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Pass-Through of Cost-Push Pressures to Consumer Prices[*]

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Abstract

Costs of intermediate inputs as well as those for product procurement facing Japanese firms have been rising markedly against the backdrop of international commodity price increases and of the depreciation of the yen, as global economy recovers from the COVID-19 pandemic. In this paper, we quantitatively measure the so-called "pass-through rate" — that is, the impact of an increase in cost-push pressures on consumer prices (namely, prices at the final demand stage) — and examine the recent changes and their context. The estimation results yield the following two implications. First, the exchange rate pass-through rate has been increasing in recent years reflecting higher import penetration. Second, the pass-through rate of raw material and other costs, excluding those attributable to exchange rate, have somewhat increased at the intermediate demand stage and even for some items at the final demand stage. Since the pass-through rates depend on: (i) the strength of cost-push pressures; (ii) the business cycle; and (iii) the tightness of demand and supply condition due partially to the pandemic, their developments should be monitored closely.

JEL classification: E30, E31, F31

Keywords: Cost-Push Pressures, Intermediate Input Costs, Exchange Rates, Consumer Prices, Pass-Through, COVID-19

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1. Introduction

The impact of cost-push pressures on prices is one of the most important issues affecting inflation dynamics. This effect can be gauged as the product of the amount of change in the cost and the degree to which the cost is passed on to the price (the so-called "pass-through rate"). In considering the trends and future developments in prices, it is essential to accurately grasp the change in cost and, on that basis, monitor the pass-through rate, which reflects the price-setting behavior of Japanese firms.

Recent developments in input costs in Japan are highlighted by higher intermediate input costs and higher exchange rate volatility. After a substantial decline during the early stages of the COVID-19 pandemic in 2020, international commodity prices have turned to follow a markedly increasing trend reflecting the rapid recovery of global demand and supply side constraints. Meanwhile, amidst the recovery from the pandemic, the exchange rate of the yen has been on a depreciation trend, partly due to the difference in the monetary policy directions in other countries. Against this backdrop, intermediate input costs and procurement costs of imported products have clearly increased and, as a result, the cost-push pressures on consumer prices have also been steadily rising. In order to assess the current price situation, as well as to forecast future price developments under these circumstances, it is of critical to quantify cost-push pressures and pass-through rates and to examine their movements and driving forces behind such movements. [1]

Against this background, this paper presents analyses on the impact of the recent increase in the cost-push pressures, triggered by the changes in raw material costs and exchange rates, on consumer prices. Specifically, first, based on the input-output table, we calculate the intermediate costs as the cost-push pressures facing Japanese firms in their production activities. Second, we estimate the pass-through rate of raw material and other costs and that of exchange rates (henceforth, we refer to the former as the "material cost pass-through" and the latter as the "exchange rate pass-through"). The estimation explicitly takes into account that exchange rates affect the cost of imported consumer goods as well as the intermediate input cost of firms. In addition, we estimate and analyze the time-series change in the pass-through rates. Third, we examine the recent situation concerning the pass-through of cost-push pressures for each stage of demand, from upstream to downstream stages. This paper is unique in two ways which will make a contribution to this field of research—through its proposal for an accurate measure of cost-pressures based on the input-

[1] In the analysis of price developments, the cost-push pressures through the wage channel and their impact on consumer prices, called wage pass-through, are also important topics. For literature discussing these topics, see, for example, Bobeica *et al.* (2021) and Koester *et al.* (2021).

output structure; and that it examines the pass-through by stage of demand.

The remainder of the paper is organized as follows. Section 2 reviews existing research, conducted both in Japan and abroad, on pass-through. Section 3 presents the estimation of the pass-through rates in Japan. Section 4 examines the characteristics of the recent developments in the pass-through. Section 5 describes the issues concerning price developments post-pandemic, which are deemed important from the perspective of the pass-through of cost-push pressures. The analyses in this paper are based on the data available in May 2022. Section 6 concludes.

2. Literature review

Looking at the literature on the pass-through in Japan, the view on pass-through rates has changed throughout the 2000s.

To begin with, many of the studies which use data through the 2000s report that both the exchange rate pass-through rate and the material cost pass-through rate decline throughout the sample period due to the intensified international competition.[2]

With respect to the exchange rate pass-through, Taylor (2000) argues that intensified international competition and stable low inflation made it difficult for firms to pass on the change in exchange rate to prices. The results from some of the empirical studies which analyze countries, including Japan, are as follows. In their study using the data for 23 OECD countries during the period between 1975 and 2003, Campa and Goldberg (2005) state the exchange rate pass-through rate declined in major countries including Japan and the United States. Sekine (2006) also finds that the pass-through rate in Japan followed a declining trend from 1974 to 2004 as a result of more firms absorbing the cost of exchange rate fluctuations amidst the intensified international competition. Otani *et al.* (2003, 2006) further confirm this trend using the data for the period between 1978 and 2002; they argue that the rise in the overseas production ratio and the associated increase in intra-firm trade are behind the

[2] Many studies find that the exchange rate pass-through declined in countries other than Japan as well during the 1980s and the 2000s (Campa and Goldberg (2005), McCarthy (2007), Takhtamanova (2010), Shintani *et al.* (2013), etc.). The material cost pass-through is also reported to have dropped during the same period (Hooker (2002), De Gregorio *et al.* (2007), Chen (2009), Clark and Terry (2010), Choi *et al.* (2017]), etc.). Intensified international competition is referred to as one of the factors behind such declines. While the number of studies on pass-through in countries other than Japan is quite limited in recent years, Forbes *et al.* (2017) and Forbes (2019) touch on the possibility that both the exchange rate pass-through and the material cost pass-through are rising in some advanced economies due to the globalization. On the other hand, Ortega and Osbat (2020), for example, discusses the possibility that the exchange rate pass-through rate in Europe has remained the same at the low level.

decline in exchange rate pass-through in this period, since the change in the exchange rate is less often passed on to transaction prices in the case of intra-firm trade. Shioji (2012) reports that the rate of exchange rate pass-through to import prices or domestic corporate goods prices declined during 1980 and 2010.

Meanwhile, regarding the material cost pass-through, Sekine (2006) discusses the impact of commodity prices on consumer prices. Specifically, he finds that the material cost pass-through also declined up until the mid-2000s, reflecting the cautious attitudes of firms towards price setting against the background of intensified international competition and stable low inflation. In their analysis using the data from 1976 to 2009, Shioji and Uchino (2010) show that the pass-through rates from oil prices to import prices and from import prices to consumer prices has declined since the 1990s. Furthermore, De Gregorio *et al.* (2007) and Chen (2009), both of which analyze the pass-through globally including Japan, state that the material cost pass-through has declined since the 1980s.

Since then, some studies have re-examined the exchange rate pass-through in Japan by extending the data through to the mid-2010s. Many of these studies find that the exchange rate pass-through has turned to an upward trend due to an increase in the import penetration rate of durable goods. Using the data from 1970 to 2013, Shioji (2014) finds that the exchange rate pass-through rate has been increasing since the latter half of the 2000s. Focusing on the production cost structure of Japanese firms, he argues that the increase in the share of imported goods in the total production costs since the early 2000s has led to this increase. In their analysis using the data for the period between 1982 and 2014, Hara *et al.* (2015) state that the exchange rate pass-through rate has trended upwards after a consistent decline ending in around 2000; the increase in the import penetration rate and the change in the price setting behavior of firms are pointed out as potential reasons for the end of the decline. The Bank of Japan (2016) conducts an analysis using the data from 1990 to 2016, finding that the exchange rate pass-through rate has been rising as a result of the marked increase in the import penetration rate — namely, that of home electrical appliances — in the 2010s. Forbes (2019) also notes that the exchange rate pass-through has picked up since the Global Financial Crisis.

On the other hand, there is only a limited number of studies on the material cost pass-through since the 2010s. One of the few studies is that by Shioji (2014). Although Shioji refers to the possibility that the impact of import prices on consumer prices increased towards the mid-2010s, the results are not necessarily statistically significant.

In sum, major empirical studies on pass-through in Japan are based on analyses using the data through to the mid-2010s and, thus, the data for the period after the outbreak of the

COVID-19 pandemic have yet to be utilized. This paper will make an important contribution to the area of pass-through, particularly of material costs where, to the best of our knowledge, studies are limited since the 2010s.

3. Estimation of pass-through rates

3.1. Calculation of the intermediate input cost index

In this paper, we calculate the 'intermediate input cost index' in order to measure upward pressure on costs including those for materials through the following two steps.[3] First, based on the transaction structure in the input-output tables, we calculate the intermediate input cost for each industry by multiplying the input prices (import prices, producer prices, etc.) of various goods and services by their respective input shares in each industry.[4] Second, we aggregate the industry-level intermediate input costs using the shares of each industry's goods and services in household consumption expenditure as weights and, thereby, calculate the intermediate input cost index which corresponds to the consumer price. In estimating the pass-through rates, many of the past studies focus on the relationship either between oil prices and consumer prices or between import prices and consumer prices. The approach of this paper has an advantage, however, in that the impact of the change in aggregate input costs (including wages and transportation costs) faced by all industries on consumer prices can be captured in a comprehensive manner. Moreover, by limiting the items which are subject to aggregation, the pass-through rate can also be estimated by major division of consumption (e.g., food, durable goods, etc.). In this paper, we calculate the intermediate input cost indices for both Japan and the United States for the period since 2000.[5]

The intermediate input cost index of Japan is increasing at a faster pace than it did during the phase of rising commodity prices in the latter half of the 2000s, reflecting the recent increase in the prices of energy, food including grains, and metals (Chart 1). Note that the degree of positive contribution of services, which are strongly affected by wages, is small. In other words, current cost-push pressures in Japan are so far mainly stemming from material cost increases and the depreciation of the yen and are only weakly attributable to wages. On the other hand, the increase in the intermediate input cost is much larger in the United States than in Japan. The source of this difference can be found in the fact that the

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[3] See also the Bank of Japan (2021, 2022).

[4] We use the values in the 2015 Input-Output Tables to calculate input shares and household consumption expenditure weights for the entire period since 2000.

[5] The index covers intermediate input costs for consumer goods (excluding fresh food and energy) and services for Japan and those for consumer goods (excluding energy) and services for the United States.

United States has seen a marked increase in the input costs of services, as well as those of goods, due to the increases in wages and logistics costs.

Looking at Japan's intermediate input cost index by major division, we notice that the degree of cost increases in the recovery phase from the pandemic is large in food and durable goods, the latter reflecting the increase in metal prices (Chart 2). Meanwhile, the increase in the cost of general services is relatively small following the sluggish growth mainly in labor costs.

3.2. Estimation methodology of pass-through rates

In this paper, a vector autoregression (VAR) model is employed to estimate pass-through rates. The estimation uses the following four variables: nominal effective exchange rate; intermediate input cost index; output gap; and consumer price index (CPI, all items less fresh food and energy).[6] The output gap is expressed in level terms, whereas the other three variables are in quarter-on-quarter change terms. Shocks are identified by Cholesky decomposition, where variables are ordered as above.[7] The lag length is set to two quarters, based on the Akaike information criterion (AIC).

We begin by (i) estimating the fixed-parameter VAR model using the long sample, spanning from the first quarter of 2002 to the fourth quarter of 2021, in order to obtain the average pass-through rates for the past 20 years. Afterwards, with the aim of capturing recent changes, (ii) we measure the pass-through rates by estimating both the fixed-parameter VAR model using the sample limited to the recent years (sub-sample estimation) and the time-varying parameter VAR (TVP-VAR) model. From the perspective of securing sufficient sample size, the sample period for the sub-sample estimation in (ii) is set from the first quarter of 2009 to the fourth quarter of 2021. The TVP-VAR model is an approach proposed in studies such as Primiceri (2005) and Nakajima (2011). The TVP-VAR model allows parameters to vary over time, whereas the fixed-parameter VAR model does not allow to do so throughout the sample period. See Appendix 1 for an explanation of the fixed-parameter

[6] The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. In the estimation of pass-through rate in the United States, we instead use the CPI (all items less energy).

[7] These model specification and shock identification strategies allow us to extract intermediate input cost shocks as cost shocks which are not attributable to changes in exchange rate. It should be noted, however, that intermediate input costs still reflect the impact of wage changes in the upstream. On the other hand, the impact of exchange rate includes both that of the direct effect (imported final goods prices in national currency basis change reflecting exchange rates developments) and the indirect effect (exchange rates changes intermediate input cost in national currency basis, and their impact on price of domestically produced goods and services).

VAR and TVP-VAR models.

3.3. Estimation results

(Results of the estimation using the long sample)

The results of the estimation using the long sample are reported in Chart 3. The chart shows the accumulated impulse response of the CPI to a 1% input cost change shock, which corresponds to +1% increase for the intermediate input cost and 1% yen depreciation for the exchange rate. We refer to the former as the material cost pass-through rate and the latter as the exchange rate pass-through rate. The material cost pass-through rate is statistically significant for both Japan and the United States. The material cost pass-through rate is lower in Japan than in the United States. The exchange rate pass-through rate in Japan is also statistically significant.

Looking at the material cost pass-through rate by major division, the degree of pass-through is relatively high for food, whereas it is not statistically significant for durable goods (Chart 4). The material cost pass-through is relatively small for general services. Meanwhile, the exchange rate pass-through rate is higher for durable goods than for food (Chart 5). The exchange rate pass-through for general services is very low, although still statistically significant.

The relatively high pass-through for food, both in terms of material costs and exchange rates, appears to reflect the share of materials in total costs being higher in most food products. As for durable goods, the increased share of imported products especially among home electrical appliances seems to be behind the high exchange rate pass-through. The statistically insignificant material cost pass-through for durable goods, on the other hand, is deemed to reflect the fact that the supply chain of durable goods is generally long, as we later describe, and it requires many negotiations on price before the change in upstream costs are passed on to consumer prices. Hahn (2003) discusses the relationship between the pass-through rate and the length of supply chain in their study of pass-through in Europe.[8] Additionally, the relatively low pass-through rate for general services may suggest that the share of materials in total costs is low in many items within this category and the change in the material cost tends to be absorbed by reducing the margin at least for the short term.

[8] Hahn (2003) argues that the exchange rate shock directly affects all imported items, whereas the impact of the material cost shock on consumer prices could become smaller or slower, as a result of the lengthy process before the increased cost reaches the final product level.

(Estimation results on changes over time)

Next, we examine the change in the pass-through rates based on the results of the two models: the fixed-parameter VAR model using the recent sample period; and the TVP-VAR model (Charts 6 and 7). The charts show four-quarter cumulative impulse responses to a 1% intermediate input cost increase or yen depreciation shock.

First, the material cost pass-through rate is more or less unchanged throughout the sample period, according to the both estimation results. In other words, even though recently the material cost has risen markedly, the degree to which firms pass on the increase in the purchasing price to the selling price does not seem to change much at least at the "aggregate level" and at the "final demand stage (consumer level)." Second, judging from both the estimation results, the exchange rate pass-through rate appears to have been on an upward trend especially for durable goods.[9] Combined with the insights from earlier studies, it can be interpreted as this trend reflecting the recent increase in the import penetration rate mainly of durable goods (Chart 8).

4. Characteristics of pass-through in recent years

The estimation results in Section 3 suggest that, up until today, the degree to which firms pass on material costs to consumer prices has not changed much. Some issues remain unclear, however, such as whether the situation at the final demand stage similarly applies to the intermediate demand stage, which is located in the upstream or middle-stream stage of demand; and as cost-push pressures continue to mount, whether changes can be observed in at least some items even at the final demand stage. In order to confirm these points, this section conducts analyses using the price index by production stage and item-level data.

4.1. Analysis from the production stage perspective

First, in order to understand how the increase in upstream costs is passed on from the upstream to the downstream in the course of the production flow, we conduct an analysis using the Final Demand-Intermediate Demand (FD-ID) price index, which the Bank of Japan started to release in June 2022 as a satellite series of the Corporate Goods Price Index and the Services Producer Price Index.[10] The FD-ID index is compiled by dividing the demand

[9] It should be noted, however, the difference between the exchange rate pass-through based on the full-sample estimation and that based on the sub-sample estimation in Chart 7 is not statistically significant.

[10] The Bank of Japan introduced the FD-ID index in conjunction with the rebasing of the Corporate Goods Price Index to the Base Year 2020, which took place in June 2022.

stage into the final demand stage and the four intermediate demand stages based on the input-output table and, then, by aggregating the price of goods and services at each stage as the FD, ID1, ID2, ID3, and ID4 indices. The four stages in the ID index are categorized in line with the production flow in Japan. Therefore, taking Stage 1 as an example, the input price of materials is measured by the ID1 index and the output price of the products is approximated by the ID2 index, which is the input price for Stage 2 (the next stage located downstream from Stage 1).[11] The FD-ID index allows us to understand whether the price setting behavior of firms has changed at the intermediate demand stage, which is located at the more upstream level than the final demand stage.

Chart 9 shows the development of the FD-ID index. The ID1 index, which is the index for the most upstream stage in the production flow, has the largest price volatility. Then, as the production flow moves to the middle-stream and the downstream (ID2, ID3, ID4, and FD indices) and the cost is absorbed by firms located in each stage, the price volatility becomes smaller. It is interesting to see that the degree of increase in the ID2, ID3, or ID4 index, in comparison to the increase in the ID1 index, seems to be larger in the current phase than in the period between 2007 and 2008 and that between 2010 and 2014. Motivated by this observation, we investigate the extent to which the impact of the change in upstream costs has spread through the production flow using the FD-ID index. In particular, we use the following two approaches.

(Approach I: Analysis using a fixed-parameter VAR model)

In the first approach, we estimate a structural VAR model whose parameters are assumed to be fixed throughout the sample period, following Inoue *et al.* (2021). The estimation period is from January 2000 to March 2022. The model uses the following eight variables: the ID2, ID3, ID4, and FD indices for domestic goods and services; and the ID1, ID2, ID3, and ID4 indices for imported goods. The imported goods indices are assumed to be exogenous. Shocks are identified by Cholesky decomposition, where variables are ordered as above. In this specification, the identified structural shocks can be regarded as proxies of the movements that cannot be explained by the long-run relationship during the sample period, such as changes in the price setting behavior of firms.

Chart 10 shows the impact of a 1% increase shock of a domestic index of each stage. The impulse responses indicate that, as Inoue *et al.* (2021) point out, when a shock occurs in the upstream, (i) the impact spreads downstream but (ii) the degree of such a spillover decreases progressively downstream.[12] For instance, a positive shock in the domestic ID2

[11] For details on the methodology on the classification of each stage, see Inoue *et al.* (2021).

[12] Looking closely, the impact of a shock in domestic ID4 index is seen in the upstream (domestic ID2

index causes the domestic ID3 index to increase to a relatively large degree. Although the domestic ID2 index shock is still statistically significant pushing up the domestic FD index, the amount of an increase is smaller than in the cases of the domestic ID3 and ID4 indices.

Chart 11 shows the results of the historical decomposition. This chart also shows that the changes in upstream costs gradually spread downstream. Furthermore, as for Stages 1–3, we can see that the shock inherent to each stage is contributing to the increase of a corresponding domestic index since 2020. This can be interpreted as firms located in the upstream and middle-stream in the production flow becoming more willing to pass on the increase in the purchasing price to the selling price than previously. The positive contributions of the structural shocks are more clearly pronounced even compared to the phase of rising commodity prices until the mid-2008. Unlike other stages, however, the positive contribution of the structural shock is non-existent for Stage 4, implying that the price-setting behavior has not changed much among firms facing final demand of households, etc.[13]

(Approach II: Analysis using a TVP-VAR model)

In the second approach, we estimate a model in which, unlike the first approach, parameters are allowed to vary over time. Specifically, we develop the TVP-VAR model with the following five variables: the ID1 index, and the mark-up rates (calculated as the output price divided by the ID index for each stage) in Stages 1–4. Shocks are identified by Cholesky decomposition, where variables are ordered as above. In this estimation, we use a positive shock to the highest upstream price as a proxy variable for the material cost increase shock, and observe the change in the price setting behavior of firms through the lens of the change in the mark-up rate in each stage against this shock.

Chart 12 shows the impulse response of the mark-up rate for each stage to a 1% ID1 index increase shock. Although the mark-up rate tends to temporarily decrease immediately after the shock, it gradually recovers towards the baseline. This suggests that, while mark-up becomes smaller in the short run, as they cannot fully pass on the material cost increase on their selling price, it recovers as firms slowly adjust their prices.

As in Approach I, let us compare the movements between the two phases: the phase of

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and ID3 indices). Herget *et al.* (2014) note that price developments in each demand stage are likely to be affected by both supply shocks in the upstream and demand shocks in the downstream.

[13] The structural shock in Stage 4 has been negative recently. This is thought to reflect the impact of a reduction in mobile phone charges since the spring of 2021, not the change in firms' price setting behavior. In fact, the recent negative contribution of the structural shock in Stage 4 virtually disappears once we estimate the same model using the domestic FD index excluding mobile phone charges, which is calculated by taking into account the price and weight of mobile phone charges.

rising commodity prices in the mid-2000s (namely, the third quarter of 2008); and the current phase (namely, the third quarter of 2021). The pace of recovery in the mark-up rates for Stages 1–3 has accelerated in recent years, suggesting that the price setting behavior of firms located in the upstream and middle-stream of the production flow has become more active. On the other hand, the impulse response for the downstream stage (Stage 4) is virtually unchanged, implying the lack of change in the price setting behavior of firms within this stage.

4.2. Analysis from the perspective of individual items

Next, we examine the recent change in the pass-through rate at the final demand stage by individual item. Specifically, we first calculate the intermediate input cost index for each of the 187 item categories in the input-output table. Then, for each item category, we select the corresponding CPI and the "domestic supply and demand conditions for products and services DI" from the *Tankan* survey. Finally, in the same way as in Section 3, we construct the four-variable fixed-parameter VAR model by item category. Chart 13 plots the distributions of item-level pass-through rates for the two periods of 2019–2021 and 2016–2018. Although the results should be interpreted with caution due to the limited sample size, the distribution appears to have skewed more to the right despite having the same median. This implies that, even at the final demand stage, the pass-through rate is rising in some item categories.

The idea of the "Average propagation lengths" (henceforth, APL), proposed by Dietzenbacher *et al.* (2005), provides a good insight into one of the reasons behind the recent increase in the pass-through rate in some items. The APL is a measure of the length of the supply chain between industries, and is calculated using the intermediate input coefficient matrix in the input-output table. The shorter APL indicates the shorter supply chain for that item. For example, the APL is relatively short for food, while it is relatively long for durable consumer goods (especially automobiles). The comparison between the APL and the change in the pass-through rate (the difference between the two aforementioned periods) shows that, the shorter the APL, the more likely the pass-through rate is to rise (Chart 14). The number of firms in the production flow, from upstream to downstream, is small for items with a short APL. Therefore, price negotiations for such items may proceed more quickly in times of a rapid increase in raw material costs as we see today.

5. Issues concerning future developments in pass-through

To summarize the discussions so far, our analyses find that the material cost pass-through rate — that is, the rate of pass-through of material and other costs to consumer prices (prices at the final demand stage) — has remained more or less unchanged at the macro level. At the same time, however, a closer look allows us to observe a few notable possible changes. First, the pass-through rate could have risen at the intermediate demand stage, following the change in the price setting behavior of firms. Second, even at the final demand stage, the pass-through rate might have been elevated for some items including food.

In considering the future developments in prices, it is important to identify whether the recent increase in the pass-through rate at some stages or in some items would further spread, with a potential structural change of the global economy following the experience of the pandemic in mind. Given that the behavior and mindset based on the assumption that prices will not increase are deeply entrenched in Japan, the rapid increase in the pass-through rate seems rather unlikely. Nevertheless, there is still a possibility that the pass-through rate could increase more than it did in the past, as suggested by the following three points.

Firstly, since the beginning of 2022, the cost-push pressure has increased considerably, even in comparison to increases seen in the past, due to multiple factors including developments in the situation surrounding Ukraine. Some studies concerning economies outside Japan point out that the greater the change in upstream costs or exchange rates, the greater the amount of increase in the pass-through rate. Colavecchio and Rubene (2020) argues that, due to the menu cost, the small change in costs will be absorbed by firms and, therefore, will not be passed on to consumer prices. We analyze whether this kind of non-linearity exists in Japan, using the data from the first quarter of 2000 to the fourth quarter of 2021. Based on Colavecchio and Rubene (2020), we use the following regression equation:

$$\begin{aligned} \ln CPI_{t+h} - \ln CPI_{t-1} = c &+ \beta_1^{(h)} \cdot SizeDum_t \cdot \Delta \ln x_t \\ &+ \beta_2^{(h)} \cdot (1 - SizeDum_t) \cdot \Delta \ln x_t \\ &+ \sum_{i=0}^{1} \boldsymbol{\gamma}_i^{(\boldsymbol{h})} \cdot \boldsymbol{z}_t + u_{t+h} \end{aligned} \quad (1)$$

where CPI_t is the CPI (all items less fresh food and energy), c is a constant term, x_t is either the intermediate input cost index or the nominal effective exchange rate, $\boldsymbol{z}_t$ is a vector of control variable including the output gap and lagged variables.[14] $SizeDum_t$ is a dummy variable which takes the value of 1 if the quarter-on-quarter change in x_t in absolute terms

[14] See Tables 1–2 for the list of variables included in $\boldsymbol{z}_t$.

(denoted as $|\Delta \ln x_t|$) is greater than 1 standard deviation for the sample period and takes the value of 0 otherwise. The parameter $\beta_1^{(h)}$ and $\beta_2^{(h)}$ shows the pass-through rate for the case where the change in the raw material cost or the exchange rate is relatively large and small, respectively. u_t is the error term. Using ordinary least squares, we estimate this equation for $h = 0, \ldots, 6$.

According to the estimation results, the material cost pass-through rate tends to increase more when there is a large change in the upstream cost (Table 1).[15] Similarly, the exchange rate pass-through rate is likely to increase to a greater extent when there is a large change in the exchange rate (Table 2). Although they should be interpreted with some latitude due to the limited sample period, the estimation results imply the possibility that, in times of a rapid increase in the cost-push pressure like today, the pass-through could increase in a rapid and non-linear fashion following the change in firms' price setting behavior.[16]

The micro data on price changes also suggest this characteristic in the price setting behavior of firms. We explain this using the example of food. Following Kurachi *et al.* (2016), we begin by estimating the frequency of price changes (excluding the temporary effects due to special sales) using the item-level price data by region from the *Retail Price Survey*. The estimation results show the occasional rapid increases in the frequency of price changes (Chart 15 (a)). In addition, following Fisher and Konieczny (2000), we calculate the FK index, which represents the synchronization in the timing of price changes. The calculated FK index shows that a synchronization in the direction of price rises tends to rapidly increase (Chart 15 (b)).[17] Looking at the past developments, we notice that the rapid increase in the cost-push pressure appears to be accompanied by an increase in the frequency of price change and a rapid strengthening of synchronization in the timing of price changes reflecting many firms revising their prices in the same time.

The second point is that Japan's economy is expected to continue to recover for the time being, as the impact of the pandemic gradually wanes. Using the European data, Ben Cheikh *et al.* (2018) claim that the exchange rate pass-through is higher during the periods of economic expansion. We analyze this business-cycle non-linearity of pass-through in Japan

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[15] Tables A1–A2 show the results from the estimation which does not use the dummy variable regarding the size of change in the upstream cost or exchange rate. The estimation results confirm the statistically significant pass-through from these costs to consumer prices.

[16] As described earlier, the intermediate input cost index in this paper is based on the transaction structure in the 2015 Input-Output Table. Although it is possible to extend the data used for the estimation backward, we decide to limit the sample to the period since 2000 so that the underlying transaction structure assumed in the intermediate input cost index does not differ significantly from the actual one.

[17] For details on the calculation method and interpretation of the FK index, see Appendix 2.

using the following equation, based on Equation (1):

$$\ln CPI_{t+h} - \ln CPI_{t-1} = c + \beta_1^{(h)} \cdot ExpansionDum_{t+h} \cdot \Delta \ln x_t + \beta_2^{(h)} \cdot (1 - ExpansionDum_{t+h}) \cdot \Delta \ln x_t + \sum_{i=0}^{1} \boldsymbol{\gamma_i^{(h)}} \cdot \boldsymbol{z_t} + u_{t+h} \quad (2)$$

where $ExpansionDum_{t+h}$ is a dummy variable which takes the value of 1 when the level of the output gap is above its average value for the sample period, and takes the value of 0 otherwise. The parameter $\beta_1^{(h)}$ and $\beta_2^{(h)}$ shows the pass-through rate of the material cost or exchange rate during the expansion and recession periods, respectively. See the above explanation for Equation (1), for details on other variables and the estimation method.

The estimation results show that both the material cost and exchange rate pass-through rates tend to increase during the expansion periods (Table 3–4). This suggests that firms' ability to pass on the cost increase to the selling price heavily depends on whether the economic recovery continues in the presence of inflation.

The third and final point is that the global economy is facing the change in demand structure and the disruption in the supply chain due to the impact of the pandemic. Against this backdrop, the domestic demand and supply conditions for some items have significantly tightened, even though the output gap, which captures the utilization of labor and capital, has been negative at the macro level. The "domestic supply and demand conditions for products and services DI" in the *Tankan* survey shows a variation within the consumption-related industries. That is, the supply and demand conditions concerning goods (retail sector) have markedly tightened in tandem with a rapid decrease in inventory reflecting the recovery in demand and the recent supply constraints, whereas the conditions are relaxed for the face-to-face services where the impact of the pandemic still remains (Charts 16–17). Besides, the relationship between the "domestic supply and demand conditions for products and services DI" in the *Tankan* survey and the stance on pass-through, as plotted in Chart 18, suggests that the tighter the supply and demand condition, the more active the stance on pass-through. This, too, implies the possibility that firms have been more likely to pass on the increase in the purchasing price to the selling price in the current phase.

6. Concluding remarks

In this paper, we estimated the pass-through rates in Japan and examined the changes in recent years and their background. The estimation results yield the following two implications. First, the exchange rate pass-through has been increasing in recent years, reflecting the higher import penetration. Second, although the material cost pass-through does not pose any change at the final demand stage in general, it seems to have somewhat increased at the intermediate demand stage—which is the more upstream level than the final demand stage—and for some items at the final demand stage.

In considering the future developments in prices, it is important to identify whether the recent increase in the pass-through rate at some stages or in some items would further spread, with a potential structural change of the global economy following the experience of the pandemic in mind. On this point, as noted in this paper, given (i) the strength of cost-push pressures, (ii) the business cycle, and (iii) the tightness of demand and supply conditions in some goods due partially to the pandemic, there is still a good possibility that the pass-through rate could increase more than it did in the past.

With that being said, these cost-push pressures themselves do not lead to achieving sustainable price stability. Ikeda *et al.* (2022) estimate the impact of cost-push pressures related to the material cost and the exchange rate on consumer prices, in contrast to the impacts of the changes in the output gap or inflation expectations on consumer prices. On this point, although this is beyond the scope of this paper, attention should be paid to the point that the material cost increase is likely to put downward pressure on the economy through deterioration in the terms of trade. There is also an uncertainty regarding the impact of inflation stemming from the material cost increase on inflation expectations. This paper pointed out that the price setting behavior of firms may have changed in some areas. It remains unclear, however, whether this is a temporary change or a sign of a change in the long-standing behavior and mindset, based on the assumption that prices and wages will not increase easily, and of a structural change in the wage- and price-setting behavior of firms. Assessment of these issues is left for future research.

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Appendix 1:

Overview of fixed-parameter and time-varying parameter VAR models

In this paper, we estimated the pass-through rates using fixed-parameter and time-varying parameter VAR models. In this appendix, we provide an overview of each model, based on Nakajima (2011), Shioji (2012), etc. See the original article for more detailed explanations.

Let us begin by considering a fixed-parameter VAR model with two variables, $y_{1,t}$ and $y_{2,t}$. For simplicity, the lag length is set to one. Then, a fixed-parameter VAR model is written as follows:

$$\begin{pmatrix} y_{1,t} \\ y_{2,t} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \end{pmatrix} + \begin{pmatrix} b_1 \\ b_2 \end{pmatrix} + \begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} \qquad \text{(A1-1)}$$

where a_{ij} is a coefficient for the lagged variable and b_i is a constant term. $u_{i,t}$ is the error term which is assumed to follow the bivariate normal distribution $N(\mathbf{0}, \boldsymbol{\Omega})$ with mean $\mathbf{0}$ and variance-covariance matrix $\boldsymbol{\Omega}$. In the case of a fixed-parameter VAR model, the estimates of a_{ij} and b_i can be obtained by estimating Equation (A1-1) using ordinary least squares.

It should be noted that the two error terms in Equation (A1-1), $u_{1,t}$ and $u_{2,t}$, are likely to be correlated with each other, making it impossible to calculate the impulse response function which shows the dynamic impact of an exogenous shock in a variable on another variable. Under such a circumstance, it is often assumed that (i) the variable y_1 is contemporaneously affected by a y_1 shock but not by a y_2 shock, whereas (ii) the variable y_2 is contemporaneously affected by both y_1 and y_2 shocks. It follows that the variance-covariance matrix $\boldsymbol{\Omega}$ can be decomposed as follows using the Cholesky decomposition:

$$\boldsymbol{\Omega} = \boldsymbol{A}^{-1}\boldsymbol{\Sigma}\boldsymbol{\Sigma}'\boldsymbol{A}^{-1'} \qquad \text{(A1-2)}$$

where $\boldsymbol{A}$ is a 2×2 lower triangular matrix with the diagonal elements 1, and $\boldsymbol{\Sigma}$ is a 2×2 diagonal matrix. Each element is defined as follows:

$$\boldsymbol{A} = \begin{pmatrix} 1 & 0 \\ c_{21} & 1 \end{pmatrix}, \boldsymbol{\Sigma} = \begin{pmatrix} \sigma_1 & 0 \\ 0 & \sigma_2 \end{pmatrix} \qquad \text{(A1-3)}$$

where σ_i is the standard deviation of the shock in variable i, and c_{ij} is a coefficient of the contemporaneous effect of the shock in variable j on variable i.

Since a fixed-parameter VAR model assumes that parameters a_{ij}, b_i, c_{ij}, and σ_i are constant over time, it cannot take into account the developments in the relationship between variables over time. One way to observe the change in the impact of the shock over time is to conduct a sub-sample analysis—that is, to estimate a fixed-parameter VAR model using different sample periods—as conducted in this paper. Another efficient way to do this is to estimate a time-varying parameter VAR (TVP-VAR) model, which is an extension of a fixed-parameter VAR model.

A TVP-VAR model assumes that a coefficient that determines the relationship between current and lagged variables as well as a constant term (a_{ij} and b_i in Equation (A1-1)) vary over time. Therefore, the time-series change in the relationship between variables can be analyzed in more detail. Although different kinds of VAR model with time-varying coefficients had been proposed since Canova (1993) and Sims (1993), the TVP-VAR model proposed by Primiceri (2005), the model in which parameters are assumed to follow the random walk process and stochastic volatility is incorporated into the time-varying variance of the shock, is broadly used today. Since the stochastic volatility model forms a non-linear state space model where the volatility is the latent variable, the maximum likelihood estimation is deemed computationally challenging. On this point, Primiceri (2005) proposes the estimation method using the Markov chain Monte Carlo (MCMC) method. The estimation in this paper is in line with this approach. We acknowledge that the actual estimation was carried out using the program developed by Nakajima (2011).

Appendix 2:
Calculation method of the Fisher-Konieczny (FK) index

The "FK index," proposed by Fisher and Konieczny (2000), is an indicator of the degree of synchronization of firms' price setting behavior. The index measures "how close the price setting behavior between firms is to the 'perfect synchronization'" using the standard deviation of the probability of price changes. Specifically, the index is calculated by the following equation:

$$FK\ index = \frac{Standard\ deviation\ (SD)\ of\ the\ actual\ price\ change\ probability}{SD\ of\ the\ price\ change\ probability\ under\ perfect\ synchronization} \quad \text{(A2-1)}$$

When the price setting behavior is the same for all firms, the probability of price changes at the macro level in each period will be either 0% (none of the firms change their price) or 100% (all firms change their price). Therefore, the standard deviation which indicates the degree of dispersion of the price change probability is expected to have a large value.[18] The denominator in Equation (A2-1) corresponds to the standard deviation of the probability of price changes in such a case. Meanwhile, the more individually firms behave, the smaller the standard deviation of the price change probability at the macro level.

The FK index is calculated based on this kind of relationship, and its value approaches the maximum value of "1" when many firms take on price setting behaviors in a synchronized manner, and approaches the minimum value of "0" otherwise.

In reality, however, it comes with difficulties to collect the "firm-level price data" of "individual items" and to estimate the degree of synchronization between firms. Against this background, using the monthly results of the *Retail Price Survey* classified by region and item, we calculate the FK index according to the following equation after regarding the goods and services classification in the CPI as "individual items" and the item-level price data "individual items" in each classification as "firm-level price data":

$$FK_{i,t} = \sqrt{\frac{\sum_{j \in i} w_j \left(p_{j,t} - \bar{p}_{i,t}\right)^2}{\bar{p}_{i,t}\left(1 - \bar{p}_{i,t}\right)}} \quad \text{(A2-2)}$$

where $FK_{i,t}$ is the FK index for group i of goods and services at time t, $p_{j,t}$ is the frequency of the change in the regular price for item j in group i, $\bar{p}_{i,t}$ is the frequency of the change in the regular price for group i, and w_j is the weight of item j in group i. The

[18] Numerically, the standard deviation of the probability of price changes could be small when either all firms either keep changing or keep holding their price. Such a case, however, is deemed rare in reality.

frequency of the change in the regular price is estimated following the methodology of Kurachi *et al.* (2016). Therefore, the FK index for food products shows the degree of synchronization in price setting for items such as bean-jam buns, white bread, and curry buns.

Table 1. Size non-linearity of material cost pass-through: Estimation results

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$				
	$h=0$ (Shock)	$h=2$ (2 quarters later)	$h=4$ (4 quarters later)	$h=6$ (6 quarters later)
Independent variables	[1-I]	[1-II]	[1-III]	[1-IV]
Constant	0.000 (0.000)	0.001 * (0.000)	0.001 ** (0.000)	0.002 *** (0.001)
$SizeDum_t \cdot \Delta \ln COST_t$	0.204 ** (0.081)	0.499 *** (0.170)	0.707 ** (0.323)	0.557 (0.463)
$(1 - SizeDum_t) \cdot \Delta \ln COST_t$	0.132 (0.175)	0.297 (0.390)	0.481 (0.530)	0.222 (0.657)
$\Delta \ln CPI_{t-1}$	0.632 *** (0.107)	1.462 *** (0.210)	1.931 *** (0.304)	2.327 *** (0.463)
$\Delta \ln COST_{t-1}$	-0.046 (0.078)	-0.170 (0.183)	-0.299 (0.285)	-0.898 ** (0.422)
GAP_t	0.000 ** (0.000)	0.001 *** (0.000)	0.002 *** (0.000)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.001)
$\Delta \ln NEER_t \cdot (-1)$	-0.001 (0.004)	0.009 (0.008)	0.023 (0.014)	0.051 *** (0.019)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.002 (0.005)	0.014 (0.011)	0.029 * (0.015)	0.070 *** (0.018)
$\hat{u}_{t+h-1}$		1.554 *** (0.194)	1.250 *** (0.155)	1.147 *** (0.146)
Adjusted R-squared	0.589	0.760	0.797	0.801
S.E. of regression	0.001	0.003	0.004	0.005

Note: CPI: CPI (all items less fresh food and energy), $SizeDum$: Dummy variable for big changes in the intermediate input costs, $COST$: Intermediate input cost index, GAP: Output gap, $NEER$: Nominal effective exchange rate, $\hat{u}$: Estimated residuals.
The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. $SizeDum$ is a dummy variable which takes the value of 1 if the q/q change (in absolute terms) in the intermediate input costs is greater than 1 standard deviation (=0.2%) of the q/q changes for the sample period. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.

Table 2. Size non-linearity of exchange rate pass-through: Estimation results

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$				
	$h=0$ (Shock)	$h=2$ (2 quarters later)	$h=4$ (4 quarters later)	$h=6$ (6 quarters later)
Independent variables	[2-I]	[2-II]	[2-III]	[2-IV]
Constant	0.000 (0.000)	0.001 ** (0.000)	0.001 *** (0.000)	0.002 ** (0.001)
$SizeDum_t \cdot \Delta \ln NEER_t \cdot (-1)$	0.003 (0.003)	0.023 *** (0.007)	0.047 *** (0.011)	0.072 *** (0.013)
$(1 - SizeDum_t) \cdot \Delta \ln NEER_t \cdot (-1)$	0.006 (0.010)	0.004 (0.025)	0.011 (0.034)	0.023 (0.041)
$\Delta \ln CPI_{t-1}$	0.649 *** (0.109)	1.490 *** (0.219)	1.931 *** (0.315)	2.227 *** (0.459)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.006 * (0.004)	0.020 ** (0.009)	0.030 ** (0.014)	0.051 *** (0.016)
GAP_t	0.000 *** (0.000)	0.001 *** (0.000)	0.002 *** (0.000)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.001 (0.001)
$\Delta \ln EPI_t$	0.027 ** (0.013)	0.051 (0.027)	0.032 (0.041)	0.018 (0.052)
$\Delta \ln EPI_{t-1}$	-0.024 * (0.013)	-0.081 *** (0.025)	-0.115 *** (0.034)	-0.164 *** (0.048)
$\hat{u}_{t+h-1}$		1.531 *** (0.187)	1.249 *** (0.141)	1.157 *** (0.128)
Adjusted R-squared	0.588	0.762	0.799	0.814
S.E. of regression	0.001	0.003	0.004	0.004

Note: CPI: CPI (all items less fresh food and energy), $SizeDum$: Dummy variable for big changes in the exchange rate, $NEER$: Nominal effective exchange rate, GAP: Output gap, EPI: Export price index, $\hat{u}$: Estimated residuals.
The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. $SizeDum$ is a dummy variable which takes the value of 1 if the q/q change (in absolute terms) in the exchange rate is greater than 1 standard deviation (=3.0%) of the q/q changes for the sample period. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.

Table 3. Business cycle non-linearity of material cost pass-through: Estimation results

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$	$h=0$ (Shock)	$h=2$ (2 quarters later)	$h=4$ (4 quarters later)	$h=6$ (6 quarters later)
Independent variables	[3-I]	[3-II]	[3-III]	[3-IV]
Constant	0.000 (0.000)	0.001 * (0.000)	0.001 ** (0.000)	0.002 ** (0.001)
$ExpansionDum_{t+h} \cdot \Delta \ln COST_t$	0.192 (0.123)	0.469 * (0.245)	1.025 *** (0.377)	1.052 ** (0.490)
$(1 - ExpansionDum_{t+h}) \cdot \Delta \ln COST_t$	0.206 *** (0.069)	0.494 *** (0.172)	0.470 (0.382)	0.185 (0.548)
$\Delta \ln CPI_{t-1}$	0.631 *** (0.108)	1.458 *** (0.203)	1.987 *** (0.311)	2.338 *** (0.491)
$\Delta \ln COST_{t-1}$	-0.045 (0.077)	-0.166 (0.181)	-0.379 (0.311)	-1.003 ** (0.426)
GAP_t	0.000 ** (0.000)	0.001 *** (0.000)	0.002 *** (0.001)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)
$\Delta \ln NEER_t \cdot (-1)$	-0.001 (0.004)	0.008 (0.008)	0.021 (0.014)	0.047 ** (0.019)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.002 (0.005)	0.015 (0.011)	0.028 * (0.015)	0.069 *** (0.018)
$\hat{u}_{t+h-1}$		1.553 *** (0.196)	1.239 *** (0.156)	1.154 *** (0.150)
Adjusted R-squared	0.589	0.759	0.789	0.795
S.E. of regression	0.001	0.003	0.004	0.005

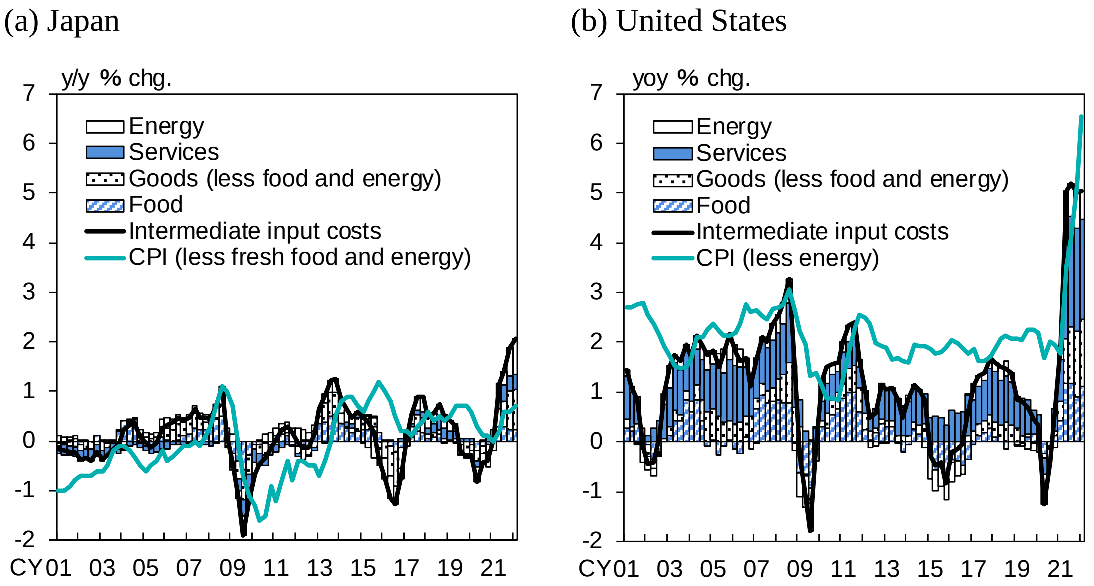
Note: CPI: CPI (all items less fresh food and energy), $ExpansionDum$: Dummy variable for expansion periods, $COST$: Intermediate input cost index, GAP: Output gap, $NEER$: Nominal effective exchange rate, $\hat{u}$: Estimated residuals.
The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. $ExpansionDum$ is a dummy variable which takes the value of 1 if the output gap is greater than the average value of the output gap for the sample period. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.

Table 4. Business cycle non-linearity of exchange rate pass-through: Estimation results

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$				
	$h = 0$ (Shock)	$h = 2$ (2 quarters later)	$h = 4$ (4 quarters later)	$h = 6$ (6 quarters later)
Independent variables	[4-I]	[4-II]	[4-III]	[4-IV]
Constant	0.000 (0.000)	0.001 ** (0.000)	0.001 ** (0.000)	0.001 ** (0.001)
$ExpansionDum_{t+h}$ $\cdot \Delta \ln NEER_t \cdot (-1)$	0.002 (0.004)	0.011 (0.012)	0.064 *** (0.015)	0.086 *** (0.019)
$(1 - ExpansionDum_{t+h})$ $\cdot \Delta \ln NEER_t \cdot (-1)$	0.004 (0.004)	0.028 *** (0.008)	0.027 ** (0.012)	0.046 ** (0.019)
$\Delta \ln CPI_{t-1}$	0.649 *** (0.107)	1.473 *** (0.211)	1.915 *** (0.290)	2.154 *** (0.457)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.006 * (0.003)	0.022 *** (0.008)	0.028 ** (0.012)	0.050 *** (0.015)
GAP_t	0.000 *** (0.000)	0.001 *** (0.000)	0.002 ** (0.000)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.001 (0.001)
$\Delta \ln EPI_t$	0.026 * (0.014)	0.041 (0.029)	0.041 (0.043)	0.029 (0.054)
$\Delta \ln EPI_{t-1}$	-0.023 * (0.014)	-0.075 *** (0.027)	-0.127 *** (0.035)	-0.176 *** (0.047)
$\hat{u}_{t+h-1}$		1.583 *** (0.172)	1.246 *** (0.134)	1.190 *** (0.121)
Adjusted R-squared	0.588	0.765	0.806	0.813
S.E. of regression	0.001	0.003	0.004	0.005

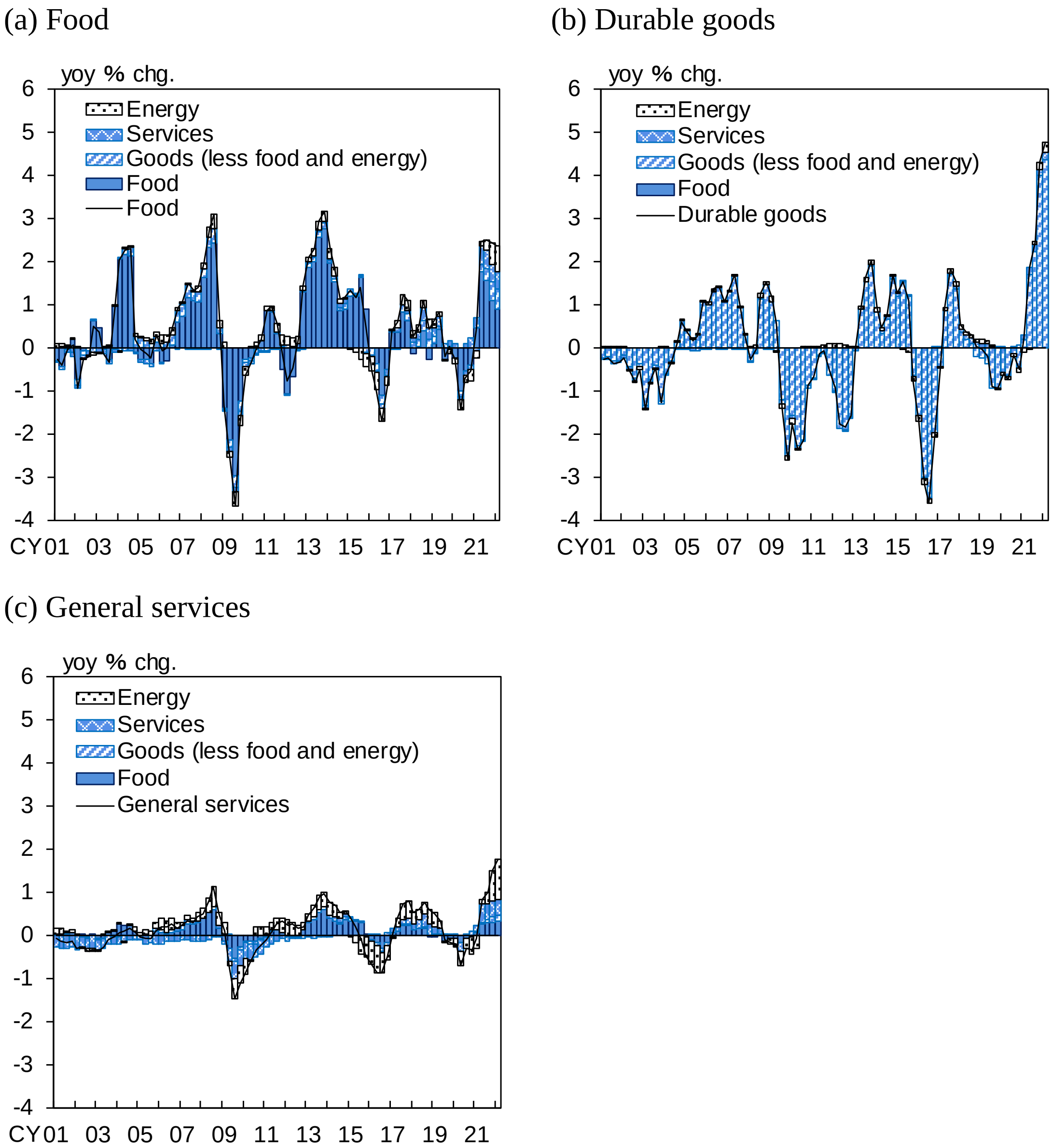
Note: CPI: CPI (all items less fresh food and energy), $ExpansionDum$: Dummy variable for expansion periods, $NEER$: Nominal effective exchange rate, GAP: Output gap, EPI: Export price index, $\hat{u}$: Estimated residuals.
The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. $ExpansionDum$ is a dummy variable which takes the value of 1 if the output gap is greater than the average value of the output gap for the sample period. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses.
***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.

Chart 1. Intermediate input cost index



Note: The CPI (all items less fresh food and energy) figures for Japan excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan; BEA; BLS.

Chart 2: Japan's intermediate input cost index: By major division

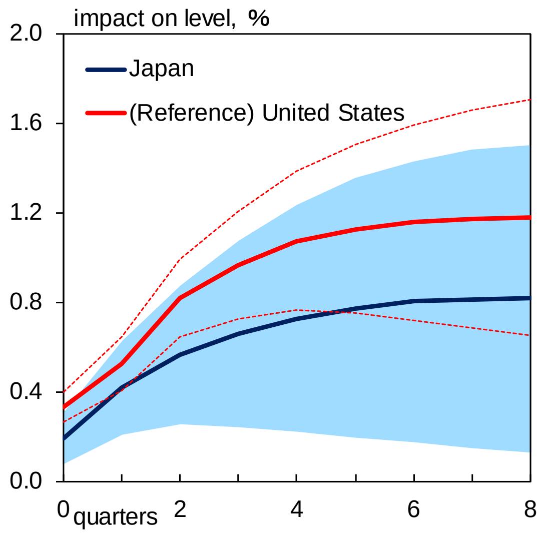


Note: The ratio of intermediate inputs to gross domestic output is used for calculating intermediate input costs. Therefore, intermediate input costs are relatively irresponsive to price changes in intermediate inputs in categories with a low intermediate input ratio (Intermediate inputs / Gross domestic output).

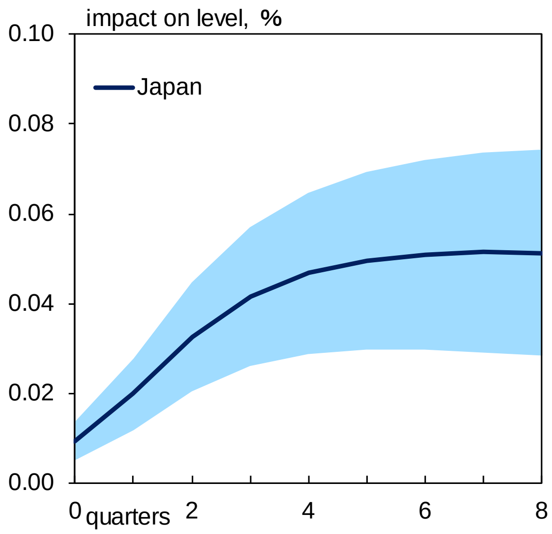
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 3. Estimated rates of pass-through (full sample; headline)

(a) Material cost pass-through



(b) Exchange rate pass-through

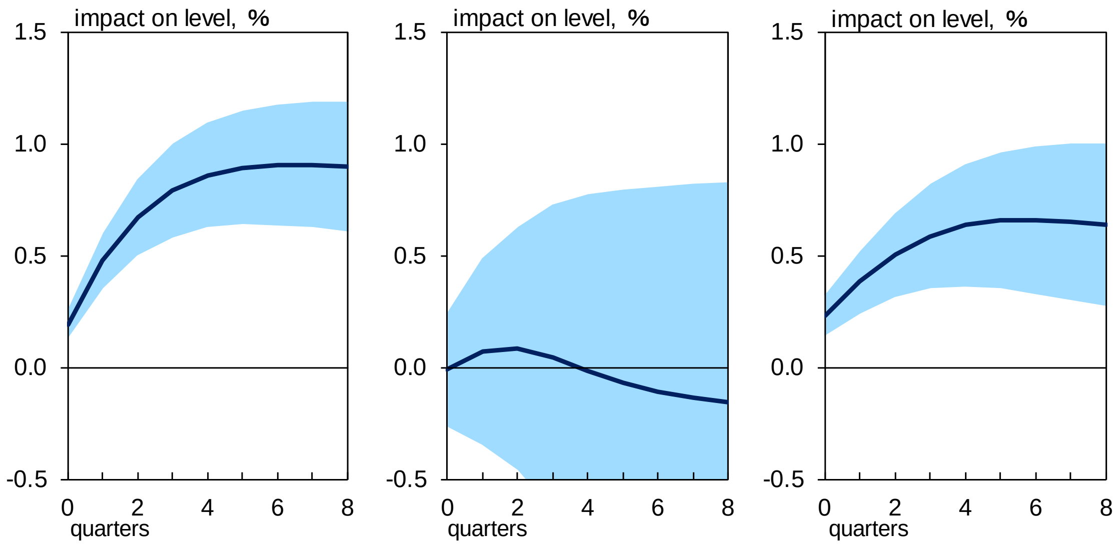


Note: (a) and (b) show the accumulated impulse responses of the CPI to a 1% intermediate input cost increase shock and to a 1% yen depreciation shock, respectively. The shaded areas and the broken lines indicate the 75% confidence intervals.

Sources: Ministry of Internal Affairs and Communications; Bank of Japan; BEA; BLS.

Chart 4. Estimated rates of raw material cost pass-through (full sample; by major division)

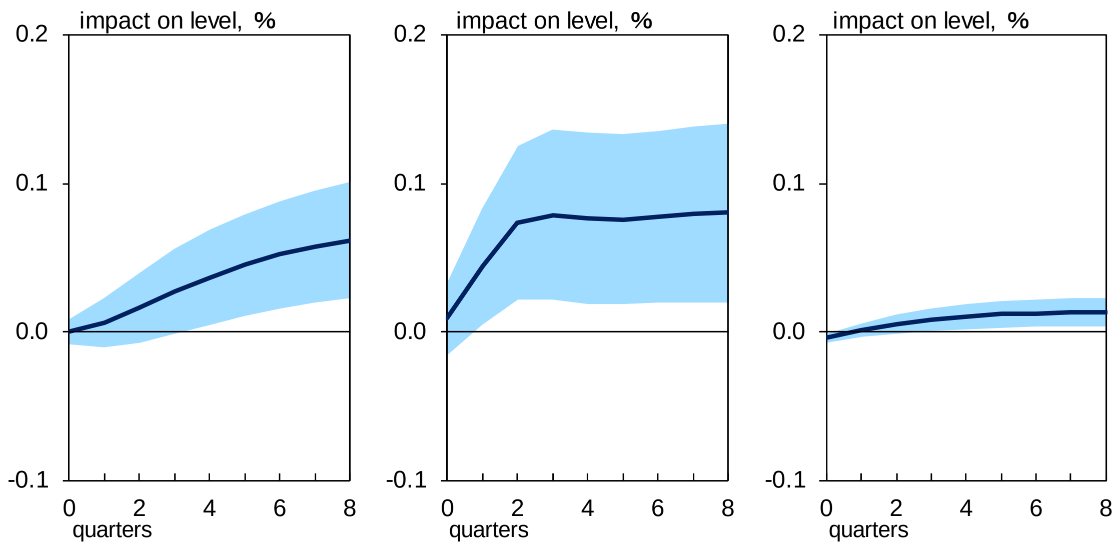
(a) Food (b) Durable goods (c) General services



Note: The charts show the accumulated impulse responses of the CPI to a 1% intermediate input cost increase shock. The shaded areas indicate the 75% confidence intervals.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 5. Estimated rates of exchange rate pass-through (full sample; by major division)

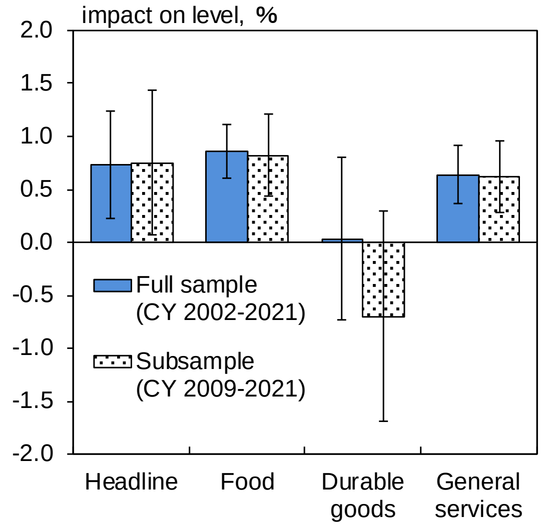
(a) Food (b) Durable goods (c) General services



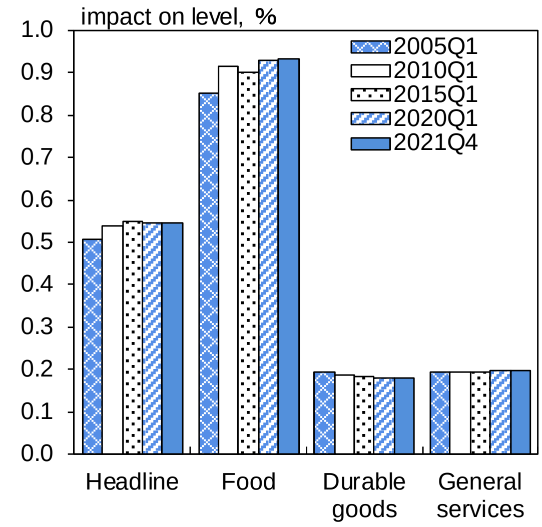
Note: The charts show the accumulated impulse responses of the CPI to a 1% yen depreciation shock. The shaded areas indicate the 75% confidence intervals.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 6. Estimated rates of material cost pass-through: Changes over time

(a) Subsample VAR estimation results



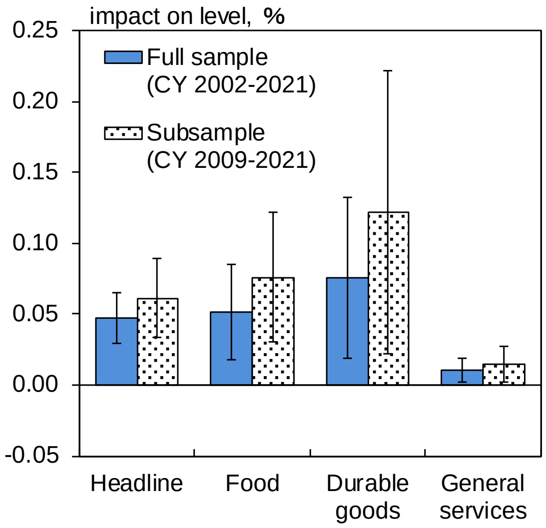
(b) TVP-VAR estimation results



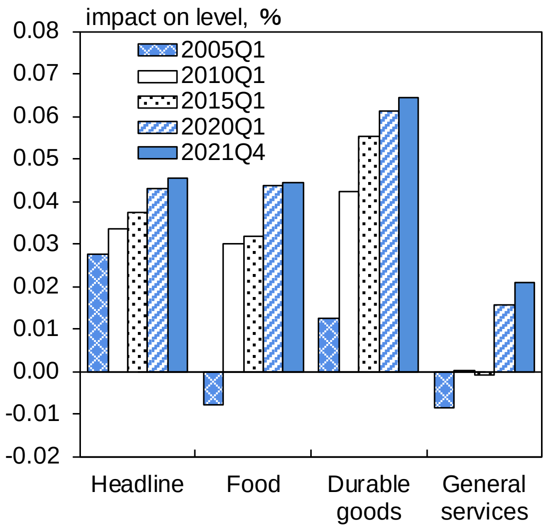
Note: The vertical lines in (a) denote one standard error bands.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 7. Estimated rates of exchange rate pass-through: Changes over time

(a) Subsample VAR estimation results

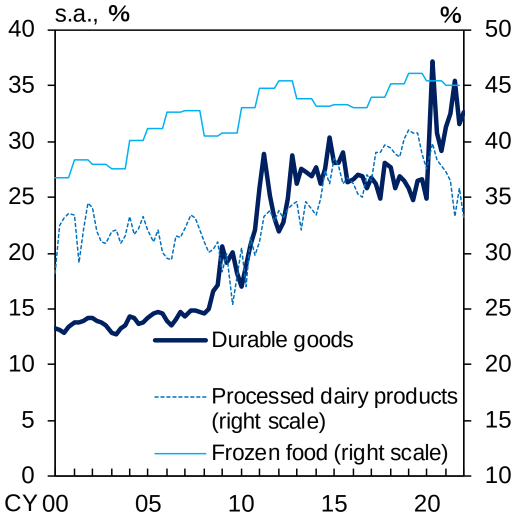


(b) TVP-VAR estimation results



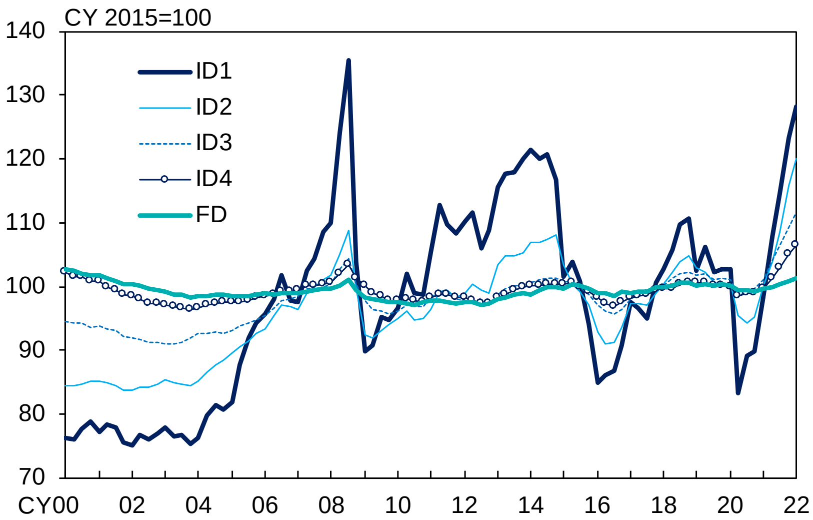
Note: The vertical lines in (a) denote one standard error bands.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 8. Import penetration rates



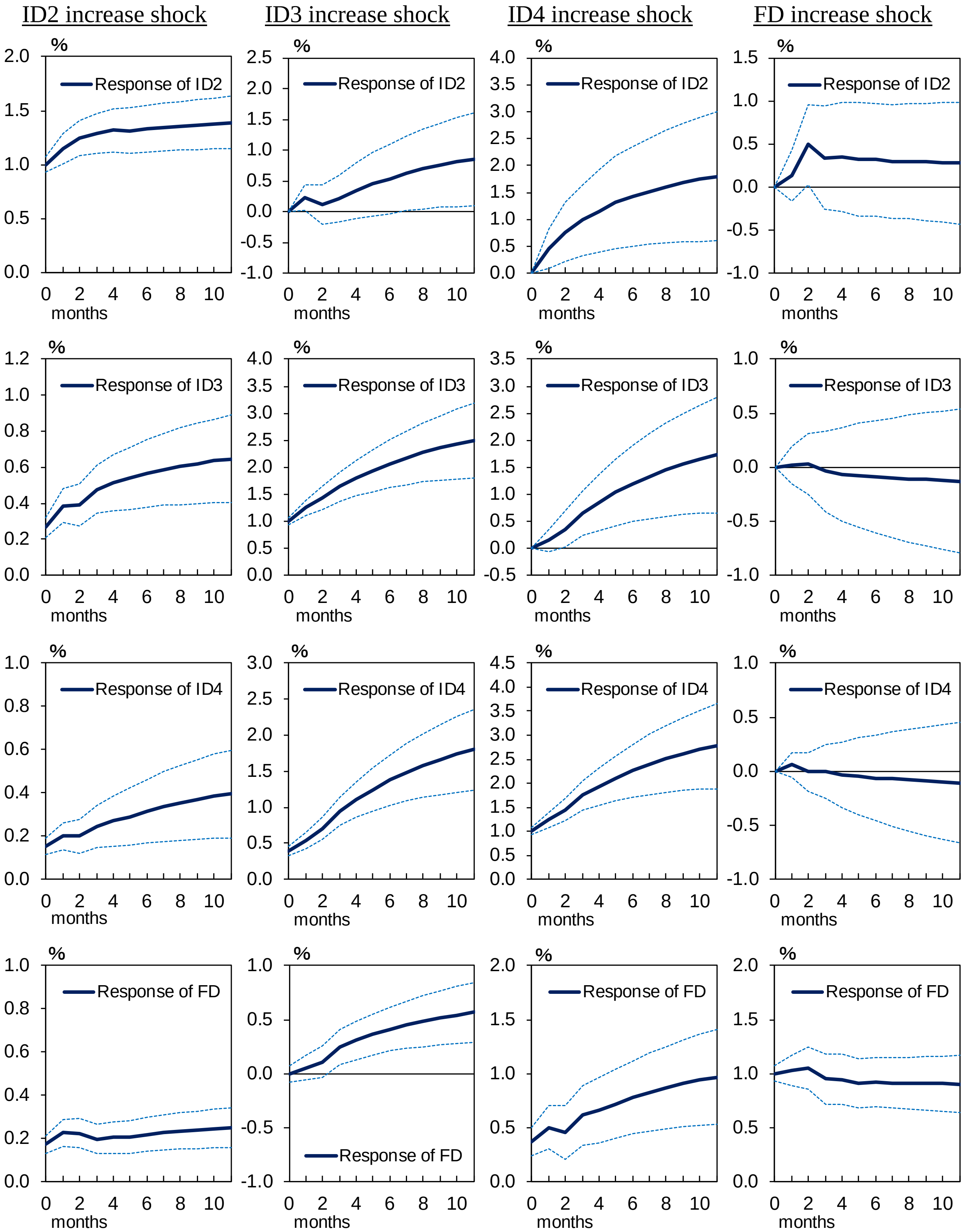
Sources: Ministry of Economy, Trade and Industry; Ministry of Finance; Ministry of Agriculture, Forestry and Fisheries; Japan Frozen Food Association.

Chart 9. Japan's FD-ID index



Note: The figures before CY 2015 are authors' estimates based on the methodology of Inoue *et al.* (2021). It should be noted that the coverage of items in the Services Producer Price Index, used in the estimation, decreases for older base year indices.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 10. Estimation results of the fixed-parameter VAR models: Accumulated impulse responses

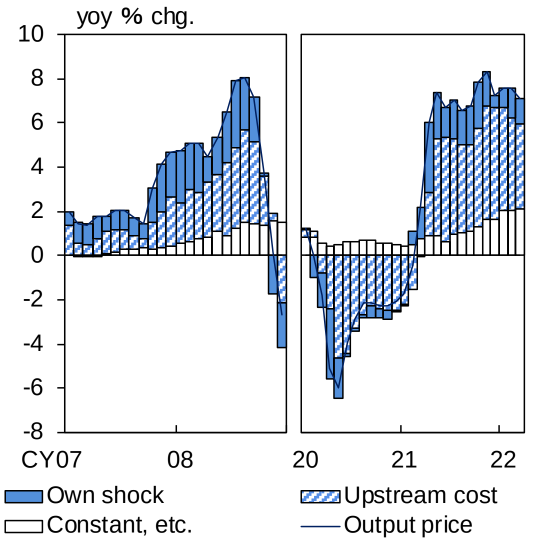


Note: Each figure shows an accumulated impulse response of each index to a 1% increase shock of each index. All indices exclude imported goods. The broken lines indicate the 90% confidence intervals.
Source: Bank of Japan.

Chart 11. Estimation results of the fixed-parameter VAR models: Historical decomposition

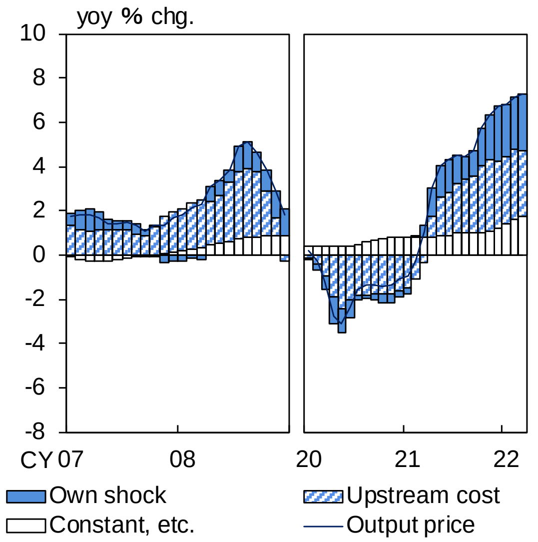
(a) Stage 1

(i) CY 2007-2008 (ii) From CY 2020



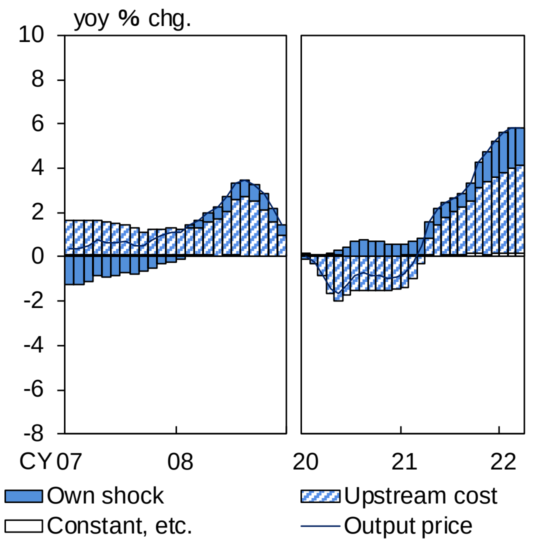
(b) Stage 2

(i) CY 2007-2008 (ii) From CY 2020



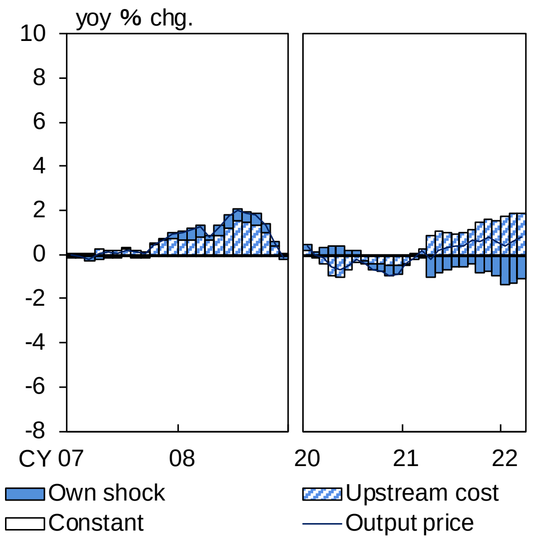
(c) Stage 3

(i) CY 2007-2008 (ii) From CY 2020



(d) Stage 4

(i) CY 2007-2008 (ii) From CY 2020

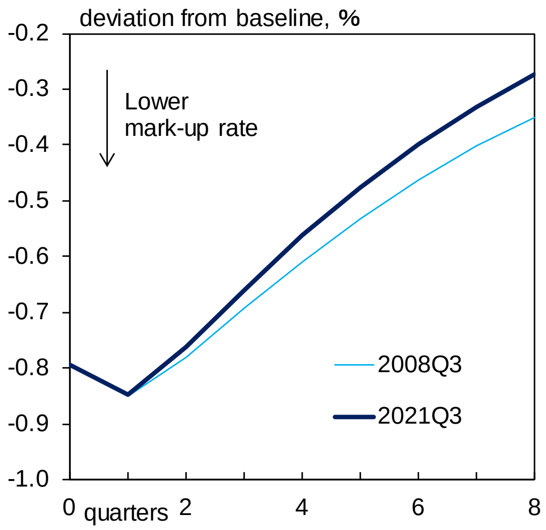


Note: The charts show the historical decompositions of ID2, ID3, ID4, and FD indices (which are approximations of the output price at each stage). All indices exclude imported goods. The figures before CY 2015 are authors' estimates based on the methodology of Inoue *et al.* (2021).

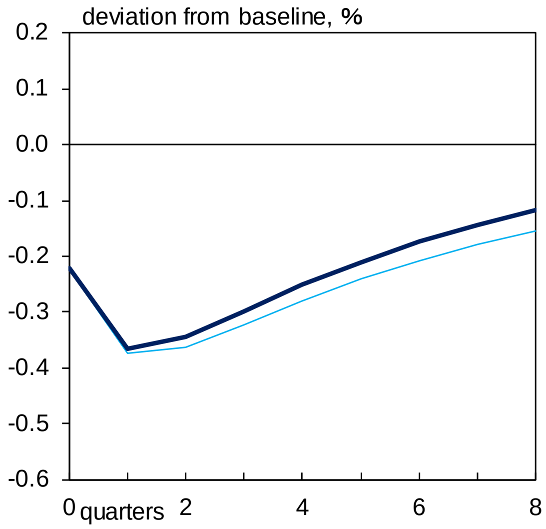
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 12. Estimation results of the TVP-VAR model:
Impulse responses of the mark-up rates to a 1% ID1 index increase shock

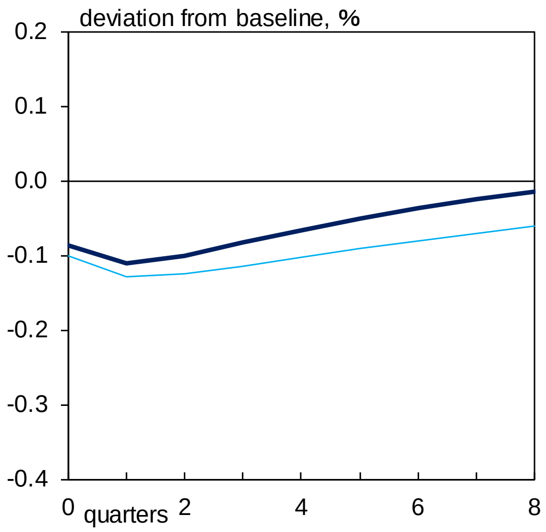
(a) Stage 1



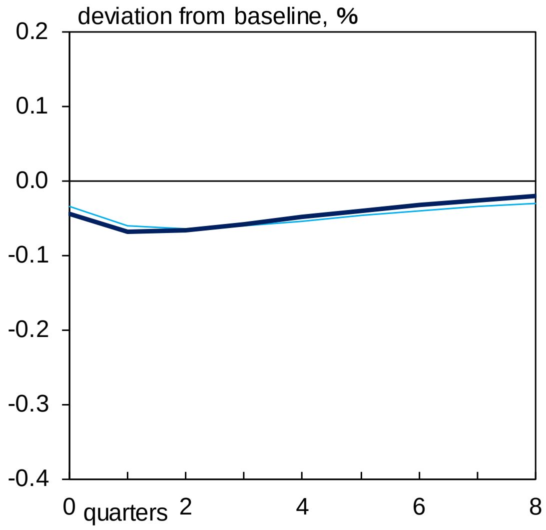
(b) Stage 2



(c) Stage 3

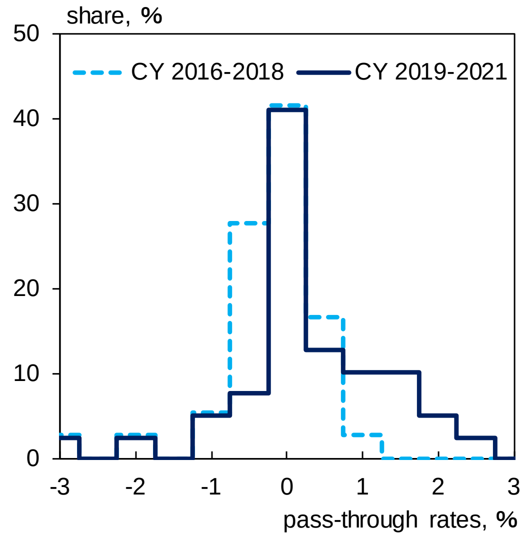


(d) Stage 4



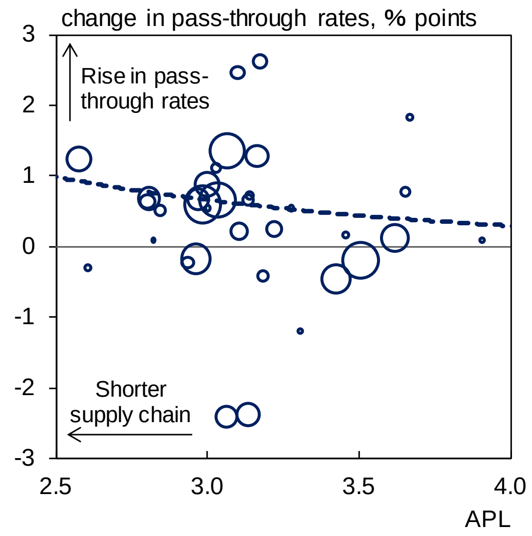
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 13. Distribution of item-level pass-through rates



Note: The distribution is plotted for items whose estimated pass-through rates fall within the range between -3% and +3%.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

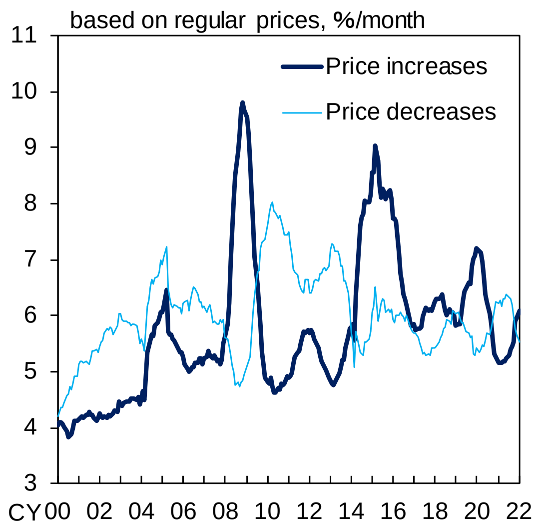
Chart 14. APL and pass-through rates



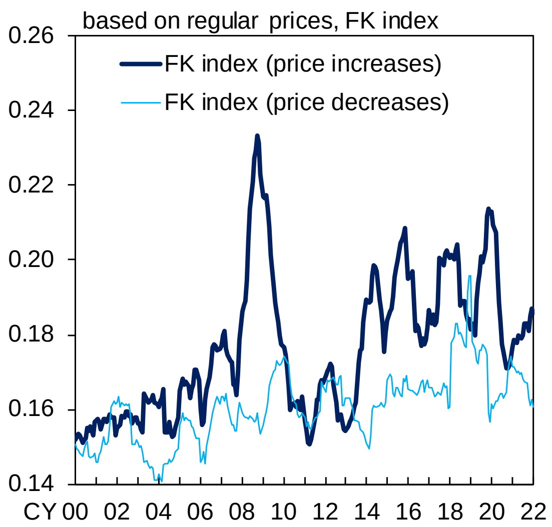
Note: The chart is plotted for items whose changes in pass-through rates from CY 2016–2018 to CY 2019–2021 fall within the range between -3% and +3%. The size of each bubble corresponds to the CPI weights. The broken line shows the fitted curve for items whose changes in pass-through rates fall within the range between 0% and +3%. The values of APL are those for CY 2015.
Sources: Ministry of Internal Affairs and Communications; Bank of Japan.

Chart 15. Price-setting behavior at retail sector (the case of food products)

(a) Frequency of price changes

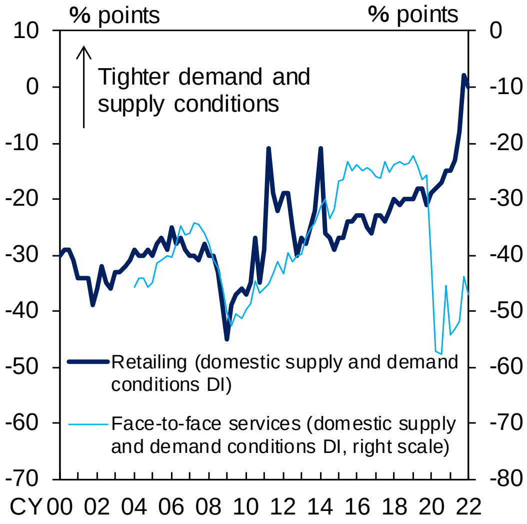


(b) Synchronization of price changes



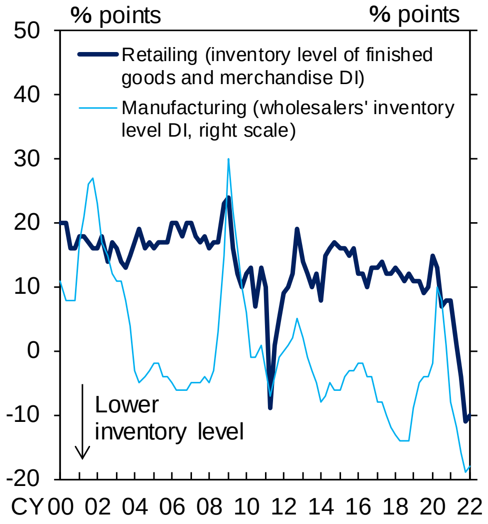
Note: Figures are the frequency of price changes and the synchronization (FK index) of price changes calculated by considering the most frequent prices in the 2 months before and after the month as the regular price (12-month backward moving averages). See Kurachi *et al.* (2016) for the method of calculating the regular prices and the frequency of price changes.
Source: Bank of Japan.

Chart 16. Domestic demand and supply conditions in consumption-related sectors



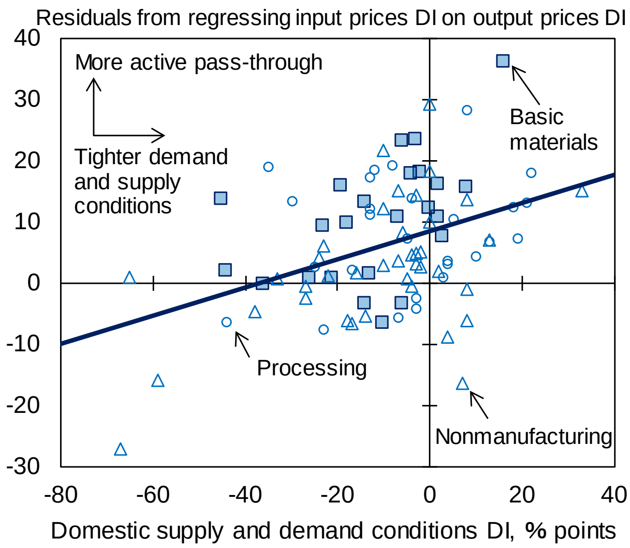
Note: Figures for face-to-face services are calculated as the weighted averages of the DIs of "services for individuals" and "accommodations, eating and drinking services" using the number of reporting companies as weights.
Source: Bank of Japan.

Chart 17. Inventory level of goods



Source: Bank of Japan.

Chart 18. Domestic demand and supply conditions and pass-through



Note: The markers indicate the DIs in 2022Q1 by industry and size.
The straight line is the fitted line for all data points.
Source: Bank of Japan.

Table A1. Material cost pass-through: Baseline estimation results

(The same estimation as in Tables 1 and 3 but without the dummy variable for non-linearity.)

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$				
	$h = 0$ (Shock)	$h = 2$ (2 quarters later)	$h = 4$ (4 quarters later)	$h = 6$ (6 quarters later)
Independent variables	[A1-I]	[A1-II]	[A1-III]	[A1-IV]
Constant	0.000 (0.000)	0.001 * (0.000)	0.001 ** (0.000)	0.002 *** (0.001)
$\Delta \ln COST_t$	0.200 ** (0.082)	0.485 *** (0.175)	0.688 ** (0.322)	0.527 (0.456)
$\Delta \ln CPI_{t-1}$	0.632 *** (0.107)	1.461 *** (0.209)	1.930 *** (0.303)	2.324 *** (0.463)
$\Delta \ln COST_{t-1}$	-0.045 (0.077)	-0.169 (0.182)	-0.298 (0.283)	-0.895 ** (0.418)
GAP_t	0.000 ** (0.000)	0.001 *** (0.000)	0.002 *** (0.000)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.001)
$\Delta \ln NEER_t \cdot (-1)$	-0.001 (0.004)	0.008 (0.008)	0.023 (0.014)	0.050 *** (0.019)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.002 (0.005)	0.015 (0.011)	0.029 ** (0.014)	0.071 *** (0.018)
$\hat{u}_{t+h-1}$		1.549 *** (0.194)	1.249 *** (0.155)	1.148 *** (0.145)
Adjusted R-squared	0.594	0.762	0.799	0.804
S.E. of regression	0.001	0.003	0.004	0.005

Note: CPI: CPI (all items less fresh food and energy), $COST$: Intermediate input cost index, GAP: Output gap, $NEER$: Nominal effective exchange rate, $\hat{u}$: Estimated residuals.

The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.

Table A2. Exchange rate pass-through: Baseline estimation results

(The same estimation as in Tables 2 and 4 but without the dummy variable for non-linearity.)

Dependent variable: $\ln CPI_{t+h} - \ln CPI_{t-1}$				
	$h = 0$ (Shock)	$h = 2$ (2 quarters later)	$h = 4$ (4 quarters later)	$h = 6$ (6 quarters later)
Independent variables	[A2-I]	[A2-II]	[A2-III]	[A2-IV]
Constant	0.000 (0.000)	0.001 ** (0.000)	0.001 *** (0.000)	0.002 ** (0.001)
$\Delta \ln NEER_t \cdot (-1)$	0.003 (0.003)	0.020 *** (0.006)	0.043 *** (0.010)	0.066 *** (0.013)
$\Delta \ln CPI_{t-1}$	0.652 *** (0.107)	1.477 *** (0.217)	1.901 *** (0.311)	2.196 *** (0.454)
$\Delta \ln NEER_{t-1} \cdot (-1)$	0.006 * (0.003)	0.021 ** (0.008)	0.030 ** (0.013)	0.052 *** (0.016)
GAP_t	0.000 *** (0.000)	0.001 *** (0.000)	0.002 *** (0.000)	0.003 *** (0.001)
GAP_{t-1}	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.001 (0.001)
$\Delta \ln EPI_t$	0.027 ** (0.012)	0.049 * (0.027)	0.029 (0.041)	0.017 (0.051)
$\Delta \ln EPI_{t-1}$	-0.024 * (0.013)	-0.081 *** (0.025)	-0.115 *** (0.034)	-0.164 *** (0.047)
$\hat{u}_{t+h-1}$		1.534 *** (0.181)	1.249 *** (0.138)	1.157 *** (0.133)
Adjusted R-squared	0.593	0.766	0.803	0.817
S.E. of regression	0.001	0.003	0.004	0.004

Note: CPI: CPI (all items less fresh food and energy), $NEER$: Nominal effective exchange rate, GAP: Output gap, EPI: Export price index, $\hat{u}$: Estimated residuals.
The CPI (all items less fresh food and energy) excludes mobile phone charges and the effects of the consumption tax hikes, policies concerning the provision of free education, and the "Go To Travel" campaign, which covers a portion of domestic travel expenses. The estimation period is from 2000Q1 to 2021Q4. HAC standard errors are in parentheses. ***, **, and * denote statistical significance at the 1, 5, and 10% level, respectively.