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The Slope of the Phillips Curve for Service Prices in Japan: Regional Panel Data Approach

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The Slope of the Phillips Curve for Service Prices in Japan: Regional Panel Data Approach*

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Abstract

We estimate the slope of the Phillips curve for service prices in Japan using prefecture-level panel data, where we control the impact of inflation expectations on inflation by including time-fixed effects instead of proxies for inflation expectations. Our estimates indicate the flattening of the slope of the Phillips curve for the majority of seven subgroups in services since the 2000s. We also examine for any changes in the slope of the Phillips curve in the 2010s and during the Covid-19 pandemic, but observe no clear evidence of such changes.

JEL classification: C32, C33, E31, E52
Keywords: Phillips curve, Service prices, Inflation expectations, Inflation dynamics

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1. Introduction

Understanding the mechanism of inflation dynamics is crucial for central banks seeking price stability. The Phillips curve is the traditional analytical framework used to analyze inflation dynamics by academics and policymakers (Hara et al. 2020). In particular, the New Keynesian Phillips curve (NKPC), with its micro-foundations of nominal price rigidities, is the primary analytical framework in modern macroeconomics.[1]

The framework of the NKPC categorizes the drivers of inflation dynamics into (1) supply-demand balance, (2) inflation expectations, and (3) other factors including supply shocks (Nishizaki et al. 2011). Various studies have suggested a weakening relationship between the supply-demand balance and inflation—seen in a flatter Phillips curve slope and less sensitive inflation to changes in supply-demand balance—since the 1990s, especially in major advanced economies (Hall 2011; IMF 2013; Del Negro et al. 2020).[2] For example, Rusticelli et al. (2015) estimate the slope of the Phillips curve (coefficient for unemployment gap) for OECD economies and find that the post-1998 estimate is flatter or insignificant compared to the long-term estimate from the 1970s. Moreover, the IMF (2013) finds the flattening of the slope of the Phillips curve in many advanced countries since 1995 by using 6-10 year ahead inflation expectations from Consensus Forecasts in their estimation. Further, the literature considers that the mild disinflation during the global financial crisis ("Missing Disinflation") and the lack of inflation rise during the post-crisis economic recovery ("Missing Inflation") imply the flattening of the slope of the Phillips curve.[3]

With respect to Japan, the flattening of the Phillips curve has been documented by many studies (Nishizaki and Watanabe 2000; De Veirman 2009; Nishizaki et al. 2011; Gemma et al. 2017; Kaihatsu and Nakajima 2018). For instance, Nishizaki and Watanabe (2000) show that the slope of the Phillips curve in Japan flattened significantly in the 1990s using prefecture-level data from 1971 to 1997. Further, Gemma et al. (2017) estimate the

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[1] Woodford (2003), Walsh (2003), and Galí (2008) explain the theoretical foundations of the NKPC. Additionally, Fuchi and Watanabe (2002), Hirata and Kato (2004), and Tsuruga and Muto (2008) provide an overview of the NKPC in Japanese.

[2] In the context of the NKPC framework, the flattening of the Phillips curve indicates an increase in nominal price rigidities, meaning a larger number of firms producing goods or services are unable to adjust their prices to their optimal levels due to certain constraints. This refers to the explanation of time-dependent nominal price rigidities such as Calvo-type price stickiness (Calvo 1983) which assumes that firms have random opportunities to adjust their prices, or Taylor-type price stickiness (Taylor 1980) which supposes that firms have periodic opportunities to adjust their prices. Furthermore, it has been established that the NKPC can be derived from the assumption of quadratic change in price cost, i.e., state-dependent price stickiness (Rotemberg 1982).

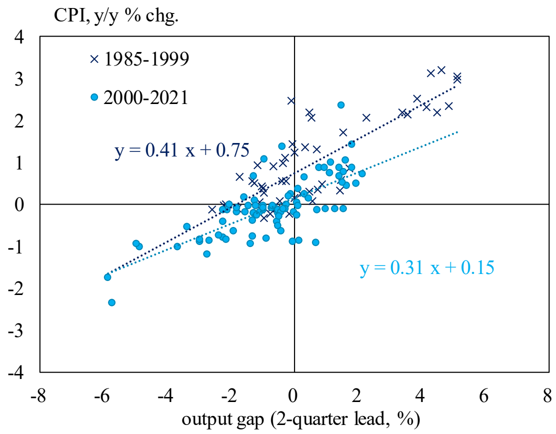
[3] See Constâncio (2015), Yellen (2017). Moreover, Gilchrist et al. (2017) and Coibion and Gorodnichenko (2015a) analyze the inflation dynamics in the United States during the Missing Disinflation, and Del Negro et al. (2015) and Harding et al. (2022) investigate the dynamics during the Missing Inflation.

Generalized Phillips curve (the extended NKPC with time-varying trend inflation) in Japan and find the flattening of the slope of the Phillips curve during the low inflation period from 1998 to 2012. Importantly, visualizing the Phillips curve by plotting the Consumer Price Index (CPI) growth rate against the output gap in Japan reveals that the slope for goods has remained relatively unchanged throughout the sample period, whereas the slope for services has declined since 2000 (Figure 1). In this regard, Watanabe and Watanabe (2017) conduct an estimation of the Phillips curve using a rolling sample window approach from 1987 to 2013 and utilizing CPI data for both goods and services. Their results show that throughout the entire sample period, the slope of the Phillips curve for services was consistently flatter compared to the slope for goods, and the slope of the Phillips curve for both goods and services has flattened since the late 1990s. In addition to the findings of Watanabe and Watanabe (2017), the flattening of the Phillips curve for service prices has also been documented by other studies such as Saita et al. (2006) and Kaihatsu et al. (2022).

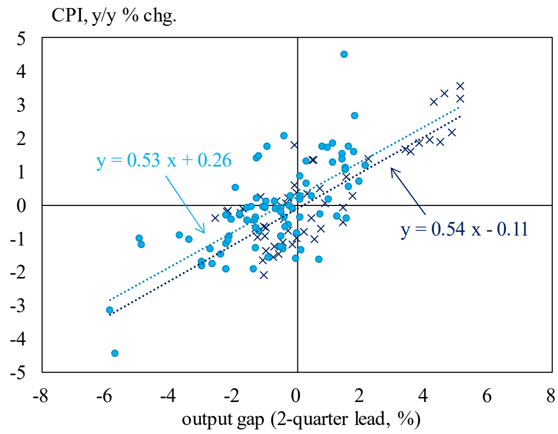
In the context of estimating the slope of the Phillips curve, one major challenge is to account for factors that may affect the inflation rate as well as the output gap, such as inflation expectations. According to the literature, there are two standard approaches employed to control the impact of inflation expectations on the inflation rate in estimating the slope of the Phillips curve: (1) actual inflation rate is utilized as a proxy variable for inflation expectations, based on the assumption of "full-information rational expectation formation" (Galí and Gertler 1999) and (2) inflation expectations gathered from survey research for each economic agent are utilized (Roberts 1995). Because the assumptions about the process of inflation expectations are different, these two approaches could generate significantly different estimation results (Mavroeidis et al. 2014). In terms of the recent developments in the literature, the use of survey data on inflation expectations has gained increasing popularity in recent years, reflecting a growing recognition that expectation formation by economic agents is not consistent with "full-information rational expectation formation" (Coibion and Gorodnichenko 2015a, 2015b; Fuhrer 2012, 2017; among others). However, the survey data collected from different types of economic agents, such as households and firms, is influenced by unique noise that causes variations in the level and movement of data from one type of agent to another. This poses another challenge in estimating the Phillips curve. Neglecting this issue can lead to biased parameters and reduced reliability of the estimation results.

Figure 1. The Phillips Curve in Japan

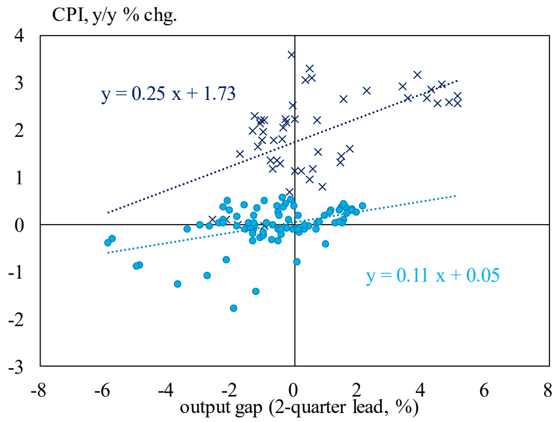
CPI (less fresh food)



CPI Goods (less fresh food)



CPI Services



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

Note: Estimation periods in each graph are 1985/1Q-1999/4Q and 2000/1Q-2021/3Q, respectively.

Against this backdrop, Hazell, Herreño, Nakamura and Steinsson (2022) (hereafter HHNS) propose a novel approach to estimate the slope of the Phillips curve controlling for the effect of inflation expectations on inflation rates, using local-level panel data and incorporating time-fixed effects.[4] Specifically, they construct "one country, two regions, and two goods" model including tradeable and non-tradeable (service) sectors, and derive the Phillips curve for each region and good. In this model, the slope of the Phillips curve for

[4] In macroeconomics, controlling the effects of external macro factors such as inflation expectations, monetary policy shocks, and supply shocks on time-series data can be challenging. To address this issue, an approach that takes advantage of the cross-sectional variation in regional data to overcome the limitations of time-series analysis is being utilized in various fields, such as the estimation of fiscal multipliers and Phillips curves. Examples of research in this area include works by Nakamura and Steinsson (2018), Guren et al. (2020), Fitzgerald and Nicolini (2014), and McLeay and Tenreyro (2019).

non-tradeable goods in each region are equal to the slope of the Phillips curve for prices of all goods (tradable and non-tradable goods) in an entire country (under the assumptions that households’ preferences, firms’ price revision opportunities, and other parameters are the same in both regions) because non-tradeable goods, which cannot be traded across regions, are not affected by country-level economic fluctuations.[5] Based on this model, they propose and estimate the slope of the Phillips curve for service prices (non-tradable goods) in the United States using state-level panel data of price indices from 1978 to 2018. In their estimation, they control for the effects of inflation expectations and other relevant factors on inflation by including time-fixed effects as common factors across regions. Importantly, the estimates by HHNS indicate that the flattening of the slope of the Phillips curve in the United States is not substantial, implying that the perceived flattening of the Phillips curve in the United States may not accurately reflect the actual economic phenomenon and instead may be a misleading observation caused by changes in inflation expectations and other relevant factors—the sensitivity of the inflation rate to changes in the balance between supply and demand has not diminished.

In this study, using the approach by HHNS, we estimate the regional Phillips curve for service prices (non-tradable goods) in Japan by utilizing prefecture-level CPI data. The objective of this analysis is to investigate whether the slope of the Phillips curve for service prices in Japan has flattened or not. On the one hand, the results of the estimation indicate that the slope of the Phillips curve for service prices in Japan has experienced a noticeable flattening during the 2000s, which contrasts with the conclusions drawn by HHNS for the United States. On the other hand, neither a significant change in the slope has been observed since the 2010s nor during the Covid-19 pandemic. As previously mentioned, based on the theory proposed by HHNS, implications of these estimation results would also be applicable to the country-level Phillips curve.

In relation to the literature, to the best of the authors' knowledge, no studies have applied the HHNS methodology to Japanese service prices.[6] This study also distinguishes itself by analyzing service prices across multiple industries, using long-term data up until the 2020s. In this manner, this study makes a novel contribution by offering fresh, detailed, and reliable estimates of the Phillips curve in Japan.

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[5] The regional Phillips curve for tradeable goods has a flatter slope compared to the country-level Phillips curve. This is because prices of tradable goods are impacted by economic fluctuations, but have a weaker correlation with regional economic fluctuations.

[6] Kuroda and Yamamoto (2005) estimate "Wage Phillips curve" by panel data approach using Japanese regional data.

It is worth noting that Nishizaki and Watanabe (2000) estimate the Phillips curve by utilizing regional panel data in Japan, which can be considered a precursor to the work of HHNS, as it also employs regional data in its analysis.[7] However, unlike HHNS, Nishizaki and Watanabe (2000) estimate the Phillips curve for aggregate CPI. In this context, as discussed by HHNS, when estimating the slope of the Phillips curve using regional data, it is appropriate to restrict the estimation scope to services whose prices are influenced by region-specific factors. This is because the prices of tradable goods that are determined across the country are not responsive to region-specific factors. Furthermore, the HHNS model postulates that the slope of the Phillips curve for services is in congruence with that of the aggregate Phillips curve, making it theoretically appropriate to limit the focus of analysis to the slope of the Phillips curve for service prices. Hence, this study, which restricts its analysis to service prices, has a unique methodological contribution to the literature on the estimation of the Phillips curve in Japan.

The remainder of this study is organized as follows. Section 2 describes the methodology, and Section 3 explains the dataset. Section 4 reports the estimation results, and Section 5 concludes.

2. Methodology

In this section, we outline the methodology for empirical analysis. First, we describe the challenges in using survey data as a proxy for inflation expectations. Subsequently, we explain the HHNS's approach to overcoming the challenges and describe the analytical framework of the study, which builds on their approach.

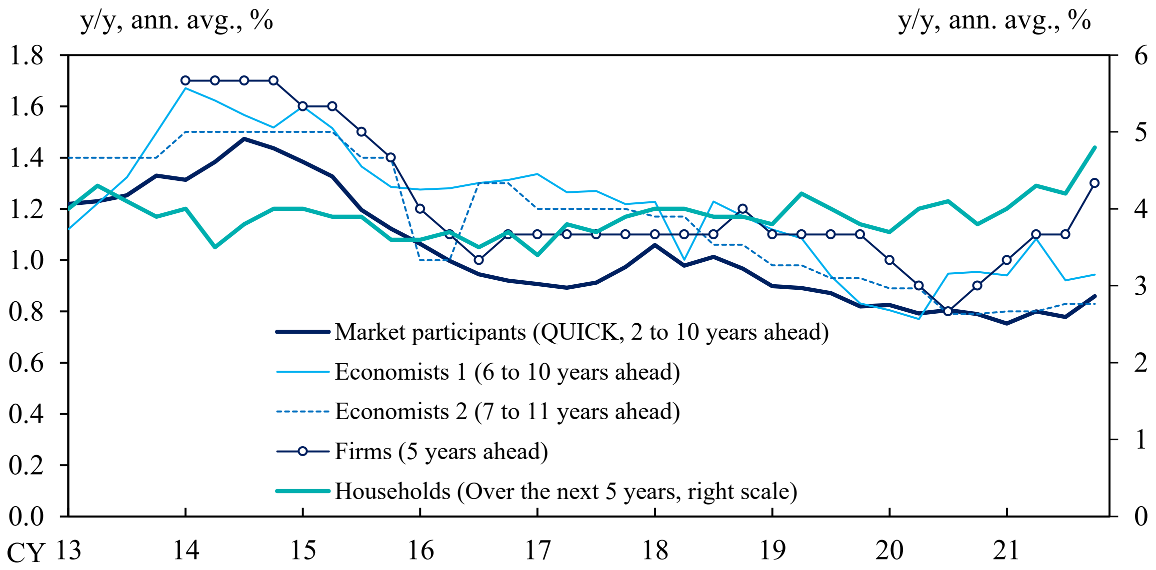
2-1. Challenges in using survey data as a proxy variable for inflation expectations

In recent years, survey data have been frequently used as a proxy variable for inflation expectations. However, two types of issues have been raised with the use of such data. First, the dynamics of inflation expectations, as measured by survey data, can vary greatly among different types of agents. In Japan, for example, the data collected from households, firms, economists, and financial market participants exhibit significant heterogeneity (Figure 2). Similarly, in other economies, the inflation expectations of economists have been shown to be more responsive to changes in monetary policy than others (Coibion et al. 2020). While there is no consensus on whose inflation expectations should be used to estimate the Phillips

[7] Nishizaki and Watanabe (2000) employ a combination of two approaches to control for a country-level factor in estimating the NKPC: (1) incorporating time-fixed effects in panel regression models and (2) expressing each variable as a deviation from the country-level average.

curve, these facts suggest that the estimation results and their implications can vary depending on whose inflation expectations are used.

Figure 2. Inflation Expectations of each Economic Agent in Japan



Sources: Bank of Japan; QUICK, "QUICK Monthly Market Survey <Bonds>"; Japan Center for Economic Research, "ESP Forecast"; Consensus Economics Inc., "Consensus Forecasts."

Notes: 1. "Economists 1" shows the forecasts of economists in the *Consensus Forecasts*. "Economists 2" shows the forecasts of professional forecasters in the *ESP Forecast*.

2. Figures for firms show the inflation outlook of enterprises for general prices (all industries and enterprises, average) in the *Tankan* survey.

3. Figures for households show the outlook for price levels over the next five years in the *Opinion Survey on the General Public's Views and Behavior*.

4. The most recent value of data is 2021/4Q.

5. Since the ESP Forecast is a semi-annual survey, the missing quarterly observation is interpolated by plugging the values of the previous quarter.

Second, recent empirical studies have shown that inflation expectations vary significantly among survey respondents, even within the same demographic, due to differences in the price information they receive. For example, Coibion and Gorodnichenko (2015a) analyze survey data of households and find that those who spend a larger portion of their budget on gasoline tend to revise their inflation expectations more frequently. Kumar et al. (2015) also analyze the results of their own survey of business managers and find considerable variation in their inflation expectations. This variation is strongly influenced by the respondents' own shopping experiences. Hence, regardless of the type of survey data used, it can be challenging to accurately estimate the Phillips curve due to the presence of such noise.

2-2. HHNS's Approach

As we have noted, the use of survey data as a proxy for inflation expectations in the estimation of the Phillips curve can potentially lead to distorted results. To avoid this problem, HHNS has proposed a novel approach for estimating the Phillips curve without relying on survey data for inflation expectations. In the following section, we present an overview of their approach.

The HHNS's approach builds on the New Keynesian model with one country, two regions, and two goods. In the model, there are two types of goods: tradeable and non-tradeable goods. Tradeable goods can be traded between regions, while non-tradeable goods can only be consumed within the region and are equivalent to services such as restaurants and beauty salons. The HHNS derives the NKPC for non-tradeable goods in each region, assuming that long-term inflation expectations uniformly respond across regions to changes in the central bank's monetary policy regime over time, as follows.

$$\pi_{r,t} = \beta \pi_t^e + \kappa y_{r,t} - \lambda \hat{p}_{r,t} + \varepsilon_{r,t} \tag{1}$$

where t indicates time and r represents the region. The first term on the right-hand side π_t^e indicates long-term inflation expectations and is assumed to have a common value across regions. The second term, $y_{r,t}$, represents the supply-demand balance in each region. The third term, $\hat{p}_{r,t}$, is the relative price of non-tradeable goods to the consumer prices for all items.[8,9] $\varepsilon_{r,t}$ is a cost push shock. The coefficient for the supply-demand balance in non-tradeable goods in each region, κ, is consistent with that at the country-level, regardless of the region.

In the panel estimation of the equation above, long-run inflation expectations are assumed to be a common factor across regions and can be considered to be captured by time-fixed effects. Therefore, survey data on inflation expectations is not necessary, and the equation can be estimated by Ordinary Least Squares (OLS). The estimation covers seven

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[8] The relative price term emerges because firms and households have different reference prices for their optimization behavior. For example, firms determine their product prices based on the real wage deflated by their own products, while households determine labor supply based on the real wage deflated by prices for all goods. Under the environments, relative prices affect the firms' real marginal costs.

[9] A coefficient of the relative price is negative. For instance, when the price of non-tradeable goods is relatively high, the inflation rate for the goods declines. This is because the real wage, paid by the firm which produces the goods, decreases by the increase in the deflator.

subgroups in services and is given as follows.

$$\pi_{i,r,t} = \alpha_{i,r} + \gamma_{i,t} + \kappa_i y_{r,t} - \lambda_i \hat{p}_{i,r,t} + \varepsilon_{i,r,t} \quad (2)$$

where i represents the industry category, $\alpha_{i,r}$ represents the regional fixed effects, and $\gamma_{i,t}$ indicates the time-fixed effects. $\gamma_{i,t}$ captures not only inflation expectations, but also the component of fluctuations in the supply-demand balance, $y_{r,t}$, that is common across the regions. Thus, the slope κ_i represents "the extent to which the inflation rate of industry i in region r is associated with the region-specific supply-demand balance". By incorporating inflation expectations as time-fixed effects, this approach reduces potential distortions in the estimates caused by measurement issues in the inflation expectations.[10]

2-3. The Analytical Framework

In this paper, using the empirical equation above, we assess whether the Phillips curve for service prices has flattened or not. Specifically, in the case in which we examine the flattening of the slope of the Phillips curve in the 2000s, we estimate equation (2) with a coefficient dummy as follows.

$$\pi_{i,r,t} = \alpha_{i,r} + \gamma_{i,t} + (\kappa_{1,i} + \kappa_{2,i} D_t) y_{r,t} - \lambda_i \hat{p}_{i,r,t} + \varepsilon_{i,r,t} \quad (3)$$

where D_t represents a dummy variable which takes zero from the initial sample period to December 1999 and takes one from January 2000 to the end of the sample period. $\kappa_{1,i}$ indicates the coefficient of the slope through all sample periods, and $\kappa_{2,i}$ represents the change in the slope from the 2000s (the slope of the Phillips curve after 2000 is captured by $\kappa_{1,i} + \kappa_{2,i}$). If the results of the estimation show $\kappa_{1,i} > 0$, $\kappa_{2,i} < 0$ and $\kappa_{1,i} + \kappa_{2,i} > 0$ in a statistically significant manner, it can be concluded that the Phillips curve has flattened since the 2000s, despite the continued positive correlation between the supply-demand balance, $y_{r,t}$, and inflation.[11] To confirm the validity of the estimation, we perform F-tests and Hausman tests, and we conclude that a two-way fixed effect model that includes both time and regional fixed effects is the most appropriate for all estimation equations, that is, a

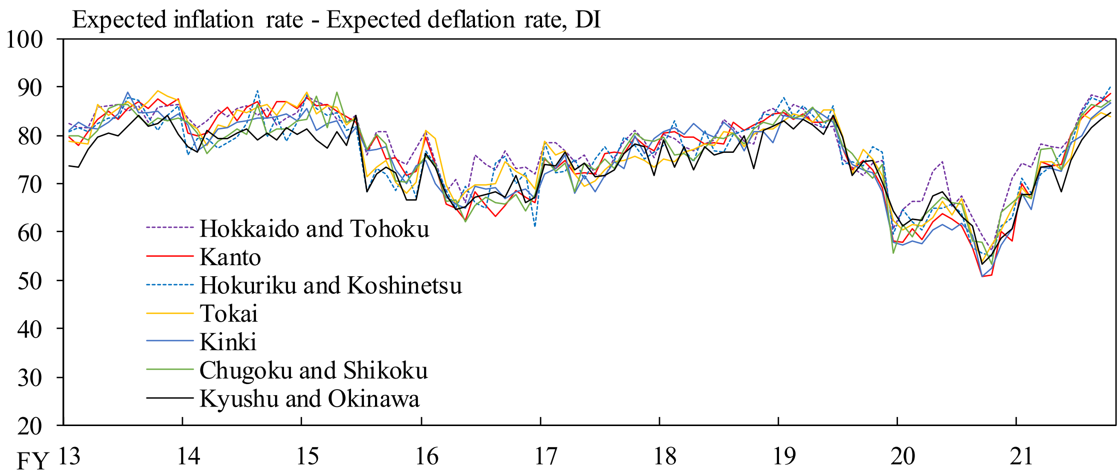
[10] Nishizaki and Watanabe (2000) highlight the importance of including time-fixed effects in their estimation, as the slope estimates can differ significantly depending on whether time-fixed effects are included or not.

[11] The estimates can indicate $\kappa_{1,i} + \kappa_{2,i} < 0$ (the slope of the Phillips curve after 2000s could be negative) due to various factors including omitted variable bias; however, this study does not regard it as "flattening" of the slope.

pooled OLS or random effect model is not selected.

The application of the HHNS's approach to Japanese data assumes that the dynamics of long-term inflation expectations in Japan is common across regions and can be treated as time-fixed effects. In Japan, it is difficult to directly verify the assumption of similar dynamics of long-term inflation expectations across regions, as data on such expectations at a regional level is not available. However, the regional one-year ahead inflation expectations in the "Consumer Confidence Survey" demonstrate a generally uniform pattern of movement over the sample period (Figure 3). Because the dynamics of short-term inflation expectations, which are expected to be more strongly influenced by regional economic fluctuations, are uniform across regions, it is reasonable to assume that long-term inflation expectations have similar dynamics. As a result, it is considered valid to treat inflation expectations as time-fixed effects.[12]

Figure 3. Households' Inflation Expectations by Region



Source: Cabinet Office

Note: The most recent value of data is January 2022.

The study examines potential shifts in the slope of the Phillips curve over three distinct time frames: (1) starting from the year 2000, (2) starting from 2000 and 2011, and (3) starting

[12] In the HHNS's analysis, they assume that long-term inflation expectations are uniform across the regions, while allowing short-term inflation expectations to be associated with regional economic fluctuations and relative prices. Consequently, the effect of regional economic fluctuations and short-term inflation expectations cannot be distinguished using equations (2) and (3). To overcome this challenge, HHNS impose additional assumptions on the process of short-term inflation expectations. By contrast, in Japan, we observe small regional differences in short-term inflation expectations, implying that short-term inflation expectations are mostly absorbed in time-fixed effects. Hence, this study does not impose assumptions on the process of short-term inflation expectations.

from 2000 and April 2020. Panel estimation is carried out by including time-fixed effect which reflects each of these time frames. In this regard, (1) flattening of the slope of the Phillips curve from 2000s has been documented in many studies and is the primary focus of this analysis. The examination of further changes in the slope of the Phillips curve over (2) the 2010s and (3) under the influence of Covid-19 pandemic are also key aspects of this analysis.

3. Data

Data used for this analysis are regional CPI inflation rates and active job openings-to-applicants ratios, as a proxy for supply-demand balance.

3-1. Inflation Rate

In this study, prefecture-level CPI (year-on-year changes) prepared by the Statistics Bureau of the Ministry of Internal Affairs and Communications is used to measure regional inflation rates. This analysis covers subgroups which are included in the "Meals outside the home" and "Other services" in the "General services" category[13] (Table 1). However, these indices are mixed with items of Goods and Public services. Therefore, we focus our analysis on the seven subgroups: (i) Meals outside the home, (ii) Repairs & maintenance, (iii) Domestic services, (iv) Services related to clothing, (v) Tutorial fees, (vi) Recreational services, and (vii) Personal care services (Table 2), where more than 50 percent of the items belong to the General services category (nationwide and CPI weight basis). The relative price appearing in the estimation equation is calculated using the CPI for all items in each region as the denominator.

[13] Rents and public services are excluded from the scope of analysis because these prices are considered to be driven not by region-specific factors, but by country-level factors including fiscal policy.

Table 1. Groups of services in CPI

	Weight	Percentage of the upper group (%)
Services	4954	–
Public services	1219	24.6
General services	3735	75.4
Meals outside the home	434	11.6
Other services	1495	40.0
House rent, private	225	6.0
Imputed rent	1580	42.3

Table 2. Subgroups covered in this analysis

Subgroup	Weight	Percentage of non-applicable item(s) in General services
(i) Meals outside the home	460	School lunch (5%)
(ii) Repairs & maintenance	316	Tools & materials for repairs & maintenance, Fire & earthquake insurance premium (49%)
(iii) Domestic services	28	Recycle fees (18%)
(iv) Services related to clothing	20	—
(v) Tutorial fees	84	—
(vi) Recreational services	518	Charges for TV license, Swimming pool charges, and Admission fees to cultural establishments (17%)
(vii) Personal care services	110	—

Source: Ministry of Internal Affairs and Communications

Note: The weight is based on 2020-base nationwide CPI. The total weight of all items is 10,000.

3-2. Supply-demand balance (the active job openings-to-applicants ratio)

The variable that represents the supply-demand balance in each region is the active job openings-to-applicants ratio by prefecture (including part-timers, seasonally adjusted) from "Employment Referrals for General Workers" prepared by the Ministry of Health, Labor, and Welfare. The unemployment rate is a potential proxy for the supply-demand balance, which is utilized in HHNS. However, in Japan, where long-term employment practices are firmly established, the fluctuation of the unemployment rate has been limited in comparison to real economic activity until the mid-1990s, as observed by Asako and Komaki (2007). Therefore, in this analysis, we use the active job openings-to-applicants ratio, which more flexibly fluctuates than the unemployment rate in accordance with the region-specific dynamics of labor market conditions.[14] Due to the lack of consensus in the literature regarding the lead-lag relationship between the active job openings-to-applicants ratio, relative prices, and inflation rates, this study examines models with the maximum lag of 12 months for the variables and selects the combination that generates the highest adjusted R-squared as a main specification of the model.

[14] It should be noted that the active job openings-to-applicants ratio is also influenced by factors beyond economic fluctuations, such as the mismatch between job seekers and job offerings. Furthermore, the geographical coverage of the regional inflation rate, which only covers the capital city of each prefecture, differs from that of the active job openings-to-applicants ratio, which covers all cities in each prefecture. This difference in coverage may impact the results of the estimation.

The descriptive statistics (mean and standard deviation) in Table 3 for each prefecture over the sample period reveal regional variations, making panel analysis with these subgroups plausible.[15] Additionally, the patterns of variation across the data differ among subgroups, indicating that it would be more suitable to separately conduct estimations for the subgroups.

[15] The coefficient of variation (standard deviation across regions divided by the average across regions) of the active job openings-to-applicants ratio and inflation expectations across regions indicates that the cross-sectional variation in the active job openings-to-applicants ratio across regions is larger than the same variation in inflation expectation. In other words, the coefficient of variation of the active job openings-to-applicants ratio is relatively large and takes around 20% throughout the sample period, suggesting that it is affected by factors specific to each region. In contrast, the coefficient of variation of inflation expectations shown in Figure 3 is relatively small at around 5% and can be regarded as a country-level factor. This observation implies that inflation expectations can be captured by time-fixed effects.

Table 3. The descriptive statistics

			CPI (year on year, %)							The active job openings-to-applicants ratio
			(i) Meals outside the home	(ii) Repairs & maintenance	(iii) Domestic services	(iv) Services related to clothing	(v) Tutorial fees	(vi) Recreational services	(vii) Personal care services	
From Jan. 1985 to Dec. 1999	Average	Maximum	1.97 (Toyama)	4.00 (Yamagata)	5.40 (Yamanashi)	2.82 (Fukuoka)	6.17 (Akita)	2.67 (Wakayama)	2.56 (Fukui)	1.50 (Gifu)
		Minimum	0.76 (Okinawa)	1.40 (Kanagawa)	0.29 (Hiroshima)	-0.03 (Iwate)	1.18 (Ishikawa)	0.90 (Iwate)	0.72 (Okinawa)	0.30 (Okinawa)
		Median	1.40 (Kumamoto)	2.40 (Gifu)	2.57 (Fukushima)	1.68 (Gifu)	3.10 (Saitama)	1.83 (Hokkaido)	1.87 (Fukushima)	0.92 (Tokyo)
	Standard deviation	Maximum	2.10 (Wakayama)	4.60 (Gifu)	13.71 (Yamanashi)	4.48 (Tochigi)	16.42 (Gifu)	4.01 (Iwate)	3.64 (Gunma)	0.66 (Aichi)
		Minimum	1.06 (Saga)	1.20 (Kagawa)	1.11 (Miyagi)	0.96 (Aomori)	2.13 (Ehime)	1.25 (Kagoshima)	0.87 (Okinawa)	0.11 (Hokkaido)
		Median	1.50 (Kagoshima)	2.46 (Kyoto)	5.54 (Aomori)	1.95 (Shimane)	4.25 (Mie)	1.77 (Tottori)	1.66 (Osaka)	0.36 (Yamagata)
From Jan. 2000 to Nov. 2021	Average	Maximum	0.84 (Oita)	1.36 (Miyazaki)	2.43 (Nagasaki)	1.26 (Shizuoka)	2.58 (Hokkaido)	0.51 (Chiba)	0.59 (Nara)	1.33 (Fukui)
		Minimum	-0.05 (Wakayama)	-0.73 (Nara)	-0.32 (Aichi)	-0.23 (Okayama)	-0.62 (Tottori)	-0.22 (Miyazaki)	-0.39 (Oita)	0.57 (Okinawa)
		Median	0.47 (Fukuoka)	0.18 (Akita)	0.23 (Hokkaido)	0.50 (Miyazaki)	0.53 (Tokyo)	0.13 (Shimane)	0.10 (Wakayama)	0.96 (Tottori)
	Standard deviation	Maximum	1.90 (Osaka)	3.68 (Fukuoka)	10.42 (Nagasaki)	4.26 (Tottori)	6.50 (Hokkaido)	2.59 (Hokkaido)	2.48 (Ishikawa)	0.50 (Tokyo)
		Minimum	0.62 (Iwate)	0.99 (Shizuoka)	0.24 (Tochigi)	0.82 (Tokyo)	0.80 (Tochigi)	1.40 (Oita)	0.29 (Hyogo)	0.26 (Kanagawa)
		Median	1.05 (Tottori)	1.93 (Wakayama)	1.21 (Akita)	1.48 (Tochigi)	2.09 (Yamaguchi)	1.82 (Tokyo)	0.65 (Okayama)	0.35 (Aomori)

Sources: Ministry of Internal Affairs and Communications; Ministry of Health, Labor and Welfare

Notes: 1. Statistics based on all (47) prefectures in Japan.

2. For CPI, the observation affected by the consumption tax hikes is excluded from the calculation.

4. Estimation Results

4-1. The slope of the Phillips curve until the 1990s

The main focus of this analysis is to detect changes in the slope of the Phillips curve since the 2000s. However, it is imperative to confirm that the slope was positive at least until the 1990s, as this provides the necessary background for any discussions about the "flattening" of the slope since the 2000s. In so doing, equation (2) is estimated using data from January 1985 to December 1999. The estimation results in Table 4 show that the slope for each subgroup is significantly positive,[16] suggesting that until the 1990s, service prices were influenced by the regional supply-demand balance. For instance, in the case of (i) Meals outside the home, when the active job openings-to-applicants ratio in a region is 1 unit higher than in other regions, the inflation rate is 0.36 percentage points higher.

Table 4. Estimates of the slope of the Phillips curve with pre-1999 data (Equation (2))

(i) Meals outside the home	(ii) Repairs & maintenance	(iii) Domestic services	(iv) Services related to clothing	(v) Tutorial fees	(vi) Recreational services	(vii) Personal care services
0.36	1.35	1.85	1.43	2.47	0.81	1.16
(0.07)	(0.17)	(0.33)	(0.13)	(0.41)	(0.07)	(0.11)
[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Notes: 1. The estimation period is from January 1985 to December 1999 (the number of samples is 8,460). Estimation results by the two-way fixed effect model with the relative price term.

2. The values in brackets are the robust standard errors of the coefficients. The values in square brackets are the p-values of the coefficients.

4-2. The flattening of the Phillips curve since the 2000s

We test whether the Phillips curve has flattened since the 2000s by utilizing equation (3) that incorporates a dummy coefficient and estimating it over the period from January 1985 to November 2021. The estimation results in Table 5 (Columns A) show that the coefficients for the active job openings-to-applicants ratio ($\kappa_{1,i}$) are significantly positive for all subgroups. By contrast, the coefficients of the cross terms between the time dummy after 2000 and the active job openings-to-applicants ratio ($\kappa_{2,i}$) are negative for all subgroups and

[16] The slope estimates vary across the subgroups. According to the theory of HHNS, this variation can be attributed to the differences in households' preferences, the structure of the markets, and the frequency of price changes by firms.

are significant except for (vi) Recreational services. In other words, for most subgroups, the Phillips curve has flattened since the 2000s. To verify the robustness of our findings, we re-estimate equation (3) without the relative prices (Columns B), and the results remain consistent. Although rejected by the F test for model selection, Columns C, which is the result of estimation by a model that does not include time effects, is larger than the results in Columns A and B. Moreover, the results of the estimation in Columns D, which uses country-level time series data instead of prefecture-level panel data, indicate an even larger coefficient of slope. These highlight the advantages of controlling inflation expectations by time-fixed effects and exploiting the variation of regional data in estimation the Phillips curve.

Table 5. Estimates of the slope of the Phillips curve (Equation (3))

	(i) Meals outside the home				(ii) Repairs & maintenance				(iii) Domestic services				(iv) Services related to clothing			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
$\kappa_{1,i}$	0.47	0.45	1.67	2.16	0.88	0.95	3.44	4.75	0.85	1.23	1.78	1.73	0.69	0.65	2.12	2.97
	(0.04)	(0.05)	(0.03)	(0.18)	(0.10)	(0.11)	(0.05)	(0.20)	(0.21)	(0.22)	(0.10)	(0.39)	(0.08)	(0.08)	(0.05)	(0.17)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
$\kappa_{2,i}$	-0.34	-0.04	-0.72	-1.04	-0.59	-0.91	-2.07	-2.73	-1.31	-0.44	-2.35	-2.27	-0.40	-0.71	-0.97	-1.21
	(0.05)	(0.05)	(0.02)	(0.14)	(0.11)	(0.12)	(0.04)	(0.20)	(0.22)	(0.22)	(0.07)	(0.23)	(0.10)	(0.11)	(0.03)	(0.12)
	[0.00]	[0.46]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.05]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Regional effects	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	NO
Time effects	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO
Relative price	YES	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO

	(v) Tutorial fees				(vi) Recreational services				(vii) Personal care services			
	A	B	C	D	A	B	C	D	A	B	C	D
$\kappa_{1,i}$	2.21	2.04	2.96	3.74	0.40	0.35	2.71	4.07	0.74	0.88	1.89	2.43
	(0.22)	(0.22)	(0.12)	(0.21)	(0.05)	(0.05)	(0.04)	(0.36)	(0.07)	(0.07)	(0.04)	(0.30)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
$\kappa_{2,i}$	-2.26	-1.21	-2.53	-3.11	-0.07	-0.17	-1.40	-2.21	-0.30	-0.74	-1.66	-2.10
	(0.24)	(0.24)	(0.07)	(0.19)	(0.06)	(0.06)	(0.03)	(0.28)	(0.08)	(0.07)	(0.02)	(0.18)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.2]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Regional effects	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	NO
Time effects	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO
Relative price	YES	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO

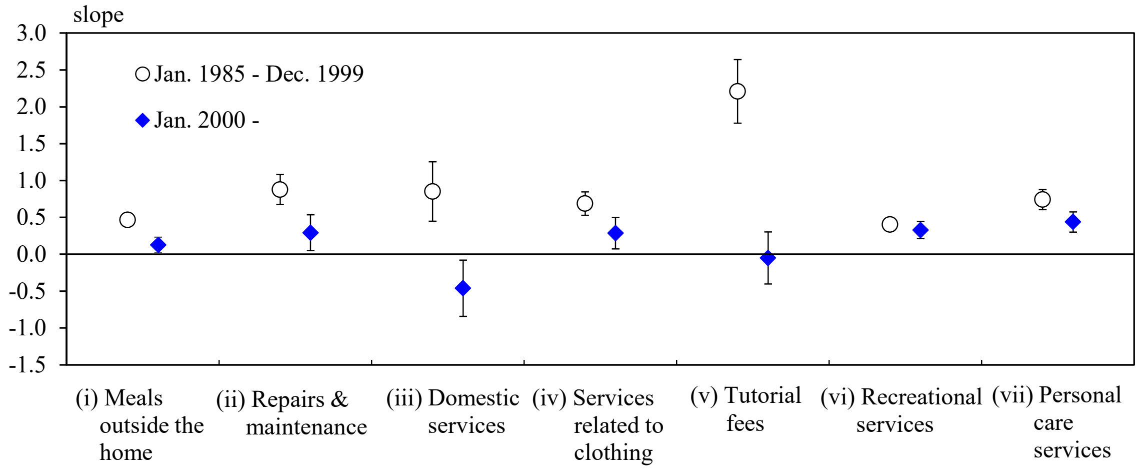
Notes: 1. Columns D are the estimation results based on $\pi_{i,t} = \alpha_i + (\kappa_{1,i} + \kappa_{2,i} D_t) y_t + \varepsilon_{i,t}$ (assuming time-invariant inflation expectations). The models used for the estimation in Columns C and D include the dummies for controlling the effects of consumption tax hikes on inflation.

2. The estimation period is from January 1985 to November 2021 (the number of samples is 443 for Columns D, 20,821 for the others).

3. The values in brackets in Columns D are HAC standard errors for coefficients. The values in brackets in the other columns are the robust standard errors of the coefficients. The values in square brackets are the p-values of the coefficients.

Figure 4 shows the estimates of the Phillips curve slope for two sample periods, that is, 1985-1999 and after 2000, based on the estimation results in Columns A in Table 5. Figure 4 indicates that the slopes have declined for all subgroups since 2000 and the declines are significant for all subgroups except for (vi) Recreational services while after 2000 the estimate of the coefficient for (iii) Domestic services is negative and that for (v) Tutorial fees is not significantly different from zero.[17]

Figure 4. Estimates of changes in Phillips curve slope since 2000



Note: Circles and diamonds indicate the point estimates of the coefficients and whiskers show the 95% confidence interval.

In terms of the interpretation of these results, even though the literature has not yet reached a consensus on the factors behind the flattening of the Phillips curve slope in Japan since the 2000s, a variety of hypotheses have been proposed to explain the phenomenon. Among others, several studies propose a view that prolonged low inflation environments in Japan has changed the pricing behavior of Japanese firms. For instance, the "menu cost hypotheses" implies that the decrease in the cost-benefit performance of price changes—the size of potential price changes decreases whereas transaction costs associated with price changes remain unchanged—in a low-inflation environment endogenously reduces frequency of the price change. In this context, using Japanese data, Kaihatsu et al. (2022) confirm this mechanism as the cross-sectional distribution of the inflation rates about items in service category is more concentrated on near zero percent during the low-inflation period

[17] Because we do not impose any restrictions on the signs of estimates of the coefficients, the estimates of the slope (e.g., $\kappa_{1,i} + \kappa_{2,i}$) can be negative.

(FY1995–2012) than that during high-inflation period (FY1982–1994). Using the model with menu cost, Kaihatsu et al. (2022) also show that a decline in trend inflation and the increase in service consumption flattened the Phillips curve by affecting the pricing behavior of firms. Relatedly, based on the "kinked demand curve" theory, Shirota (2015) and Aoki et al. (2019) theorize that firms that fear losing customers become reluctant to raise their prices in line with marginal costs if consumers who are accustomed to low inflation environments do not expect a price increase. Additionally, several studies indicate that the Phillips curve for service prices has flattened since the 2000s and explain the mechanism behind the observation (see, Ikeda et al. 2022 and references therein).

While our results above show that the Phillips curve in Japan has flattened since the 2000s, they are silent about the developments in the slope of the Phillips curve afterward. In the following, we examine the possibility that the slope has changed during the periods by estimating the two-way time fixed effect model with a "time dummy for 2000-2010" and a "time dummy from 2011", which is given as follows.

$$\pi_{i,r,t} = \alpha_{i,r} + \gamma_{i,t} + \left(\kappa_{1,i} + \kappa_{2,i} D1_t + \kappa_{3,i} D2_t\right) y_{r,t} - \lambda_i \hat{p}_{i,r,t} + \varepsilon_{i,r,t} \tag{4}$$

where $D1_t$ represents a time dummy which takes one from January 2000 to December 2010 and $D2_t$ indicates a time dummy which takes one after January 2011 (both take zero in other periods). Moreover, $\kappa_{1,i}$ represents the slope of the Phillips curve for all sample periods, and $\kappa_{1,i} + \kappa_{2,i}$ and $\kappa_{1,i} + \kappa_{3,i}$ correspond to the slope from 2000 to 2010 and after 2011, respectively. Therefore, if estimation results indicate $\kappa_{1,i} > 0$, $\kappa_{3,i} < \kappa_{2,i} < 0$, $\kappa_{1,i} + \kappa_{2,i} > 0$ and $\kappa_{1,i} + \kappa_{3,i} > 0$ in a statistically significant manner, then it can be concluded that the Phillips curve has further flattened since the 2010s in addition to the 2000s.

Table 6 shows that $\kappa_{1,i}$ is significantly positive in all subgroups. In addition, both $\kappa_{2,i}$ and $\kappa_{3,i}$ are significantly negative in (iii) Domestic service, (iv) Services related to clothing, (v) Tutorial fees, and (vii) Personal care services (although the sum of the coefficients, e.g., $\kappa_{1,i} + \kappa_{2,i}$, takes negative in several subgroups). Based on estimation results in Table 6, Figure 5 compares the estimates of the slope of the Phillips curve for three sample periods, that is, 1985-1999, 2000-2010, and after 2011. Figure 5 indicates that no statistically significant difference is observed between the estimates of the slopes in 2000-2010 and after 2011 in any subgroups. Hence, we conclude that we find no clear evidence on the further flattening of the Phillips curve since the 2010s.

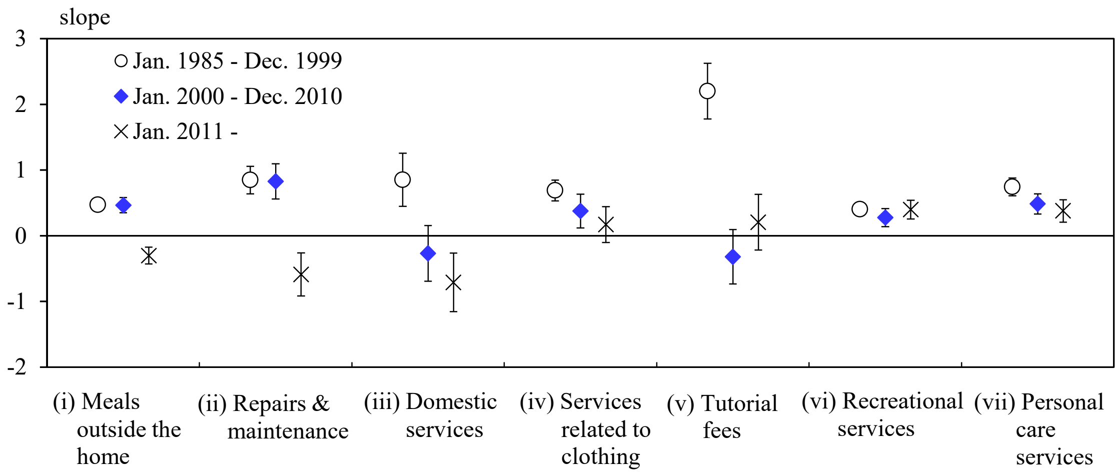
Table 6. Estimates of the slope of the Phillips curve (Equation (4))

	(i) Meals outside the home	(ii) Repairs & maintenance	(iii) Domestic services	(iv) Services related to clothing	(v) Tutorial fees	(vi) Recreational services	(vii) Personal care services
$\kappa_{1,i}$	0.47	0.85	0.85	0.69	2.20	0.40	0.74
	(0.04)	(0.11)	(0.21)	(0.08)	(0.22)	(0.05)	(0.07)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
$\kappa_{2,i}$	-0.01	-0.02	-1.12	-0.31	-2.52	-0.13	-0.26
	(0.06)	(0.12)	(0.25)	(0.13)	(0.26)	(0.07)	(0.08)
	[0.9]	[0.87]	[0.00]	[0.01]	[0.00]	[0.07]	[0.00]
$\kappa_{3,i}$	-0.77	-1.44	-1.56	-0.52	-2.00	0.00	-0.37
	(0.07)	(0.16)	(0.24)	(0.14)	(0.28)	(0.07)	(0.09)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.96]	[0.00]

Notes: 1. The estimation period is from January 1985 to November 2021 (the number of samples is 20,821). Estimation results by the two-way fixed effect model with the relative price term.

2. The values in brackets are the robust standard errors of the coefficients. The values in square brackets are the p-values of the coefficients.

Figure 5. Estimates of changes in Phillips curve slope since 2000 and 2010

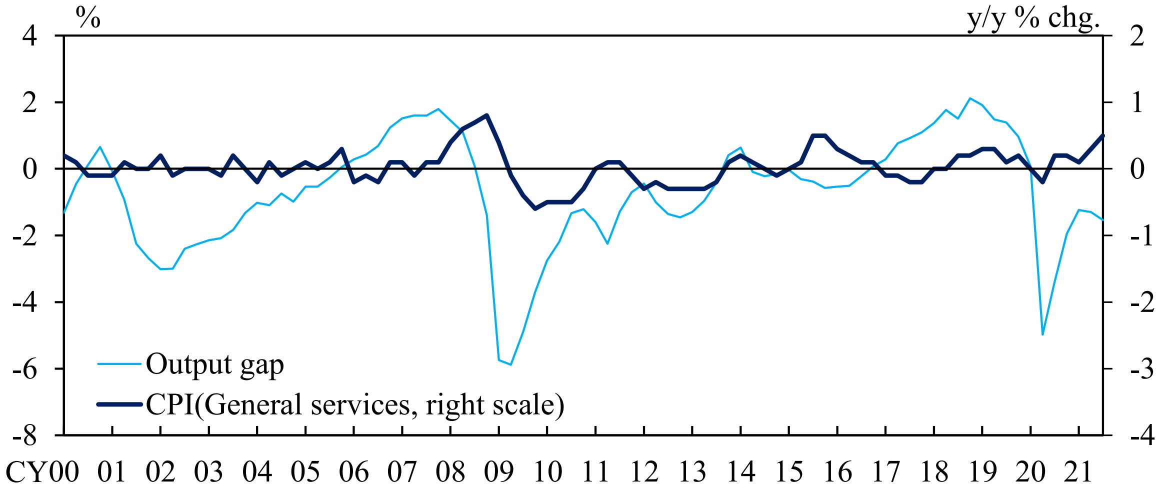


Note: Circles, diamonds, and crosses indicate the point estimates of the coefficients and whiskers show the 95% confidence interval.

4-3. The slope of the Phillips curve during the Covid-19 pandemic

Next, we examine whether or not the slope of the Phillips curve has changed in Japan during Covid-19 pandemic. Globally, there are two contrasting views on the impact of the pandemic on the slope of the Phillips curve. The first view is that the Phillips curve may have flattened, at least temporarily, during the outbreak phase of the pandemic when public health measures were intermittently imposed (Ikeda et al. 2022). In fact, casual observation of the time series data of CPI inflation and the output gap in many countries including Japan supports this view: during the pandemic, (1) the output gap sharply deteriorated due to a stagnation of economic activity in service industries such as restaurants and lodging caused by people avoiding non-essential outings. Meanwhile, (2) inflation rates for services remained relatively stable, indicating the absence of disinflationary pressures (Figure 6). During the Covid-19 pandemic, despite a decrease in sales and production, firms' costs seem to have remained relatively stable. This is attributed to the implementation costs of infection control measures, including the purchase of hand sanitizers and thermometers, and efforts to avoid the dismissal of employees in anticipation of a demand recovery following the end of the pandemic. It is also possible that, due to consumers avoiding outings, the increase in demand resulting from price cuts was expected to be limited, and firms prioritized securing their markups.

Figure 6. The output gap and CPI inflation (General services)



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

Notes: 1. The most recent value of data is 2021/3Q.

2. The CPI excludes the effects of the consumption tax hikes, policies concerning the provision of free education, the "Go To Travel" campaign, which covers a portion of domestic travel expenses, and the reduction of mobile phone charges (in 2021) on inflation.

The second view is that the Phillips curve may have steepened. This view builds on the observation in major advanced economies, in particular in the United States, that the inflation rate experienced a significant increase as the effects of the Covid-19 pandemic on real economic activity, particularly in the service sector, abated. However, it should be noted that the increase in the inflation rate during this period could be caused by multiple factors including soaring raw material costs, supply chain disruptions, and structural changes in the labor market (Ikeda et al. 2022), and thus it does not necessarily indicate changes in the relationship between supply-demand balance and inflation rate.

Against this background, in the following analysis, we estimate a two-way time-fixed effect model for each subgroup to investigate if the slope of the Phillips curve has flattened/sharpened during the pandemic. In Japan, given that economic activity in the service sector has not fully recovered within the estimation period (up to November 2021), our focus is on the possibility that the Phillips curve flattened during the Covid-19 pandemic.

$$\pi_{i,r,t} = \alpha_{i,r} + \gamma_{i,t} + \left(\kappa_{1,i} + \kappa_{2,i} D3_t + \kappa_{3,i} D4_t\right) y_{r,t} - \lambda_i \hat{p}_{i,r,t} + \varepsilon_{i,r,t} \tag{5}$$

where $D3_t$ represents a time dummy for pre-Covid-19 pandemic which takes one from January 2000 to March 2020, and $D4_t$ is a time dummy variable for during the Covid-19 pandemic which takes one after April 2020 (both take zero in other periods). If the estimation results suggest $\kappa_{1,i} > 0$, $\kappa_{3,i} < \kappa_{2,i} < 0$, $\kappa_{1,i} + \kappa_{2,i} > 0$ and $\kappa_{1,i} + \kappa_{3,i} > 0$ in a statistically significant manner, then it can be concluded that the slope has flattened further during the Covid-19 pandemic.

Estimation results in Table 7 show that $\kappa_{1,i}$ is significantly positive in all subgroups and $\kappa_{2,i}$ is significantly negative except for (vi) Recreational services. Additionally, both $\kappa_{2,i}$ and $\kappa_{3,i}$ are significantly negative in most subgroups. The only subgroup which satisfies $\kappa_{3,i} < \kappa_{2,i}$ and $\kappa_{1,i} + \kappa_{3,i} > 0$ is (vii) Personal care services. Based on the estimates in Table 7, Figure 7 compares the estimates of the slope of the Phillips curve for three sample periods, that is, 1985-1999, 2000-March 2020, and after April 2020. It indicates that no statistically significant difference is observed between the estimates of the slopes in 2000-March 2020 and after April 2020 in any subgroups. Hence, we conclude that we find no clear evidence for any changes in the slope of the Phillips curve since the Covid-19 pandemic began.

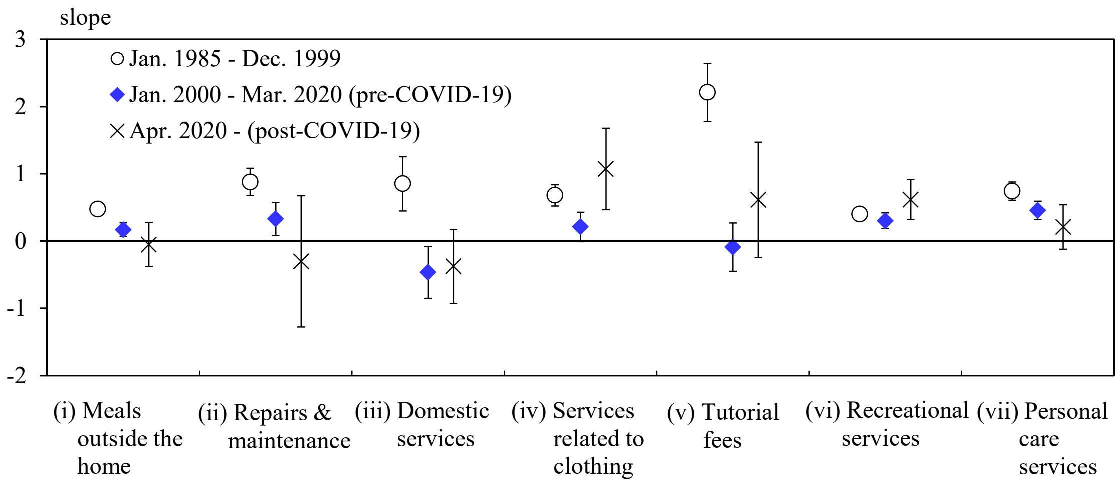
Table 7. Estimates of the slope of the Phillips curve (Equation (5))

	(i) Meals outside the home	(ii) Repairs & maintenance	(iii) Domestic services	(iv) Services related to clothing	(v) Tutorial fees	(vi) Recreational services	(vii) Personal care services
	0.47	0.88	0.85	0.68	2.21	0.40	0.74
$\kappa_{1,i}$	(0.04)	(0.10)	(0.21)	(0.08)	(0.22)	(0.05)	(0.07)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
	-0.30	-0.55	-1.32	-0.47	-2.30	-0.10	-0.29
$\kappa_{2,i}$	(0.05)	(0.11)	(0.22)	(0.11)	(0.25)	(0.06)	(0.08)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.1]	[0.00]
	-0.52	-1.18	-1.23	0.39	-1.60	0.22	-0.53
$\kappa_{3,i}$	(0.17)	(0.50)	(0.29)	(0.31)	(0.47)	(0.15)	(0.17)
	[0.00]	[0.02]	[0.00]	[0.2]	[0.00]	[0.15]	[0.00]

Notes: 1. The estimation period is from January 1985 to November 2021 (the number of samples is 20,821). Estimation results by the two-way fixed effect model with the relative price term.

2. The values in brackets are the robust standard errors of the coefficients. The values in square brackets are the p-values of the coefficients.

Figure 7. Estimates of changes in the Phillips curve slope since 2000 and April 2020



Note: Circles, diamonds, and crosses indicate the point estimates of the coefficients and whiskers show the 95% confidence interval.

To sum up, we do not find evidence for flattening of the slope of the Phillips curve for service prices during the Covid-19 pandemic—in contrast to the casual observation in Figure 6. Having said that, we admit the limitations of this analysis: the sample period during the pandemic is limited and the structural changes in the relationship between supply-demand balance and the active job openings-to-applicants ratio might have occurred because the government introduced labor market policy measures during the pandemic.[18]

5. Concluding Remarks

In this study, using prefecture-level CPI data for Japan, the possibility of structural changes in the slope of the Phillips curve for service prices, in particular since the 2000s, is explored. The key contribution of this study is controlling for the impact of inflation expectations on the inflation rate by employing panel dataset and including time-fixed effect in estimation.

The estimation results suggest that the Phillips curve has flattened significantly since the 2000s in the majority of subgroups in services. However, this study neither obtains clear evidence of structural changes in the slope of the Phillips curve in the 2010s nor during the Covid-19 pandemic.

It is important to note that the analysis in this study, which uses panel data, has an advantage over a time-series analysis in that it enables us to conduct more plausible and timely empirical assessment with short period of the samples. This advantage is especially crucial in the present context, where a number of factors, including the global increase in raw material costs, appear to significantly influence inflation dynamics in Japan, and the impact of the Covid-19 pandemic on the dynamics remains uncertain. The analytical framework used in this study holds potential as a valuable tool for assessing any potential changes in the slope of the Phillips curve in Japan in the future.

Finally, it is important to understand a limitation of this study, which is that it does not control the impact of region-specific supply shocks on inflation. This aspect of the study remains an open question for future research.

[18] As previously stated, the results of the estimation may be influenced by supply shocks. The HHNS method is capable of controlling country-level supply shocks, but the Covid-19 pandemic may have resulted in region-specific supply shocks due to the heterogeneous public health measures implemented in each prefecture.

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