)	PC	Exp	Stage 1	Stage 2	Stage 3	Stage 4	FD+ID
Selected transaction value/ total transaction value	63%	73%	67%	88%	79%	86%	87%	72%

(2) Number of Commodities

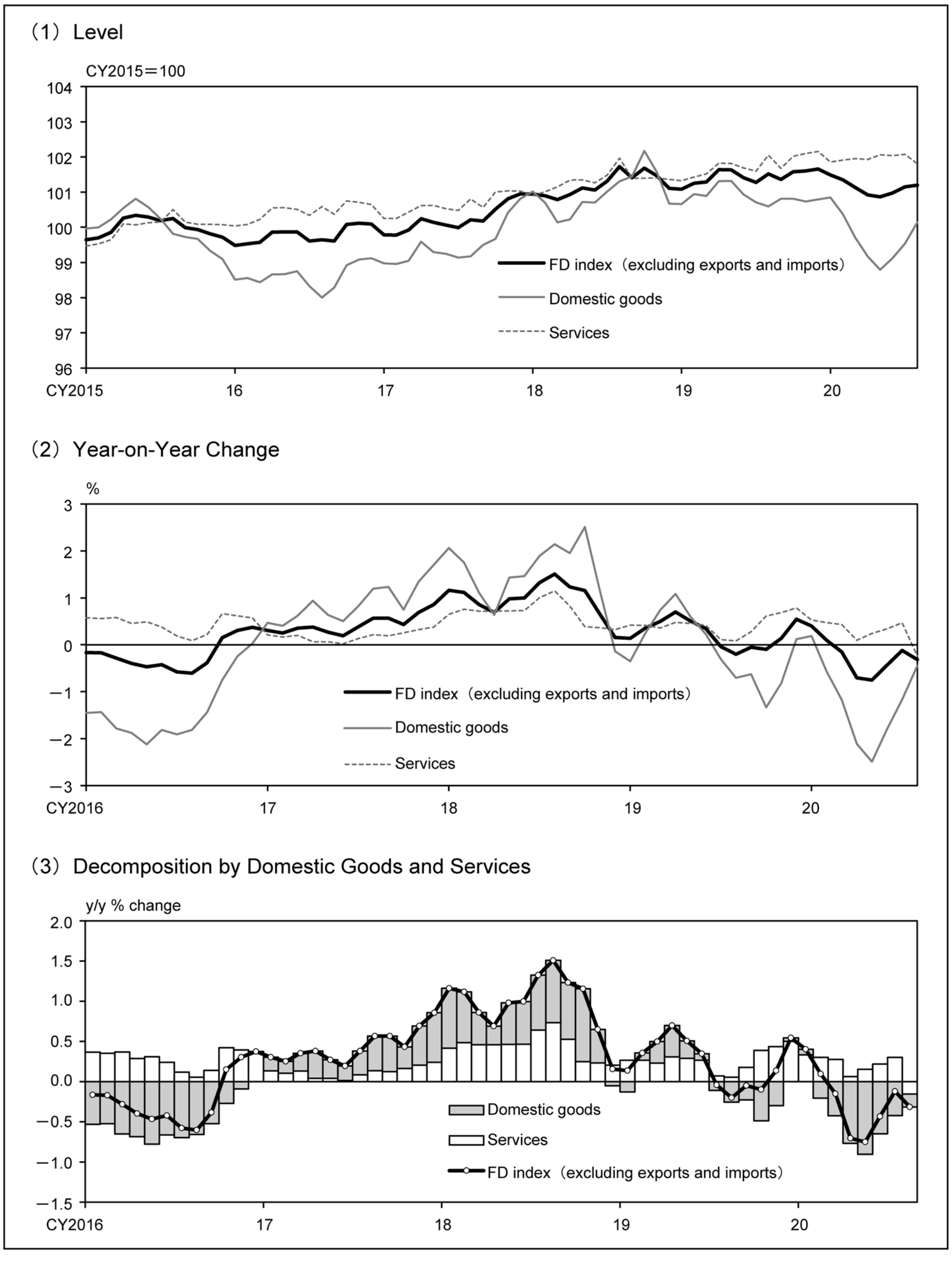
	FD (including exports and imports)	PC	Exp	Stage 1	Stage 2	Stage 3	Stage 4	FD+ID
PPI	459	345	0	559	391	435	523	743
IPI	168	149	0	202	198	201	204	256
EPI	207	0	207	0	0	0	0	207
SPPI	54	50	0	108	82	117	143	151
CPI	126	126	0	38	41	31	8	126
Total	1,014	670	207	907	712	784	878	1,483

and services that focuses on the stage of final demand. However, regarding the extent of aggregation, there may be some versions, depending on the purpose of analysis, in terms of whether only domestic goods and services should be covered or exports and imports should also be included. If the purpose is to track the domestic supply-demand condition, only domestic goods and services should be covered, whereas exports and imports may be included for the purpose of tracking a comprehensive price trend concerning overall final demand components.

First, we construct the FD index (excluding exports and imports) that covers only domestic goods and services in order to track the domestic supply-demand condition (Figure 10). This index was constructed by weight-averaging prices of domestic goods and services in final demand. The weights assigned are 36% for domestic goods and 64% for domestic services. Comparison of the price trends for domestic goods and services shows that prices of domestic goods are more volatile than prices of services. As prices of domestic goods comprised by the FD index are limited to prices in the stage of final demand, they are not affected by the multiple counting problem. However, it still shows a certain degree of volatility. For example, in the period since 2016, the rate of year-on-year change in the FD index for goods (excluding exports and imports) alone exceeded plus 2% at the peak and fell below minus 2% at the bottom. Nevertheless, the FD index integrating prices of domestic goods and services (excluding exports and imports) shows more moderate movements than the price trend for domestic goods alone, reflecting the greater weight of services. The breakdown of contributions to year-on-year price changes in the FD index (excluding exports and imports) shows that domestic goods and services make mostly similar contributions.

When the FD index (excluding exports and imports) is compared with the output

Figure 10 FD Index (Excluding Exports and Imports)



gap, which is calculated by the Bank of Japan's Research and Statistics Department, in order to look at its relationship with the domestic supply-demand condition, the two follow roughly parallel trends (Figure 11). Namely, when the positive output gap continued to expand from the end of 2016 through the second half of 2018, the rate of year-on-year change in the FD index (excluding exports and imports) remained positive. However, when the positive output gap gradually shrank from the end of 2018 onward against the backdrop of the U.S.-China trade friction, among other factors, the positive rate of the increase in the FD index (excluding exports and imports) decreased. When the output gap turned negative after the beginning of 2020 due to the COVID-19 pandemic, the rate of year-on-year change in the FD index (excluding exports and imports) also clearly turned negative. From the above, it may be said that the trend of year-on-year changes in the FD index (excluding exports and imports) is roughly consistent with the trend in the supply-demand condition for domestic goods and services, although this assessment is provisional given the limited period of analysis (the period from 2016 to mid-2020).

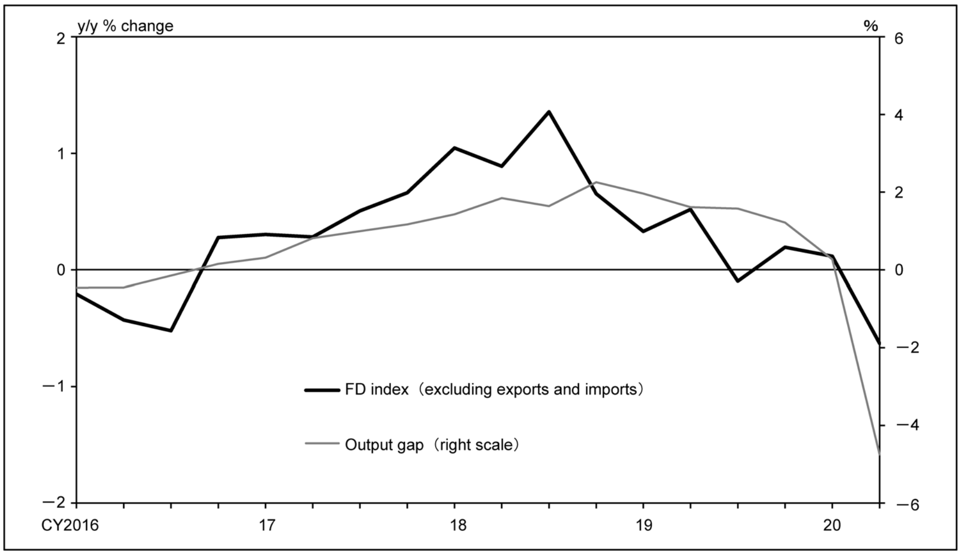
Next, we constructed the FD index (including exports and imports) that covers exports and imports as well as domestic goods and services (Figure 12). In this case, the weights assigned are 26% for domestic goods, 20% for export goods, 8% for import goods, and 46% for services. Reflecting the importance of exports and imports for the Japanese economy, the weights of domestic goods and the weights of export and import goods are mostly similar. Regarding the trend in the FD index (including exports and imports), the index shows a much greater volatility than the FD index (excluding exports and imports), reflecting the significant volatility of export and import prices. In particular, it is noteworthy that export goods make considerable contributions to price changes not only because of their large weight but also because of the effects of the global supply-demand environment and the effects of fluctuations in the rates of exchange used for the conversion of contract currency prices into the yen. As described above, the FD index that covers exports and imports as well is affected not only by the supply-demand condition for domestic goods and services but also by global factors.

B. ID Index

Next, let us look at the calculation results of the ID index, which represents prices of goods and services in the stages of intermediate demand (Figure 13). The calculation of the ID index includes imports as well as domestic goods and services, and the index is comprised of four indexes for their corresponding stages of intermediate demand. Regarding the trend in the ID index, price volatility is greatest in Stage 1, which is the upstream stage in the production flow, and becomes progressively smaller as the production process moves to more downstream stages, with the volatility in Stage 4 being very small. One possible reason is that while prices in Stage 1 are directly affected by the volatility of markets for the many types of raw materials included in that stage, including crude petroleum, natural gas, naphtha, iron ore and nonferrous metals, prices tend to become stickier in more downstream stages in the production flow because price changes that occur in upstream stages are gradually absorbed stage by stage.

If the rate of year-on-year change in the ID index is broken down into three components, namely domestic goods, import goods, and services, in order to look at this trend from another perspective, price changes in Stage 1 are attributable almost entirely to the price volatility of import goods (Figure 14). Therefore, it may be presumed that price changes in Stage 1 are caused by such factors as international commodity prices, overseas economic conditions, and foreign exchange volatility, rather than by the domestic supply-demand factor. However, in more downstream stages in the production

Figure 11 FD Index (Excluding Exports and Imports) and Output Gap

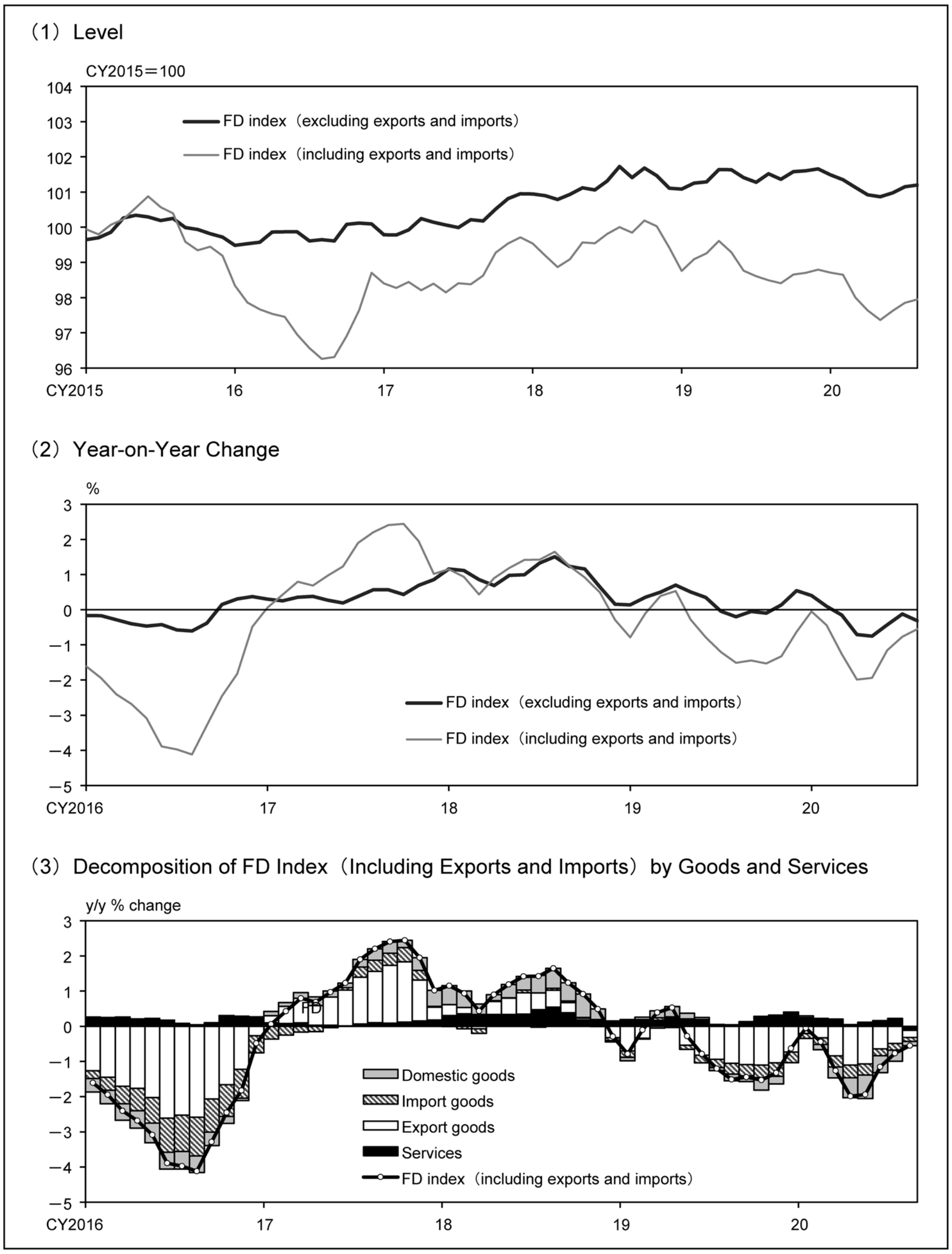


Note: The output gap is estimated by the Research and Statistics Department, Bank of Japan.

flow, namely in Stages 2 and 3, the contribution of prices of import goods becomes smaller while the contribution of domestic goods becomes larger. In Stage 4, not only is the contribution of domestic goods large, but also the contribution of services, which is unremarkable in upstream stages, becomes clearly visible. The results of the above breakdown by type of commodity indicate that price changes for import goods, which represent an exogenous factor, are important for Japan in upstream stages of intermediate demand in the production flow but that the price changes are absorbed stage by stage as the production process moves on. As a result, in the most downstream stage of intermediate demand, which is close to the stage of final demand, the supply-demand condition for domestic goods and services is a stronger factor of price change, according to the breakdown data. In fact, Hergt, Kowal, and Weinhagen (2014) used the U.S. FD-ID price index to sort out facts related to the transmission of price changes between different stages and pointed to the possibility that price changes in the indexes for their corresponding stages of demand may be affected not only by supply shocks transmitted from upstream to downstream stages but also by demand shocks transmitted from downstream to upstream stages.

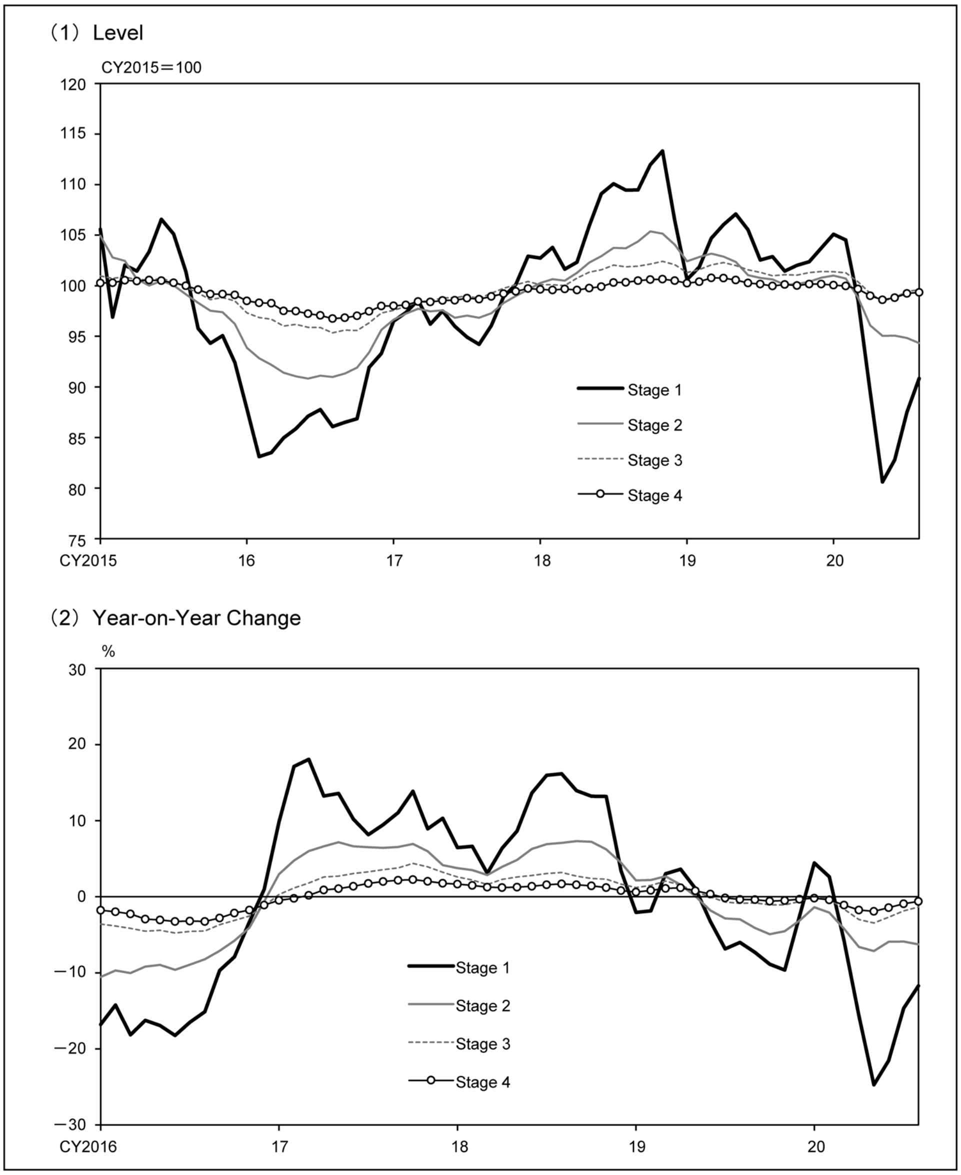
There are several theoretical possibilities for the underlying factors that price changes in the production flow are absorbed in the process of passing demand stages although it can not be clear only based on the experimental results of FD-ID indexes. One of those is that the businesses set the price of their products considering the cost changes other than in intermediate inputs of goods and services (e.g., wage paid to their workers). Assuming that the sectors belonging to Stage 2 are regarded as a representative business, even in the case where the intermediate costs for the business (ID index of Stage 2) change significantly, it can still keep a constant profit (markup) even if it keeps price changes in their own products (roughly corresponding to ID index of Stage 3) at a minimum as long as the change in wage is limited in the short

Figure 12　FD Index: Including and Excluding Exports and Imports



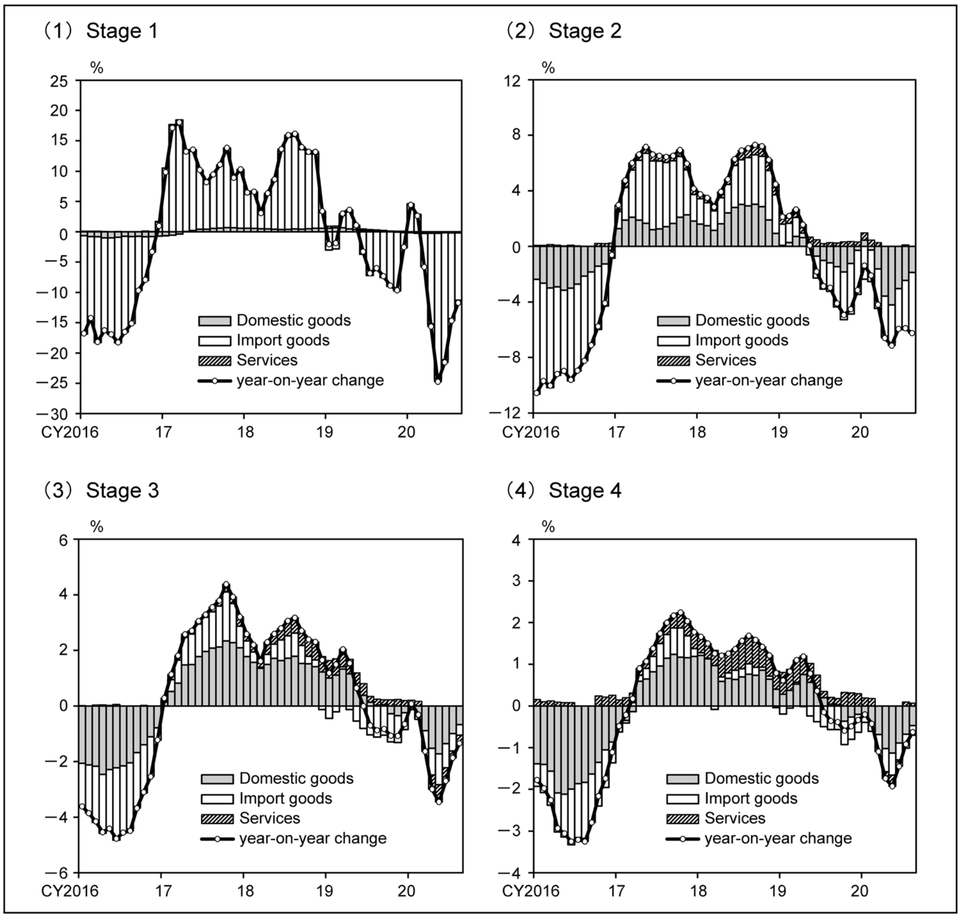
term. Especially, if the stage of downstream includes more sectors which have larger rate of labor costs than the stage of upstream, the price changes in upstream has limited influence on those in downstream. Besides, another possibility is that the frequency of price revision in the businesses included in downstream sectors close to final demand can be less than that in the upstream sectors. In that case, as so-called sticky price model implies, even if the price in upstream changes significantly in the short term,

Figure 13 ID Indexes



the businesses in downstream with low frequency of price revision may not pass it on the price of their own products as long as the price changes in upstream are not considered persistent. As just described above, the price changes by demand stage in the FD-ID indexes can give some implications for the analysis on the relationship between business activities and inflation dynamics.

Figure 14 Decomposition of Year-on-Year Changes in ID Indexes



VI. Comparison of the FD-ID Price Index with Existing Price Indexes

This section compares the FD-ID price index described above with existing price indexes ((i) the all commodities indexes of the CGPI and the SPPI, (ii) the Index by Stage of Demand and Use [ISDU, which is one of the reference indexes in the CGPI], (iii) the GDP deflator, and (iv) the CPI) and sort out commonalities and differences.

A. Comparison with the All Commodities Indexes of the CGPI and the SPPI

As explained in Section II, the all commodities indexes of the CGPI and the SPPI are currently used as the headline indexes of the PPI system with regard to prices of goods and services, respectively. Each of these indexes is constructed by aggregating all commodity-level indexes within its coverage through weight-averaging by gross trade value without distinguishing between different stages of processing or demand. In contrast, the FD-ID price index constructed in this study attempts to avoid the multiple counting problem by dividing demand into the stage of final demand and the four stages of intermediate demand.

This section compares the trends in the FD-ID price index with those in the CGPI and SPPI all commodities indexes (Figure 15). Of the component indexes of the FD-ID price index, the FD index for goods (excluding exports and imports) and for services are used for the comparison with the CGPI and SPPI all commodities indexes. That is because the FD index (excluding exports and imports), which covers goods and services in the stage of final demand, is considered to most directly reflect the supply-demand condition for goods and services in the stage of final demand in Japan while excluding the effects of the multiple counting problem.

First, according to a comparison of the FD index (for goods; excluding exports and imports) with the CGPI all commodities index in terms of year-on-year change, the CGPI all commodities index is much more volatile than the FD index, particularly around 2016, when the crude petroleum price was falling. While the CGPI all commodities index is affected by the multiple counting problem due to the absence of distinction between different demand stages, the FD index (for goods; excluding exports and imports) excludes the effects of the problem, and this point is clearly reflected in the difference in volatility at that time. To put it another way, because it is affected by the multiple counting problem, the CGPI all commodities index significantly overstates price changes for commodities, including raw materials, in upstream stages. Next, according to a comparison of the FD index (for services) with the SPPI all commodities index, the FD index (for services) stayed stable on the whole, despite showing some month-by-month fluctuations, compared with the SPPI all commodities index. After the beginning of 2020 in particular, the SPPI all commodities index fell steeply, whereas the volatility of the FD index (for services) remained small. That is because although price indexes for some specific types of services, such as advertising, real estate rental and marine freight transportation, among the component indexes of the SPPI all commodities index, dropped steeply, these services are intended for business use in stages of intermediate demand, which means that under the FD-ID price index system, they are covered by the ID indexes, rather than by the FD index.[27]

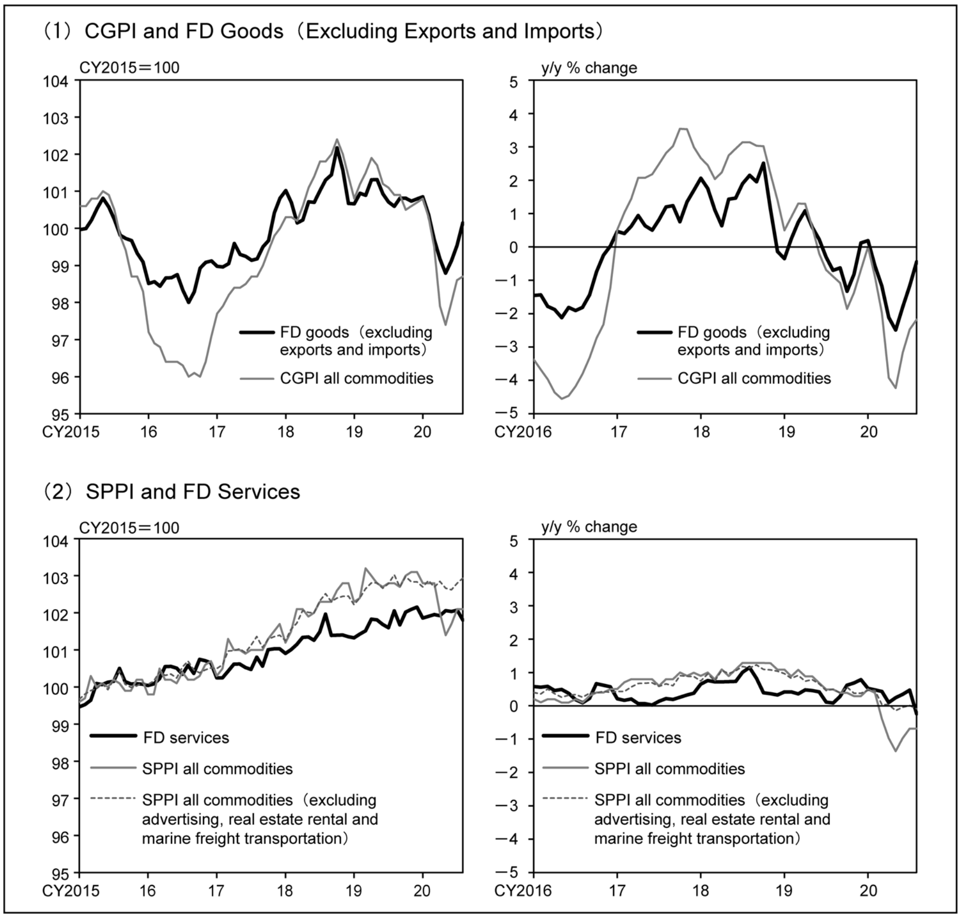
In light of the above, the FD-ID price index is different from the CGPI and SPPI all commodities indexes in that it excludes the effects of the multiple counting problem (regarding goods in particular) and makes a clear distinction between the stages of intermediate and final demand. As a result, the FD index (excluding exports and imports) constructed in this study is considered to be more appropriate as an aggregate price index that represents the macro-level supply-demand condition in the stage of final demand in Japan than the CGPI and SPPI all commodities indexes.

B. Comparison with the ISDU

Under the Japanese PPI system, the ISDU is constructed and published by the Bank of Japan's Research and Statistics Department as a reference index regarding the CGPI. This index is constructed by aggregating prices of goods adopted for the CGPI classified into three stages of processing, namely raw materials, intermediate materials and final goods (Figure 16). With respect to raw materials and intermediate materials, the

27. Indeed, Figure 15 shows that an index that represents the SPPI all commodities index excluding advertising real estate rental and marine freight transportation followed a trend similar to that of the FD index (for services) after the beginning of 2020.

Figure 15 Comparison with CGPI and SPPI All Commodities Indexes

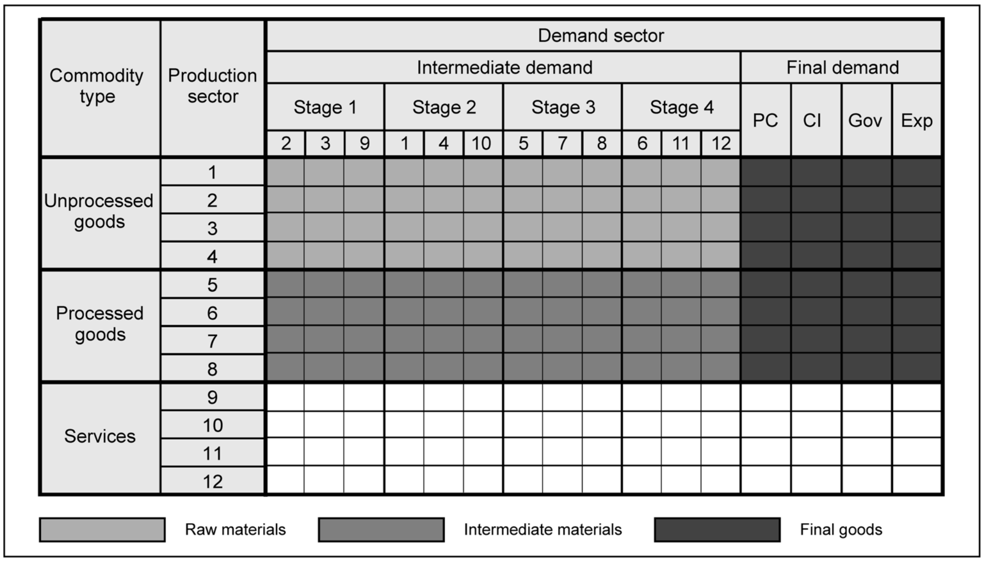


Note: These indexes exclude comsumption tax.
Source: Bank of Japan

aggregation method of the ISDU is significantly different from that of the FD index because sectors of intermediate goods in the IO table are classified on the basis of the level of processing by commodity type (row sectors of the IO table), rather than being assigned to demand stages (column sectors of the IO table). Unlike the ID index, for which intermediate demand is divided into separate stages, the index for intermediate materials, a component of the ISDU, is characterized by the risk of being seriously affected by the multiple counting problem because goods at very wide-ranging levels of processing are treated as one group without distinction. It is difficult to conduct a simple comparison between the ISDU and the ID index with respect to sectors of intermediate goods because their scopes are significantly different as described above.

However, with respect to final goods, the scopes of the ISDU and the FD index are almost the same as each other. That is because final goods are classified by demand stages (column sectors of the IO table) in the case of the ISDU as well, and in this respect, there is no fundamental difference between the two indexes. A trend comparison

Figure 16 Scope of Index by Stage of Demand and Use (ISDU)



between the ISDU for final goods and the FD index (for goods) conducted with this point in mind shows that the trends of the two are somewhat similar, reflecting the absence of significant difference in concept (Figure 17).[28] However, if looked at in detail, since 2017, the FD index (for goods) has stayed slightly higher than the ISDU for final goods. The main cause of this disparity is the omission of electricity service for final demand (namely for households) from the coverage of the ISDU for final goods. On the other hand, the FD index (for goods) uses the electricity price index of the CPI as its component index for electricity for final demand. As electricity rates rose in that period, the FD index (for goods) showed a higher trend than the ISDU for final goods.

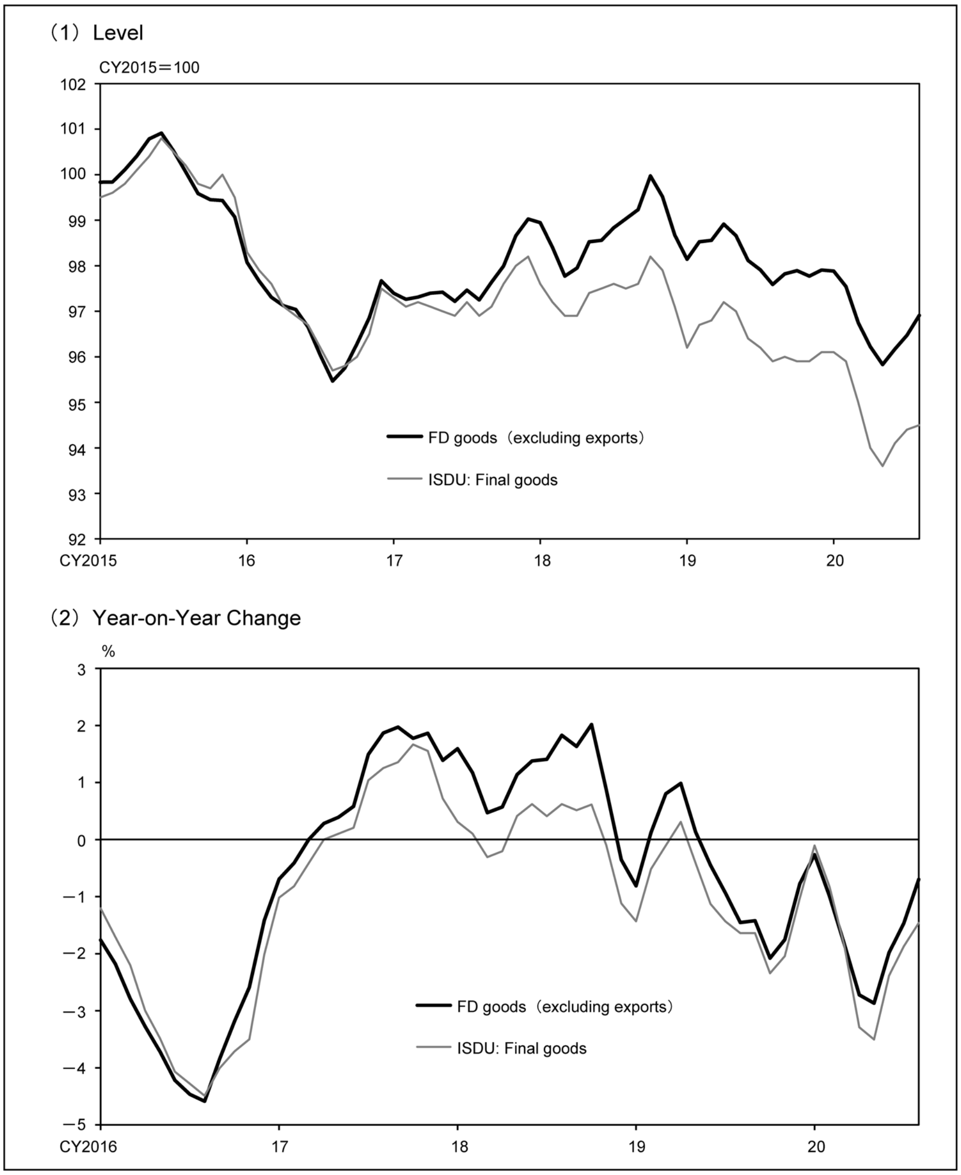
C. Comparison with the GDP Deflator

The GDP deflator is a price index that is used for calculating gross domestic product (GDP, System of National Accounts). It is implicitly calculated by dividing nominal GDP by real GDP. In Japan, in addition to annual GDP data, quarterly data are published in the QE (preliminary quarterly GDP estimates), and like the PPI and CPI, this data set is widely used as a macro-level price trend indicator.

Regarding the GDP deflator as part of QE, in addition to a data series corresponding to overall GDP as viewed from the expenditure side, there are several component series on the demand side. Of the demand-side series, the deflator for domestic demand has a scope closest to the scope of the FD index constructed in this study.[29] The scope

28. Depending on the purpose of analysis, it may be possible to examine the long-term trend in prices in the stage of final demand by connecting the ISDU for final goods in the period before 2015 with the FD index (for goods).
29. The expenditure-side GDP deflator, which corresponds to overall GDP, covers overall production of value added to goods and services. If looked at from the demand side, this represents domestic demand plus net exports (exports − imports). Therefore, as the expenditure-side GDP deflator recognizes the international balance of payments as net exports, the effects of price changes for all import goods faced by Japan, including those consumed in the stages of intermediate demand, are explicitly excluded. On the other hand, the FD

Figure 17　Comparison with ISDU



Source: Bank of Japan

of the deflator for domestic demand is equivalent to "domestic demand" among the final demand components of GDP, which excludes net exports. Conceptually, this covers all goods and services domestically consumed in final demand in Japan, regardless of where those goods and services are produced, and therefore import goods are also in-

index constructed in this study does not exclude imports consumed in the stages of intermediate demand, as it captures prices in the respective stages of demand not on a value added basis, which subtracts input prices from output prices, but on a gross output price basis. In this respect, the FD index is different from the expenditure-side GDP deflator.

cluded. As a result, the deflator for domestic demand has strong similarity particularly to the FD index (excluding exports) among the component indexes of the FD index.

Indeed, a comparison between the deflator for domestic demand and the FD index (excluding exports) shows that the two indicators follow mostly similar trends and that they are somewhat comparable (Figure 18 (1)). The FD index (excluding exports) has characteristics of a monthly deflator for domestic demand as explained above, and as a result, compared with existing statistics, it may be useful as a speedily available comprehensive indicator of price trends for a broad range of goods and services in the stage of final demand in Japan, including the direct effects of import goods.

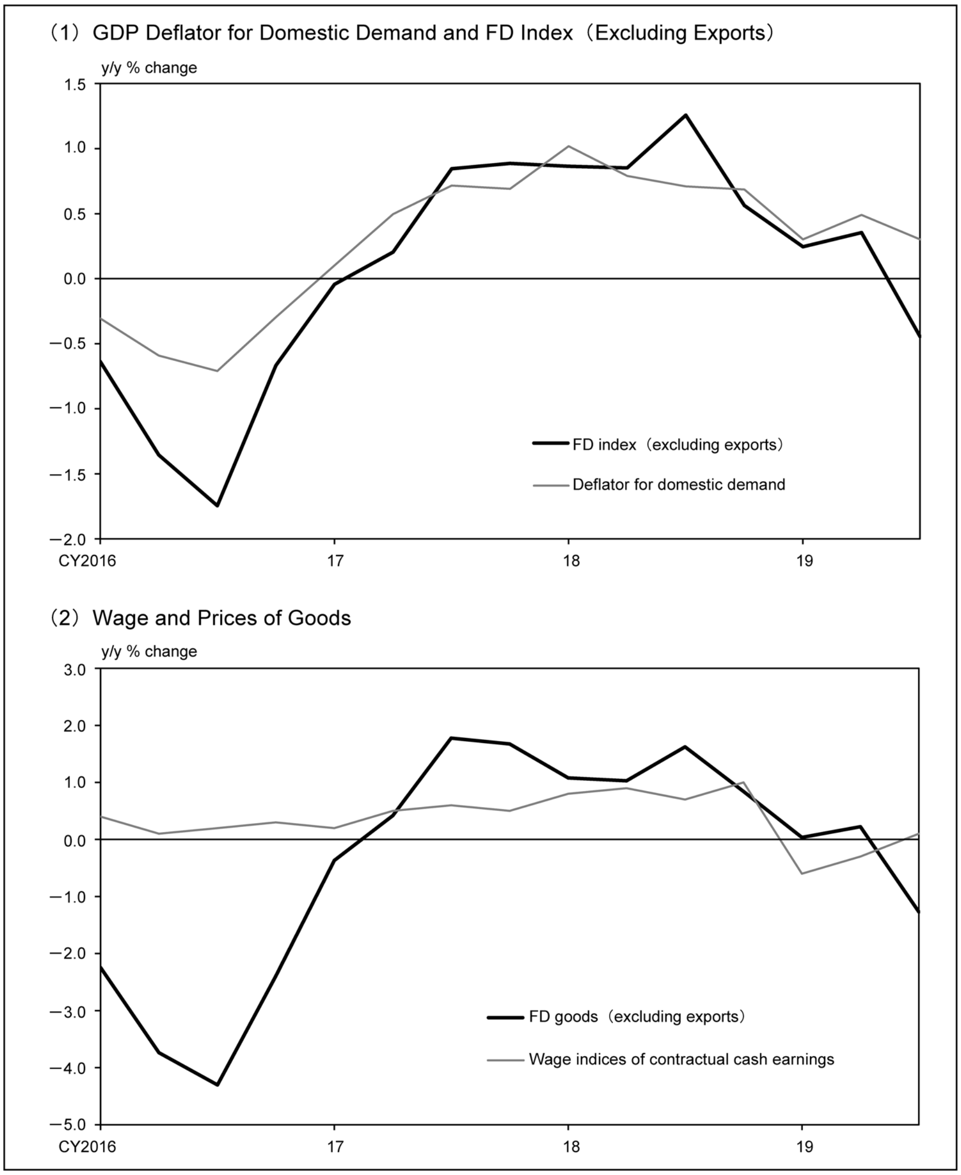
However, according to a more detailed comparison, it is noteworthy that the deflator for domestic demand shows smaller volatility than the FD index (excluding exports) at some times, including in 2016, when the level of price volatility was relatively high. One possible factor behind this difference is the use of different aggregation methods between the two indexes with respect to services sectors for which appropriate price indexes do not exist. Specifically, in the case of GDP, there are not output-based price indexes for such services as research and development, school education, and public services, so real-term data are calculated based on an estimated input cost-based deflator. As a result, the deflator for domestic demand, which is calculated as an implicit deflator, also includes the effects of price changes for input factors in services sectors. In those sectors in particular, the weight of compensation of employees as an input factor is large, so the sectors are presumed to be prone to the effects of changes in the wage level. On the other hand, the FD index (excluding exports) is constructed by aggregating only prices of goods and services covered by the CGPI, the SPPI and the CPI. As a result, the abovementioned effects of changes in the wage levels in the services sectors are not included. Meanwhile, in 2016, when significant volatility was observed in international commodity markets and exchange markets, changes in the wage levels remained moderate compared with changes in prices of goods (Figure 18 (2)). Presumably, that is why the deflator for domestic demand, which is prone to the effects of changes in the wage levels in services sectors showed smaller volatility than the FD index (excluding exports). As indicated above, when the FD index (excluding exports) is used as a substitute for the deflator for domestic demand, it should be kept in mind that there are some differences in the scopes of the two indicators.[30, 31]

....

30. The differences in scope between the GDP deflator and the FD-ID price index have been pointed out in the United States, too. For detailed information see Weinhagen (2014).

31. In addition, the GDP deflator and the FD index are different in terms of the index calculation formula as well. Namely, the GDP deflator, which is implicitly calculated by dividing nominal GDP by real GDP also has characteristics of a chain index because the basic unit deflator used to calculate GDP in real terms is constructed by integrating price indexes, including the CGPI, the SPPI, and the CPI, through the Fisher-type chain-linking method. In contrast, the FD index is constructed by aggregation through the fixed-base Laspeyres formula. It has been generally pointed out that a fixed-base Laspeyres formula is prone to an upward bias compared with the Fisher-type chain-linking method, which is considered to be an ideal method, because it does not take into consideration the effects of a volume decrease (volume increase) for commodities whose prices are rising (falling). Even so, at least in the period since 2015, for which the FD index was constructed in this study, such bias is not conspicuously visible. For detailed information on the characteristics of the abovementioned index calculation methods, see the PPI Manual (International Labour Organization *et al.* [2004]).

Figure 18 Comparison with GDP Deflator



Note: Wage Indices of Contractual Cash Earnings is calculated based on all industries, total employment type, and establishments with 5 or more employees in the Monthly Labor Survey.
Sources: Cabinet Office; Ministry of Health, Labour and Welfare.

D. Comparison with the CPI

As mentioned in Section II, the PPI comprehensively covers goods and services traded in all demand stages, and its scope includes the scope of the CPI, which is limited to goods and services consumed by households as a part of final demand. As a result, it is possible to construct a price index with a scope similar to the scope of the CPI by aggregating only price indexes for goods and services intended for personal consumption selected from among the component indexes of the FD index.We call the index constructed in this way the Personal Consumption Index (PCI).[32, 33]

Below, we look at similarities between the CPI and the PCI. A trend comparison shows that the CPI (all items, less fresh food and energy) and the PCI (all commodities, less imports, fresh food, and energy) follow similar trends (Figure 19). In terms of the rate of year-on-year change, there is little difference between the trends of the two indexes. This finding is not surprising given the similarity between the scope of the PCI constructed in this study and the CPI.

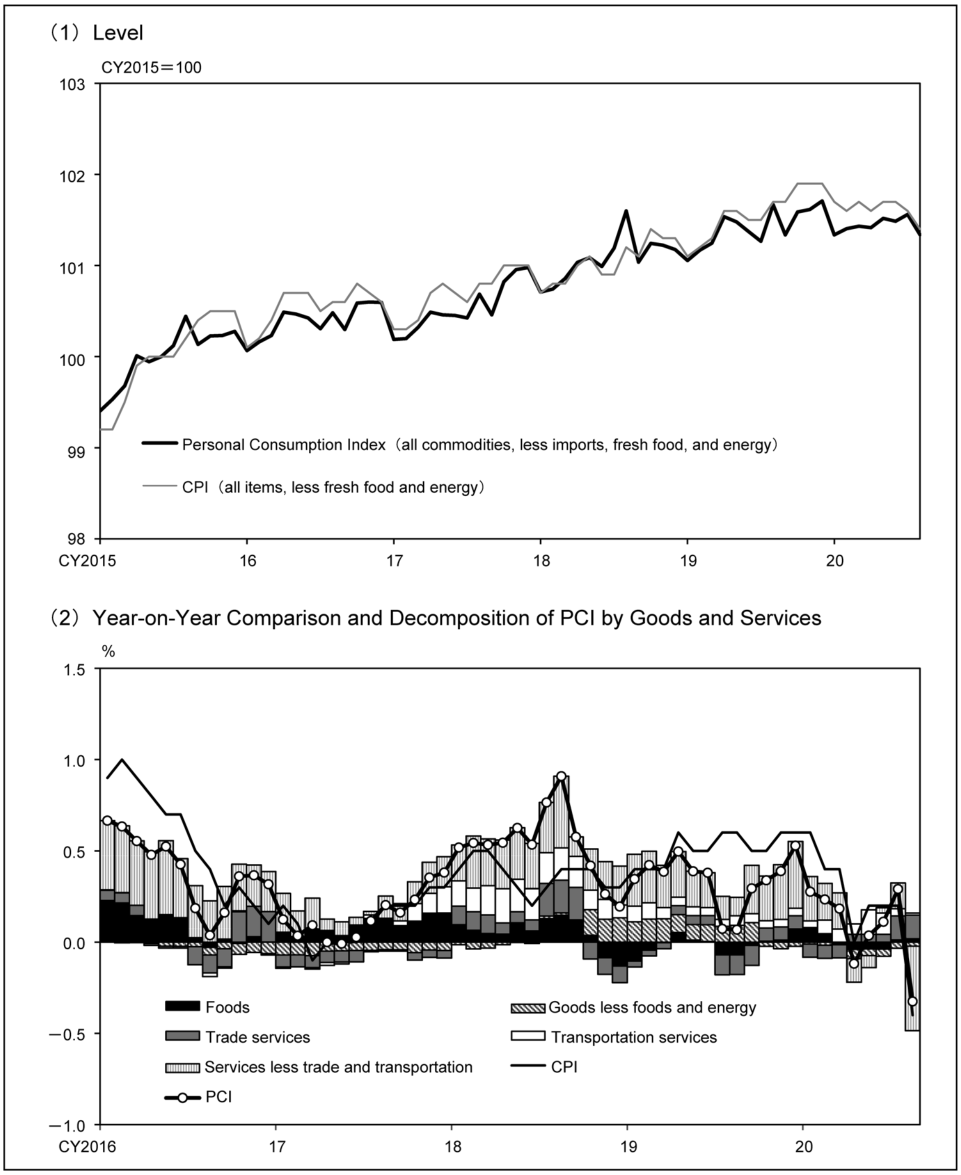
It should be noted that in a sense, the PCI enables us to look at the underlying factors of price changes in the stage of household consumption from a viewpoint different from the CPI. The CPI captures retail prices (purchasers prices) actually faced by consumers with respect to specific goods and services, and therefore, in the case of goods in particular, the price trend is affected not only by changes in prices of goods themselves but also by changes in commercial and transportation margins. On the other hand, the PCI captures producer prices for goods and services, so it is possible to individually identify contributions of goods themselves and margins to price changes through a commodity-by-commodity breakdown.

If we look at the breakdown of contributions to the rate of year-on-year change in the PCI (all commodities, less imports, fresh food, and energy) in detail from this viewpoint, while the index's trend since 2016 can be explained in most part by changes in prices of goods and services, the positive contributions of commercial and transportation margins were visible relatively clearly when the rate of year-on-year increase was rising in 2018. Presumably, this reflects rises in wholesale margins and charges for road freight transportation at that time that came with increases in prices of goods amid robust domestic demand.

32. A detailed comparison between the CPI and the PCI constructed in this study shows that the main difference lies in the treatment of "imputed rent of owner-occupied dwellings." Namely, the CPI includes imputed rent of owner-occupied dwellings, as emphasis is placed on the CPI's nature as a cost-of-living index. On the other hand, in the case of the PCI, emphasis is placed on the index's nature as a PPI and, therefore, imputed rent of owner-occupied dwellings, which is a non-marketable product, is excluded based on the approach described in Footnote 3.

33. Regarding goods, the PCI as referred to here represents an aggregation of price indexes for domestic goods alone, excluding import goods. The CPI covers transactions not only for domestic goods but also for import goods in the stage of household consumption. Therefore, it may be assumed that the PCI including imports, namely an index integrating prices of domestic goods with retail prices for import goods, which represent import prices before margins plus commercial and transportation margins added in the domestic transaction, is more suitable to be compared with the CPI. However, yen-denominated import prices fluctuate widely due to the effects of exchange rate volatility because the share of foreign currency-denominated transactions in Japan's overall imports is very high (foreign currency-denominated transactions account for 74% of all transactions covered by the IPI all commodities index [as of the end of 2019]). In the short term, the effects of exchange rate volatility may be partially absorbed by changes in commercial and transportation margins and therefore may not necessarily be directly reflected in retail prices of import goods. However, this study does not necessarily verify the linkage between import goods prices before margins and retail prices to a sufficient extent because no retail service price index serving as a producer price index exists in Japan. In light of this point, here, this study focuses on domestic goods, whose weight is large, and compares the PCI (excluding imports) with the CPI.

Figure 19 Comparison with CPI



Note: PCI and CPI exclude consumption tax.
Source: Ministry of Internal Affairs and Communications

VII. Analysis regarding the Transmission of Inflationary Pressures Using the FD-ID Price Index

As explained until now, the construction of the FD-ID price index in this study is intended to express the forward production flow in the entire Japanese economy based on detailed classification of goods and services by demand stages at the commodity-level and to accurately identify the transmission of inflationary pressures between different stages of demand. This section provides a brief analysis concerning the transmission of inflationary pressures between stages of intermediate and final demand using a vector auto regression (VAR) model as an example of analysis for the purpose of examining whether the constructed index actually performs the abovementioned intended functions.

A. Overview of a VAR Analysis

As mentioned in Section IV, the FD-ID price index constructed in this study captures most of the total output in Japan in value terms (84.5%) as forward flow through optimized classification of goods and services by stage of intermediate demand. As a result, most of the outputs of goods and services assigned to Stage 2 intermediate demand, for example, are used as inputs for production of goods and services in Stages 3 and 4, which come downstream in the production flow, or used for final demand, whereas only a very tiny portion is used as input in the upstream Stage 1. Therefore, if it is assumed that companies pass changes in their own input cost onto output prices of their products, a shock to prices in each demand stage under the FD-ID price index system is expected to transmit to downstream stages, whereas transmission to upstream stages should be limited. Here, in order to examine whether or not the constructed FD-ID price index performs their intended functions, we build a VAR model using the FD index and ID indexes for their corresponding stages and quantitatively identify the process of transmission of shocks between different stages of demand.

In the VAR model used in this section, indexes that exclude the effects of exports and imports are adopted as endogenous variables for analysis in order to focus on the transmission of inflationary pressures through production activity in domestic sectors in Japan (Figure 20). Namely, regarding the ID indexes, only those for domestic goods and services are used with respect to each stage. To be more specific, the ID indexes for domestic commodities included in Stages 2, 3, and 4 (hereinafter referred to as "DID2," "DID3," and "DID4," respectively) are used. The ID index for Stage 1 is excluded from the model because, as described in Section V, its trend depends in most part on import prices of raw materials and because the trend for domestic goods in Stage 1 alone has no material effects on prices in downstream stages in the production flow.[34] As for the FD index, those that exclude exports and imports are used (DFD). In addition, in order to incorporate exogenous changes in import prices into the model, the indexes for imports in Stages 1, 2, 3, and 4 (hereinafter referred to as "IID1," "IID2," "IID3," and "IID4," respectively) are used as exogenous variables in the VAR model.

The variables are seasonally adjusted, and in order to ensure stationarity, month-to-month logarithmic change in each variable is used for analysis. As for the number of lags for the VAR model, one lag is adopted based on Akaike's Information Criterion (AIC). Regarding the ID index for imports, which is an exogenous variable, the values at no lag and at one lag, for which there is a strong lag correlation with the endogenous

....

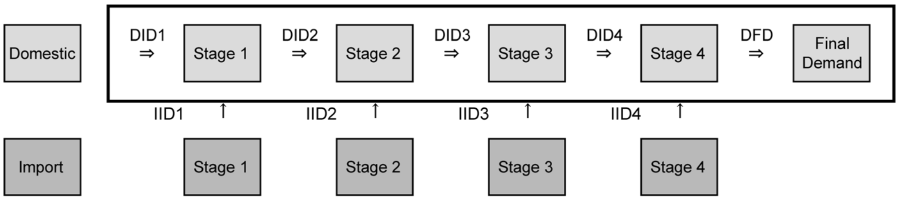
34. This formularization was adopted in reference to the analysis of a previous study using the U.S. FD-ID price index. Weinhagen (2016), using a VAR model comprising four variables—ID indexes for Stages 2, 3 and 4, and an FD index—confirmed that the shock of price changes in each stage has a more significant impact in downstream stages. This finding is consistent with the analysis results obtained for this study, which will be mentioned later.

Figure 20　VAR Analysis of Transmission of Inflationary Pressures

（1）Overview and Objective

- VAR model is used to check whether or not the constructed FD-ID price index tracks transmission of inflationary pressures in line with domestic production flow as intended.
- The domestic indexes (DID2, DID3, DID4, DFD) are adopted as endogenous variables while the import indexes (IID1, IID2, IID3, IID4) are adopted as exogenous variables.
- Each variable is seasonally adjusted month-to-month logarithmic change. For the lag length in VAR, one lag is selected by AIC.
- Structual model is estimated through a Cholesky decomposition (the ordering is: DID2→DID3→DID4→DFD).

（2）Structure of FD-ID Price Index



（3）Regression Equation（Ex: DFD）

$$DFD_t = \varphi_1 \cdot DID_{2,t-1} + \varphi_2 \cdot DID_{3,t-1} + \varphi_3 \cdot DID_{4,t-1} + \varphi_4 \cdot DFD_{t-1} \quad \Big\} \ \boxed{\text{Endogenous Variables}}$$

$$+\sum_{i=0}^{1}(\varphi_{5,i} \cdot IID_{1,t-i} + \varphi_{6,i} \cdot IID_{2,t-i} + \varphi_{7,i} \cdot IID_{3,t-i} + \varphi_{8,i} \cdot IID_{4,t-i}) \quad \Big\} \ \boxed{\text{Exogenous Variables}}$$

variables, are taken into consideration. However, variables for which the sign condition is negative in all regression equations under the VAR model are considered to be not explanatory as an exogenous variable and are therefore excluded from the model. As a result, as an exogenous variable in the regression equation, the value at no lag with the endogenous variables is adopted with respect to IID4, the value at one lag with respect to IID2, and the values at no lag and at one lag with respect to IID1 and IID3.

As the analysis in this section places emphasis on examining the interactions between indexes for different demand stages, variables that represent macro-level supply-demand trends are not incorporated into the model. The estimation period is from March 2015 to March 2020. As the period covered by the FD-ID price index is limited, parameters are lacking in stability if the most recent data, which are considered to reflect the effects of the COVID-19 pandemic, are included in the estimation. Therefore, the period from April 2020 onward is excluded from the estimation period.

B. Impulse Responses

First, the impulse responses are calculated in order to identify shocks to prices in the respective stages of demand and examine how the shocks are transmitted between different demand stages. Shocks are identified through a Cholesky decomposition, and the ordering of the decomposition is: DID2 → DID3 → DID4 → DFD. This ordering of the Cholesky decomposition has been chosen in light of the fact that sectors of goods and services are assigned to stages in such a way that the FD-ID index price proposed in this study expresses the forward production flow, from upstream to downstream stages of intermediate demand, and ultimately to the stage of final demand.

According to the estimation results of accumulated impulse response functions, generally speaking, a shock to prices in each stage of demand has a statistically significant impact on more downstream stages of demand, whereas the impact on upstream stages are not necessarily significant (Figure 21). For example, in the case of the ID index for Stage 2 (DID2), which is the most upstream stage under the model, the transmission of price changes up from downstream stages is limited, reflecting the tiny amount of inputs of goods and services from those stages. On the other hand, in the case of the FD index (excluding exports and imports) (DFD), which corresponds to the stage of final demand, a broad range of goods and services are included in more upstream stages, and therefore, this index is presumed to be affected by price changes transmitted from the various stages of intermediate demand (DID2, DID3, and DID4). Meanwhile, the response to a shock that arises in each stage of demand is strongest in the next downstream stage and tends to become weaker in further downstream stages.

The above results indicate the appropriateness of the classification of goods and services by stage of intermediate demand that resulted from the maximization of net forward flow (NFF) in the production flow. It also suggests that the FD-ID price index constructed in this study can accurately capture the transmission of inflationary pressures from upstream to downstream stages of intermediate demand and ultimately to the stage of final demand.

C. Historical Decomposition

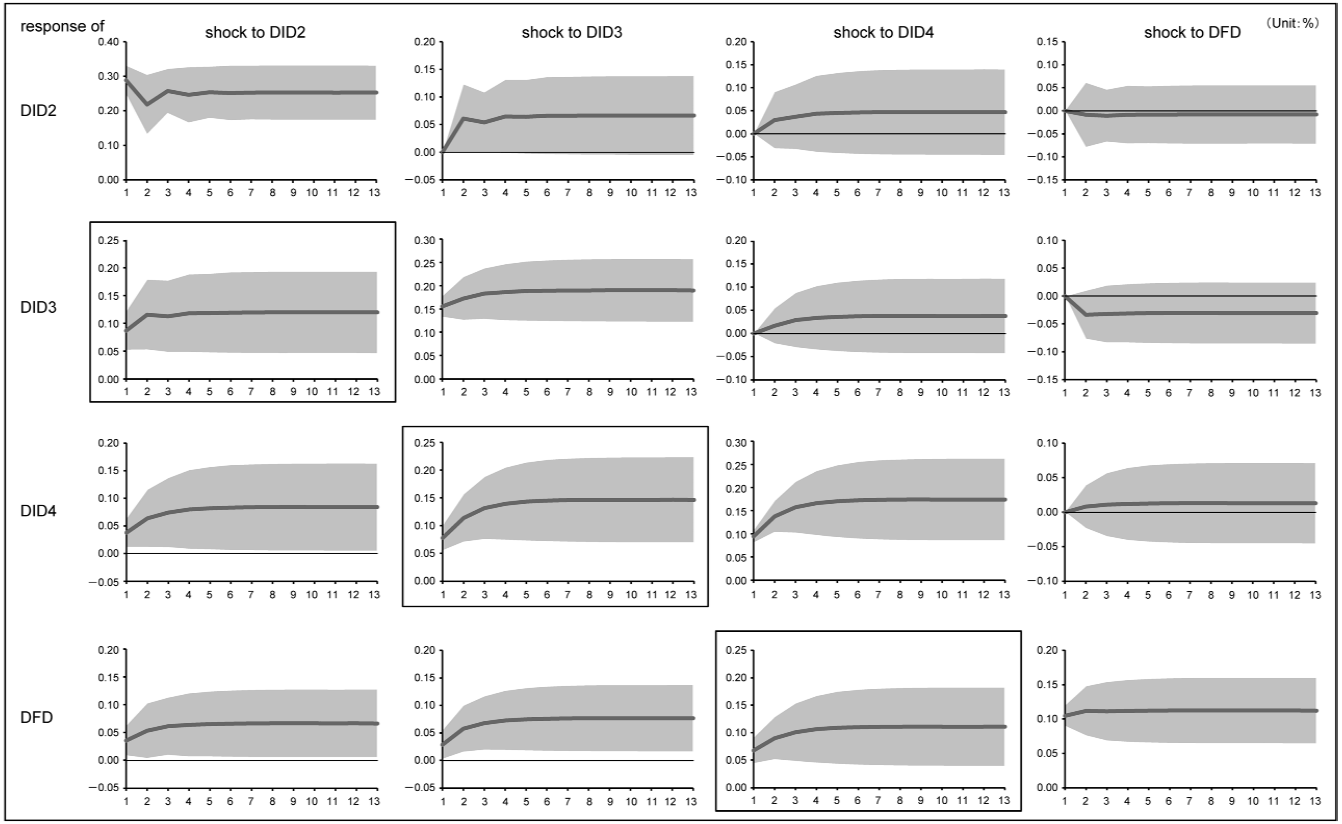
Next, we review the background to changes in the indexes for the different demand stages by conducting historical decomposition based on the abovementioned impulse responses.[35]

A decomposition of changes in the indexes into contributions from the domestic price shock (shock to the endogenous variable) and the import price (exogenous variable) in each of the four demand stages shows that in a price-falling phase in 2016, the import price effect was the main factor in all four stages (Figure 22). In particular, regarding Stages 2 and 3, which are relatively upstream in the production flow, it is noteworthy that the price trends for domestic commodities consumed there can be explained almost entirely by the import price effect.

In a price-rising phase in 2017 through the middle of 2019, regarding the ID indexes for Stages 2 and 3, the rate of year-on-year price increase first turned positive following an import price rise, and subsequently, the positive contribution of shocks to domestic prices within the same stage gradually increased. Regarding the ID index for the relatively downstream Stage 4 and the FD index, while the positive contribution of the import price effect to the rate of year-on-year price increase has generally remained

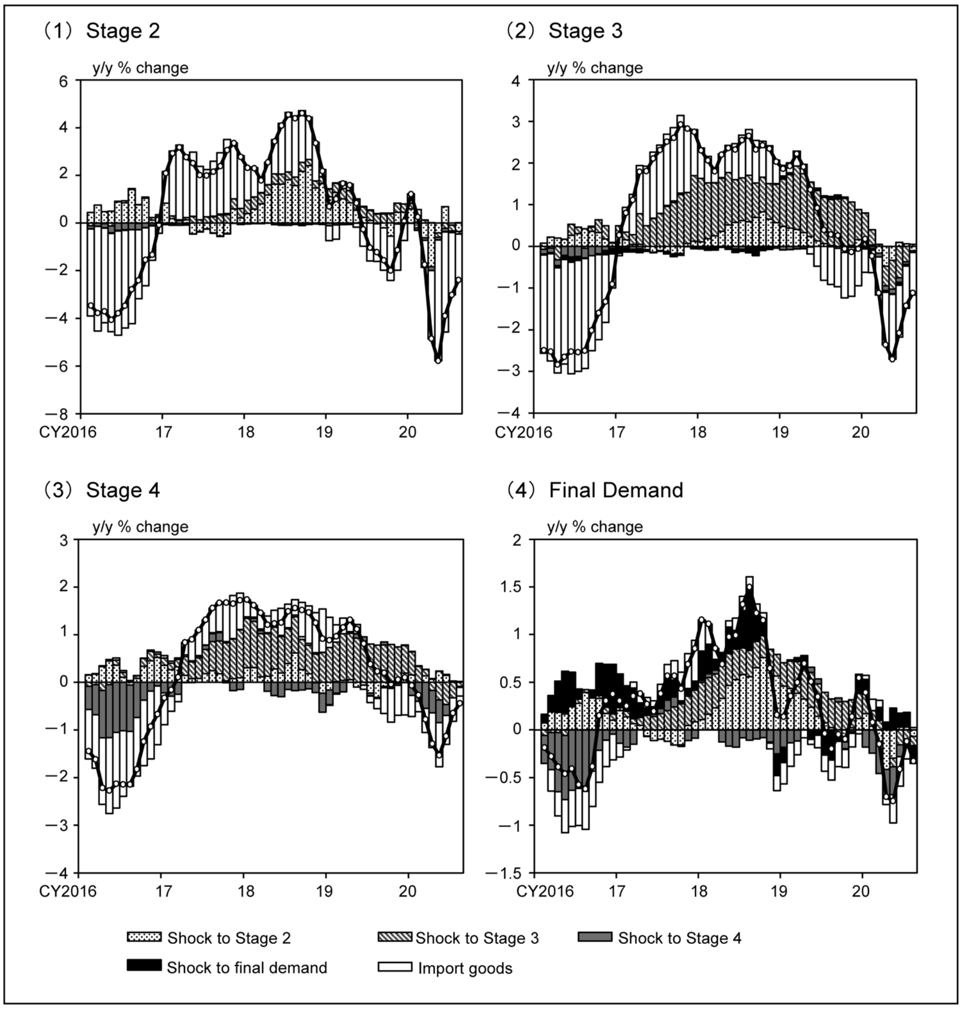
35. Specifically, month-to-month logarithmic differences regarding the indexes for the different demand stages are decomposed into contributions from the identified four shocks and the import price effect. In Figure 22, the results show trends similar to year-on-year changes because contributions made on a month-to-month logarithmic difference basis are measured in terms of accumulation in the previous 12 months. Therefore, the starting point of the decomposition is set at February 2016. Here, a historical decomposition is conducted extrapolatively by applying parameters obtained for the estimation period from March 2015 to March 2020 to data for the period from April 2020 onward.

Figure 21 Accumulated Impulse Response Functions



Note: These are accumulated impulse responses of one standard deviation shock. The bands represent 90 percent confidence interval.

Figure 22 Historical Decomposition



in a certain range, upward shocks on domestic prices mainly in Stages 2 and 3 of intermediate demand became the main factor of the overall uptrend. Looking at the shares of goods and services as components of the index for each stage of demand, we can see that the share of services is relatively large in Stage 2, whereas the share of goods excluding food and energy is relatively large in Stage 3 (Figure 23). This suggests the possibility that in the price-rising phase from 2017 onward, some kind of factors common to a broad range of goods and services consumed in the stages of intermediate demand may have contributed to the trends of the indexes for those stages.

Later, in the period from the second half of 2019, the contribution of the import price effect turned negative following falls in international commodity prices in all stages of demand, and since then, both the import price effect and the domestic price shock have recently made negative contributions to the rate of year-on-year price increase because of the effects of the COVID-19 pandemic as well.

The results of the decomposition regarding the stage of final demand in the same period confirm that the price volatility is attributable in large part to the transmission of price shocks that occurred in the stages of intermediate demand. This suggests that the mechanism of price change transmission from upstream to downstream stages in the production flow, which the FD-ID price index is intended to capture, is very important for price changes in the stage of final demand in Japan.

VIII. Concluding Remarks

This study first explained the challenges for the Japanese PPI as an aggregate price index ((i) integrating prices of goods and services and (ii) multiple counting problem) and then described the construction of the Japanese FD-ID price index and provided a brief analysis concerning the characteristics of the index.

The calculation results of the FD-ID price index in this study can be summed up as follows. First, the FD index (excluding exports and imports), which is constructed by integrating prices of goods and services in the stage of final demand in Japan, shows a trend mostly consistent with the macro-level supply-demand condition in the entire Japanese economy, as its scope is limited to prices of goods and services in the stage of final demand. Second, the FD index (excluding exports and imports) shows a stable trend compared with the all commodities index that serves as the headline index of the current PPI because it appropriately excludes the effects of the multiple counting problem, among other reasons. Third, looking at the ID indexes constructed based on the division of the intermediate demand category into four stages in accordance with the production flow of the IO table, we can see that prices in upstream stages are more volatile due to the strong effects of price changes of import goods. On the other hand, those effects are absorbed stage by stage as the production process moves on, and in the most downstream stage of intermediate demand, which is the closest to the stage of final demand, it is clear that the effects of price changes of domestically produced goods and services are predominant.

These characteristics are considered to greatly increase the usefulness of the Japanese PPI in that they enable the Japanese FD-ID price index constructed in this study to (i) perform the function of tracking the supply-demand condition for goods and services in the entire country in an integrated manner and (ii) track the process of price changes being transmitted from upstream to downstream stages in the production flow through precise classification by demand stages. In addition, the FD-ID price index may be useful as a speedily available indicator compared with the GDP deflator, and it is also considered to be different from existing price indexes in that it can capture changes in prices of goods and services in the stage of final demand not only from the viewpoint of purchaser's prices, as is the case with the CPI, but also from the viewpoint of producer prices.

As explained above, the FD-ID price index has the potential to increase the usefulness of the PPI in various aspects, and there is room for expanding the scope of its usage in the future. In particular, in Japan, when tracking the macro-level price trend, attention tends to focus on price indexes for the stage of final demand, such as the

Figure 23 Shares of Goods and Services as Components of Index for Each Stage of Intermidiate Demand

		Stage 1	Stage 2	Stage 3	Stage 4
Goods		41.5%	30.9%	56.4%	52.9%
	Foods	1.8%	2.4%	9.5%	6.4%
	Energy	7.9%	10.0%	7.5%	5.5%
	Goods less foods and energy	31.8%	18.4%	39.4%	41.0%
Services		58.5%	69.1%	43.6%	47.1%
	Trade services	6.9%	8.3%	7.0%	10.0%
	Transportation services	12.0%	6.1%	5.7%	4.8%
	Services less trade and transportation	39.6%	54.7%	30.9%	32.4%

Note: These are calculated based on domestic goods (excluding imports).

CPI and the GDP deflator. However, from the viewpoint of understanding the price change mechanism, it is also important to clarify how price changes are transmitted from upstream to downstream stages in the production flow. On this point, one possible approach is to enhance quantitative analysis using a time-series model—an example of analysis was shown in Section VII—by taking advantage of the comprehensive scope and precise classification by demand under the FD-ID aggregation system. For the moment, the analysis in this study examined the interactions between the indexes for the different demand stages using a simple VAR model. However, as the pool of accumulated time series data is small, there are still remaining problems regarding the verification of the robustness of estimated parameters and identified shocks, for example. In the future, it is desirable to expand the scope of analysis by adopting additional variables regarding the macro-level supply-demand condition and other factors and to continue a multi-faceted examination of the characteristics unique to each stage of demand that have been identified through the FD-ID price index.

APPENDIX: PROVISIONAL STAGE ASSIGNMENT AND NFF CALCULATION

This appendix provides detailed explanation into the process for provisional stage assignment of each intermediate demand sector in the IO table and NFF calculation under the assignment with numerical example, which is one of the processes for stage assignment by demand stage described in Section IV.C.

The following matrix shows the IO table under the assumption that a whole economy is composed of eight goods and services sectors from A to H (Figure A-1). In other words, the columns are divided into eight demand sectors and final demand while the rows are composed of eight production sectors. The following explains how to assign each sector to stages and calculate NFF with the case where the value of the cut-off variables are fixed at: X=70, Y=65, and Z=60, which are finally adopted in this study (Figure A-2).

[Step 1]
The sectors whose output value to final demand is the cut-off variable X=70% or more are assigned to Stage 4.

[Step 2]
The sectors whose total output value to final demand and Stage 4 is the cut-off variable Y=65% or more are assigned to Stage 3.

[Step 3]
The sectors whose total output value to final demand, Stage 4, and Stage 3 is the cut-off variable Z=60% or more are assigned to Stage 2.

[Step 4]
The remaining sectors are assigned to Stage 1.

[Step 5]
The matrix is re-composed with the rows and columns respectively sorted by the order of the stage each sector assigned to, and then NFF is calculated under this matrix as follows (Figure A-3);

The above steps from [Step 1] to [Step 5] are repeatedly tested with 729 combinations of the values of cut-off variables (X, Y, and Z) with a grid search in increments of 5 points within the range of $50 \leqq X, Y, Z \leqq 90$, which enables to compare the value of NFF between each of the cases.

Figure A-1 An Economy Composed of Eight Sectors (Numerical Example)

	Value of inputs								
	Sector A	Sector B	Sector C	Sector D	Sector E	Sector F	Sector G	Sector H	FD
Sector A	5	30	5	10	5	10	5	10	20
Sector B	10	10	25	5	0	5	20	20	5
Sector C	0	5	10	20	10	0	20	5	30
Sector D	0	0	0	0	0	5	5	10	80
Sector E	30	20	10	15	10	0	5	0	10
Sector F	0	5	10	15	0	10	25	10	25
Sector G	5	0	5	0	0	5	5	10	70
Sector H	5	0	10	20	25	10	25	5	0

Figure A-2　Process for Provisional Stage Assignment

[Step 1]

	Rate of inputs to FD
Sector A	20%
Sector B	5%
Sector C	30%
Sector D	80%
Sector E	10%
Sector F	25%
Sector G	70%
Sector H	0%

[Step 2]

	Rate of inputs to FD and stage 4		
		FD	Stage 4 (D+G)
Sector A	35%	20%	15%
Sector B	30%	5%	25%
Sector C	70%	30%	40%
(Done) Sector D			
Sector E	30%	10%	20%
Sector F	65%	25%	40%
(Done) Sector G			
Sector H	45%	0%	45%

[Step 3]

	Rate of inputs to FD, stage 4, and stage 3			
		FD	Stage 4 (D+G)	Stage 3 (C+F)
Sector A	50%	20%	15%	15%
Sector B	60%	5%	25%	30%
(Done) Sector C				
(Done) Sector D				
Sector E	40%	10%	20%	10%
(Done) Sector F				
(Done) Sector G				
Sector H	65%	0%	45%	20%

[Step 4]

	Rate of inputs to the other stages				
		FD	Stage 4 (D+G)	Stage 3 (C+F)	Stage 2 (B+H)
Sector A	90%	20%	15%	15%	40%
(Done) Sector B					
(Done) Sector C					
(Done) Sector D					
Sector E	60%	10%	20%	10%	20%
(Done) Sector F					
(Done) Sector G					
(Done) Sector H					

Figure A-3 Calculation of NFF

		Stage 1		Stage 2		Stage 3		Stage 4		FD
		Sector A	Sector E	Sector B	Sector H	Sector C	Sector F	Sector D	Sector G	
Stage 1	Sector A	5	5	30	10	5	10	10	5	20
	Sector E	30	10	20	0	10	0	15	5	10
Stage 2	Sector B	10	0	10	20	25	5	5	20	5
	Sector H	5	25	0	5	10	10	20	25	0
Stage 3	Sector C	0	10	5	5	10	0	20	20	30
	Sector F	0	0	5	10	10	10	15	25	25
Stage 4	Sector D	0	0	0	10	0	5	0	5	80
	Sector G	5	0	0	10	5	5	0	5	70

NFF = (+) − (+) = 650

References

Berry, Francien, Brian Graf, Michael Stanger, and Mari Ylä-Jarkko, "Price Statistics Compilation in 196 Economies: The Relevance for Policy Analysis," IMF Working Papers No. 19/163, International Monetary Fund, 2019.

Bureau of Labor Statistics, "2002 BEA Data Analysis for the Development of the Experimental PPI Aggregation System," Bureau of Labor Statistics, 2011.

Hergt, Brian, Joseph Kowal, and Jonathan C. Weinhagen, "Analyzing Price Movements within the Producer Price Index Final Demand-Intermediate Demand Aggregation System," *Monthly Labor Review*, January 2014, Bureau of Labor Statistics, 2014.

International Labour Organization, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations Economic Commission for Europe, and World Bank, eds. "Producer Price Index Manual: Theory and Practice," International Monetary Fund, 2004.

Weinhagen, Jonathan C., "A New, Experimental System of Indexes from the PPI Program," *Monthly Labor Review*, February 2011, Bureau of Labor Statistics, 2011.

———, "Comparing New Final-Demand Producer Price Indexes with Other Government Price Indexes," *Monthly Labor Review*, January 2014, Bureau of Labor Statistics, 2014.

———, "Price Transmission within the Producer Price Index Final Demand-Intermediate Demand Aggregation System," *Monthly Labor Review*, August 2016, Bureau of Labor Statistics, 2016.