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What Caused the Pandemic-Era Inflation?: Application of the Bernanke-Blanchard Model to Japan

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Abstract

Many countries have experienced high inflation since the COVID-19 pandemic. Japan is no exception, albeit lower levels than those of other countries. This paper analyzes the direct and indirect effects of product-market and labor-market shocks on prices and nominal wages using the model proposed by Bernanke and Blanchard (2023). With minor modifications to incorporate the dual structure of the Japanese labor market, the model achieved a good fit to actual Japanese data. The main findings are as follows. First, the high inflation that Japan has experienced in the wake of the pandemic can be explained mostly by product-market specific shocks such as energy and food price spikes, but not by labor market tightness. This result is similar to the U.S. results presented in the Bernanke-Blanchard paper, which is somewhat surprising given the differences between Japan and the U.S. in labor market structure and firms' price- and wage-setting behavior. Second, Japan's low inflation relative to the U.S. during this period can be explained by a difference in the initial conditions of the underlying inflation trend before the pandemic and a difference in the degree of labor market tightness. Lastly, the model suggests that the impact on inflation of changes in labor market tightness was weaker in Japan.

JEL Classification: E31, E24, E52
Keywords: Inflation, Wages, Labor Market, Inflation Expectation, COVID-19

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1. Introduction

This paper analyzes the sources of high inflation in Japan since the COVID-19 pandemic by applying the small-scale economic model proposed by Bernanke and Blanchard (2023, hereafter BB) to the Japanese economy. This work is part of a joint project by Ben Bernanke, Olivier Blanchard, and economists from ten central banks: the Bank of England, the European Central Bank, the Bank of France, the Bank of Italy, the Bank of Spain, De Nederlandsche Bank, the Deutsche Bundesbank, the National Bank of Belgium, the Bank of Canada, and the Bank of Japan. Each regional project applies the BB model to their economy with some modifications, and the comparative analysis across economies is explored in Bernanke and Blanchard (2024), which summarizes regional commonalities and differences in inflation dynamics and finds surprisingly similar results across regions regarding the sources of the post-pandemic inflation.

The question posed in the original BB paper is, what explains the U.S. high inflation since the pandemic? Specifically, the paper analyzes the role of labor market overheating and product-market shocks in the inflation dynamics. Their results suggest that the high inflation was mainly driven by an increase in energy and food prices, and only partly by labor market overheating. This goes against the view of those economists who argued that wage growth could rise much more than predicted by a conventional Phillips curve relationship and consequently contribute to higher inflation (Summers, 2021; Blanchard, 2021). However, the paper also points out that, in predicting future price developments, it is necessary to pay attention to labor market conditions, given the persistent impact of labor market overheating on nominal wages and inflation. Since the high inflation observed since the pandemic is a phenomenon commonly seen across countries, international comparisons will provide further insight into the question of whether the conclusions in the BB paper are specific to the U.S. or are more general and applicable to other countries, including Japan.

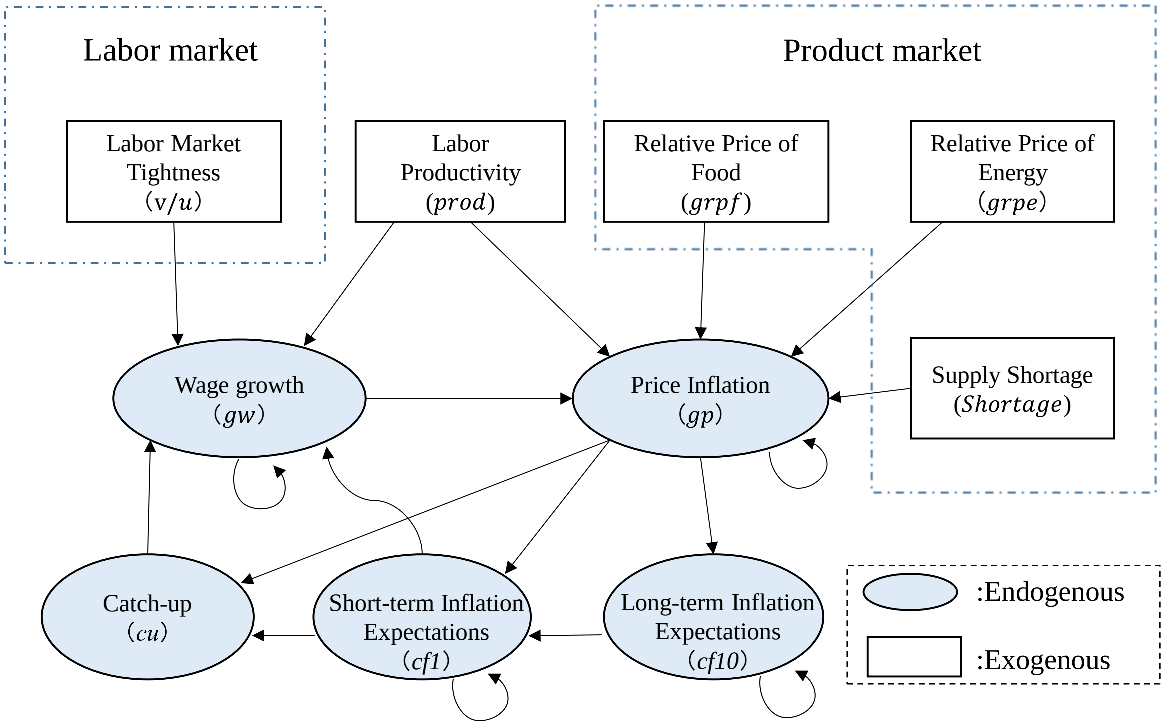
The remainder of the paper proceeds as follows. Section 2 introduces the original BB model and describes the modifications we made to the model in applying it to the Japanese economy. Section 3 reports our main results regarding post-pandemic inflation in Japan. Section 4 concludes.

2. Empirical economic model

2.1. Basic structure of the Bernanke-Blanchard model

In this section, we first overview the economic model proposed in the BB paper. The BB model follows the spirit of a structural vector autoregression (SVAR) model with additional exogenous variables. It consists of four endogenous variables: inflation rate (*gp*), nominal wage growth rate (*gw*), short-term and long-term inflation expectations (*cf1* and *cf10*). In addition to these four variables, a variable that represents catch-up behavior *(cu)* is also included as an endogenous variable to capture the impact on wages of unexpected inflation, which is calculated by the difference between the actual inflation rate and inflation expectations from the previous year. Next, the model includes the following exogenous variables: labor market tightness (*v/u* = vacancy-to-unemployment ratio), changes in relative prices of energy and food to wages (*grpe* and *grpf*), a supply shortage index (*shortage*), and labor productivity growth (*prod*). Figure 1 provides a visual representation of the relationship among these variables in the BB model.

Figure 1. Structure of the Bernanke-Blanchard model



Notes: Arrows toward each endogenous variable in the circles indicate how the variable is explained by lagged values of itself and other variables. For instance, wage growth is estimated with lags of wage growth, short-term inflation expectations, catch-up, labor market tightness, and labor productivity.

In the model, labor market tightness directly affects nominal wage growth but only indirectly affects price inflation, while product-market shocks (i.e., changes in energy and food prices, and supply shortages) affect price inflation both directly and indirectly. These indirect effects include second-round effects through the formation of inflation expectations and the catch-up behavior in the VAR dynamics.

More concretely, the BB model is represented by the following equations:

$$gw_t = \alpha_0 + \sum_{i=1}^{4} \alpha_{1,i} gw_{t-i} + \sum_{i=1}^{4} \alpha_{2,i} cf1_{t-i} + \sum_{i=1}^{4} \alpha_{3,i} cu_{t-i} + \sum_{i=1}^{4} \alpha_{4,i} (v/u)_{t-i} + \alpha_5 prod_{t-1} + \epsilon_{1,t} \quad s.t. \sum_{i=1}^{4} \alpha_{1,i} + \sum_{i=1}^{4} \alpha_{2,i} = 1 \tag{1}$$

$$gp_t = \beta_0 + \sum_{i=1}^{4} \beta_{1,i} gp_{t-i} + \sum_{i=0}^{4} \beta_{2,i} gw_{t-i} + \sum_{i=0}^{4} \beta_{3,i} grpe_{t-i} + \sum_{i=0}^{4} \beta_{4,i} grpf_{t-i} + \sum_{i=0}^{4} \beta_{5,i} shortage_{t-i} + \beta_6 prod_t + \epsilon_{2,\mathrm{t}} \quad s.t. \sum_{i=1}^{4} \beta_{1,i} + \sum_{i=0}^{4} \beta_{2,i} = 1 \tag{2}$$

$$cf1_t = \sum_{i=1}^{4} \gamma_{1,i} cf1_{t-i} + \sum_{i=0}^{4} \gamma_{2,i} cf10_{t-i} + \sum_{i=0}^{4} \gamma_{3,i} gp_{t-i} + \epsilon_{3,t} \quad s.t. \sum_{i=1}^{4} \gamma_{1,i} + \sum_{i=0}^{4} \gamma_{2,i} + \sum_{i=0}^{4} \gamma_{3,i} = 1 \tag{3}$$

$$cf10_t = \sum_{i=1}^{4} \delta_{1,i} cf10_{t-i} + \sum_{i=0}^{4} \delta_{2,i} gp_{t-i} + \epsilon_{4,t} \quad s.t. \sum_{i=1}^{4} \delta_{1,i} + \sum_{i=0}^{4} \delta_{2,i} = 1 \tag{4}$$

$$cu_t = \frac{1}{4} \sum_{i=0}^{3} gp_{t-i} - cf1_{t-4} \tag{5}$$

Equations (1) - (4) have autoregressive terms with four quarter lags and current and lagged values of other variables, therefore we interpret this system of equations as a VAR model. As proposed in the BB paper, the regressions are run equation-by-equation with homogeneity restrictions on endogenous variables. Imposing such homogeneity restrictions on a VAR model is novel in the sense that it brings unique characteristics to the model. Specifically, it ensures that, in the long-run, price inflation and (short- and long-term) inflation expectations converge to a certain value, i.e. trend inflation, and wage growth converges to a value consistent with trend inflation and labor productivity growth.[1] Analysis of the long-run equilibrium and/or trend inflation of the model is potentially promising, though it is beyond the scope of this paper.

2.2. Japanese model: dual structure of labor market

Next, we explain the modifications made in applying the BB model to the Japanese economy.

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[1] In the long-run equilibrium, we assume that exogenous variables such as vacancy-to-unemployment ratio will converge to unique (natural) values, while the BB model does not have such a mechanism internally. Under this assumption, steady-state rates of price inflation and wage growth would be determined regardless of the labor market conditions as the long-run Phillips curve would be vertical.

Specifically, we take into account the heterogeneity in wage determination between full-time and part-time workers. It is well-known that one of the notable features of the Japanese labor market is the dual labor market structure between these two (see, for example, Bank of Japan, 2018, 2023a).

Even before the pandemic, the Japanese labor market had continued to show clear tightening, but the growth of nominal wages for full-time workers, who constitute the majority of the labor force, remained modest. Previous studies have pointed out that the low sensitivity of full-time workers' nominal wages to labor market tightness can be attributed to the wage-negotiation practices that are specific to Japan. Since many full-time workers belong to seniority-based salary systems under long-term employment practices, their nominal wages are basically insensitive to labor market conditions (Date et al., 2023). On the other hand, this is not the case for part-time jobs. Nominal wages for part-time workers tend to reflect labor market conditions as part-time workers can easily change jobs across firms. Existing research finds that they respond significantly to changes in labor market tightness (Hoshi and Kashyap, 2021). All told, when analyzing wage dynamics in Japan, it is critical to consider both types of workers separately.

Against this backdrop, in our application of the BB model to the Japanese data, we modify the nominal wage equation (Equation 1) to the following equations for full-time and part-time workers.[2] To calculate average nominal wage growth for total gw, we use the number of full-/part-time employees as weights.

$$gw_t^L = \alpha_0^L + \sum_{i=1}^{4} \alpha_{1,i}^L gw_{t-i}^L + \sum_{i=1}^{4} \alpha_{2,i}^L cf1_{t-i} + \sum_{i=1}^{4} \alpha_{3,i}^L cu_{t-i} + \sum_{i=1}^{4} \alpha_{4,i}^L (v/u)_{t-i} + \alpha_5^L prod_{t-1} + \epsilon_{1,t}^L \quad \textit{for } L = \{\, FT \textit{ or } PT \,\} \qquad (1')$$

$$gw_t = w^{FT} gw_t^{FT} + w^{PT} gw_t^{PT}$$

This setup enables us to take into account the difference in the elasticity of wages to labor market tightness in the Japanese dual labor market.

3. Data and estimation results

In this section, we give the details of our dataset for the Japanese model and present the estimation results.

[2] We use monthly base pay for full-time workers and hourly earnings for part-time workers, respectively. This reflects the fact that full-time workers typically receive a fixed monthly salary and overtime pay, while part-time workers are usually paid based on an hourly rate and hours worked.

3.1. Data

Table 1 summarizes the data used for the Japanese model. To make our model comparable to the original BB model, we try to make the definitions of the data similar to the BB model as far as possible. That said, some differences are unavoidable due to data availability in the Japanese statistics.

Table 1. Data description for the Japanese model

Variable (Endogenous)	Description	Source
gp	Price inflation: Consumer Price Index (CPI), all items excluding the effects of the consumption tax hikes, q/q change, s.a., annualized.	Ministry of Internal Affairs and Communications, "Consumer Price Index."
gw (full-time)	Monthly base pay: Scheduled Cash Earnings for full-time workers, monthly average, q/q change, s.a., annualized.	Ministry of Health, Labour and Welfare, "Monthly Labour Survey."
gw (part-time)	Hourly earnings: Scheduled Cash Earnings for part-time workers, hourly average, q/q change, s.a., annualized.	
cf1	Short-term inflation expectations (1-year ahead): composite indicator estimated using data of inflation expectations for households, firms, and experts	Bank of Japan, "Opinion Survey on the General Public's Views and Behavior" and "Short-term Economic Survey of Enterprises in Japan (*Tankan*)"; Concensus Economics Inc., "Concensus Forecasts"; QUICK, "QUICK Monthly Market Survey <Bonds>"; Bloomberg (for inflation swap data).
cf10	Long-term inflation expectations (10-year ahead): composite indicator estimated using data of inflation expectations for households, firms, and experts	

Variable (Exogenous)	Description	Source
grpe	Relative energy prices: ratio of the CPI energy index to Scheduled Cash Earning, q/q change, s.a., annualized.	Ministry of Internal Affairs and Communications, "Consumer Price Index"; Ministry of Health, Labour and Welfare, "Monthly Labour Survey."
grpf	Relative food prices: ratio of the CPI food index to Scheduled Cash Earning, q/q change, s.a., annualized.	
shortage	Supply shortage index: search volume in Google for the term "供給不足" ("supply shortage" in Japanese) in Japan.	Google Trends, available at: .trends.google.co.jp/trends/explore?date=all&geo=JP&q =供給不足&hl=ja（Accessed: December 2023)
v/u	Labor market tightness: ratio of job vacancy to unemployment.	Ministry of Internal Affairs and Communications, "Labour Force Survey"; Ministry of Health, Labour and Welfare, "Employment Referrals for General Workers."
prod	Labor productivity: real GDP / (number of employed persons * hours worked), q/q change, s.a., annualized, eight-quarter average.	Cabinet Office, "SNA (National Accounts of Japan);" Ministry of Health, Labour and Welfare of Japan, "Monthly Labour Survey."

First, for price inflation, we use seasonally-adjusted quarterly annualized rates of change in the Consumer Price Index (CPI) for all items excluding the effects of the consumption tax hikes. For nominal wages, we use monthly base pay for full-time workers and hourly earnings for part-time workers from the establishment survey called "Monthly Labour Survey." Since the seasonally-adjusted quarterly changes of these figures are very volatile, we extract the trend and cycle components based on the seasonal adjustment models.

For short- and long-term inflation expectations, we construct aggregated indicators using data of inflation expectations for households, firms, and experts (including economists and market participants). Specifically, we calculate them based on the first principle component extracted from these inflation expectations.[3]

Next, the relative price of food and energy is calculated as the ratios of the corresponding CPI subgroup indices to nominal wages. For the supply shortage index, we use the volume index of Google Trends for the term "供給不足" ("supply shortage" in Japanese) searched from Japan. This indicator shows a large spike at the time of the Great East Japan Earthquake in 2011, due to earthquake-related supply shortages, which is considered to be a phenomenon with a mechanism that differs significantly from the global supply chain disruption during the pandemic.[4] In our estimation, this spike is treated as an outlier and interpolated using its pre-pandemic average. For a labor market slack indicator, we use the vacancy-to-unemployment ratio, following the BB model. Labor productivity is calculated as the ratio of real GDP to labor input (i.e., employment numbers times labor hours).

Finally, the estimation period starts at 1990Q1 in the BB paper, while the beginning of the period for Japan varies between 1991Q4 to 1993Q2, depending on data availability. The end of the estimation period is 2023Q2 for all equations.[5] We have included two dummies (for 2020Q2 and 2020Q3) in the wage equations to deal with the unusual wage changes during the pandemic.

3.2. Estimation results

Next, we present the estimation results for each equation, comparing them with the U.S. results presented in the BB paper.

3.2.1. Price equation

Table 2 shows the regression results for the price inflation equation. It reports the sum of the estimated coefficients for each variable and two relevant p-values: the *p-value (sum)* denotes the probability of rejection of the null hypothesis that the sum of coefficients is zero; and the *p-value (joint)* tests the joint hypothesis that each of the lagged coefficients is separately zero.

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[3] Developments in inflation expectations sometimes differ significantly across households, firms, economists and market participants. After the pandemic, firms' indicators showed a significant increase around late 2021, while economists' indicators have started to increase very recently. This is why we use the composite indexes in our exercise. For a related discussion, see Nishino et al. (2016).

[4] For the analysis of the effect of the earthquake on inflation, see Nakamura (2011).

[5] See Appendix A for the estimation results using the pre-pandemic sample (until 2019Q4). See also Appendix B for the actual data used for our estimation.

As in the BB paper, the regression model is constrained such that the sum of the coefficients on lagged inflation and lagged nominal wages is to be one. Labor productivity, which is included as an explanatory variable in the BB model, is excluded from the Japanese price model because the estimated coefficient on labor productivity becomes significantly positive, which does not satisfy the sign condition, when we regress the original specification.

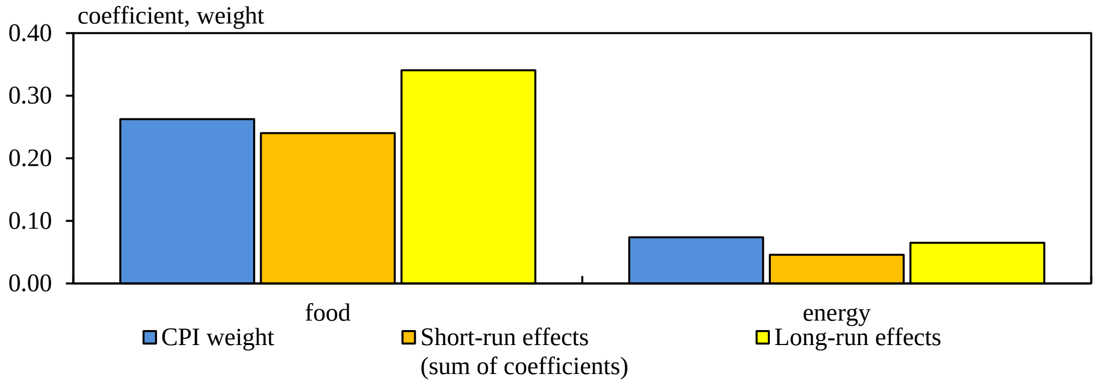
Table 2. Price inflation regression (dependent variable: *gp*)

Independent variables:	gp	gw	grpe	grpf	shortage
Lags	-1 to -4	0 to -4	0 to -4	0 to -4	0 to -4
Sum of coefficients	0.295	0.705	0.046	0.240	0.043
p-value (sum)	0.198	0.002	0.019	0.002	0.153
p-value (joint)	0.110	0.000	0.000	0.000	0.008
R-squared			0.838		
Estimation period			1993/2Q-2023/2Q		

Notes: p-value (sum) denotes the p-value for the null hypothesis that the sum of coefficients is zero, and p-value (joint) denotes the p-value for the joint hypothesis that each of the current and lag coefficients separately equals zero.

The sums of estimated coefficients on changes in relative prices of energy and food are significantly positive at 5% confidence levels, while the sum of coefficients on the shortage variable is not statistically significant based on its p-value (sum). To evaluate the size of coefficients on the relative prices, we compare them with their weight in the CPI. Figure 2 shows that the sums of the coefficients are almost the same as the CPI weight, suggesting that the estimated short-run effects of changes in food and energy prices within the quarter are basically identical to their own contributions to the index. On the other hand, it also shows that their long-run effects including spillovers are larger than the short-run effects.

Figure 2. CPI weight vs sum of coefficients



Notes: Long-run effects of *grpf* and *grpe* are calculated as the ratio of the sum of coefficients on each of them to one minus the sum of coefficients on *gp*, respectively.

3.2.2. Wage equations

Tables 3 and 4 give the estimation results for nominal wage equations for full-time and part-time workers. As well as the price equation, we impose a homogeneity restriction that the sum of coefficients on lagged nominal wage growth and lagged short-term inflation expectations is to be one.

Table 3. Full-time wage growth regression (dependent variable: *gw (full-time)*)

Independent variables:	gw	v/u	catch-up	cf1	gpty
Lags	-1 to -4	-1 to -4	-1 to -4	-1 to -4	-1
Sum of coefficients	0.778	-0.070	-0.022	0.222	0.060
p-value (sum)	0.000	0.636	0.797	0.003	0.348
p-value (joint)	0.000	0.841	0.608	0.073	0.348
R-squared			0.765		
Estimation period			1992/4Q-2023/2Q		

Notes: p-value (sum) denotes the p-value for the null hypothesis that the sum of coefficients is zero, and p-value (joint) denotes the p-value for the joint hypothesis that each of the current and lag coefficients separately equals zero. Coefficients on pandemic dummies are 0.049 for 2020Q2 and 1.708 for 2020Q3.

Table 4. Part-time wage growth regression (dependent variable: *gw (part-time)*)

Independent variables:	gw	v/u	catch-up	cf1	gpty
Lags	-1 to -4	-1 to -4	-1 to -4	-1 to -4	-1
Sum of coefficients	0.177	0.934	-0.202	0.823	0.061
p-value (sum)	0.251	0.003	0.219	0.000	0.581
p-value (joint)	0.000	0.028	0.234	0.000	0.581
R-squared			0.602		
Estimation period			1993/2Q-2023/2Q		

Notes: p-value (sum) denotes the p-value for the null hypothesis that the sum of coefficients is zero, and p-value (joint) denotes the p-value for the joint hypothesis that each of the current and lag coefficients separately equals zero. Coefficients on pandemic dummies are 0.239 for 2020Q2 and -2.311 for 2020Q3.

For full-time workers, the sum of coefficients of v/u is not statistically significant from zero, while that for part-time workers is significantly positive. This result suggests the existence of a dual labor market in Japan, which is consistent with the results of previous studies. The catch-up, which represents the effect of unexpected price fluctuations, has no significant effect for both full-time and part-time workers. This is the same as the U.S. results in the BB paper and implies that wage negotiations to counter changes in real wages due to unexpected price inflation are limited. The coefficient on labor productivity growth is positive but not statistically significant, similar to the U.S. results.

3.2.3. Inflation expectations equations

Tables 5 and 6 show the results of the short-term and long-term inflation expectations equations. The long-term inflation expectations equation is quite simple, consisting of its lagged values and the past inflation, while for short-term inflation expectations, the specification is the same but also includes long-term expectations. These regressions are constrained so that the sum of the coefficients is to be one.

Table 5. Short-term inflation expectations regression (dependent variable: *cf1*)

Independent variables:	cf1	cf10	gp
Lags	-1 to -4	0 to -4	0 to -4
Sum of coefficients	0.981	0.018	0.001
p-value (sum)	0.000	0.154	0.979
p-value (joint)	0.000	0.000	0.016
R-squared	0.975		
Estimation period	1991/4Q-2023/2Q		

Notes: p-value (sum) denotes the p-value for the null hypothesis that the sum of coefficients is zero, and p-value (joint) denotes the p-value for the joint hypothesis that each of the current and lag coefficients separately equals zero.

Table 6. Long-term inflation expectations regression (dependent variable: *cf10*)

Independent variables:	cf10	gp
Lags	-1 to -4	0 to -4
Sum of coefficients	0.994	0.006
p-value (sum)	0.000	0.396
p-value (joint)	0.000	0.004
R-squared	0.908	
Estimation period	1991/4Q-2023/2Q	

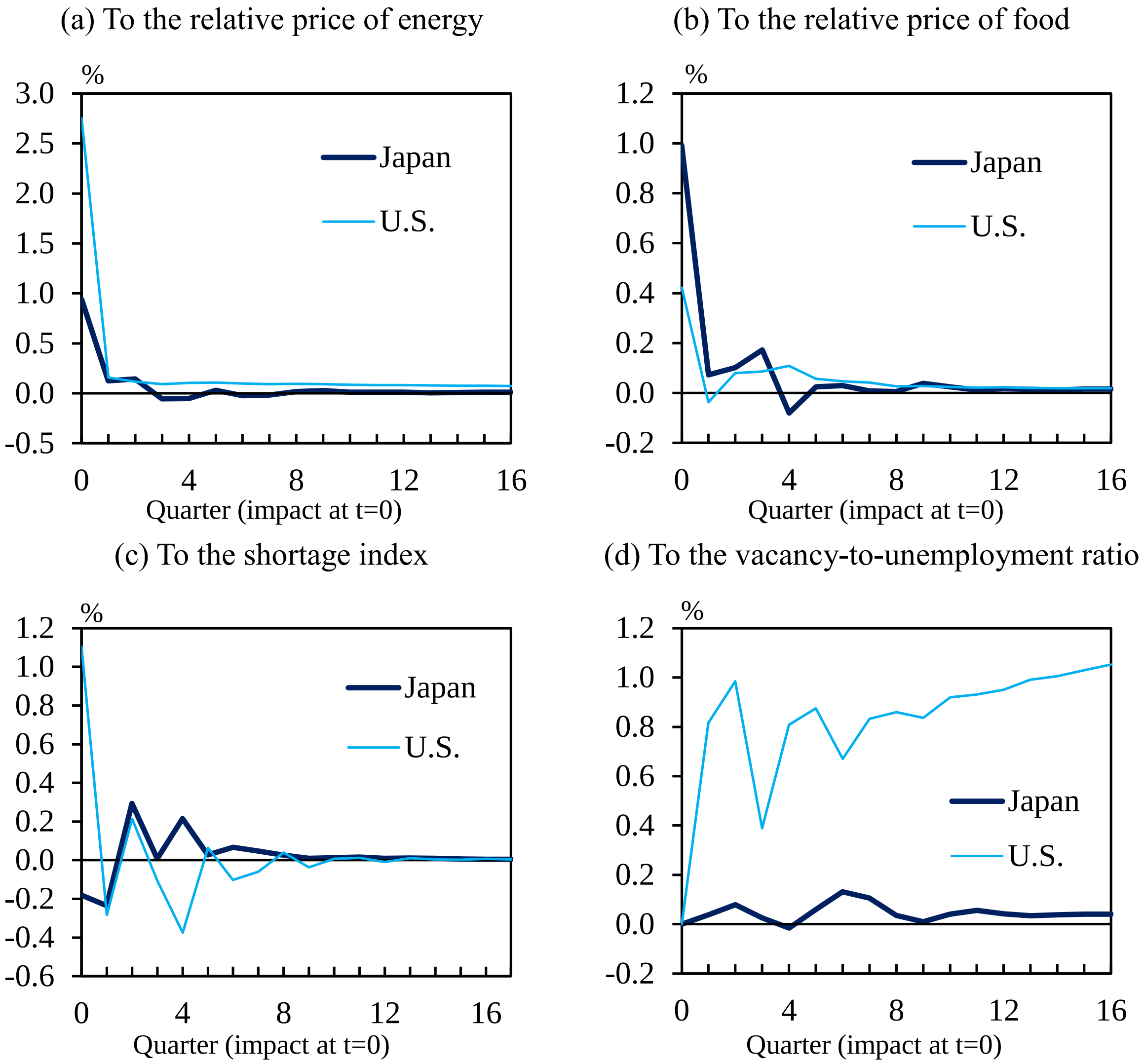
Notes: p-value (sum) denotes the p-value for the null hypothesis that the sum of coefficients is zero, and p-value (joint) denotes the p-value for the joint hypothesis that each of the current and lag coefficients separately equals zero.

Our results indicate a high persistence of inflation expectations in Japan. The sum of coefficients on the lagged values of dependent variables is 0.981 for short-term and 0.994 for long-term, where both coefficients are much larger than those in the U.S. results. This reflects the fact that inflation expectations were persistently low at well below 2% in Japan during the estimation period, and our model also implies that shocks to inflation are unlikely to lead to a wage-price spiral through the dynamics of inflation expectations. That said, we should pay attention to any shocks to inflation expectations that cannot be captured in the model.

3.3. Impulse response functions

Since the BB model has a structure of a VAR model, it is possible to calculate impulse response functions for endogenous variables. Figure 3 shows the impulse responses of price inflation to product-market and labor-market shocks.

Figure 3. Impulse response functions of price inflation



Notes: Figures show impulse responses of price inflation to one-standard-deviation positive shocks to relative energy price, relative food price, the shortage variable, and the v/u ratio.

First, as shown in Panels (a) and (b), the impact of food and energy price shocks on price inflation looks large but is basically short-lived, as is the case with the U.S. results. On the other hand, the supply shortage has some lagged effects (Panel (c)). This is likely because the supply shortage affected the inflation mainly through import prices, thus the impact unfolds more gradually than in the U.S.

Next, Panel (d) shows that the impact of the labor-market slack (v/u ratio) on inflation is positive but relatively small for Japan, which contrasts with the U.S. results. This reflects the fact that in Japan wages for full-time workers, which account for a large share of the total number of workers, are insensitive to labor-market slack. As the first-round effect of labor market tightness on inflation is smaller in Japan, second-round effects through inflation expectations also become smaller than in the U.S.

3.4. Quantifying the sources of the post pandemic inflation

In this section, we present the historical decompositions of developments in price inflation and wage growth using our estimation results. In the decomposition, we refer to the portion explained by shocks prior to 2019Q4 as the *initial condition*. This approach helps us to understand the effects of exogenous shocks on inflation dynamics since the pandemic.

Figure 4 presents the decomposition of price inflation since the pandemic. It shows that the increase in inflation since the pandemic is largely explained by the increase in energy and food prices. The large contribution of food and energy prices mainly reflects the fact that the Japanese economy is heavily dependent on imported food and energy. Large increases in imported commodity prices since 2022, largely due to geopolitical tensions and a rapid depreciation of the yen, have had a lagged effect on domestic food prices. These factors have also affected the contribution of energy prices, though it has been relatively contained because of the government's measures to directly reduce the high price of gas and electricity during this period. In addition, supply shortage indicators have pushed prices higher since 2022.[6] On the other hand, the impact of labor market tightening during this period has been limited. This result is similar to the U.S. results in the BB paper, which says that the cause of high inflation in the post-pandemic period can be explained primarily by food and energy price shocks. This similarity of inflation dynamics between Japan and U.S. since the pandemic is somewhat surprising, given that the two economies have totally different labor market structures and firms' price- and wage-setting behaviors. Our findings suggest that their respective inflation dynamics were driven by the same product-market factors during this period.

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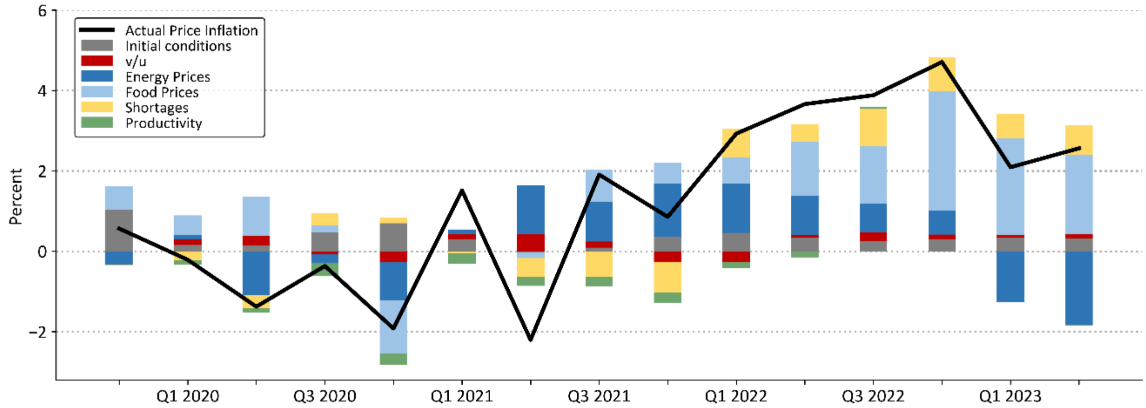
[6] Meanwhile, the estimated contributions of supply shortage that lowered price inflation during 2021 seem contaminated due to the large reduction in mobile phone charges in response to the government's request, which happened during the same period (Bank of Japan, 2021).

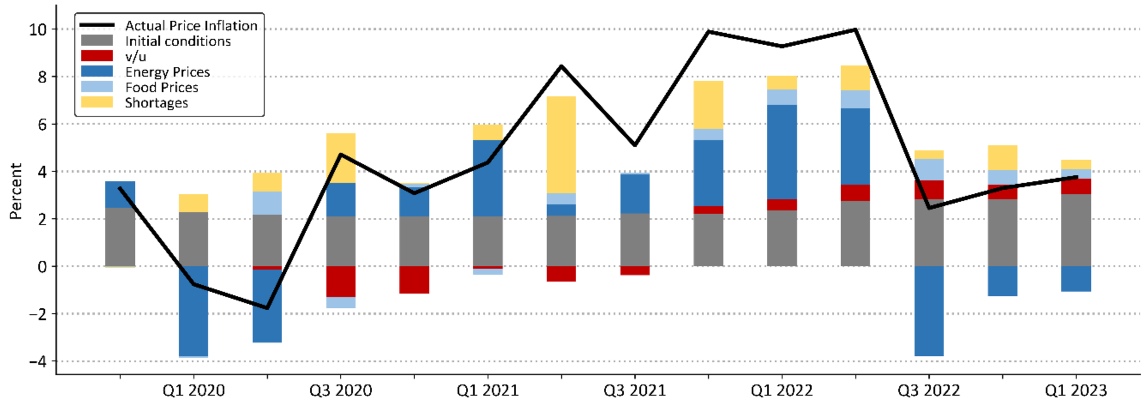
Figure 4 also shows a difference: the level of Japan's inflation rate has been low relative to that of the U.S. which peaked at around 10%. This can be explained by the following two reasons. First, there is a difference in the initial conditions of the underlying inflation trend. In fact, inflation rate and inflation expectation levels in Japan were significantly lower than in the U.S. for over two decades before the pandemic. Second, there has been a difference in the degree of labor market tightness. In the U.S., the v/u ratio recovered strongly after a sharp decline due to the outbreak, but improvement of the v/u ratio in Japan during this period was smaller in comparison.[7]

Figure 4. Historical decompositions of price inflation

Japan



U.S.



Notes: Figures show decomposition of price inflation by source, based on the regression results of the full model. The black line indicates actual inflation.
Sources: Authors' calculation; Bernanke and Blanchard (2023)

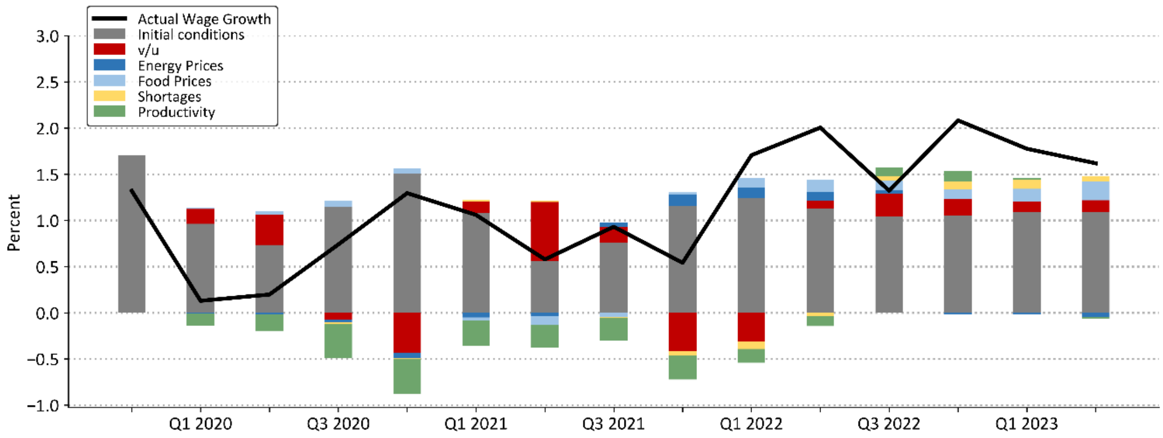
Next, we show the decomposition of wage growth in Figure 5. For Japan, the contribution of the v/u ratio is smaller than that in the U.S. results, which is seen in the price

[7] Uchida (2024) discusses the sources of the relatively contained price/wage developments in Japan since the pandemic and points out that it is likely attributable to the limited impact of the pandemic on labor supply due to labor hoarding, and to the behavior and mindset based on the assumption that prices and wages will not increase easily, which are entrenched due to the past experience of prolonged deflation.

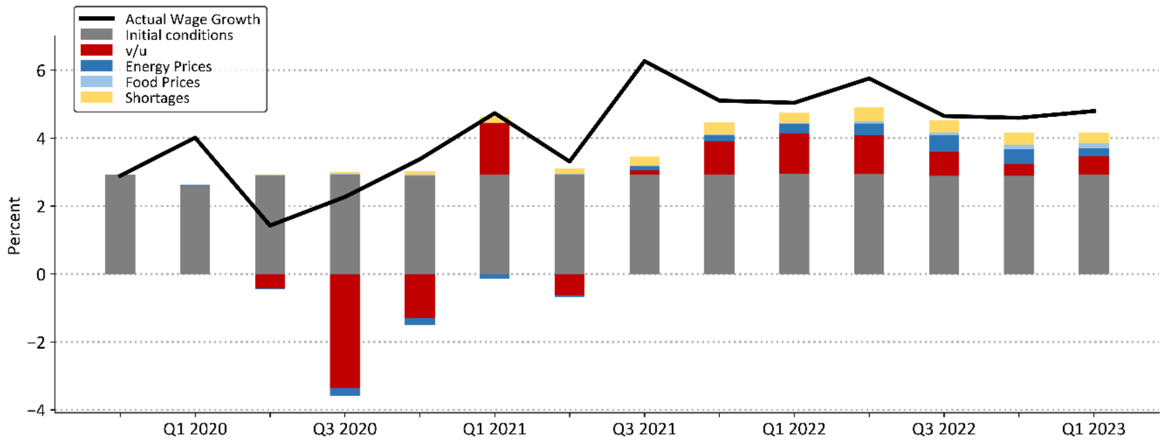
decomposition as well. The contribution has turned positive since the middle of 2022, while remaining limited relative to the U.S. results. For product-market shocks, food prices and supply shortages have recently been seen to have a moderate impact. This may reflect the fact that the recent price hikes have been taken into consideration in the wage negotiations for full-time workers.

Figure 5. Historical decompositions of wage inflation

<u>Japan</u>



<u>U.S.</u>



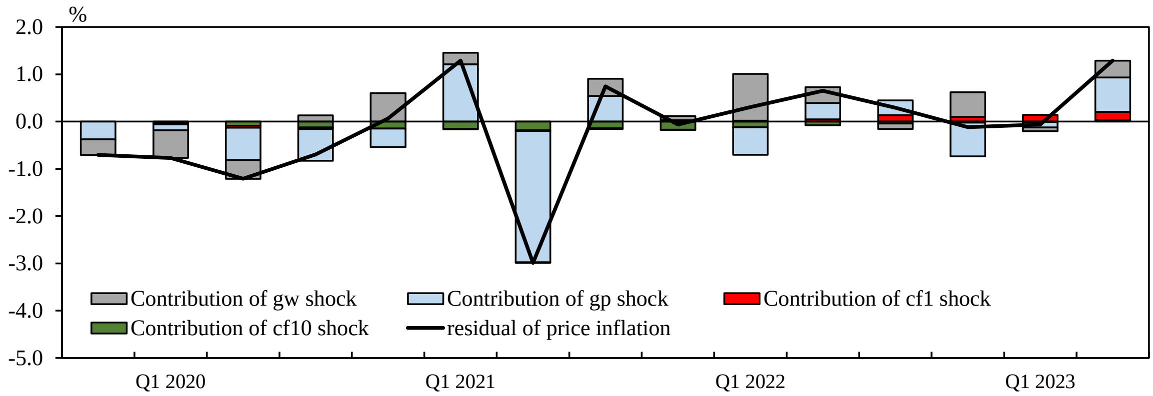
Notes: Figures show decomposition of nominal wage growth by source, based on the regression results of the full model. For Japan, figures are for weighted average of full-time and part-time workers. The black line indicates actual wage growth.
Sources: Authors' calculation; Bernanke and Blanchard (2023)

3.5. Residual analysis of price inflation and wage growth

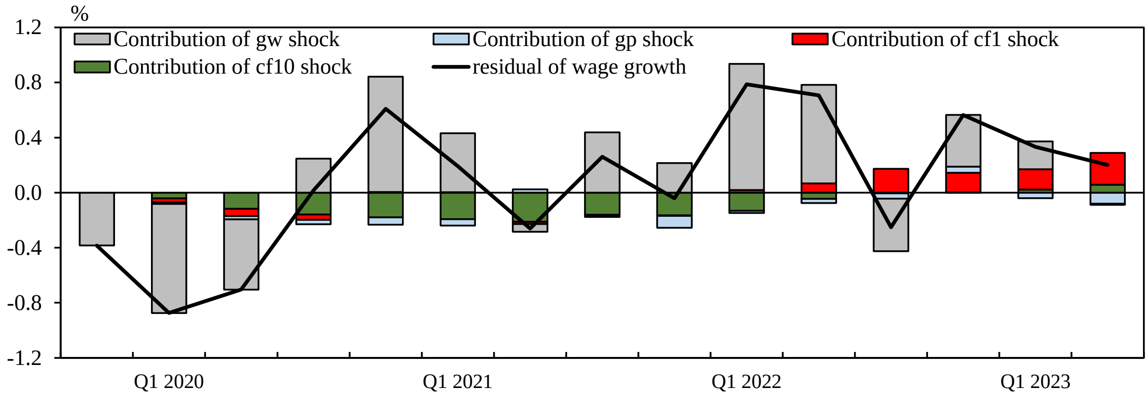
Figures 4 and 5 also indicate that the fitted values, which are calculated as the sum of the contributions from exogenous variables as well as initial conditions, move almost parallel with actual developments. This suggests that the model achieved a good fit to actual Japanese data. That said, there are some differences between the fitted and actual values. These residuals emerged due to the design of our calculation for the decomposition where we do not take into account additional shocks that are not explained by the endogenous and exogenous variables considered in our model. It would be beneficial to examine what kind of shocks contribute to the fluctuations in the residuals. To see this point, in Figure 6, we decompose the price inflation residuals and wage growth residuals into the impact of four shocks originally stemming from each equation.[8]

Figure 6. Decomposition of residuals

Residuals of price inflation



Residuals of wage growth



Notes: Black solid lines indicates the residuals for price inflation and nominal wage growth equations that are calculated as differences between actual values and the sum of the contribution of sources considered in Figures 4 and 5, respectively. The *gw* shock contribution includes the effects of pandemic dummies for 2020Q2 and 2020Q3.

Regarding shocks stemming from the price and wage equations, the figures show a large negative price shock in the price inflation equation in 2021Q2, which is likely due to the one-time large reduction in mobile phone charges in the same period, and large negative wage shocks in the wage growth equations in early 2020, which can be interpreted as pandemic shocks. Aside from these shocks, it should be noted that shocks from inflation expectations equations have been gradually pushing up the residuals in both panels. This indicates that there are some upward movements in inflation expectations that are not explained by its lagged values or an actual inflation surge in our inflation expectations

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[8] These shocks are not necessarily independent and may be correlated with each other.

equations, and these shocks have gradually spilled over to price inflation and wage growth. This may reflect the recent positive changes in firms' wage- and price-setting behavior, which had been subdued for a long time mainly due to the experience of prolonged low growth and deflation. To examine this possibility and its impact on trend inflation, we have to wait for more data and information.

4. Conclusion

This paper applies the model proposed by Bernanke and Blanchard (2023) to the Japanese economy and finds that the model is useful in analyzing the direct and indirect effects of product-market and labor-market shocks on price inflation and nominal wage growth in the period since the COVID-19 pandemic.

The main results of the Japanese model are as follows. First, the high inflation that Japan has experienced since the pandemic can be explained mostly by product-market specific shocks such as energy and food price spikes, but not by labor market tightness. This result is similar to the U.S. results, which is somewhat surprising given the differences between Japan and the U.S. in labor market structure and firms' price- and wage-setting behavior. Second, Japan's low inflation relative to the U.S. during this period can be explained by a difference in the initial conditions of the underlying inflation trend before the pandemic and a difference in the degree of labor market tightness. Lastly, the model suggests that the impact on inflation of changes in labor market tightness was weaker in Japan.

Overall, our findings are consistent with the situation that the Japanese economy has faced since the pandemic. That said, since the model does not explicitly identify independent demand and supply shocks in the labor market and the goods market, further investigation of these could be critical to fully understand the current situation and to forecast future developments precisely. Specifically, the impact of labor shortages on wages and changes in price-setting behavior on food prices, often cited by Japanese companies, has not been examined in detail, while these factors have likely played an important role in recent price and wage developments. Exploring the formation of inflation expectations and trend inflation may also be promising future research.

This work also contributes to the joint project with Ben Bernanke, Olivier Blanchard and economists of various central banks. This project is an unprecedented opportunity, allowing central bank economists to analyze inflation and wage growth dynamics using a common framework, which enables us to make comparison across economies and to explore some insights into post-pandemic inflation. This paper documents the detailed results of the model applied to the Japanese economy as an input for the international comparison explored in Bernanke and Blanchard (2024).

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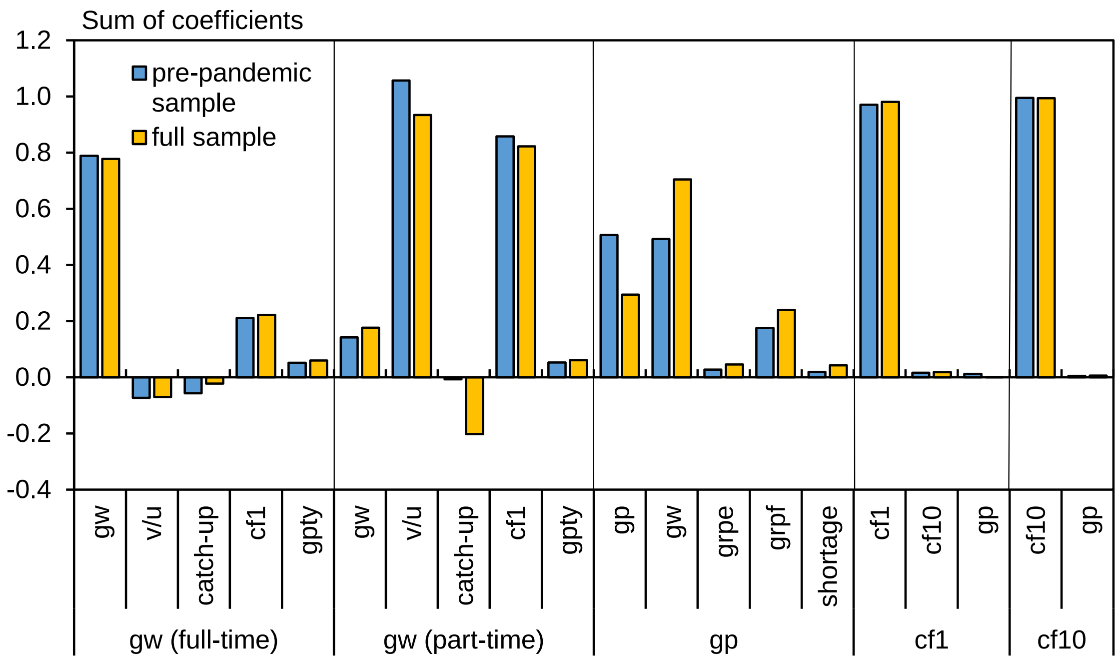
Appendix A. Estimation results with the pre-pandemic sample

The economic shocks caused by COVID-19 were unprecedented, both in size and characteristics, and thus the ways in which the economy responded to those shocks might have been very different from in regular circumstances, and they may also have brought permanent structural changes to the economy. To examine this possibility and the robustness of our model specifications, we compare the parameters of the model estimated using the full sample (until 2023Q2) with those estimated using the pre-pandemic sample (until 2019Q4).

Figure A.1. Estimation results using full sample and pre-pandemic sample



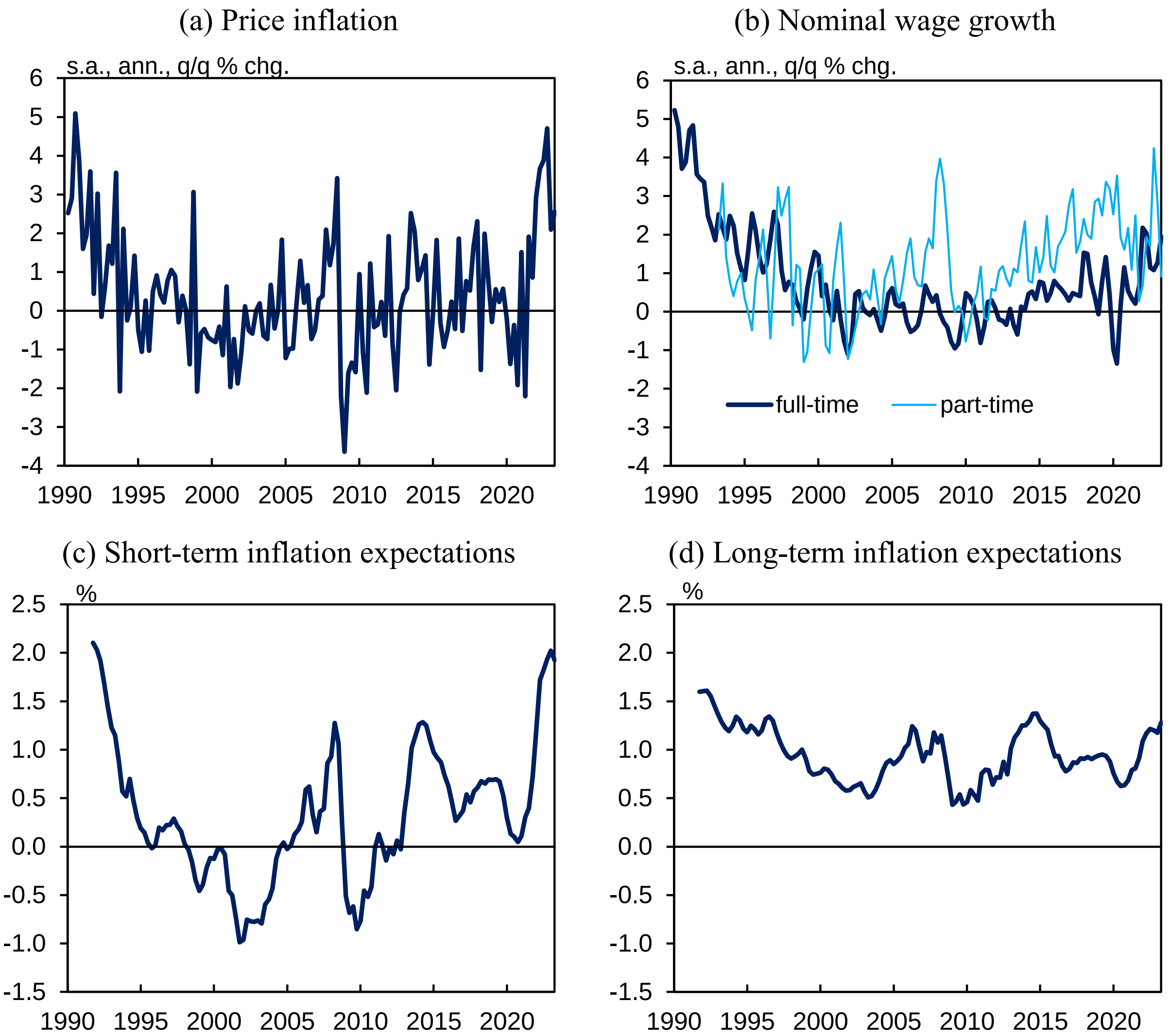
Notes: The estimation period ends 2019Q4 for the pre-pandemic sample and 2023Q2 for the full sample estimation.

As shown in Figure A.1, the coefficients from both results are generally similar for all equations. There is no material difference in the results for short- or long-term inflation expectations. For the wage equations, all estimated coefficients are similar in terms of size and statistical significance.[9] For the price equation, the sum of coefficients of its lags (*gp*) is smaller for the results using the full sample than those with the pre-pandemic sample. This implies that price inflation has become less persistent since the pandemic, or put differently, it might imply that the linkage between price inflation and nominal wage growth has gradually intensified since the pandemic, as also discussed in Bank of Japan (2023b).

[9] For the part-time wage equation, the coefficient on catch-up is larger with the pre-pandemic sample, while this is not statistically significant, as is the case with the full sample.

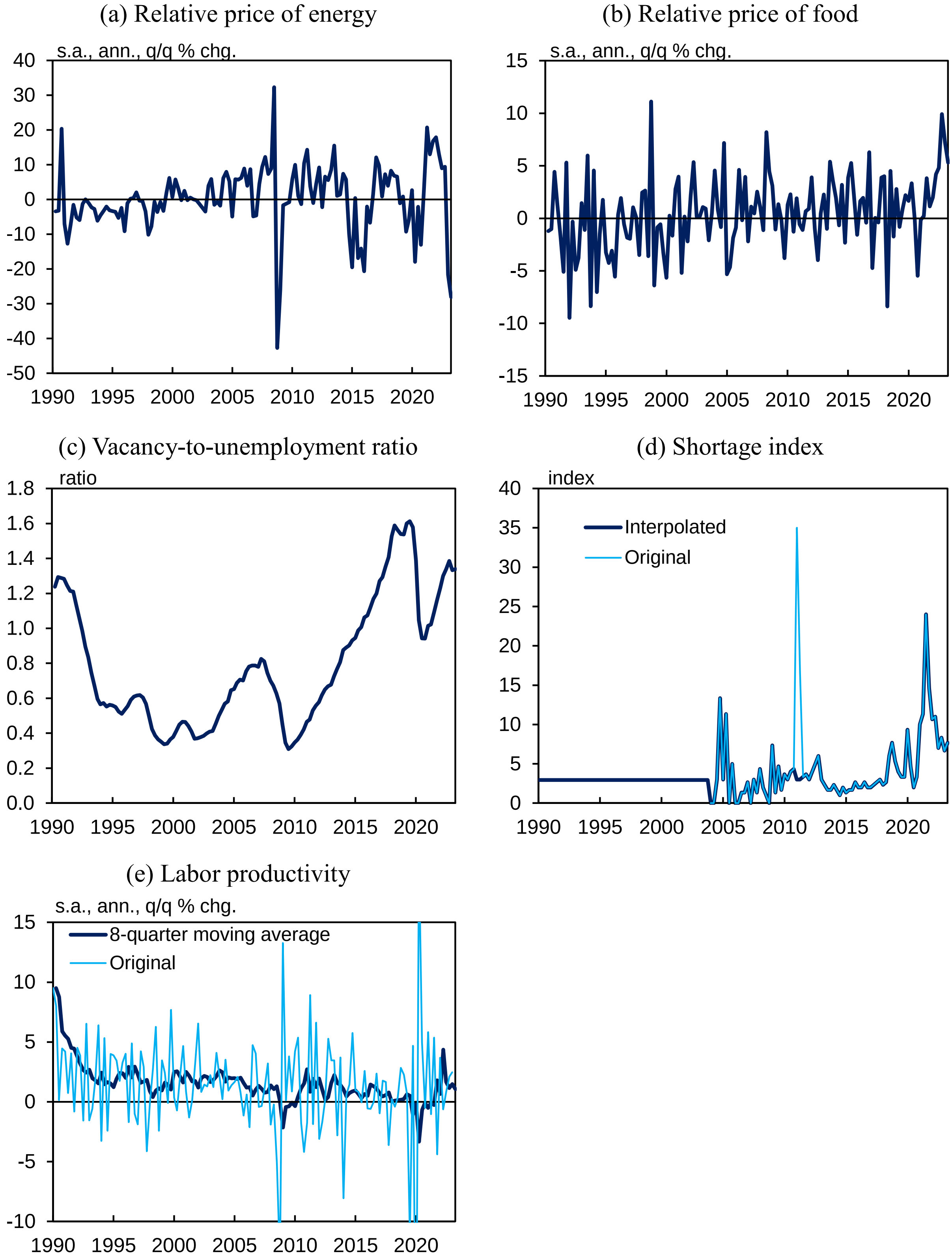
Appendix B. Data used for the Japanese model

Figure B.1. Endogenous variables



Sources: Ministry of Internal Affairs and Communications; Ministy of Health, Labour and Welfare; Bank of Japan; Concensus Economics Inc., "Consensus Forecasts"; QUICK, "QUICK Monthly Market Survey <Bonds>"; Bloomberg.

Figure B.2. Exogenous variables



Sources: Ministry of Internal Affairs and Communications; Ministry of Health, Labour and Welfare; Google Trends; Cabinet Office.