

Online Appendix

“Cyclical Activity and Inflation under Secular Stagnation: Empirical Evidence Using Data on Japan’s Lost Decades” by Masahiko Shibamoto

A.1 Preliminary analyses on the cyclical activity measures

First, we present the contemporaneous relationships among the year-over-year change filtered activity measures over the sample period. Table A1 reports the Pearson correlation coefficients between two filtered measures. From the table, the filtered measures are highly correlated. In particular, unemployment is strongly intercorrelated with unemployment insurance beneficiaries and has a strong negative correlation with the employment/population ratio, vacancy, job opening/applicant ratio, overtime worked hours, industrial product, capital utilization, and tertiary industry activity. This result suggests there exist common components characterizing the labor market and economic activity at business cycle frequencies.

Table A1: Correlations among year-over-year change filtered indicators

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
[2]	-0.67							
[3]	-0.74	0.36						
[4]	-0.78	0.48	0.95					
[5]	0.81	-0.33	-0.78	-0.82				
[6]	-0.50	0.18	0.78	0.76	-0.69			
[7]	-0.64	0.44	0.71	0.72	-0.76	0.76		
[8]	-0.64	0.35	0.73	0.71	-0.77	0.80	0.95	
[9]	-0.27	0.38	0.48	0.54	-0.36	0.46	0.57	0.38

- [1] Unemployment (% , MA(12), yoy)
- [2] Employment/population (% , MA(12), yoy)
- [3] Vacancy (% , MA(12), yoy)
- [4] Job opening/applicant (ratio, MA(12), yoy)
- [5] Unemployment insurance beneficiaries (log, MA(12),yoy)
- [6] Overtime worked hour (log, MA(12), yoy)
- [7] Industrial product (lagged 3 months, log, MA(12), yoy)
- [8] Capital utilization (lagged 3 months, log, MA(12), yoy)
- [9] Tertiary industry activity (log, MA(12),yoy)

Notes: This table reports pairwise Pearson correlation coefficients among the year-over-year-change filtered indicators listed below. The sample period is February 1983–September 2025.

Figure A1 plots the nine year-over-year change filtered and standardized indicators of the labor market and economic activity. To simplify the comparison of time-series trends among the indicators in the figure, the employment/population, vacancy, job opening, overtime worked hours, industrial product (lagged 3 months), capacity utilization (lagged 3 months), and tertiary industry activity are multiplied by -1 , so they co-vary positively with the unemployment. Additionally, the filtered indicators are standardized to have zero mean and unit variance.

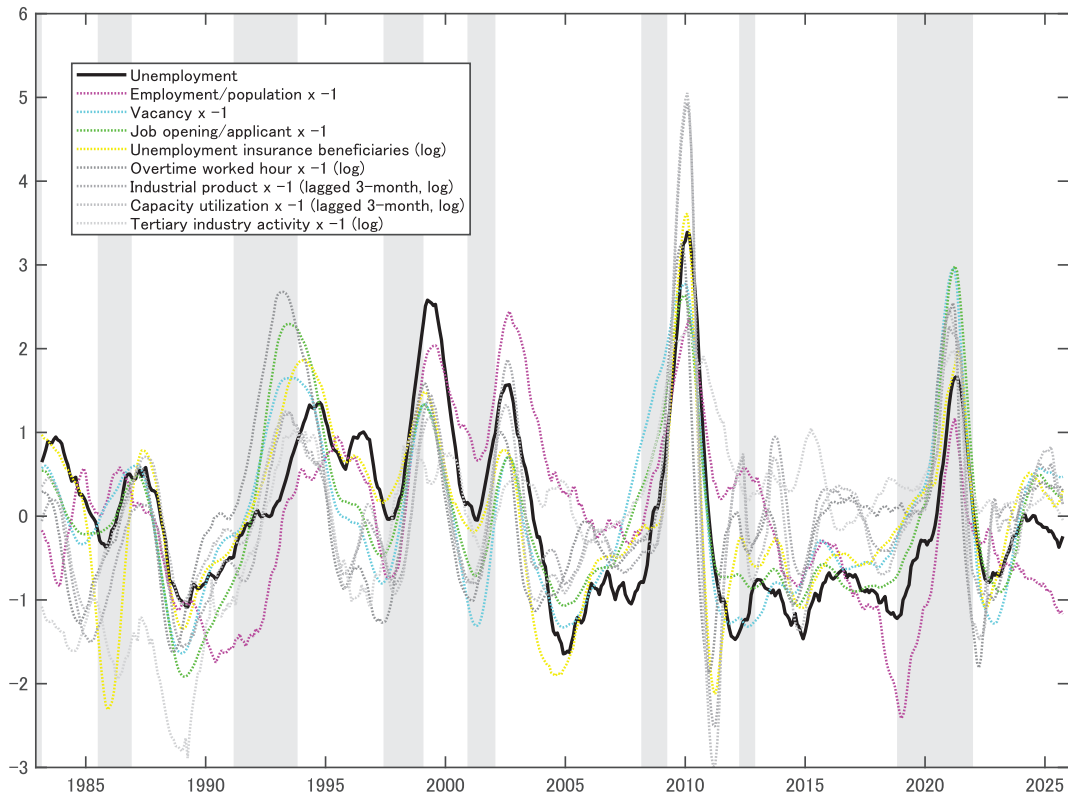


Figure A1: Year-over-year change filtered indicators of the labor market and economic activity

Notes: The sample period is from February 1983 to September 2025. The year-over-year change filtered indicators are listed in the legend. The filtered indicators are standardized to have zero mean and unit variance. The employment/population, vacancy, job opening, overtime worked hours, industrial product (lagged 3 months), capacity utilization (lagged 3 months), and tertiary industry activity are multiplied by -1 , so they co-vary positively with unemployment.

As shown in the figure, most indicators are highly correlated with unemployment. In particular, the filtered unemployment and other filtered indicators show a surge during recessions.

A.2 Alternative constructions of the cyclical activity index

This section assesses whether the cyclical activity index depends on the particular choice of underlying indicators. In addition to the benchmark index constructed from all nine standardized labor-market and real-activity series, we construct three variants that deliberately restrict the information set: (i) a “low-risk” index combining a parsimonious subset of labor-quantity measures and real-activity measures, (ii) a labor-quantity-only index, and (iii) a real-activity-only index. Each variant is obtained by taking the first principal component of the corresponding standardized indicators and then scaling and signing it to match the year-over-year-change-filtered unemployment series, following the benchmark procedure.

Table A2 shows that the estimated factor loadings for these variants have the expected signs and that the single-factor representation fits the individual indicators reasonably well across the alternative constructions. Figure A2 further demonstrates that the resulting indices track the benchmark closely over time and line up well with recession episodes. Consistent with this visual evidence, Table A3 reports very high correlations between the benchmark and the variants (0.97 with the “low-risk” index, 0.98 with the labor-quantity index, and 0.91 with the real-activity index). Overall, these results indicate that the cyclical activity index captures a stable common component of business-cycle-frequency demand conditions and is not driven by any single indicator group.

A.3 Sensitivity analyses for estimating short-run Phillips curve

A.3.1 Using alternative measures for cyclical activity index

This subsection evaluates whether the estimated short-run Phillips-curve relationship is sensitive to how cyclical activity is measured. Table A4 re-estimates the benchmark specification using the three alternative cyclical activity indices introduced in Section A.2. Across all variants, the estimated slope remains negative and economically meaningful in the full sample and in both pre- and post-1997 subsamples. The point estimates are typically in the range of about -1.7 to -2.6, and formal stability tests (sup-Wald and a Chow test at January 2020) do not provide evidence of parameter instability at conventional levels. Taken together, these results indicate that the benchmark conclusion is not an artifact of a particular index construction.

Table A5 further shows that the IV results are also robust when the unemployment gap is used as the regressor and each alternative cyclical activity index is used as an instrument. The TSLS estimates remain close to the benchmark magnitude (roughly -1.6 to -2.7), and the Hausman tests frequently reject the equality of OLS and IV estimates, consistent with endogeneity bias when the unemployment gap is used directly.

From an instrumental-variables perspective, these TSLS estimates can be interpreted as identifying the response of inflation to the component of the unemployment gap that is predicted by broad cyclical conditions, i.e., the demand-driven variation that comoves with a wide set of

Table A2: OLS estimation results for the factor model among alternative measures for the cyclical activity index

Regressand	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
“Low risk”									
Estimates of									
λ_1	0.01 (0.03)	0.17 (0.05)	0.04 (0.03)	0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.00)	0.03 (0.01)
λ_x	1 (0.08)	-0.92 (0.13)	-0.86 (0.08)	-0.48 (0.06)	0.37 (0.03)	-0.15 (0.02)	-0.19 (0.01)	-0.20 (0.02)	-0.10 (0.02)
R ²	0.73	0.40	0.65	0.73	0.76	0.53	0.86	0.79	0.33
Labor-quantity									
Estimates of									
λ_1	0.01 (0.02)	0.17 (0.05)	0.04 (0.02)	0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.00)	0.03 (0.01)
λ_x	1 (0.08)	-0.78 (0.14)	-0.96 (0.05)	-0.52 (0.03)	0.36 (0.02)	-0.16 (0.01)	-0.16 (0.02)	-0.18 (0.03)	-0.08 (0.02)
R ²	0.78	0.31	0.87	0.92	0.80	0.63	0.64	0.65	0.24
Real-activity									
Estimates of									
λ_1	0.01 (0.04)	0.17 (0.06)	0.04 (0.03)	0.01 (0.02)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.00)	0.03 (0.01)
λ_x	1 (0.13)	-0.90 (0.18)	-1.10 (0.12)	-0.60 (0.08)	0.43 (0.04)	-0.23 (0.03)	-0.28 (0.01)	-0.29 (0.02)	-0.17 (0.03)
R ²	0.38	0.20	0.55	0.58	0.55	0.61	0.96	0.85	0.48

- [1] Unemployment (% , MA(12), yoy)
- [2] Employment/population (% , MA(12), yoy)
- [3] Vacancy (% , MA(12), yoy)
- [4] Job opening/applicant (ratio, MA(12), yoy)
- [5] Unemployment insurance beneficiaries (log, MA(12),yoy)
- [6] Overtime worked hour (log, MA(12), yoy)
- [7] Industrial product (lagged 3-month, log, MA(12), yoy)
- [8] Capital utilization (lagged 3-month, log, MA(12), yoy)
- [9] Tertiary industry activity (log, MA(12),yoy)

Notes: Notes: This table reports OLS estimates of the factor model in equation (3) in the main text. The composite cyclical activity index is constructed as the first principal component of the relevant standardized indicators and then rescaled and signed to match the year-over-year-change filtered unemployment series. The numbers in parentheses are Newey and West (1987) heteroskedasticity and autocorrelation robust standard errors with 12-month truncation. The sample period is February 1983–September 2025.

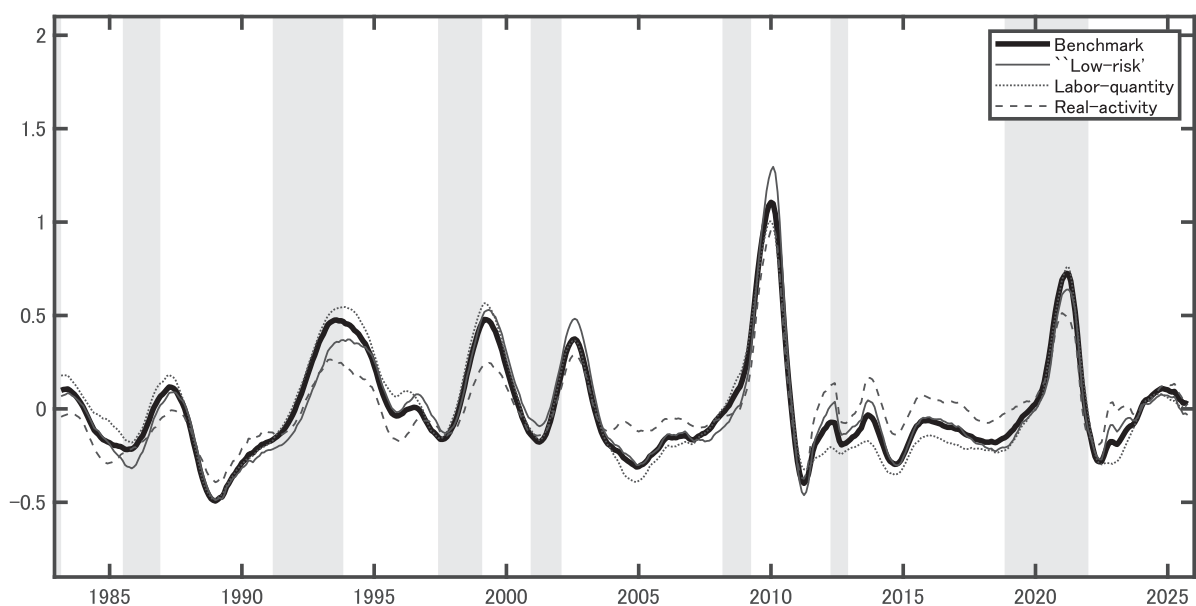


Figure A2: Alternative measures for the cyclical activity index

Notes: The sample period is February 1983–September 2025. The benchmark cyclical activity index is constructed by taking the first principal component of the nine standardized indicators and then rescaling and signing it so that it comoves positively with the year-over-year-change filtered unemployment series. The “Low-risk” index is constructed analogously using labor-quantity measures ([1], [2], and [5]) and real-activity measures ([7]–[9]). The labor-quantity index uses only labor-quantity measures, and the real-activity index uses only real-activity measures. Shaded areas indicate recession periods in Japan as dated by the Cabinet Office.

Table A3: Correlations among alternative measures for the cyclical activity index

	Benchmark	“Low risk”	Labor-quantity
“Low risk”	0.97		
Labor-quantity	0.98	0.94	
Real-activity	0.91	0.93	0.81

Notes: This table reports pairwise Pearson correlation coefficients among the benchmark cyclical activity index and its alternative variants. The sample period is February 1983–September 2025.

Table A4: OLS estimation results for the short-run Phillips curve: using alternative measures for cyclical activity index

Regressand	Year-over-year change in 12-month rate of inflation (%)		
	Repressor	CPIxF	Cyc-A
	“Low risk”	Labor-quantity	Real-activity
Full sample:1983m2-2025m9			
Estimate of β	-1.71 (0.38)	-1.83 (0.38)	-2.13 (0.54)
Adjusted R ²	0.22	0.27	0.17
<i>sup</i> -Wald	4.16 [0.35]	2.60 [0.64]	8.17 [0.06]
Chow-2020m1	0.54 [0.46]	0.47 [0.49]	0.15 [0.70]
Sub-sample:1983m2-1997m4			
Estimate of β	-1.98 (0.48)	-1.89 (0.41)	-2.46 (0.47)
Adjusted R ²	0.29	0.36	0.23
1997m5-2025m9			
Estimate of β	-1.75 (0.48)	-1.78 (0.52)	-2.61 (0.67)
Adjusted R ²	0.22	0.23	0.23

Notes: This table reports OLS estimates of the short-run Phillips curve, regressing the year-over-year change in the 12-month inflation rate on a constant and an alternative cyclical activity index (Cyc-A). Each cyclical activity index is constructed as the first principal component of standardized indicators and then rescaled and signed to match the year-over-year-change filtered unemployment series. Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors with 12-month truncation are in parentheses. *sup*-Wald is the Andrews (1993) and Hansen (1996) test for an unknown break in β ; p-values are in brackets. Chow-2020m1 tests for a break in β in January 2020; p-values are in brackets. CPIxF denotes CPI excluding fresh foods.

labor-market and real-activity indicators. This interpretation is important because conventional unemployment-gap measures may embed persistent low-frequency movements (e.g., gradual shifts in the underlying equilibrium concept), which can attenuate the OLS slope. Using the cyclical activity index as an instrument helps purge such low-frequency contamination and isolates the cyclical slack variation that is most relevant for inflation dynamics.

Table A5: IV estimation results for the short-run Phillips curve with the unemployment gap: alternative measures for cyclical activity index as IVs

Regressand	Year-over-year change in 12-month rate of inflation (%)					
	CPIxF			Gap-U		
Regressor	1983m2-2025m9			1997m5-2025m9		
Sample	[a]	[b]	[c]	[a]	[b]	[c]
IV: Cyc-A						
Estimate of β						
TOLS	-1.65 (0.49)	-2.21 (0.75)	-2.33 (0.92)	-1.57 (0.54)	-1.74 (0.65)	-2.71 (1.24)
Hausman	8.32 [0.00]	6.19 [0.01]	4.53 [0.03]	6.27 [0.01]	5.12 [0.02]	3.62 [0.06]

[a] “Low risk” [b] Labor-quantity [c] Real-activity

Notes: This table reports TOLS estimates of the short-run Phillips curve with the unemployment gap (Gap-U) as the endogenous regressor and an alternative cyclical activity index as an instrument. The unemployment gap is defined as the difference between the actual unemployment rate and the equilibrium unemployment rate constructed by the Japan Institute for Labour Policy and Training. Each cyclical activity index is constructed as the first principal component of standardized indicators and then rescaled and signed to match the year-over-year-change filtered unemployment series. Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors with 12-month truncation are in parentheses. Hausman reports the Hausman (1978) test of equality between the OLS and IV estimates of β ; p-values are in brackets. CPIxF denotes CPI excluding fresh foods.

A.3.2 For alternative inflations

We examine the slope of the Phillips curve for different inflation measures and their stability. Table A6 reports the OLS regression results of the short-run Phillips curve (1) in the main text for alternative inflations. The first three columns on the left-hand side of the table are the OLS regression results of the short-run Phillips curve for the HCPI inflation, CPIxFE inflation, and Wage/h inflation, respectively, using the cyclical activity index as the regressor. The three columns on the middle and right-hand side of the table show the results for the alternative inflations using the unemployment gap and detrended unemployment, respectively, as the regressors.

We confirm the robustness of the quantitative assessment of the short-run trade-off in the benchmark model for alternative inflations. In particular, it is robust for other inflations and (i) the cyclical activity index has an economically meaningful relationship with the short-term inflation, (ii) the short-run Phillips curve using the cyclical activity index is stable over time,

and (iii) these results are different from the results using the unemployment gap or detrended unemployment.

Note that there are slight differences in the estimates of the slope of the Phillips curve depending on the inflation measure used. In particular, the slope of the Phillips curve for CPIxFE inflation is relatively flat compared to HCPI or CPIxF inflation. By contrast, the slope of the Phillips curve for Wage/h inflation is relatively steep. This result reflects that the sensitivity of a demand-pull pressure varies by CPI items and that the sensitivity of the demand-pull pressure concerning wages is relatively high compared to prices.

The results for the slope of the Phillips curve using the unemployment gap are also robust. Table A7 shows the IV regression results of the short-run Phillips curve using the unemployment gap for alternative inflations. We can confirm the benchmark result is robust for alternative inflations and that the cyclical activity index works well to solve the endogenous bias problem.

Table A7: IV estimation results for the short-run Phillips curve for alternative inflations using the unemployment gap

Regressand	Year-over-year change in 12-month rate of inflation (%)					
	HCPI	CPIxFE	Wage/h	HCPI	CPIxFE	Wage/h
Regressor	Gap-U	Gap-U	Gap-U	Gap-U	Gap-U	Gap-U
Sample	1983m2–2025m9			1997m5–2025m9		
Estimate of β	-2.35 (0.82)	-1.89 (0.72)	-3.87 (1.66)	-2.04 (0.75)	-1.64 (0.63)	-3.02 (1.35)
Hausman	6.03 [0.01]	4.75 [0.03]	3.93 [0.05]	5.47 [0.02]	4.70 [0.03]	3.32 [0.07]

Notes: This table shows the IV regression results of the year-over-year change in alternative inflations on constant term and the unemployment gap (Gap-U). We use the cyclical activity index as an instrument for the unemployment gap in the IV regression. The unemployment gap represents the difference between the actual unemployment rate and the equilibrium unemployment rate constructed by the Japan Institute for Labour Policy and Training. We obtain the cyclical activity index by scaling and signing the first principal component calculated using the nine standardized indicators to the year-over-year change filtered unemployment. The numbers between parentheses are Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors for least squares with a 12-month lag truncation. The estimated constant term and its standard error are not reported. Hausman indicates the HAR statistic on the Hausman (1978) test under the null hypothesis that the OLS and IV estimators of β are consistent, but the OLS estimate is efficient. The numbers between brackets are p-values for the Hausman test. HCPI: CPI, all items (headline CPI). CPIxFE: CPI, all items excluding food and energy. Wage/h: hourly wage.

A.3.3 Using inflation expectations proxies

A standard expectations-augmented Phillips curve emphasizes that expected inflation can matter for short-run inflation dynamics. While our baseline dependent variable focuses on short-term inflation by differencing year-over-year inflation (thereby removing slow-moving components), it is useful to confirm that the estimated response to cyclical activity remains when expected inflation is controlled for more explicitly. To this end, we redefine the dependent variable as an inflation gap, $\pi_t^{gap} \equiv \pi_t^{12} - \pi_t^e$, where π_t^{12} denotes year-over-year CPIxF inflation and π_t^e proxies expected inflation.

We first proxy expected inflation using a slow-moving component constructed from past inflation. Specifically, we compute the 3-year moving average of inflation and use lagged values to avoid mechanically subtracting contemporaneous short-run movements. Table A8 reports OLS estimates of the Phillips curve using the inflation gap and cyclical activity as the regressor. When the moving-average proxy is lagged by 12 months, the estimated slope is close to the benchmark (around -2.1 in the full sample) and remains stable across subsamples. When the

same moving average is lagged by 1 month, the estimated slope remains negative and statistically significant, but the magnitude is smaller (around -1.6). A natural interpretation is that using a very short lag may remove not only trend inflation but also part of the cyclical component of inflation, thereby attenuating the measured short-run response to cyclical activity.

Table A8: OLS estimation results for the short-run Phillips curve: using 3-year moving average as a proxy for expected inflation

Regressand π_t^e Regressor	CPIxF inflation gap	
	12-month-lag of 3-year MA Cyc-A	1-month-lag of 3-year MA
Full-sample:1983m2-2025m9		
Estimate of β	-2.10 (0.32)	-1.60 (0.20)
Adjusted R ²	0.23	0.32
<i>sup</i> -Wald	3.30 [0.49]	2.30 [0.71]
Chow-2020m1	0.81 [0.37]	0.64 [0.42]
Sub-sample:1983m2-1997m4		
Estimate of β	-2.42 (0.78)	-1.83 (0.40)
Adjusted R ²	0.21	0.37
1997m5-2025m9		
Estimate of β	-2.09 (0.34)	-1.57 (0.23)
Adjusted R ²	0.30	0.34

Notes: This table reports OLS estimates of the CPIxF inflation gap on a constant and the cyclical activity index (Cyc-A). The inflation gap is defined as $\pi_t^{gap} = \pi_t^{12} - \pi_t^e$, where π_t^{12} is year-over-year CPIxF inflation and π_t^e is proxied by the lagged 3-year moving average of CPIxF inflation (lagged by 12 months or 1 month as indicated). Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors with 12-month truncation are in parentheses. *sup*-Wald is the Andrews (1993) and Hansen (1996) test for an unknown break in β ; p-values are in brackets. Chow-2020m1 tests for a break in β in January 2020; p-values are in brackets. CPIxF denotes CPI excluding fresh foods.

Table A9 repeats the exercise in an IV framework that uses the unemployment gap as the regressor and the cyclical activity index as an instrument. The IV estimates preserve the same qualitative pattern: TSLS slopes remain economically meaningful and are larger in absolute value than OLS, while the 1-month-lag proxy yields somewhat smaller magnitudes than the 12-month-lag proxy. Hausman tests provide evidence consistent with endogeneity bias in the unemployment-gap specification, which the IV approach mitigates.

Finally, Table A10 uses the survey-based inflation expectations series compiled by Osada and Nakazawa (2024) at different maturities. Re-estimating the Phillips curve over the post-2007 sample yields a robust negative relationship between cyclical activity and the inflation gap. The magnitude varies with maturity: when shorter-horizon expectations (e.g., one year) are used,

Table A9: IV estimation results for the short-run Phillips curve with the unemployment gap: using 3-year moving average as a proxy for expected inflation

Regressand π_t^e	CPIxF Inflation gap			
	12-month-lag of 3-year MA		1-month-lag of 3-year MA	
Regressor	Gap-U			
Sample	1983m2-2025m9	1997m5-2025m9	1983m2-2025m9	1997m5-2025m9
Estimate of β				
OLS	-0.74 (0.22)	-0.69 (0.24)	-0.44 (0.16)	-0.41 (0.18)
TSLS	-2.50 (0.98)	-2.14 (0.81)	-1.90 (0.72)	-1.61 (0.59)
Hausman	3.40 [0.07]	3.46 [0.06]	4.38 [0.04]	4.52 [0.03]

Notes: This table shows the OLS and IV regression results of the CPIxF inflation gap on the constant term and the unemployment gap (Gap-U). We use the cyclical activity index as an instrument for the unemployment gap in the IV regression. The unemployment gap is the difference between the actual and the equilibrium unemployment rates constructed by the Japan Institute for Labour Policy and Training. We obtain the cyclical activity index by scaling and signing the first principal component, calculated using the nine standardized indicators to the year-over-year change filtered unemployment. The numbers between parentheses are Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors for least squares with a 12-month lag truncation. The estimated constant term and its standard error are not reported. Hausman indicates the HAR statistic on the Hausman (1978) test under the null hypothesis that the OLS and IV estimators of β are consistent, but the OLS estimate is efficient. The numbers between brackets are p-values for the Hausman test. CPIxF: consumer price index, all items excluding fresh foods.

the estimated slope is smaller in absolute value, whereas for longer-horizon expectations (five years or longer) the slope is more stable and remains economically meaningful (around -1.4 to -1.5). This pattern is consistent with the view that short-horizon expectations incorporate more temporary influences, while longer-horizon expectations are more closely tied to slow-moving trend inflation. Overall, these exercises indicate that the main findings do not hinge on a specific proxy for inflation expectations.

Table A10: OLS estimation results for the short-run Phillips curve: using survey-based expectations as a proxy for expected inflation

Regressand π_t^e	CPIxF Inflation gap					
	Survey-based expectation series					
Maturity	1-year	2-year	3-year	5-year	7-year	10-year
Regressor	Cyc-A					
Estimate of β	-0.76 (0.23)	-1.01 (0.28)	-1.18 (0.30)	-1.38 (0.33)	-1.44 (0.35)	-1.46 (0.35)
Adjusted R ²	0.12	0.15	0.17	0.19	0.20	0.20

Notes: This table shows the ordinary least squares regression results of the CPIxF inflation gap on constant term and the cyclical activity index (Cyc-A). We use the survey-based inflation expectations series compiled by Osada and Nakazawa (2024) at different maturities as a proxy for the expected inflation π_t^e . The survey-based expectations series are available at quarterly frequency; we linearly interpolate them to monthly frequency to match the monthly inflation and activity measures. We obtain the cyclical activity index by scaling and signing the first principal component calculated using the nine standardized indicators to the year-over-year change filtered unemployment. The numbers between parentheses are Newey and West (1987) heteroskedasticity and autocorrelation robust (HAR) standard errors for least squares with a 12-month lag truncation. The estimated constant term and its standard error are not reported. CPIxF: consumer price index, all items excluding fresh foods. The sample period is January 2007–March 2024.

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