On the Source of Seasonal Cycles of Price Changes: the Role of Seasonality in Menu Costs

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SWET参加者限り

Outline

1. Motivation
2. Data and Methodology
3. Facts about Seasonal Cycles
4. State-Dependent Model with Seasonal Cycles of Menu Costs
5. Discussion

Motivation: Questions we are trying to answer

- How do seasonal cycles look like?
  1. Seasonal cycles occur because more firms change prices or because firms charge more in specific months?
  2. Are seasonal cycles of frequency and size related?
- Why do seasonal cycles occur?
- What are the macroeconomic implications?

Motivation: Questions we are trying to answer

- How do seasonal cycles look like?

$\Rightarrow$ Two peaks in frequency of price changes that are synchronized across directions (ups and downs) and across categories.

$\Rightarrow$ Negative correlation between frequency and size of price changes.

- Why do seasonal cycles occur?

$\Rightarrow$ There are seasonal cycles in menu costs.

- What are the macroeconomic implications?

$\Rightarrow$ Months may matter to the transmission of shocks.

Motivation: Related Studies in Macroeconomics

- Studies on seasonal cycles of quantities.
  1. Barsky and Miron (1989): Seasonal variations are sizable in standard macroeconomic quantity variables, increases in 2Q and 4Q, a large decrease in 1Q, and a mild decrease in 3Q.
  2. Cecchetti and Kashyap (1996) and Matas-Mir and Osborn (2004): Summer shut-downs are shorter during the boom year.

- Olivei and Tenreyro (2010) : Month matters for monetary transmission
  1. The response of macroeconomic activity to monetary policy shock occurring in 1Q is nil and activity responds strongly to the policy shock when the shock takes place in other quarters in Japan.
  2. The observations may be driven by Japan’s non-uniform distribution of wage contracts over the calendar year due to *Shunto*.

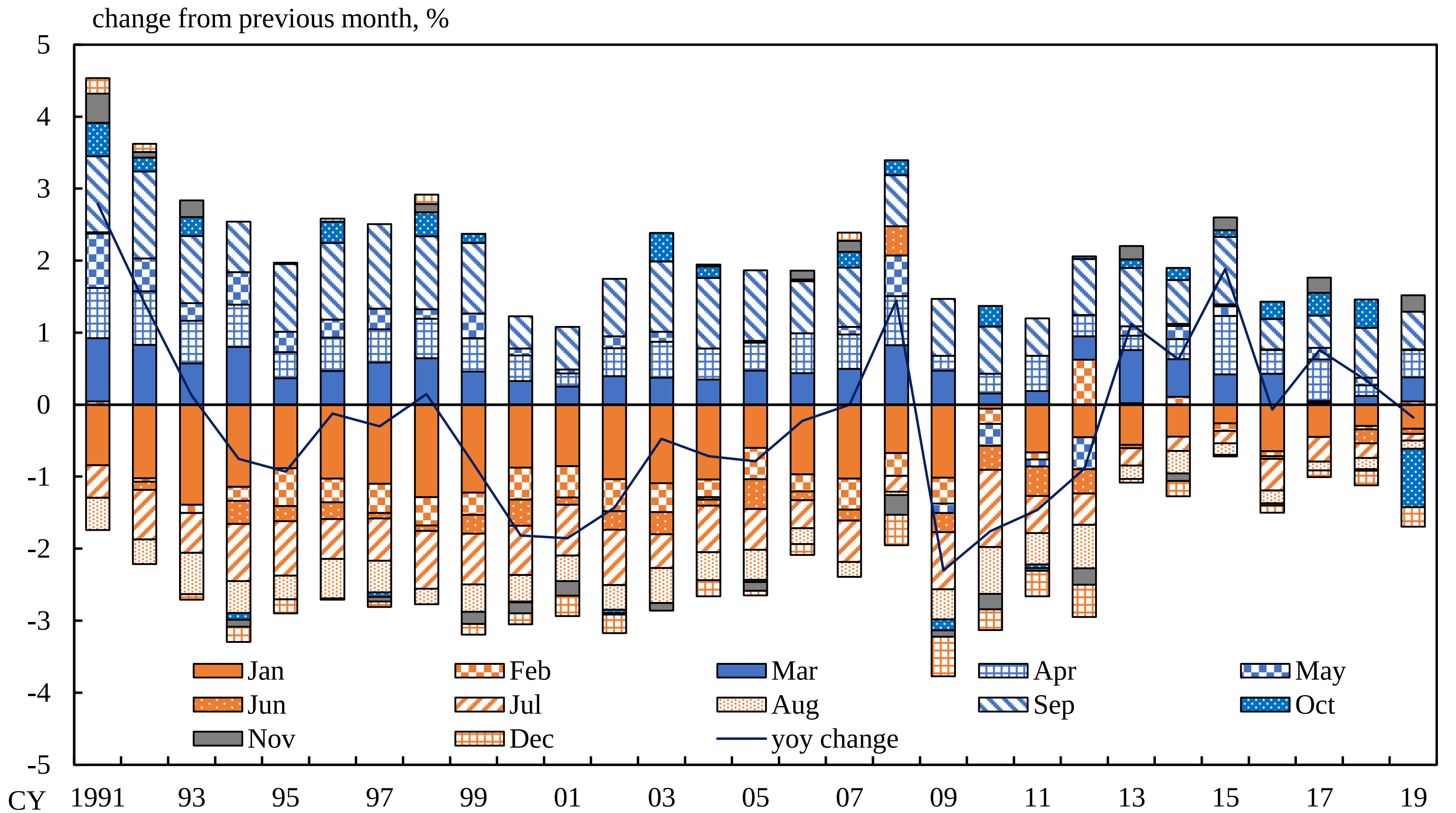
Motivation: Related Studies in Macroeconomics

- Seasonal cycles have been documented in a number of existing studies,…
- Nakamura and Steinsson (2008): Five facts about prices
  1. Frequency of nonsale price changes ~ 1/2 of all price changes.
  2. 1/3 of nonsale price changes are price decreases.
  3. Frequency of price increases covaries strongly with inflation.
  4. Frequency of price change is highly seasonal.
  5. Hazard function is not increasing.

- Not much detailed studies have been conducted…
  - ✓ Relationship between frequency and size, cause of seasonal cycles, etc…

Motivation: MOM difference in CPI

- The sign of monthly changes has been stable over time.



Note: The panel plots monthly change of Japanese CPI (goods, less fresh food and energy) adjusted for changes in the consumption tax rate.

2. Data and Methodology

Data and Methodology: Data

- Nikkei Point-of-Sales data by Nikkei:
  - ✓ Daily scanner data from Jan. 1990 to Dec. 2021.
  - ✓ 575 stores for food and daily commodities (fresh food excluded) of 199 categories, corresponding to 170 items out of 588 items of the CPI and 17% of the CPI basket.
  - ✓ Over 11 billion observations.

- Regular Price:
  - ✓ Mode of the prices within the window of 89 days (between 44 days before and 44 days after the day).

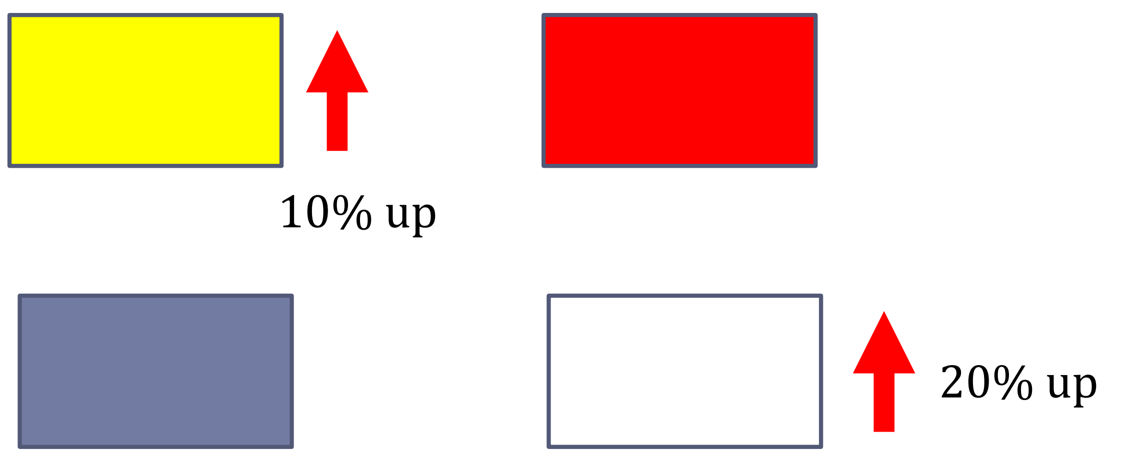
Data and Methodology: Definitions

- Frequency of price increase/decrease:
  - ✓ Portion of products in the category that has changed the price.

$$FREQ^{\pm}_{Jm} = \frac{\sum_{i\in J, d\in m} 1(p_{id} \gtrless p_{id-1})}{\sum_{i\in J, d\in m}[1(p_{id} > p_{id-1}) + 1(p_{id} = p_{id-1}) + 1(p_{id} < p_{id-1})]}$$

($1(\cdot)$ is the indicator function)

  - ✓ Frequency of price increases for the category "Tofu" is 0.5 in the case below.

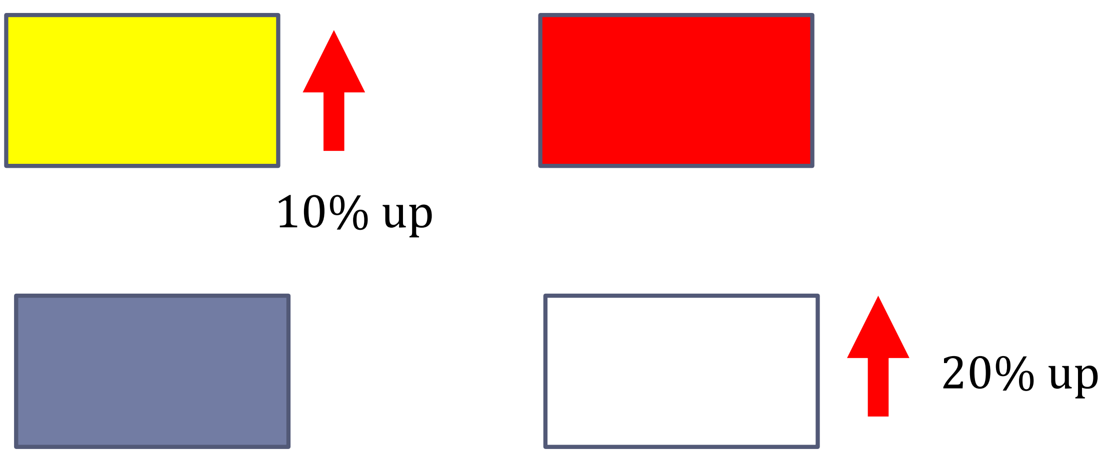


Data and Methodology: Definitions

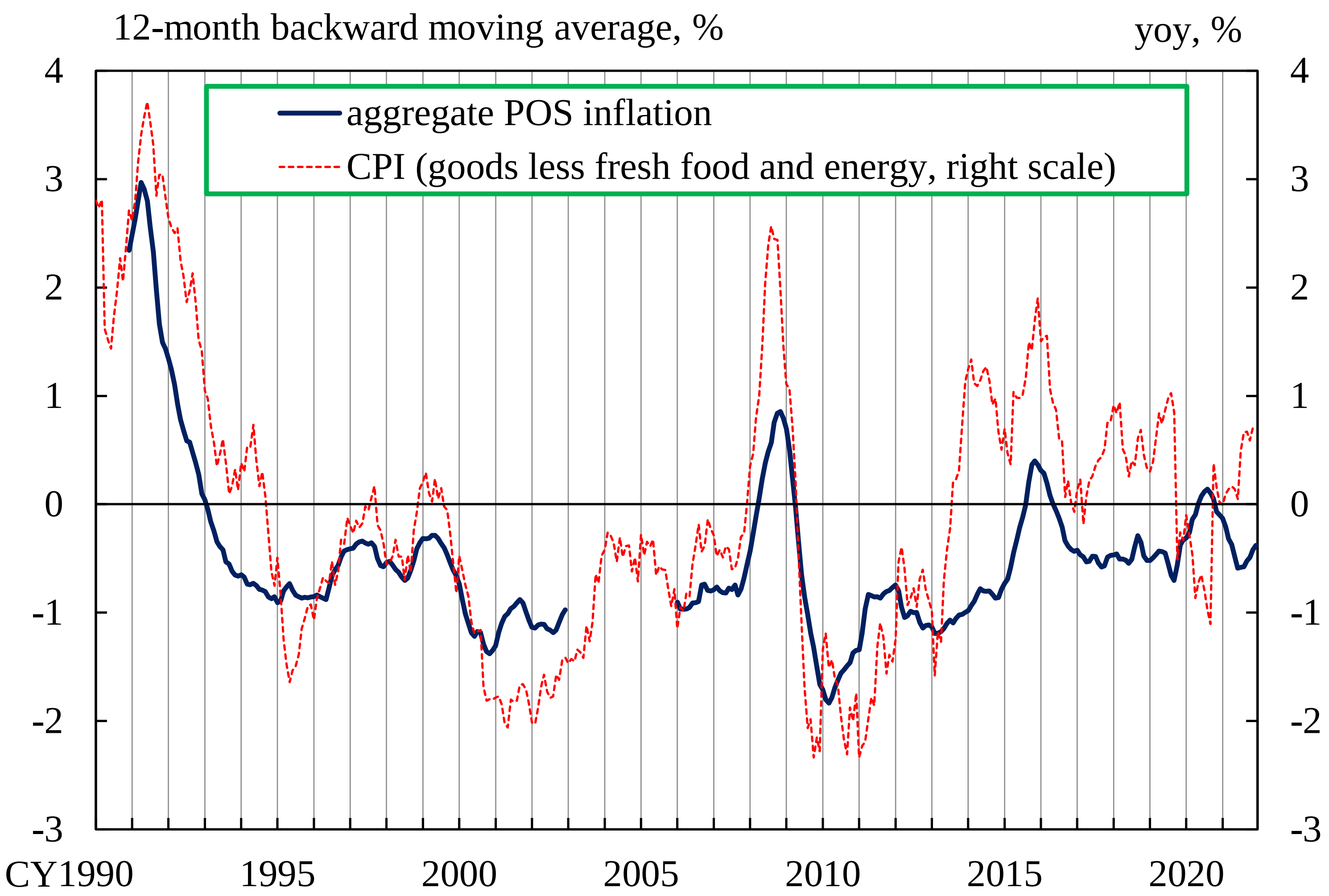
- Size of price increase/decrease:
  - Average price change of products that have changed the price.

$$SIZE_{Jm}^{\pm} = \frac{\sum_{i \in J, d \in m} |\log(p_{id}/p_{id-1})| 1(p_{id} \gtrless p_{id-1})}{\sum_{i \in J, d \in m} 1(p_{id} \gtrless p_{id-1})}$$

  - Size of price increases for category "Tofu" is 0.15 in the case below.



Data and Methodology: POS vs CPI



Data and Methodology: Seasonal Cycles

- Seasonal cycles are computed by regressing the original series of a variable of interest (e.g., frequency of upward price change of a category *J)* on 12 monthly dummies.

$$y_{J,t} = \sum_{m=1}^{12} \left(a_{J,m} dum_{m,t}\right) + \beta_{J,0} + \beta_{J,1} \times t + \beta_{J,2} \times t^2 + \epsilon_{J,t}$$

$$subject\ to \sum_{m=1}^{12} a_{J,m} = 0$$

- Rolling estimates to obtain the time series.
- Sensitivity analysis using other methods to extract seasonal cycles :X12 and non-seasonal adjusted series.

3. Facts about Seasonal Cycles

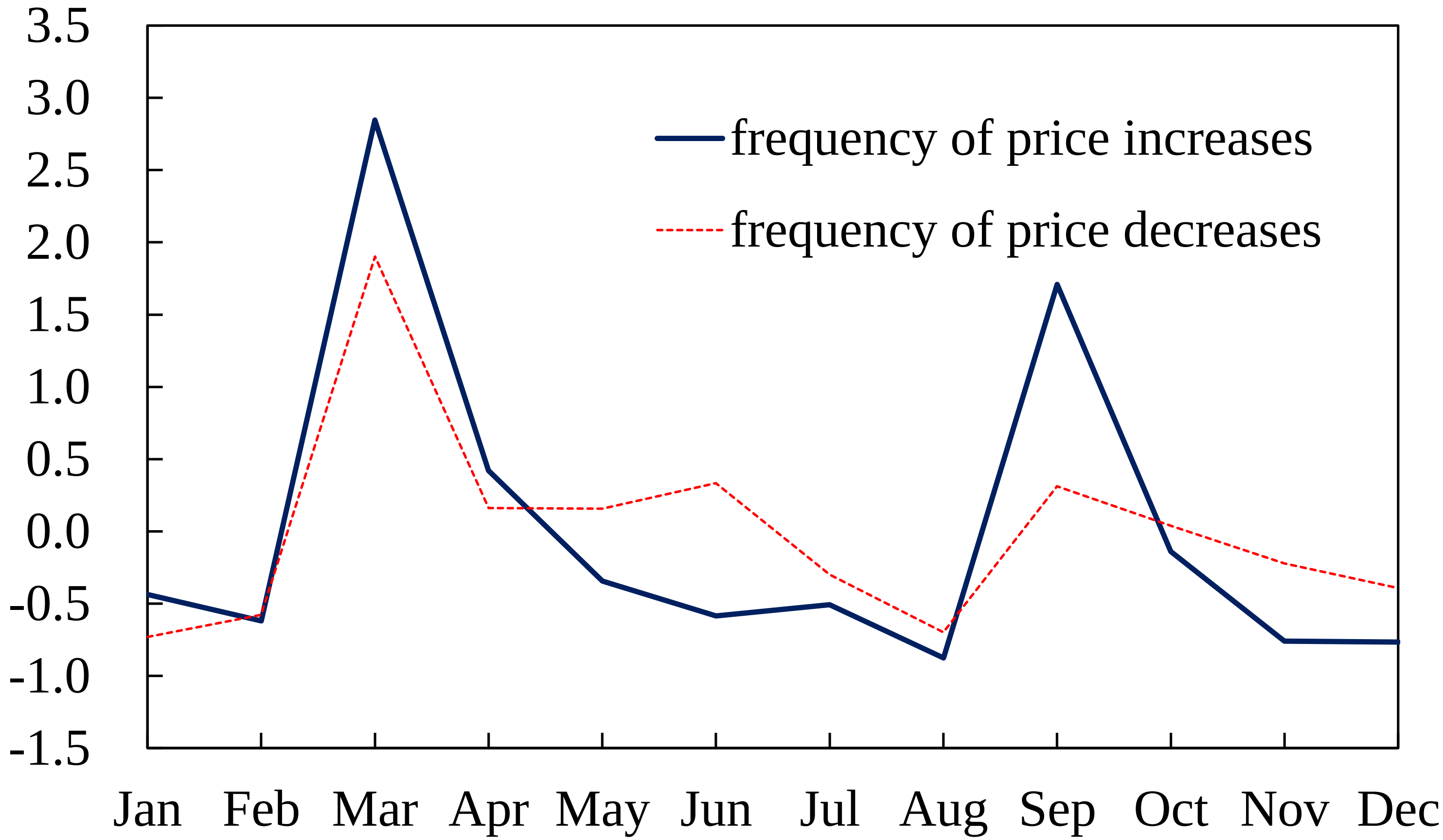
Facts about Seasonal Cycles: Summary

1. Frequency of price changes has two peaks.
2. Size is negatively correlated with frequency, and the seasonal cycles of the former are less pronounced and less synchronized across categories and between directions.
3. Seasonal cycles of inflation track seasonal cycles of net frequency.
4. Seasonal cycles of the frequency are stable but they are responsive to changes in the category-level inflation rate.

Fact 1 : Frequency

- Frequency has two peaks, March and September, for Tofu.

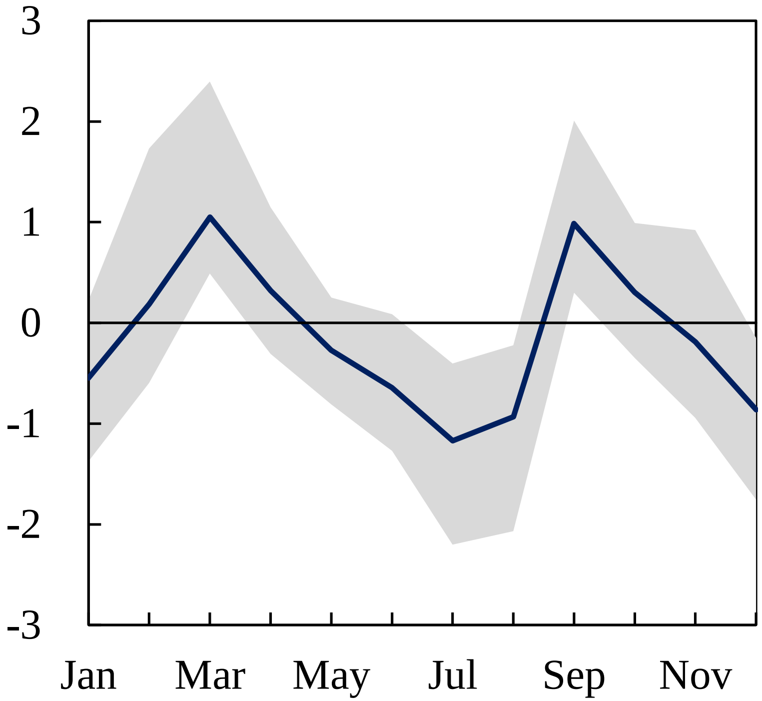
<Average seasonality>



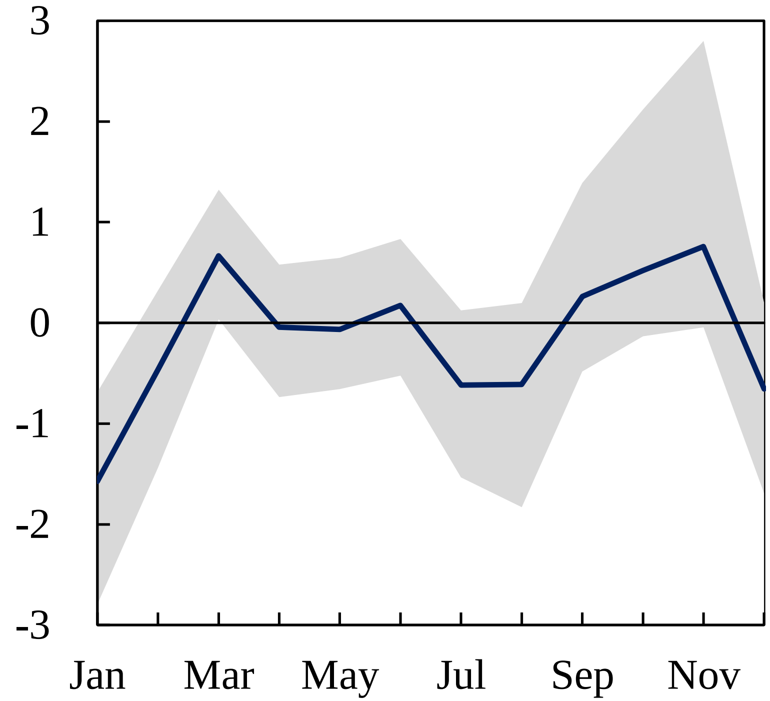
Fact 1 : Frequency

- Frequency rises in March and September for most categories for both price increases and decreases.

<Frequency of price increases>



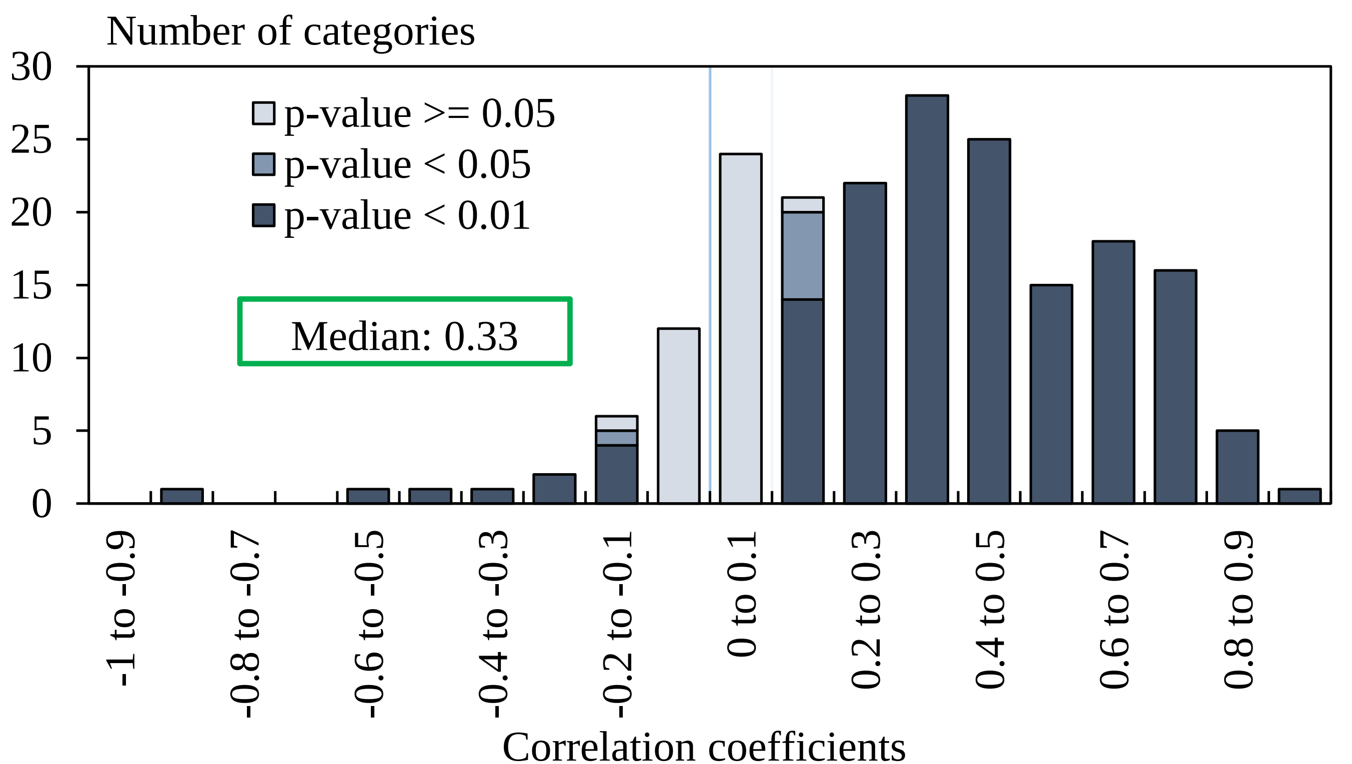
<Frequency of price decreases>



Note: The panels plot the median of the average seasonal component of frequency of price changes across all categories.
The shaded area indicates the 25th and 75th percentile bands.

Fact 1 : Frequency

- Frequency is synchronized across directions. When upward frequency rises, downward frequency rises, too.

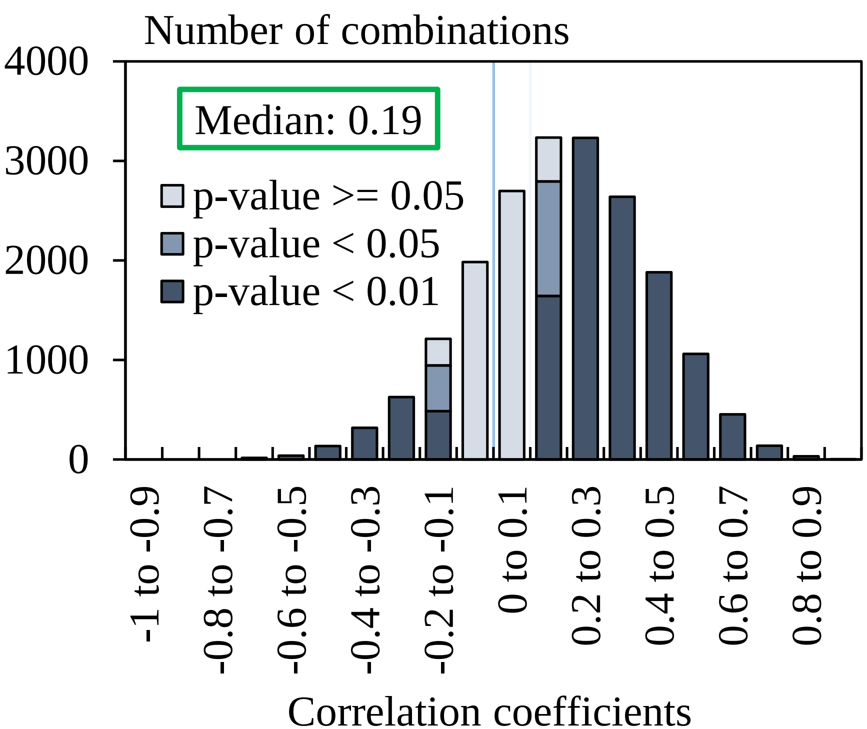


Note: The panel shows a histogram of the correlation between the seasonal components of the frequency of price increases and price decreases within the same category.

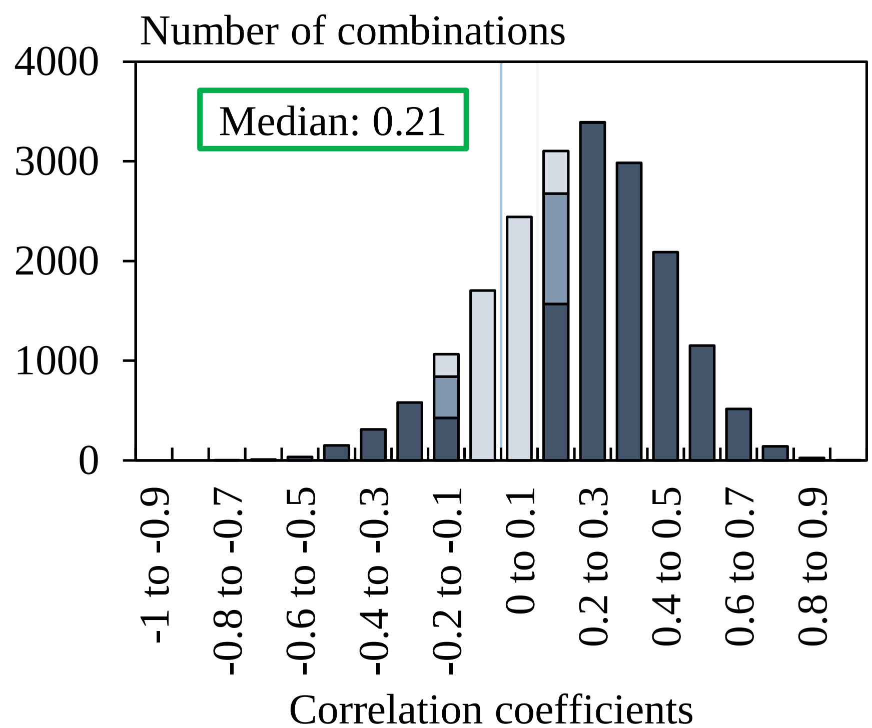
Fact 1 : Frequency

- Frequency is synchronized across categories. When Tofu sees a rise in frequency, Soap sees that, too.

<Frequency of price increases>



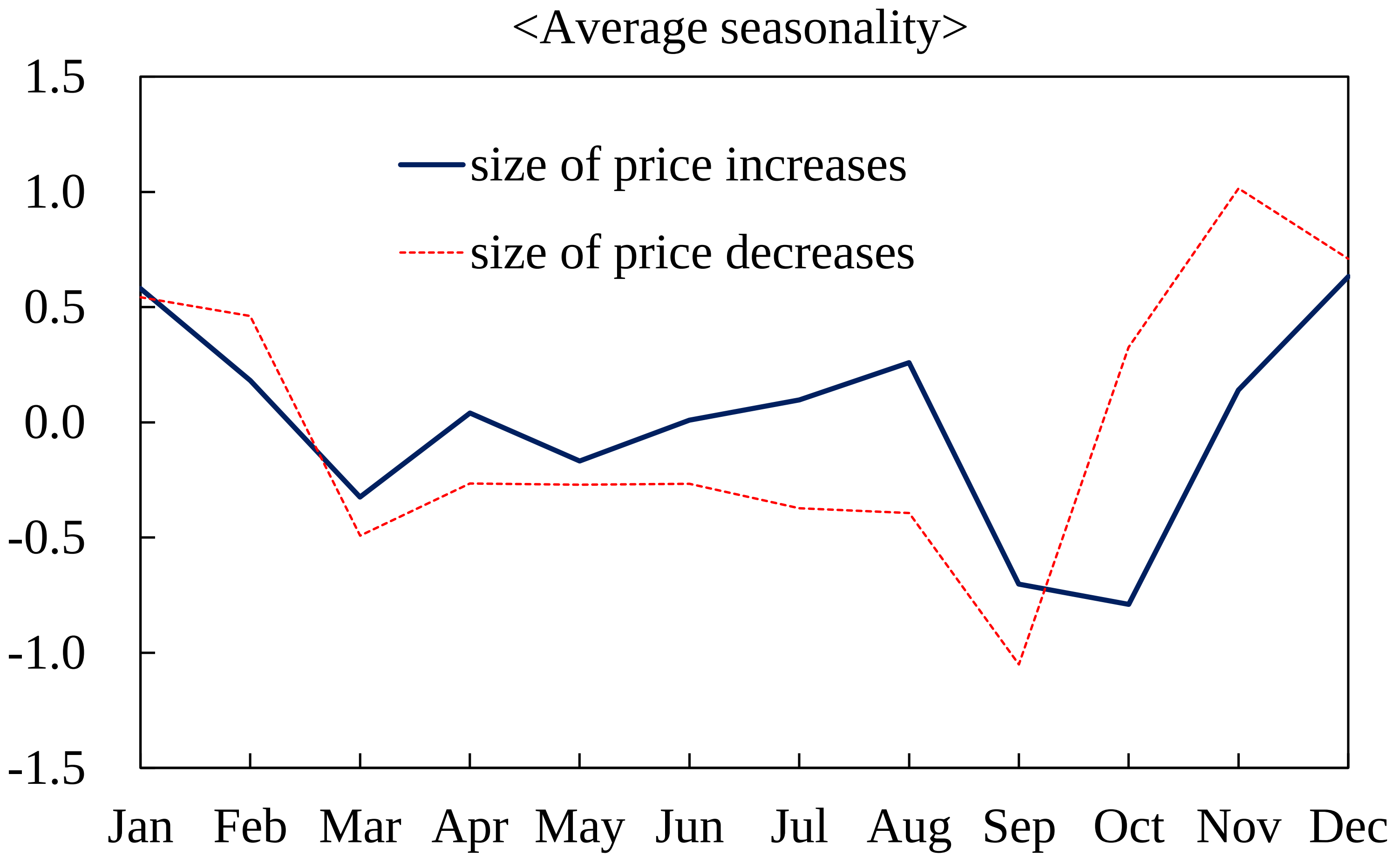
<Frequency of price decreases>



Note: The panels show histograms of the correlations of the seasonal components of frequency of price changes across pairs of 199 categories.

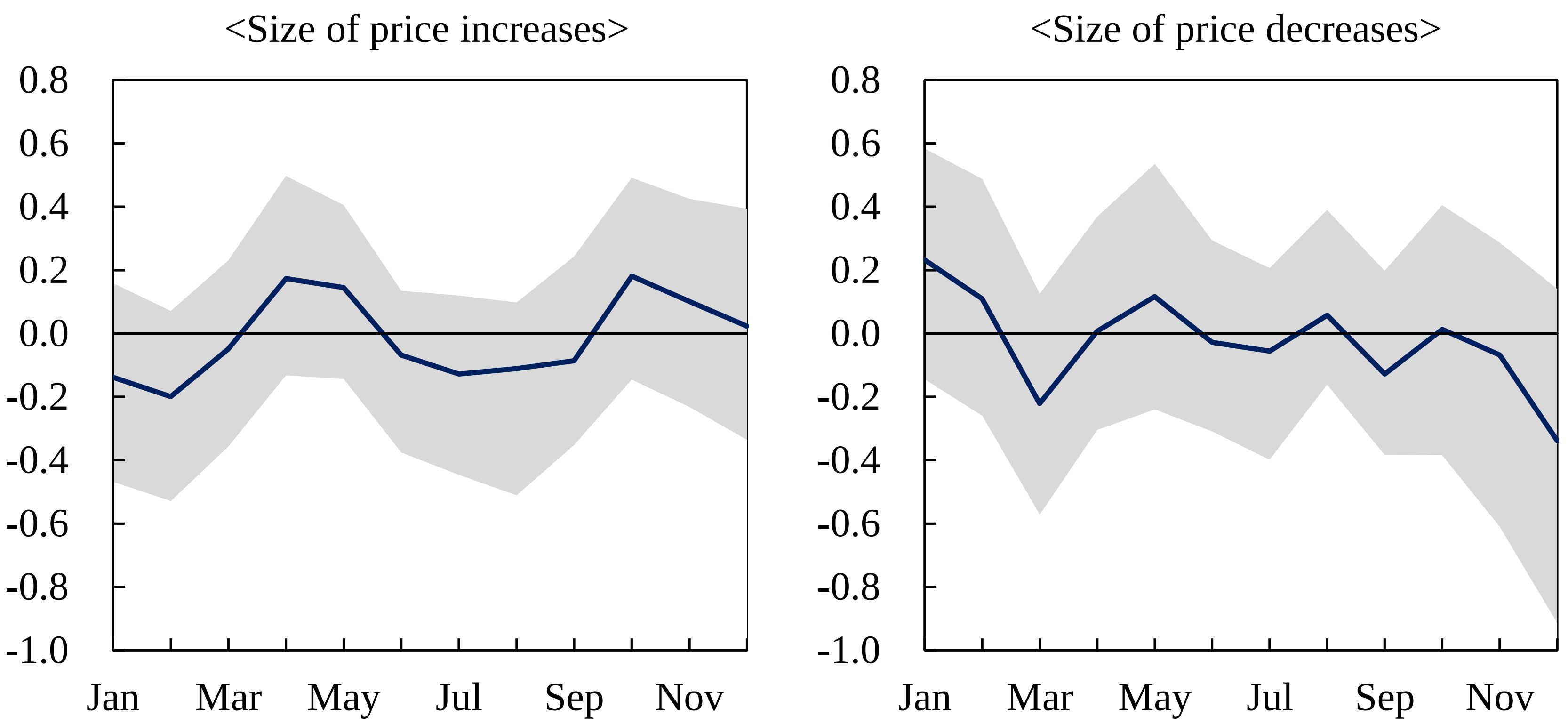
Fact 2 : Size

- Size declines in March and September for Tofu.



Fact 2 : Size

- For all categories, such patterns are less visible.

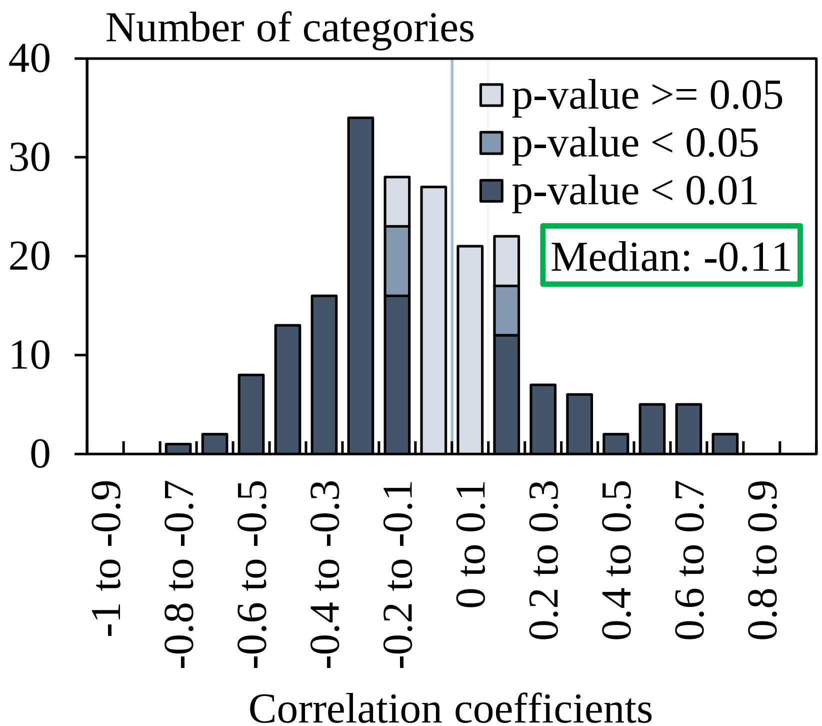


Note: The panels plot the median of the average seasonal component of size of price changes across all categories.
The shaded area indicates the 25th and 75th percentile bands.

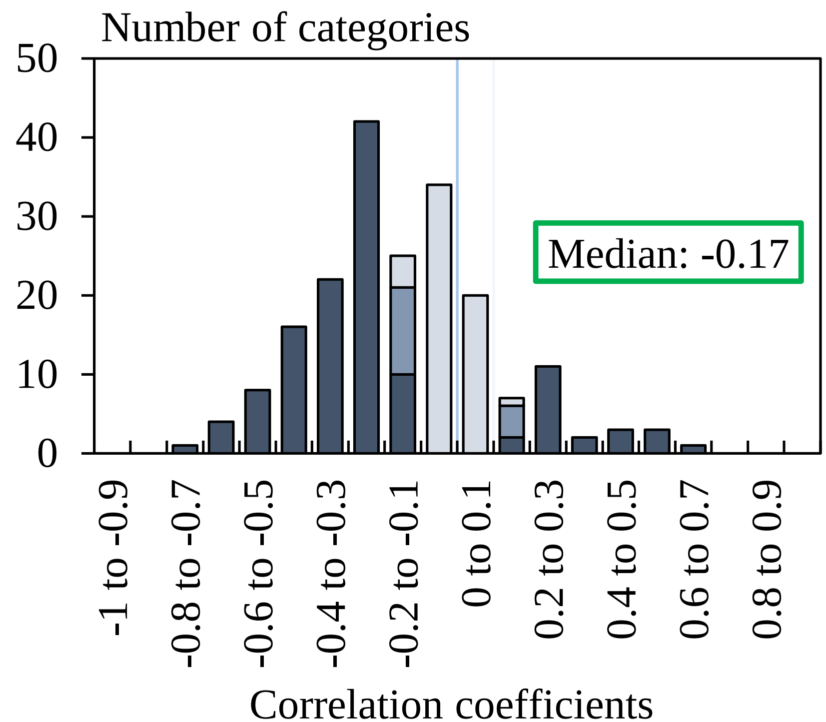
Fact 2 : Size

- Frequency and size are negatively correlated (but weakly).

<Frequency and size of price increases>



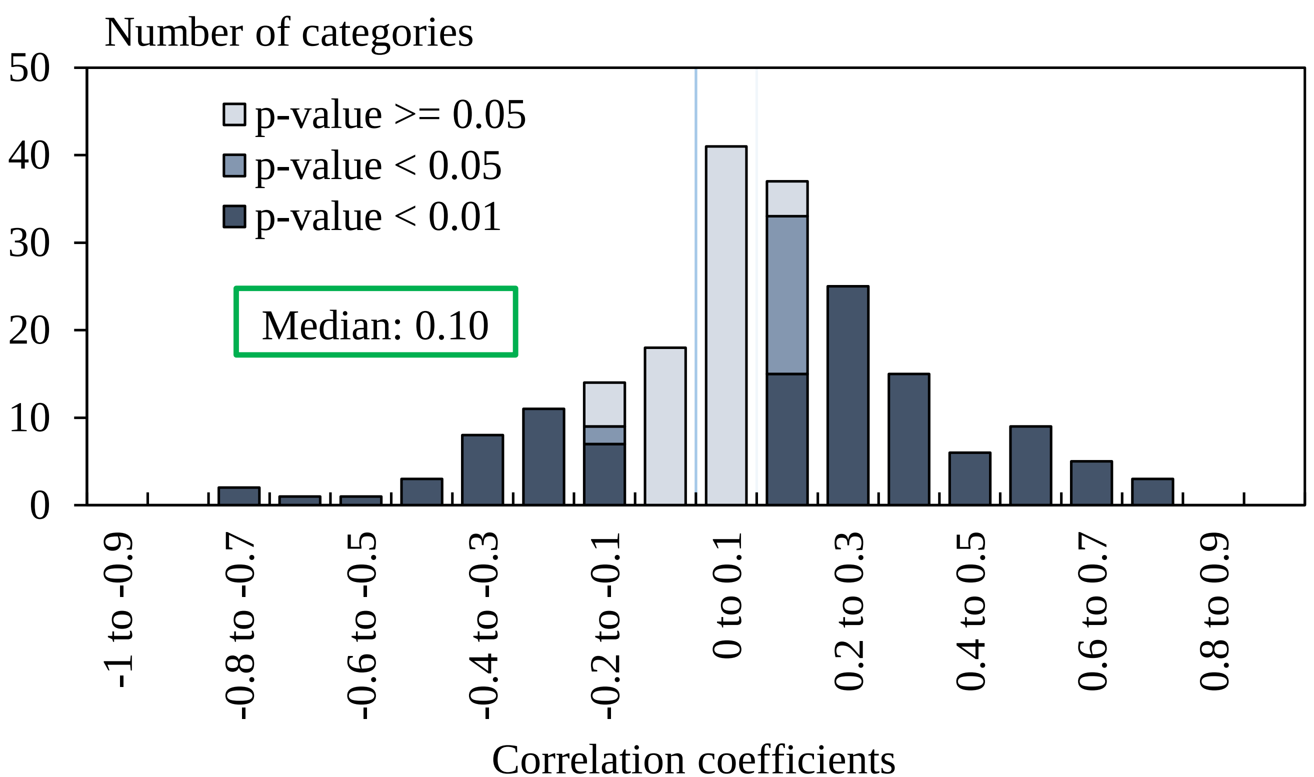
<Frequency and size of price decreases>



Note: The panels show histograms of the correlation between the seasonal components of frequency of price increases (decreases) and size of price increases (decreases) within the same category.

Fact 2 : Size

- Size is weakly synchronized between price increase and decrease.

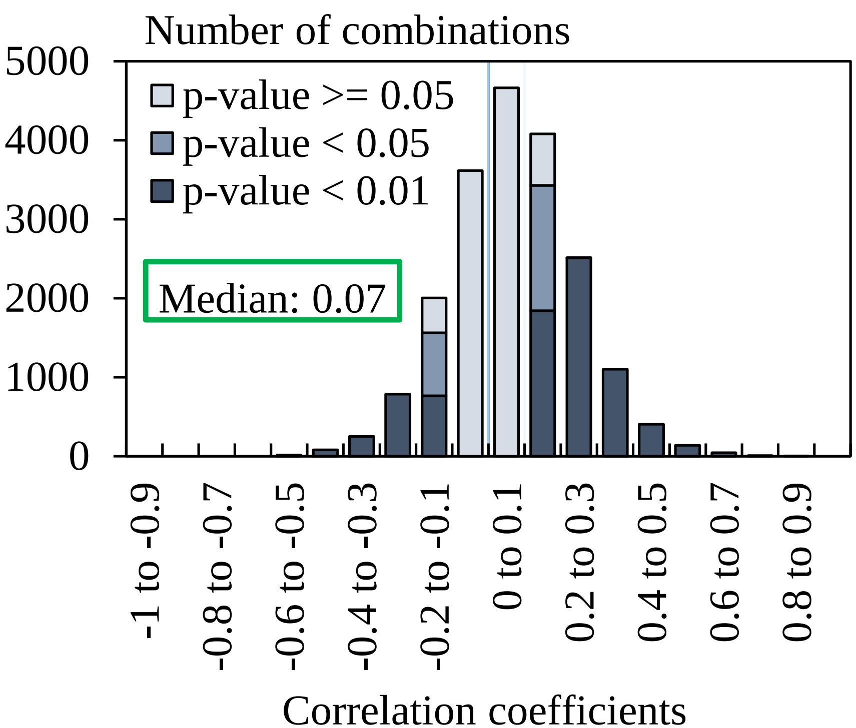


Note: The panel shows a histogram of the correlation between the seasonal components of the size of price increases and price decreases within the same category.

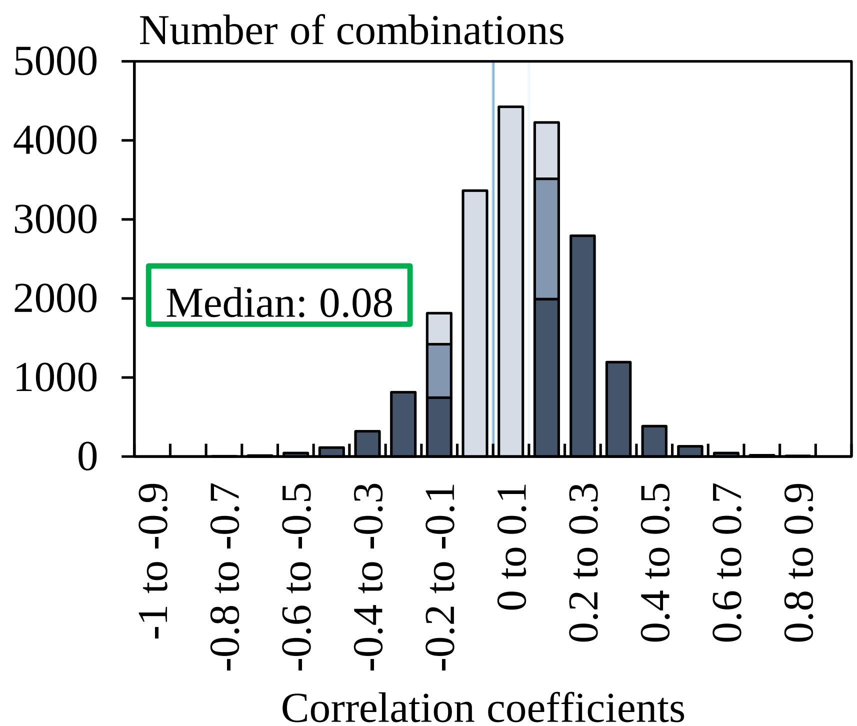
Fact 2 : Size

- Size is weakly synchronized across categories.

<Size of price increases>



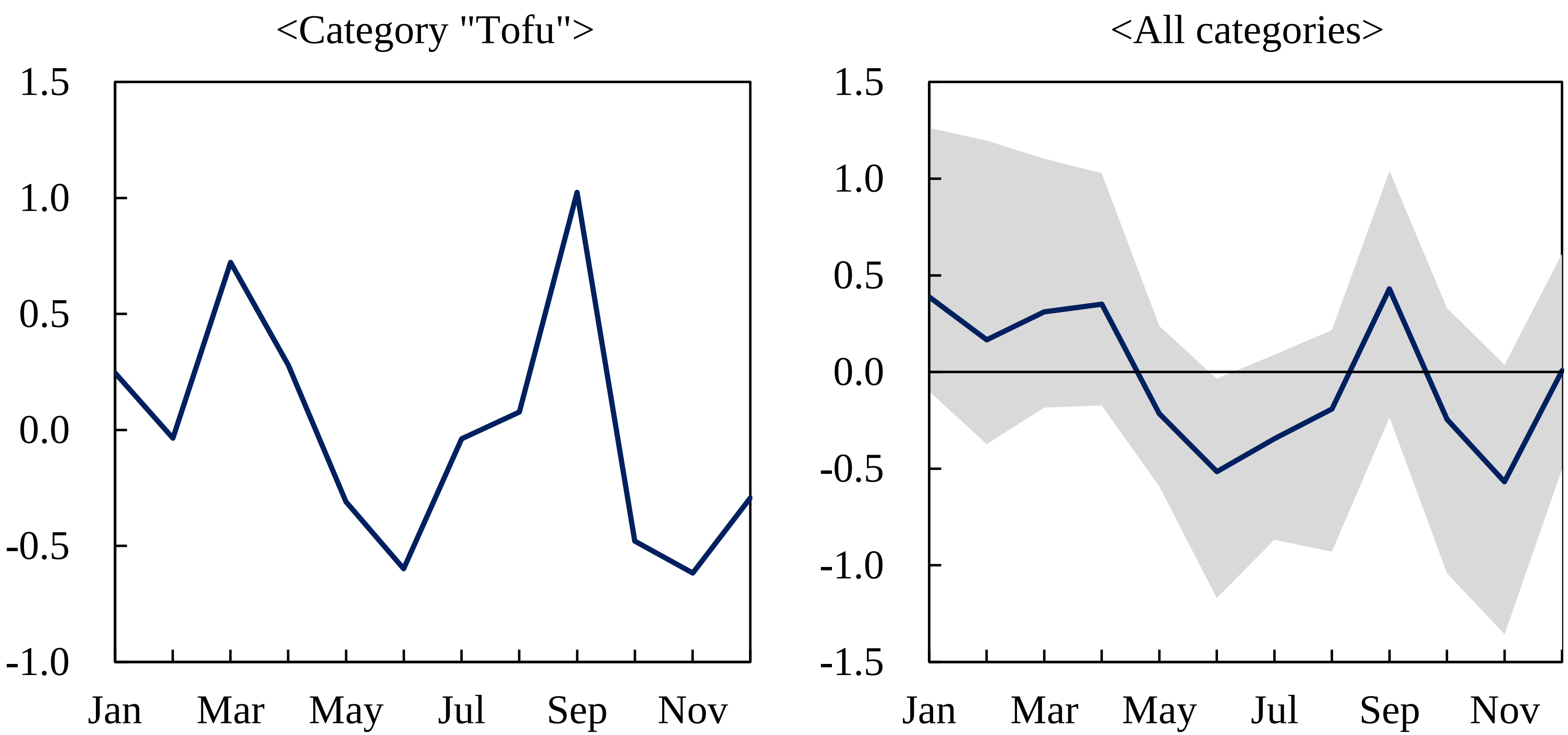
<Size of price decreases>



Note: The panels show histograms of the correlations of the seasonal components of size of price changes across pairs of 199 categories.

Fact 3 : Inflation

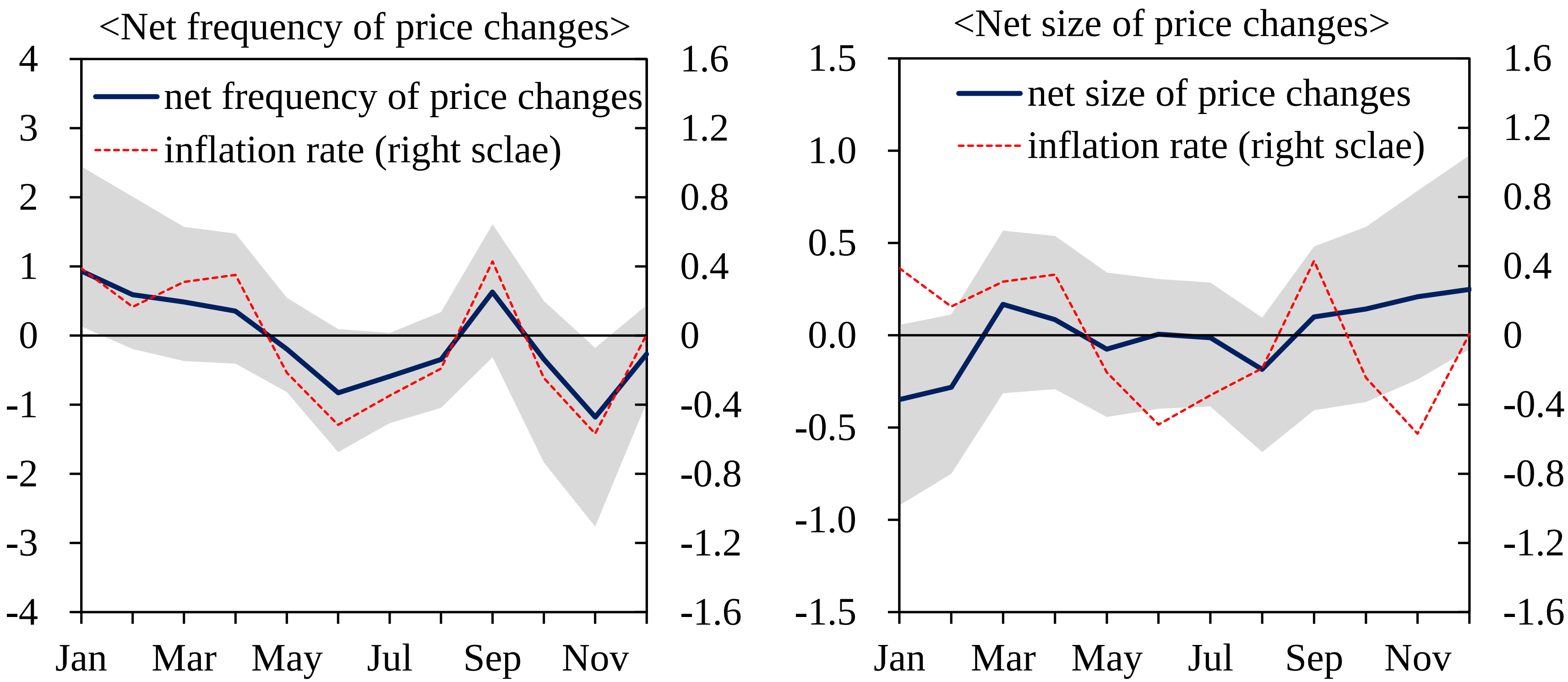
- For most categories, inflation rate rises around January-April and in September.



Note: The left panel plots the average seasonal component of inflation rate of category “Tofu.” The right panel plots the median of the average seasonal component of inflation rate across all categories. The shaded area indicates the 25th and 75th percentile bands.

Fact 3 : Inflation

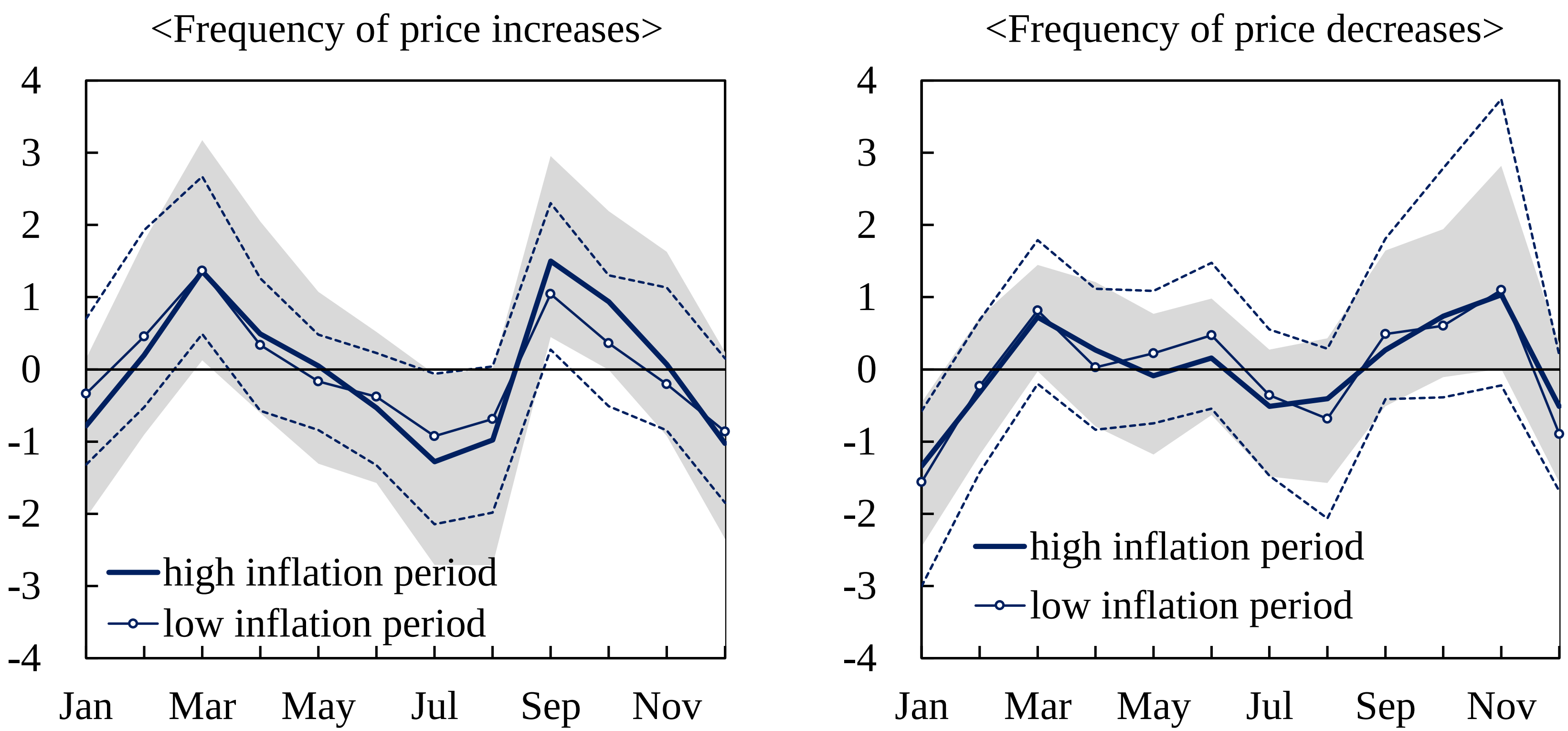
- Net frequency (= difference between upward frequency and downward frequency) roughly tracks inflation.



Note: The panels plot the median of the average seasonal component of net frequency of price changes and net size of price changes across all categories. The shaded area indicates the 25th and 75th percentile bands.

Fact 4: Time Series Properties

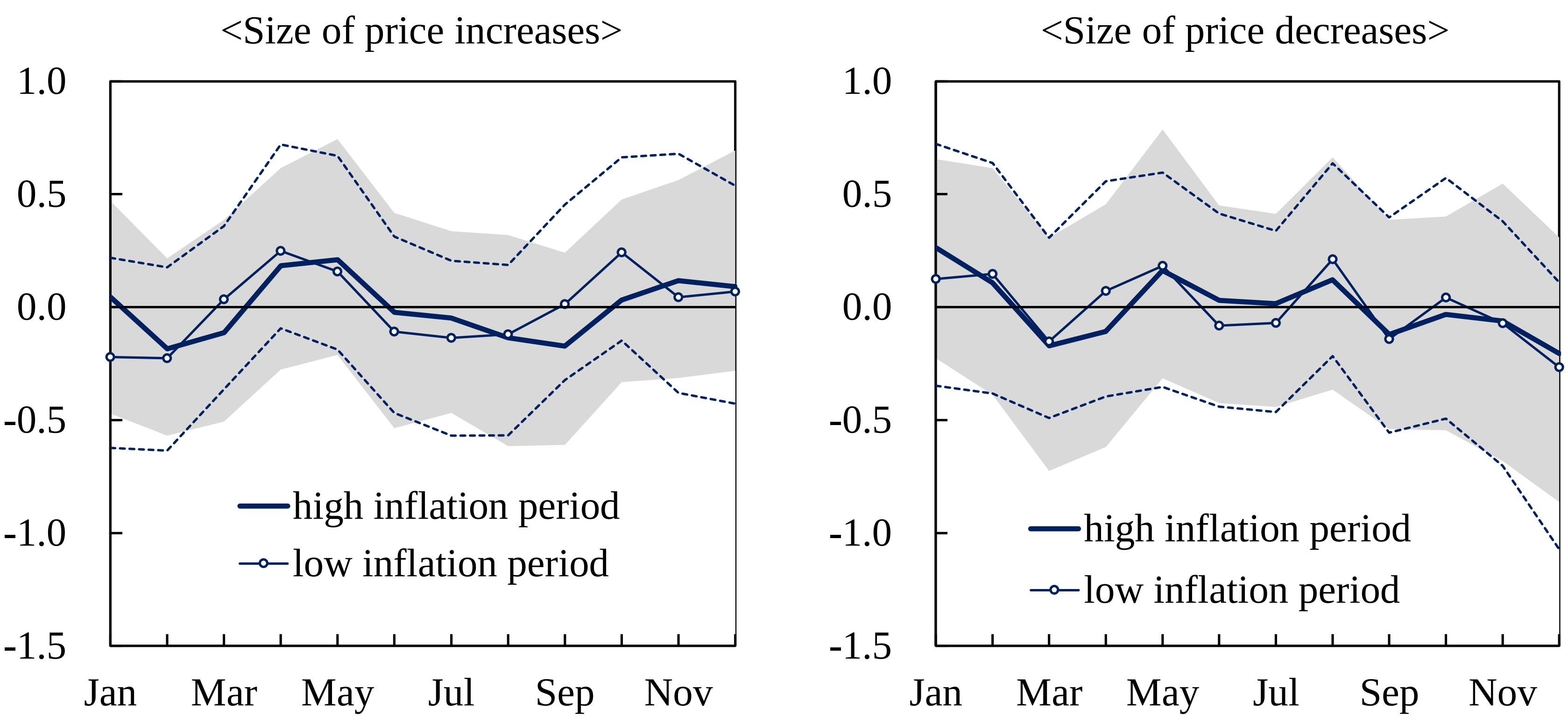
- Seasonal cycles of frequency have been stable, but the pattern looks responsive to the category-level inflation rate.



Note: The panels plot the median of the average seasonal component of frequency of price changes across all categories. The shaded area and dotted line indicate the 25th and 75th percentile bands.

Fact 4: Time Series Properties

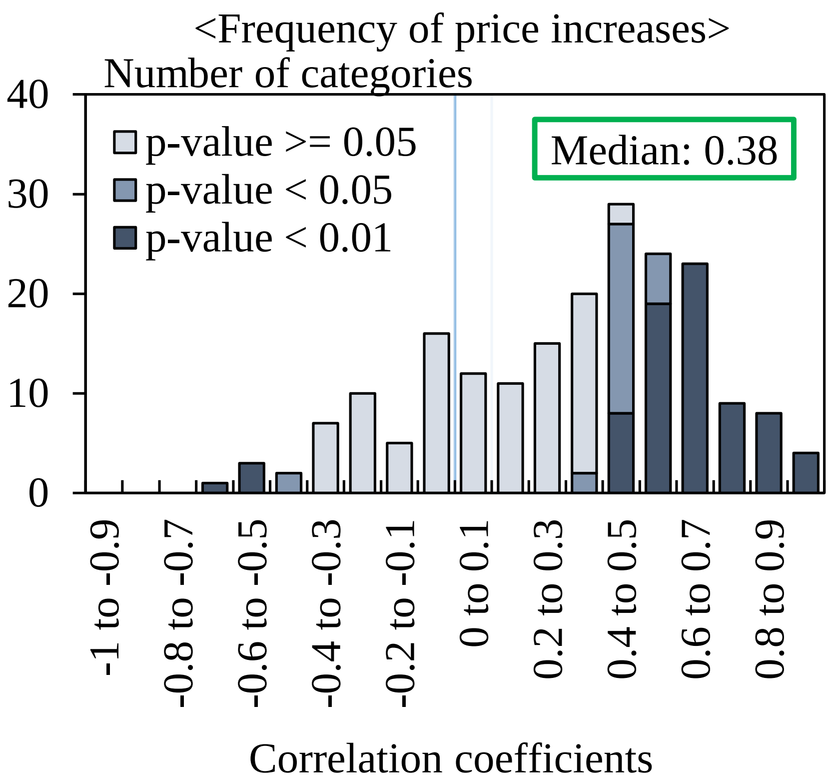
- Seasonal cycles are less stable for size.

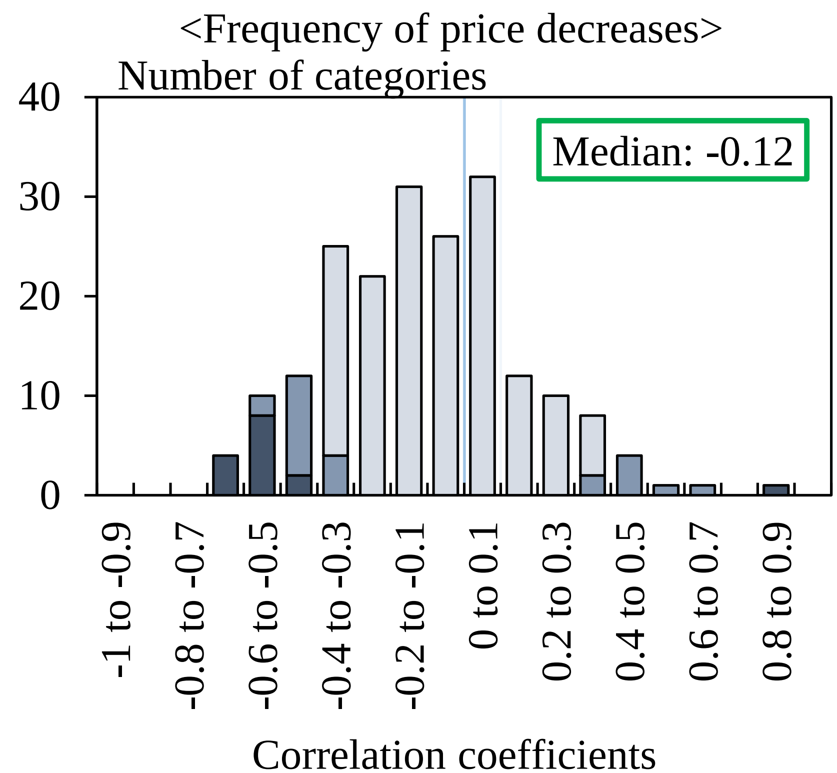


Note: The panels plot the median of the average seasonal component of size of price changes across all categories. The shaded area and dotted line indicate the 25th and 75th percentile bands.

Fact 4: Time Series Properties

- Greater (Smaller) seasonal variations when annual inflation rate is high for upward (downward) frequency.

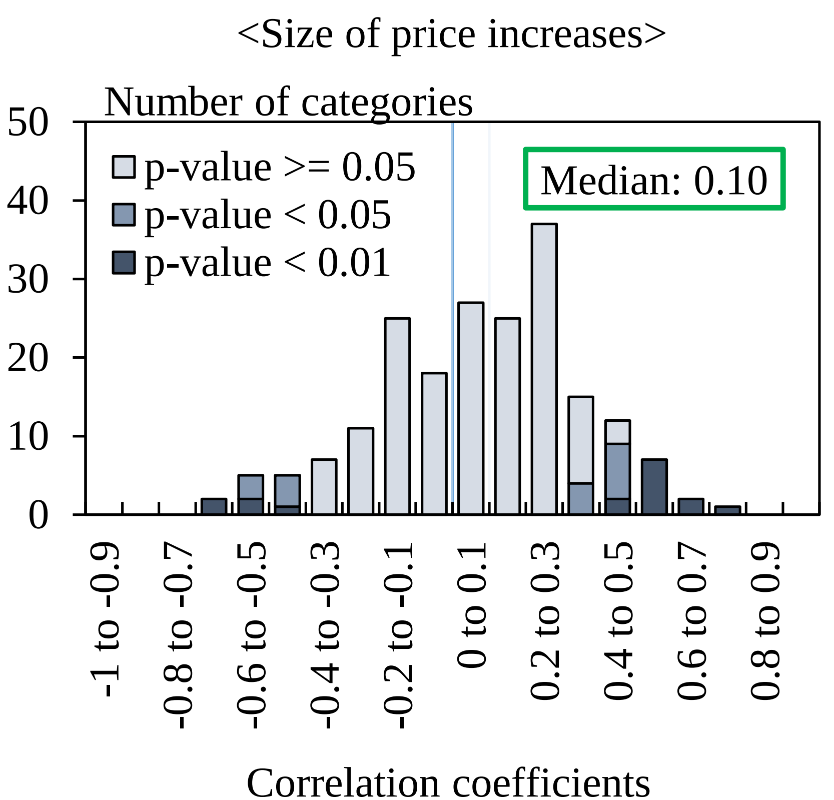


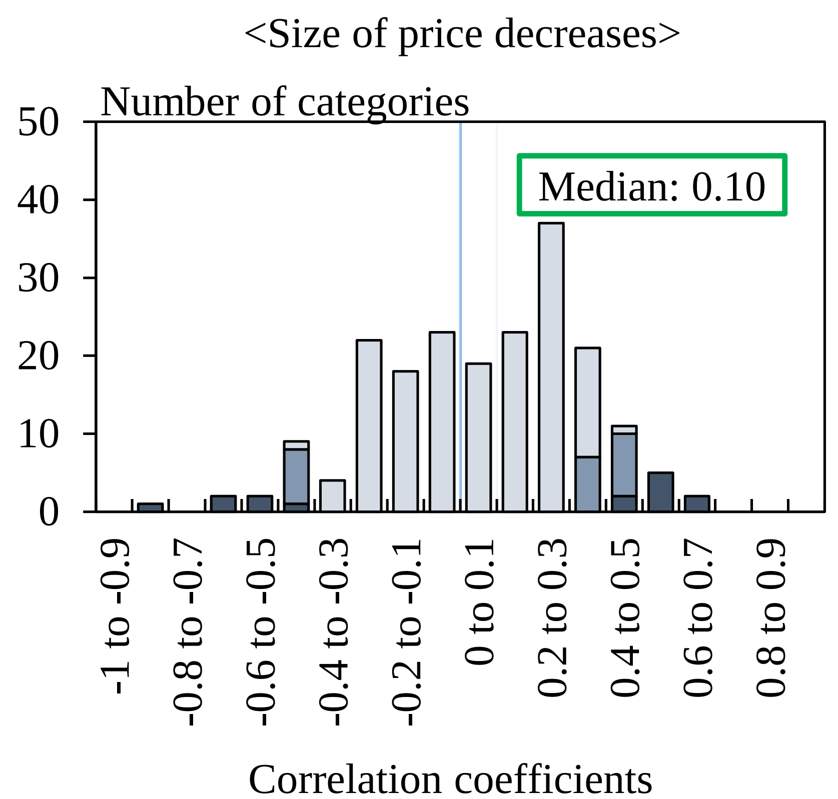


Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the frequency of price changes.

Fact 4: Time Series Properties

- Seasonal variations are not related to annual inflation rate.





Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the size of price changes.

4. State-Dependent Model with Seasonal Cycles of Menu Costs

Model: Direction

- What are behind the seasonal cycles of price changes?

- Flexibility of wages (Olivei and Tenreyro (2007)), or time-dependency (Nakamura and Steinsson (2008))?

- Simulation analysis, using an extended version of the state-dependent pricing model of Nakamura and Steinsson (2008), to see what features are needed to replicate the four observations.

Model: Setting

- Firm z's Profits:

Firms' cost depends on wage + firm specific productivity

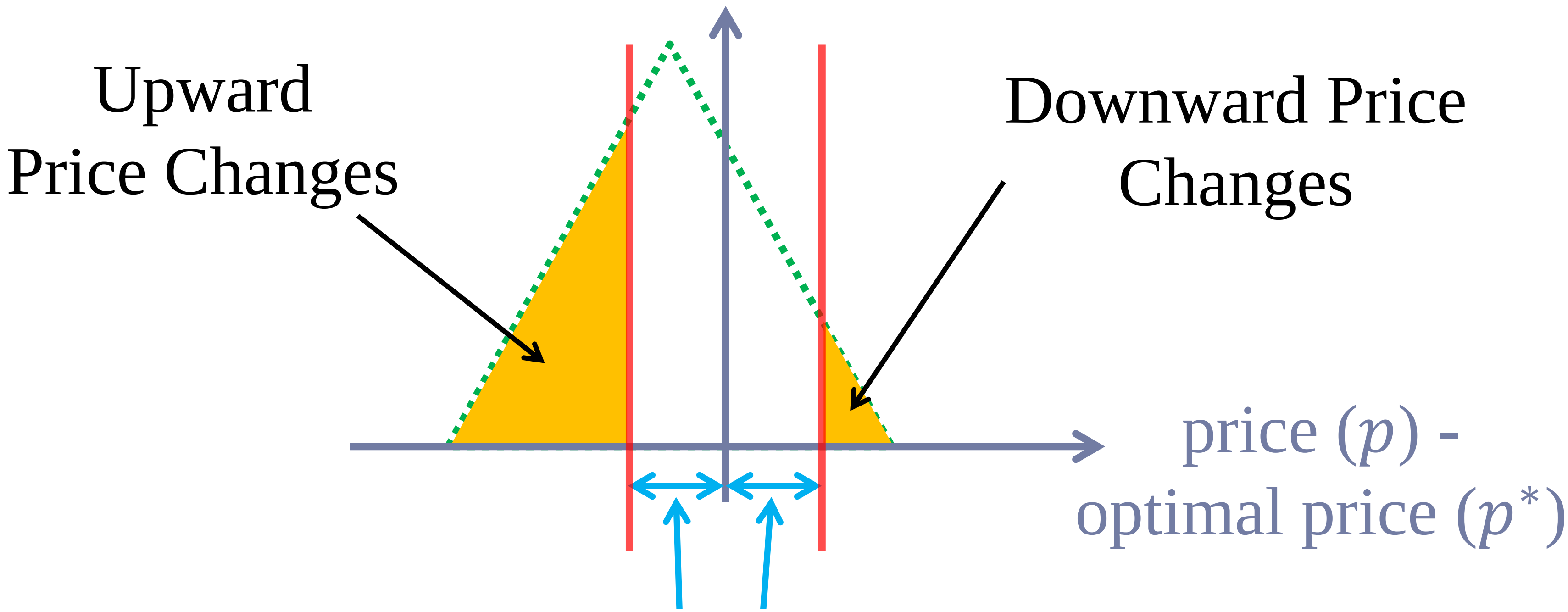
$$\Pi_t(z) = C\left(\frac{p_t(z)}{P_t}\right)^{-\theta}\left(\frac{p_t(z)}{P_t} - \frac{\omega_{m(t)}}{A_t(z)}\right)$$

$$-\omega_{m(t)}K_{m(t)}1\big(p_t(z) \neq p_{t-1}(z)\big).$$

Firms need to pay menu costs when changing the price

Model: Distribution of Price Gap (= p – p*)

- Price changes occur when |p – p*| is sufficiently larger than menu costs.

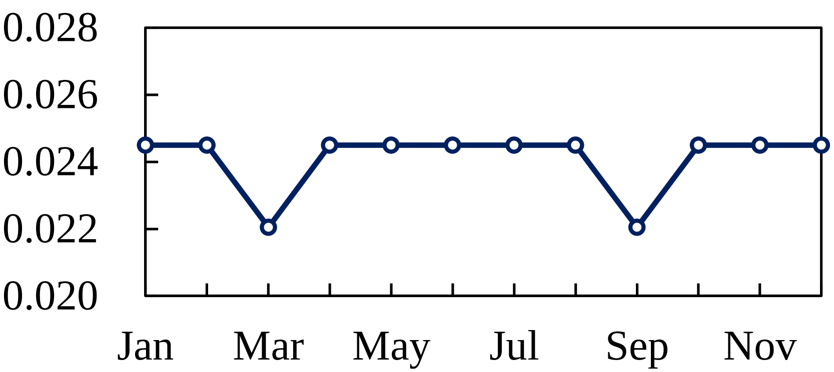


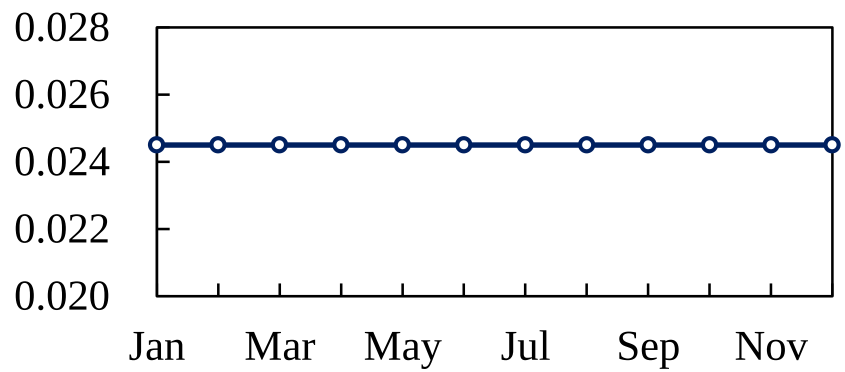
Firms do not change the price *as* $|p - p^*|$ is small relative to menu cost (K)

Model: Parameterization

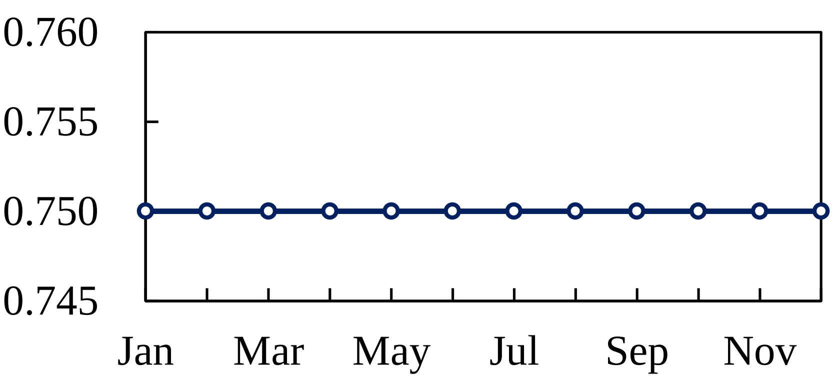
model K: Changes in K | model ω : Change in ω

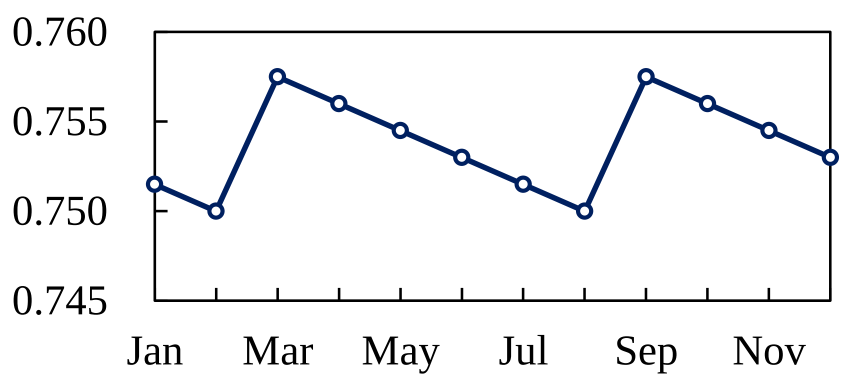
- Time path of the menu cost





- Time path of the real wage



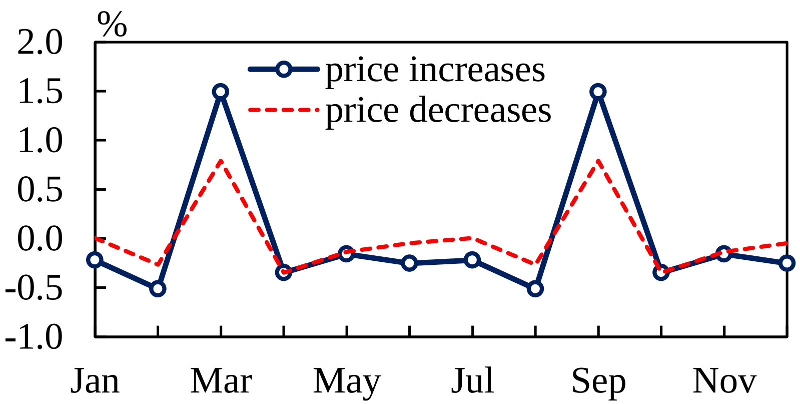


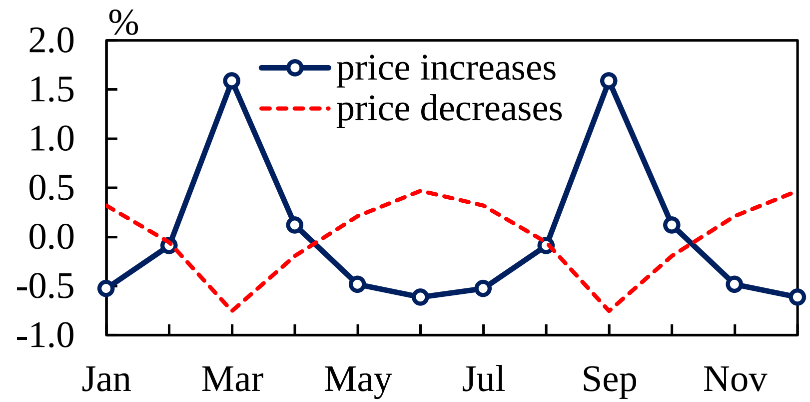
Model: Fact 1 and 2

model K: Changes in K

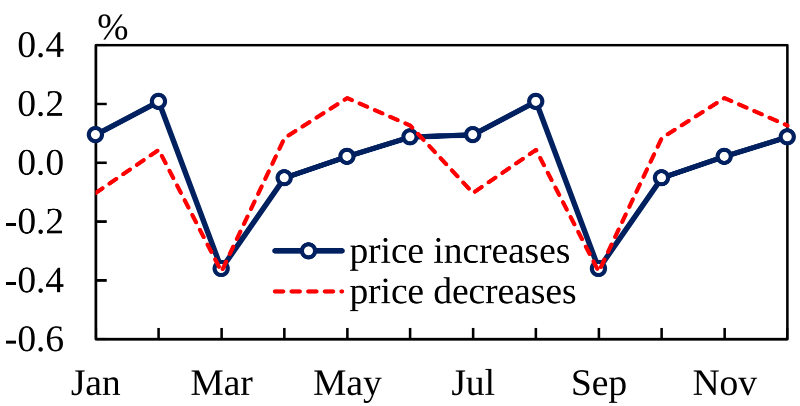
model ω : Change in ω

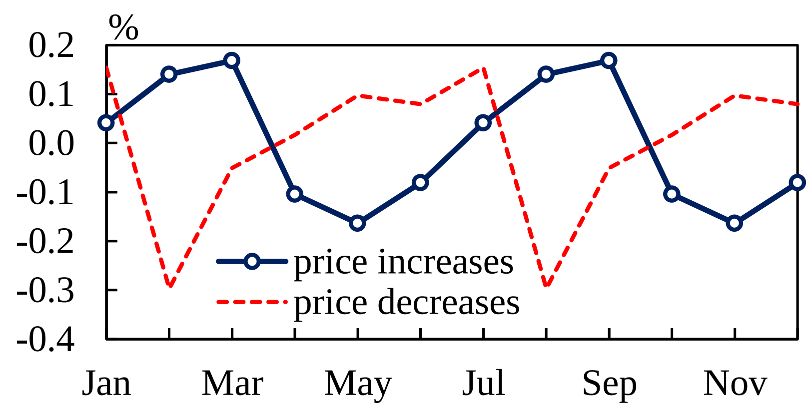
- Frequency





- Size

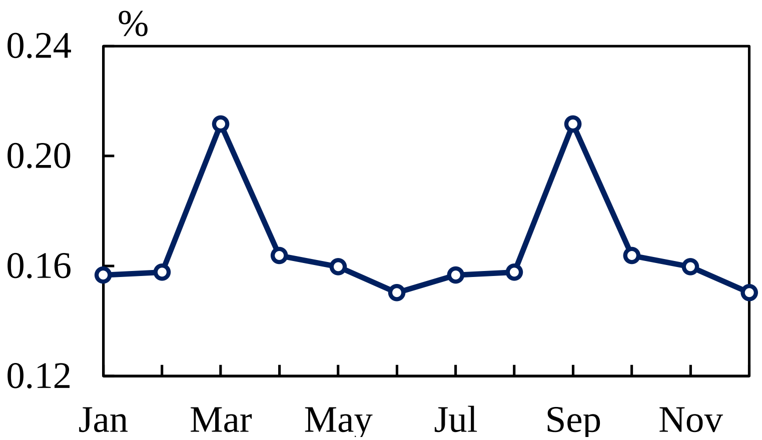


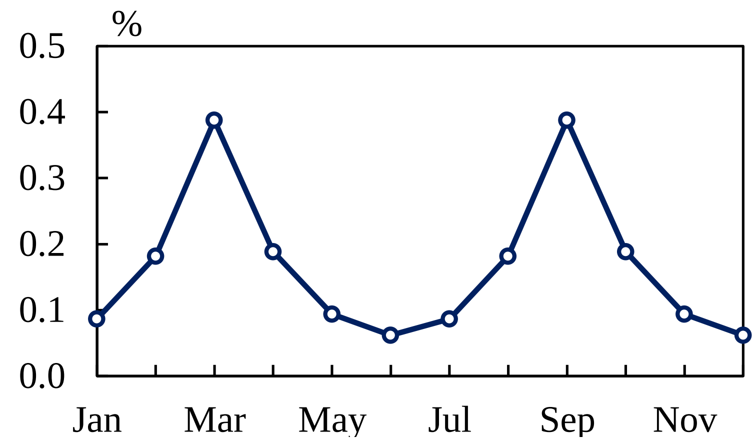


Model: Fact 3

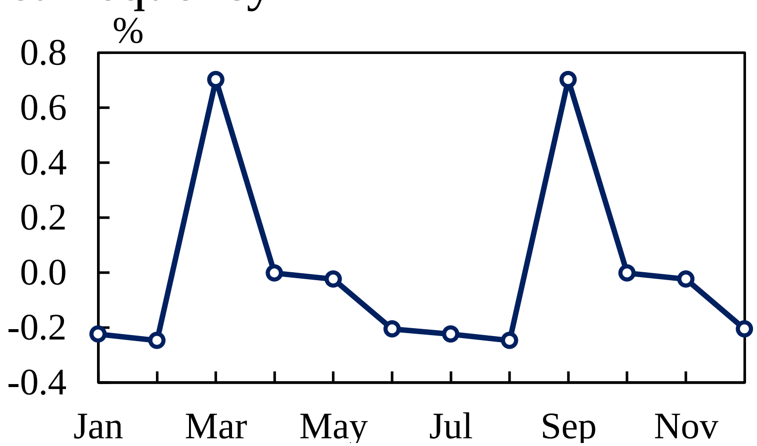
model K: Changes in K | model ω : Change in ω

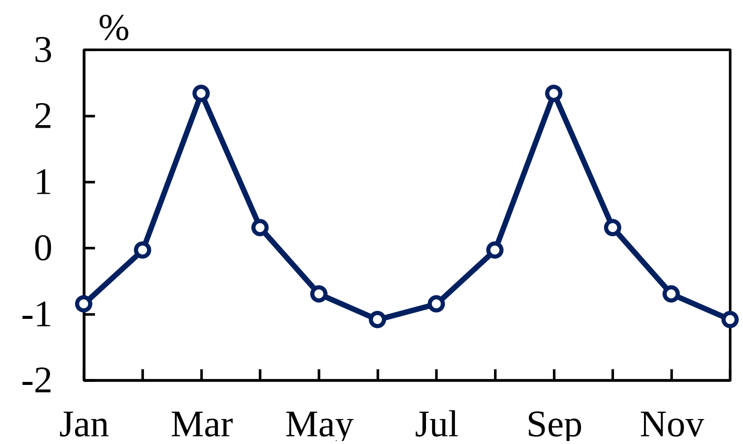
- Inflation



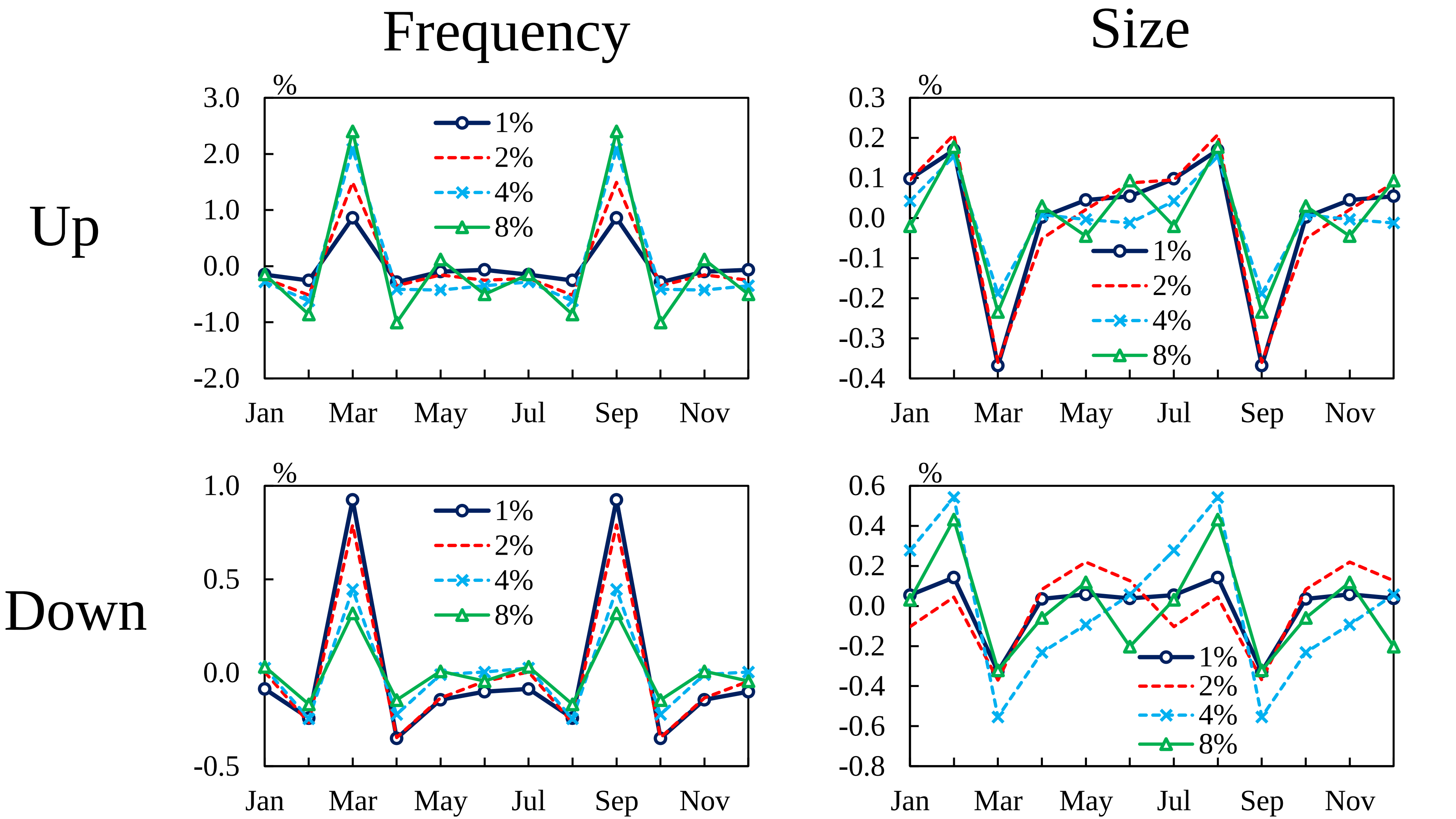


- Net frequency





Model: Fact 4 (model K with various inflation rates)



Note: Each panel indicates the seasonality in the frequency and size of price changes in model K for different annual inflation rates.

Model: Discussion

- Qualitatively, model K is consistent with the data, while model ω fails to replicate Fact 1 and 2.

		Data	Model K	Model ω
Fact 1	Up + Down Frequency	Positive	Positive	Negative
	Up + Down Size	(Weakly) Positive	Positive	Negative
Fact 2	Frequency and Size (Up)	(Weakly) Negative	Negative	Positive
	Frequency and Size (Down)	(Weakly) Negative	Negative	Positive

5. Discussion and Conclusion

Discussion : What are seasonal cycles of menu costs?

- Why do they change?

-- Costs of communication and negotiation? Zbaracki et al. (2004) document managerial costs (information gathering, decision-making, communication) + customer costs (communication strategy, negotiation) >> physical menu cost.

- Why are they synchronized?

-- Coordination may play an important role. Blinder (1991) "firms might like to raise or lower prices, but hesitate to do so unless and until other firms move first. Once other firms move, they follow quickly."

- Implicit coordination among firms in March and September, so that non-physical menu cost declines in these months?

Discussion : Implications of changes in menu cost

- Due to seasonal changes in menu costs, transmission of shocks to the economy and price dynamics may differ depending on in which month the shocks occur, as discussed in Olivei and Tenreyro (2010).

- Low-frequency price dynamics such as annual inflation rate, are related to seasonal dynamics, similar to the findings by Cecchetti and Kashyap (1996) and Matas-Mir and Osborn (2004) for quantities, which may make real-time analysis more difficult.

Conclusion

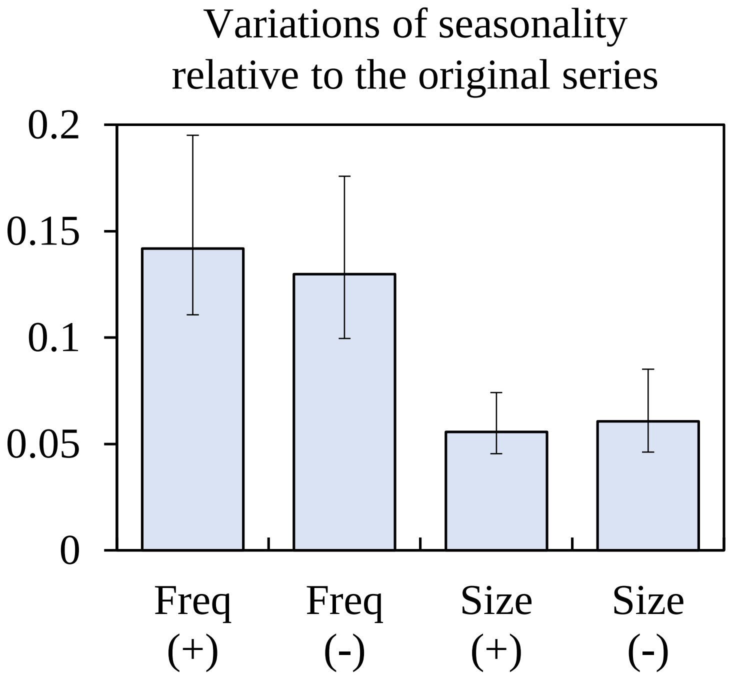
- We study seasonal cycles of prices in Japan, using the scanner data from 1990 to 2021.
- Seasonal cycles for frequency are
  (i) high in March and September.
  (ii) negatively correlated with size.
  (iii) roughly tracks seasonal cycles of inflation rate.
  (iv) responsive to changes in category-level inflation rate.
- Our observations suggest that there are seasonal cycles in menu costs that synchronize across categories and are stable over time, which in turn give a potentially novel insight on price dynamics.

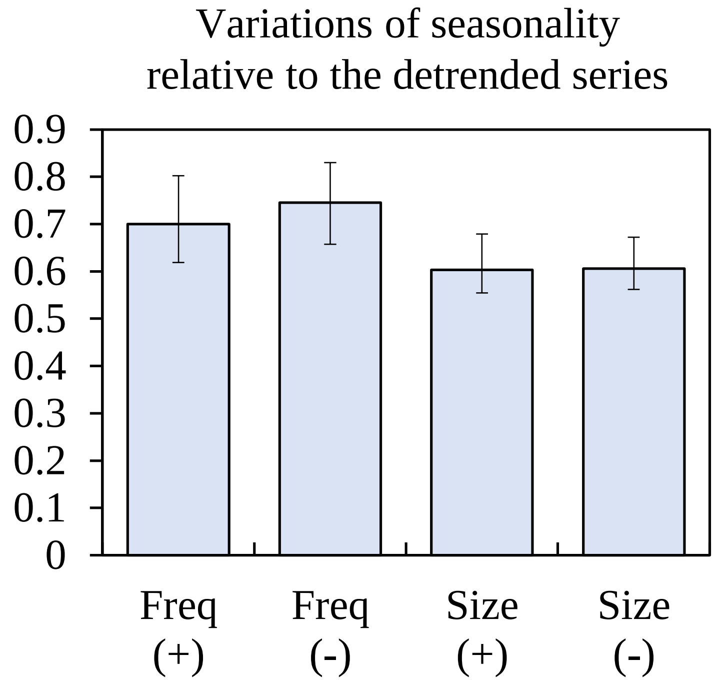
Thank you!

Appendix

Data and Methodology: Seasonal Cycles

- Seasonal cycles constitute an important portion of variations in particular for frequency.

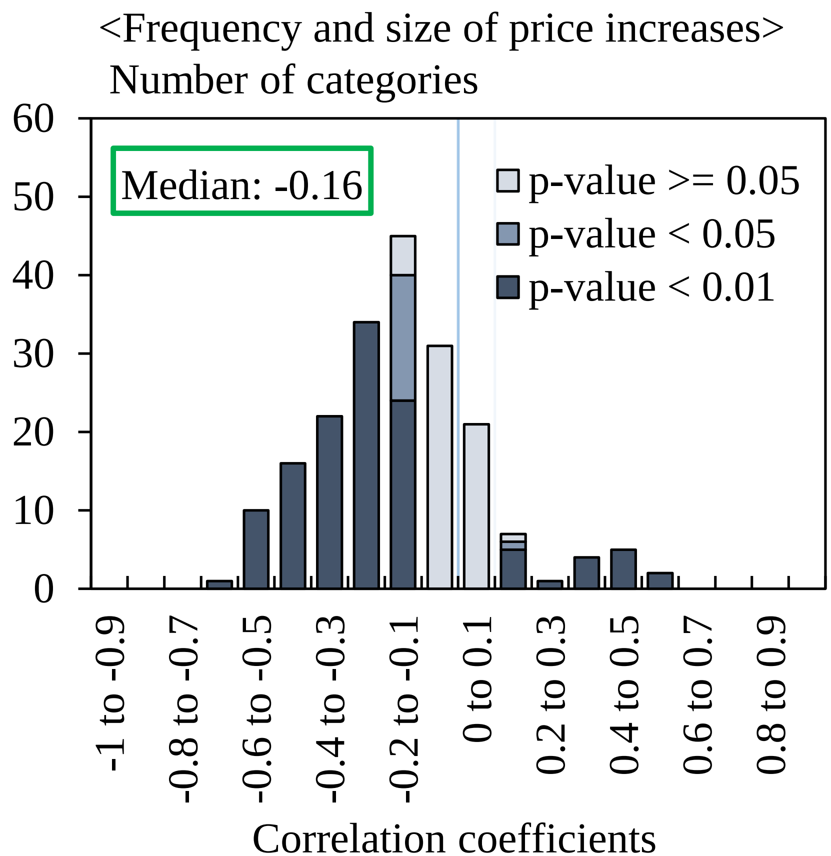


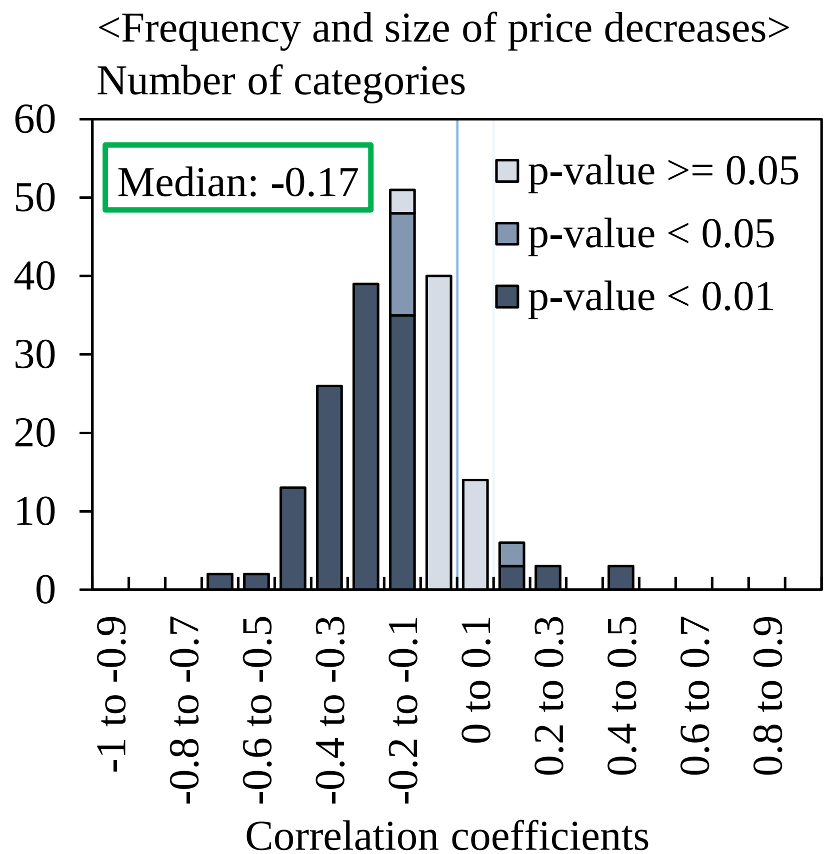


Note: Both panels show the across-category distribution of the standard deviation of the seasonal component relative to the average of the original series and to the standard deviation of the detrended series, respectively.
All panels show the median of all categories and the error bands indicate 25th and 75th percentiles.

Fact 2 : Size (Alternative Method)

- Correlation between frequency and size.



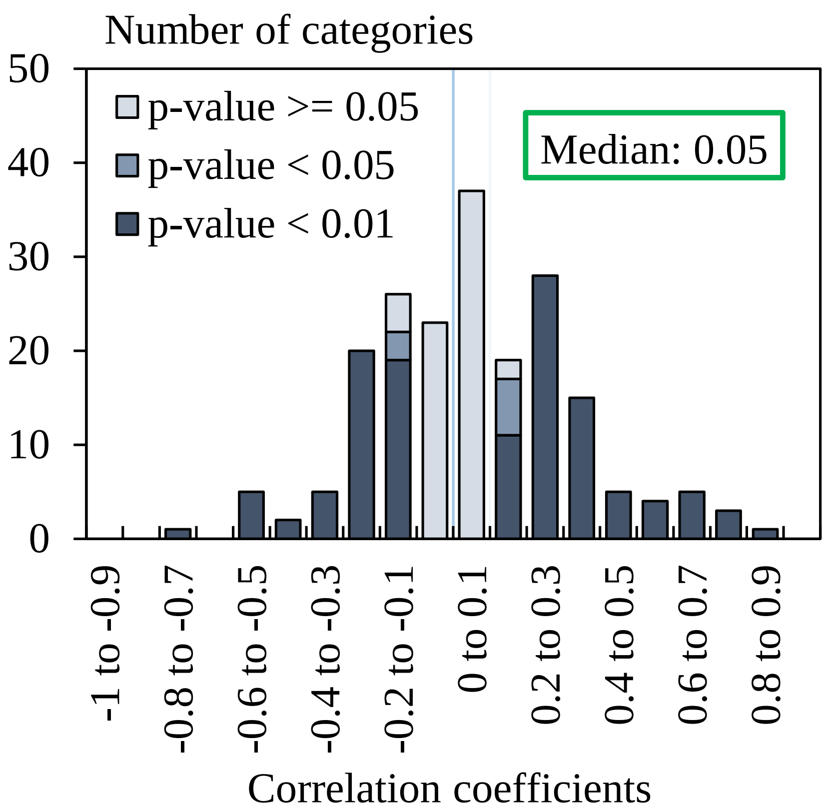


Note: The panels show histograms of the correlation between the seasonal components of frequency of price increases (decreases) and size of price increases (decreases) within the same category.

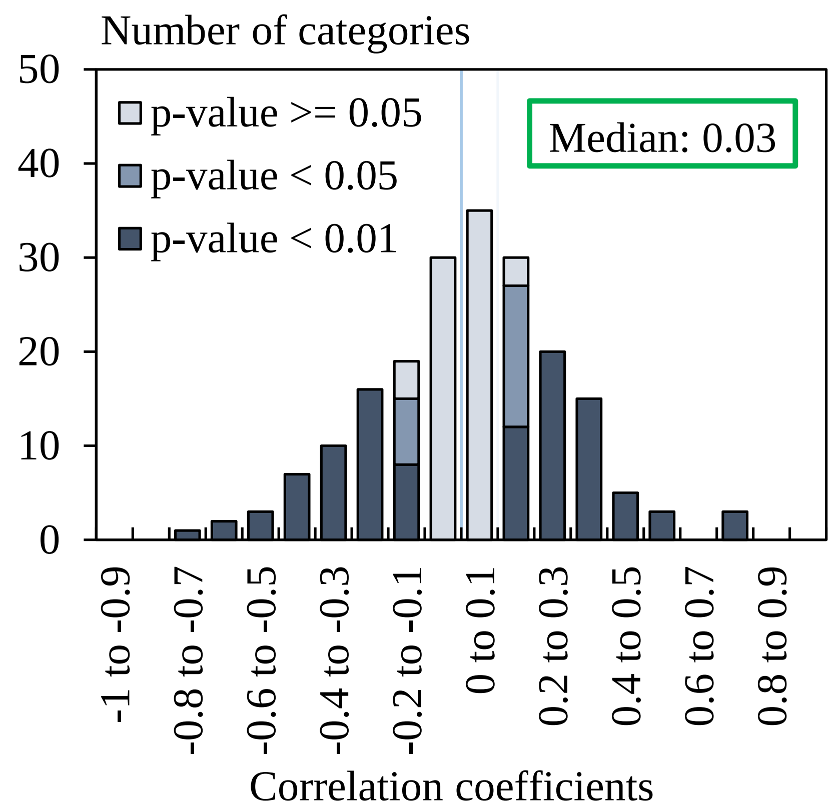
Fact 2 : Size (X12)

- Correlation between frequency and size.

<Frequency and size of price increases>



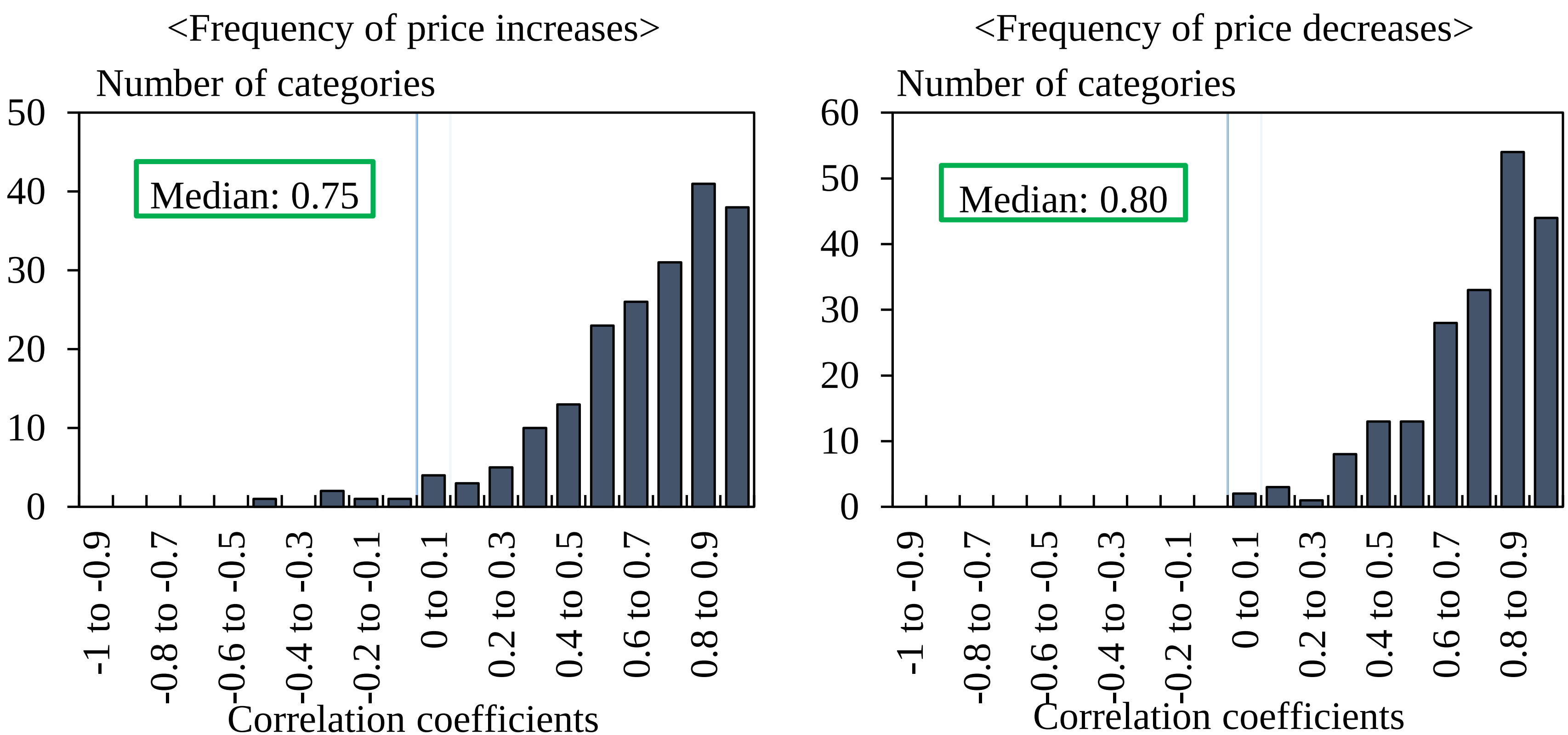
<Frequency and size of price decreases>



Note: The panels show histograms of the correlation between the seasonal components of frequency of price increases (decreases) and size of price increases (decreases) within the same category.

Fact 4 : Time Series Property

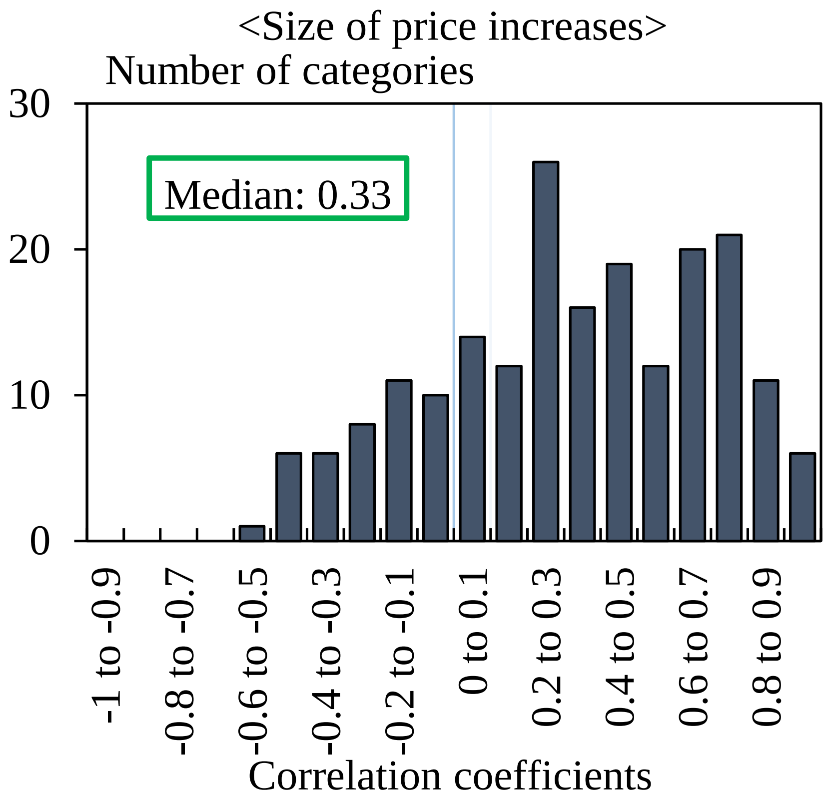
- Correlation between the first and second half of each series is positive.

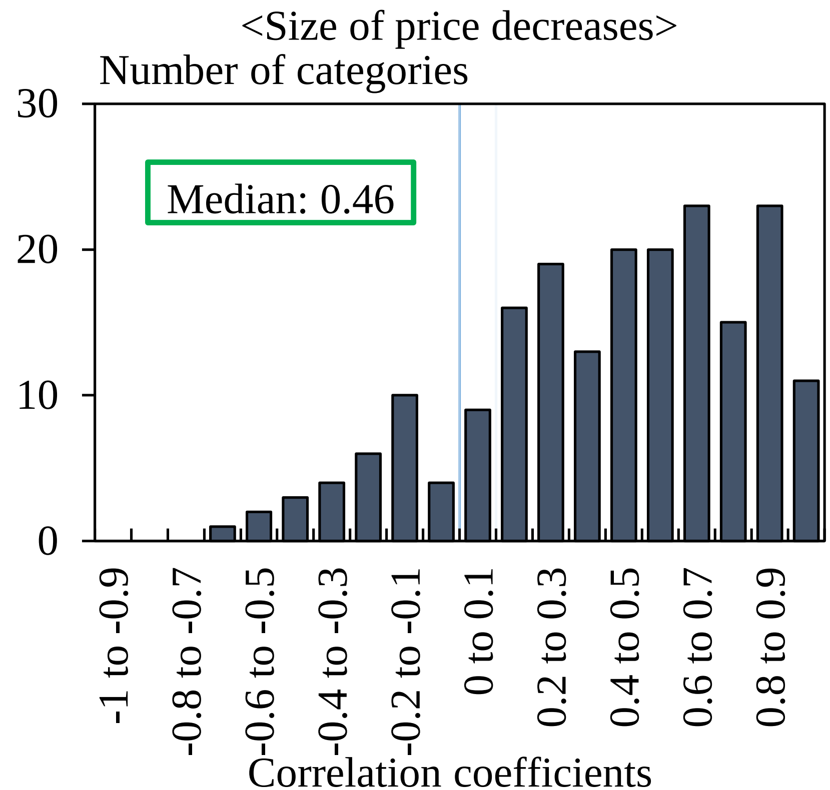


Note: These panels show histograms of 199 categories for the correlation of the average seasonal component between the early and latter half of the sample for each series.

Fact 4 : Time Series Property

- Correlation between the first and second half of each series is positive but smaller.



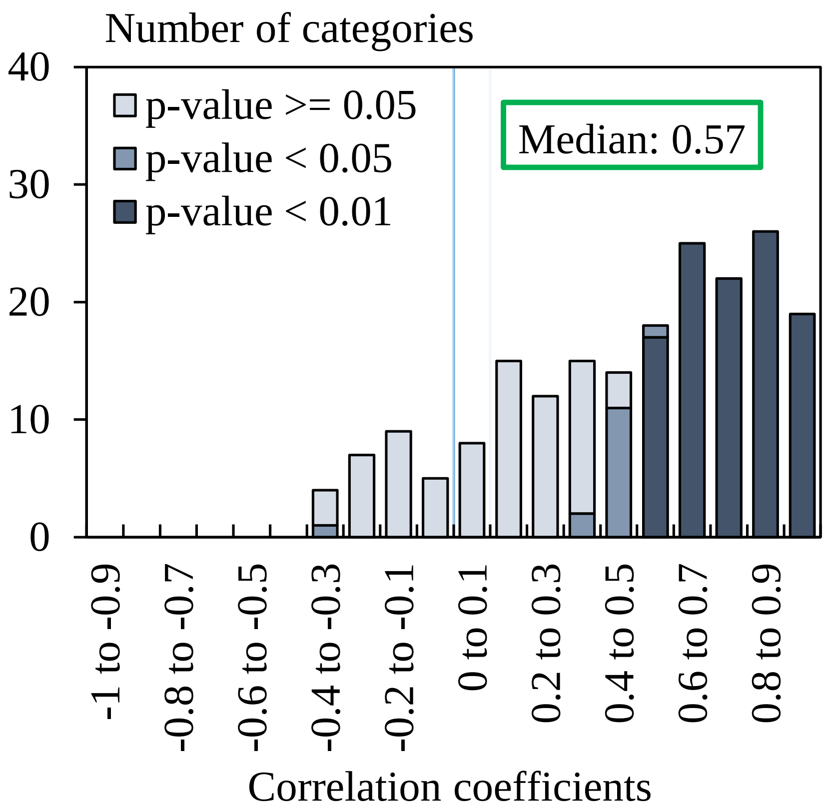


Note: These panels show histograms of 199 categories for the correlation of the average seasonal component between the early and latter half of the sample for each series.

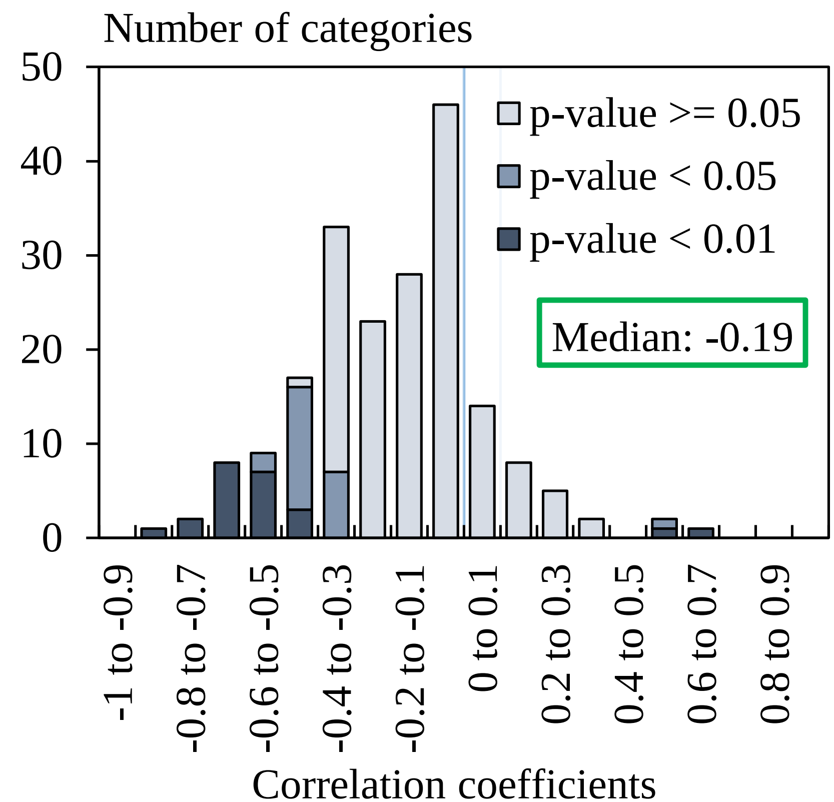
Fact 4 : Time Series Properties (Alternative Method)

- Correlation between frequency and annual inflation.

<Frequency of price increases>



<Frequency of price decreases>

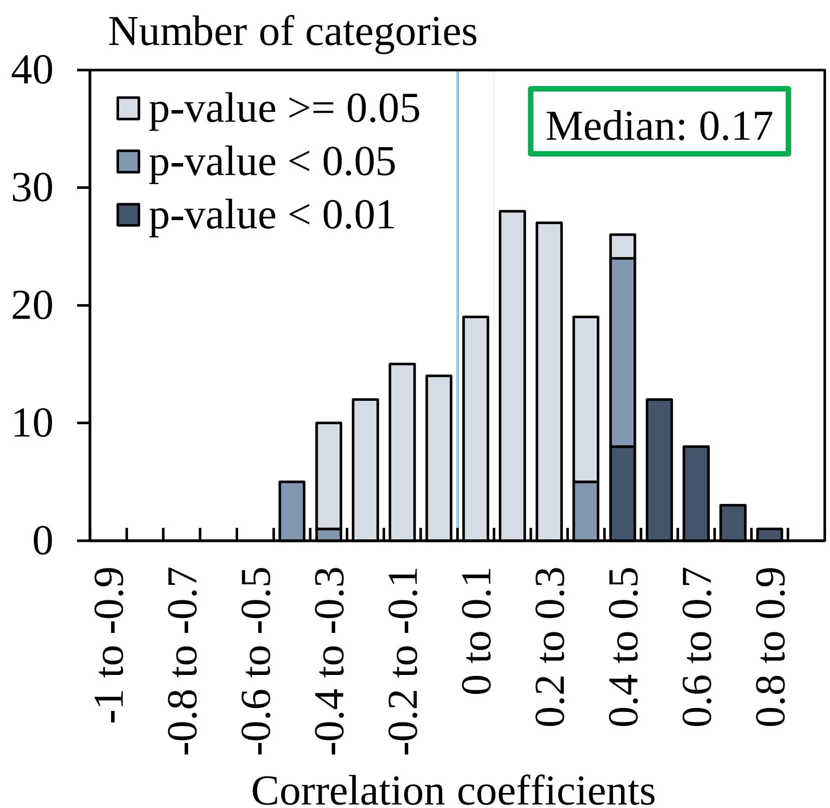


Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the frequency of price changes.

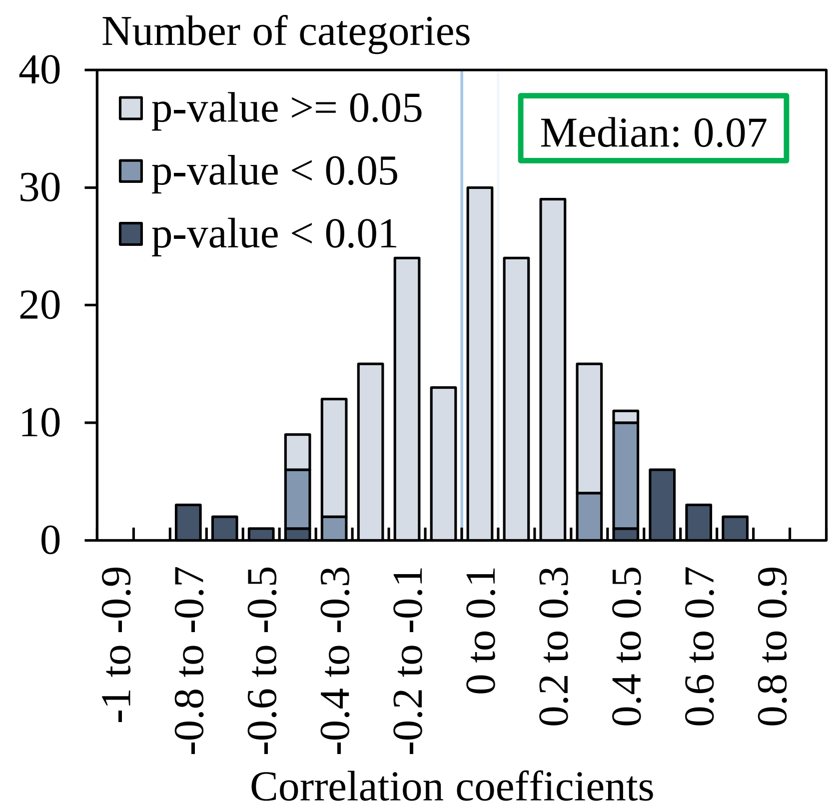
Fact 4 : Time Series Properties (Alternative Method)

- Correlation between size and annual inflation.

<Size of price increases>



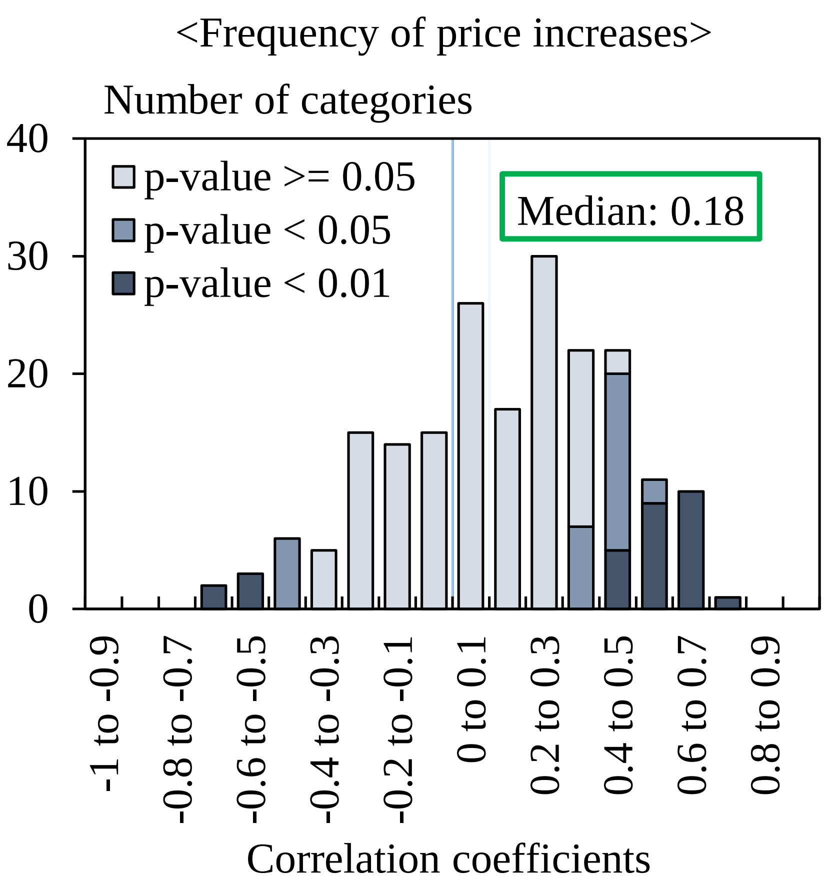
<Size of price decreases>

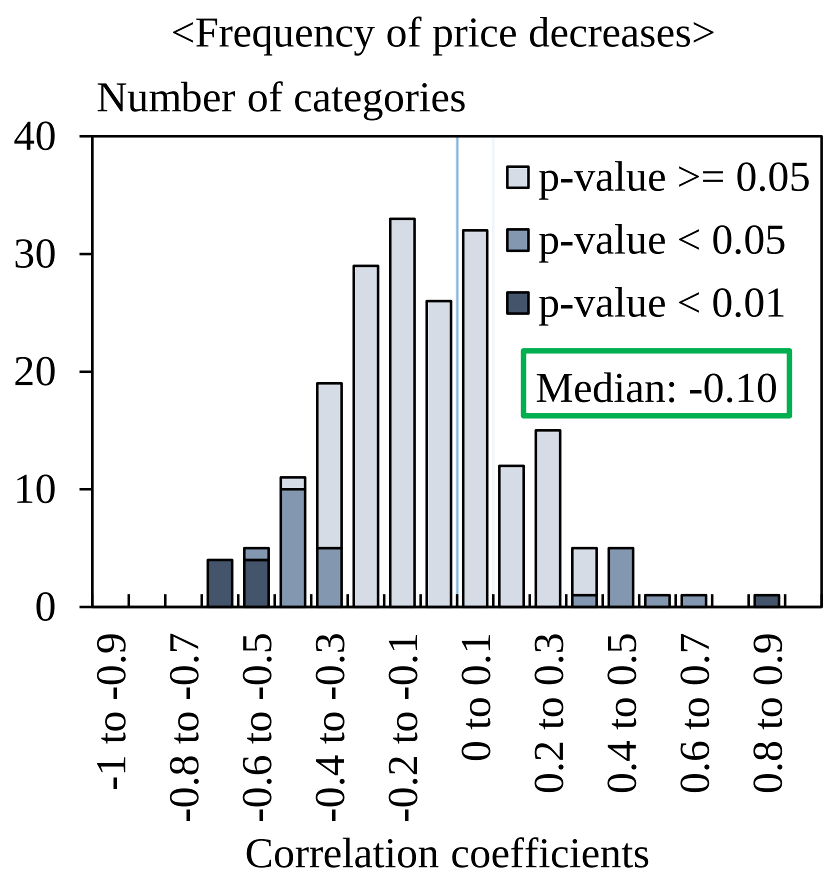


Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the size of price changes.

Fact 4 : Time Series Properties (X12)

- Correlation between frequency and annual inflation.



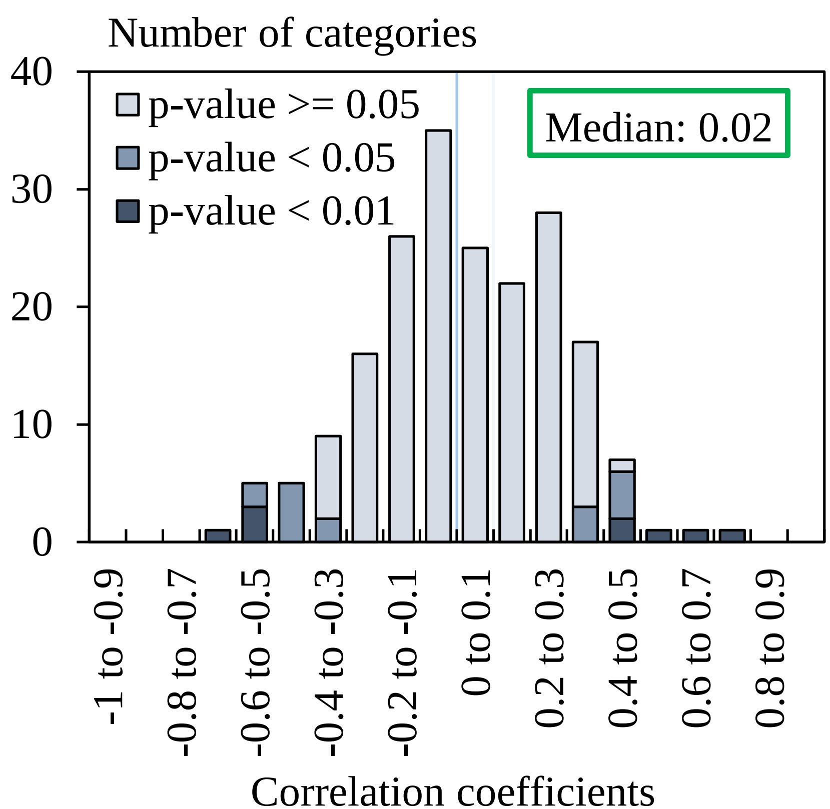


Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the frequency of price changes.

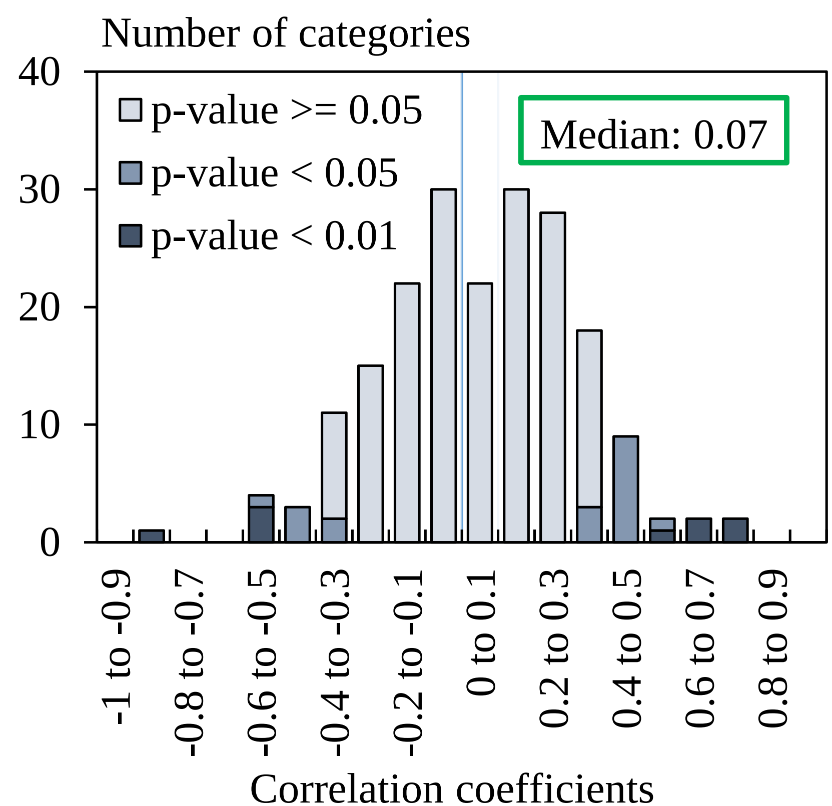
Fact 4 : Time Series Properties (X12)

- Correlation between size and annual inflation.

<Size of price increases>



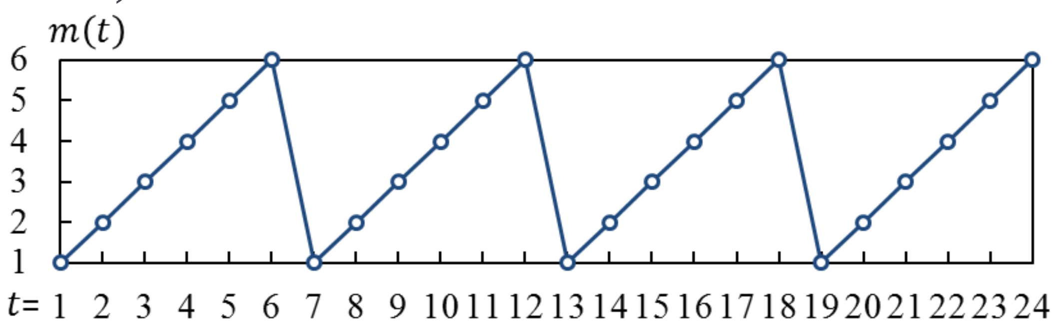
<Size of price decreases>



Note: The panels show histograms of the correlations between the annual POS inflation rate and the standard deviation of the seasonal components for the size of price changes.

Model: Setting

- Partial equilibrium menu cost model
  - ✓ Based on Nakamura and Steinsson (2008)
  - ✓ Idiosyncratic productivity shocks makes price increases and decreases coexist.
  - ✓ For simplicity, calculate only steady without aggregate shocks.
- Seasonality with 6-month cycle in the deep parameters
  - ✓ Seasonality in a deep parameter a : $a_{m(t)}$, where $m(t)$ represents the season (month) of time t.



  - ✓ While total inflation rate over a cycle is exogenously set, monthly inflation rates are endogenously determined by seasonal parameters.

Model: Setting

- Model outline
  - Production function for firm z with idiosyncratic productivity:

$$y_t(z) = A_t(z)L_t(z)$$

$$\log\big(A_t(z)\big) = \rho\log\big(A_{t-1}(z)\big) + \varepsilon_t(z), \qquad \varepsilon_t(z) \sim N(0, \sigma_\varepsilon^2)$$

  - Demand for the product of firm z:

$$c_t(z) = C_{m(t)}\left(\frac{p_t(z)}{P_t}\right)^{-\theta}$$

  - Real marginal cost:

$$\frac{W_t}{P_t} = \xi_{m(t)}\omega_{m(t)}$$

  - Real menu cost:

$$\omega_{m(t)}K_{m(t)}$$

Model: FOC and Solution Algorithm

- Optimization problem for firm z

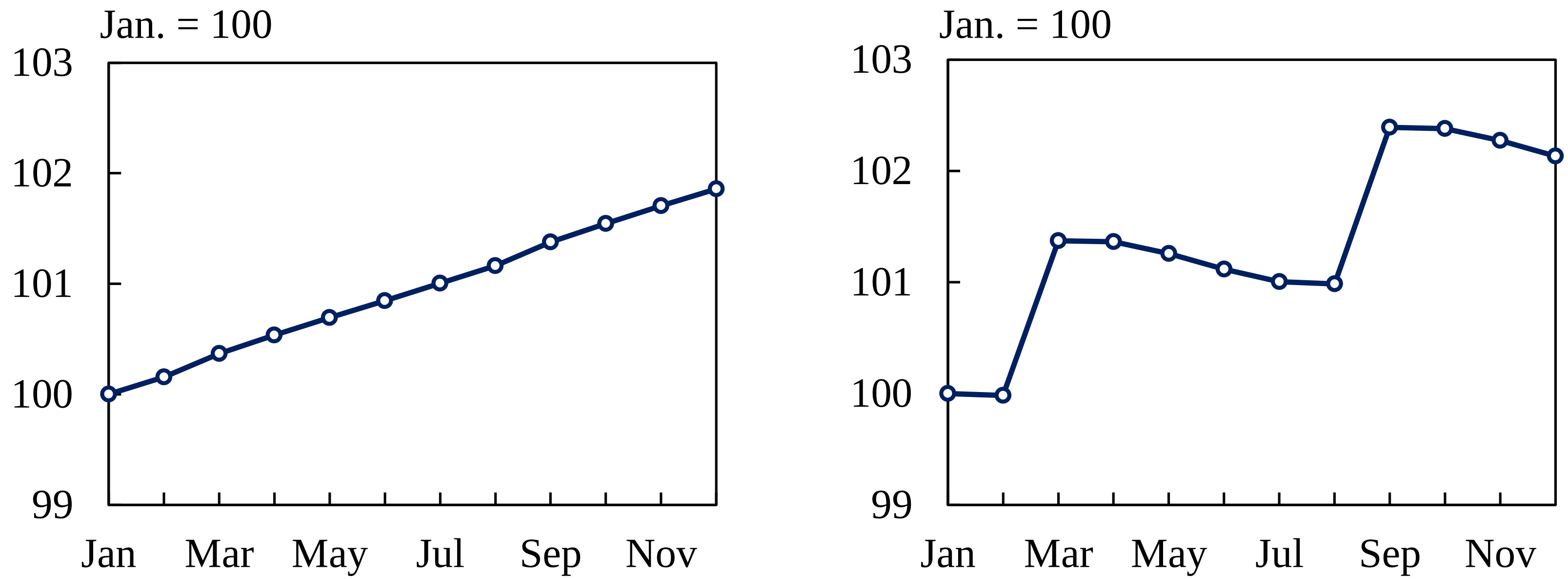
$$V_{m(t)}\left(\frac{p_{t-1}(z)}{P_t}, A_t(z)\right)$$
$$= \max_{p_t(z)} \left[\begin{array}{r} C_{m(t)}\left(\frac{p_t(z)}{P_t}\right)^{-\theta}\left(\frac{p_t(z)}{P_t} - \frac{\xi_{m(t)}\omega_{m(t)}}{A_t(z)}\right) - \omega_{m(t)}K_{m(t)}\mathbf{1}\big(p_t(z) \neq p_{t-1}(z)\big) \\ + \beta \mathrm{E}_t V_{m(t+1)}\left(\frac{p_t(z)}{P_{t+1}}, A_{t+1}(z)\right) \end{array} \right]$$

- Solution algorithm: iterate 1 to 3 until convergence
  1. Based on a guess of inflation rate for each month, for each state of firms (relative price of last month and productivity), calculate a policy function (relative price of current month).
  2. Calculate the steady-state density implied by the policy function.
  3. Calculate monthly inflation rates implied by the policy function and steady-state density.

Model: Parameterization

- Nominal wage dynamics:

model K: Changes in K model ω : Change in ω



Notes: Each panel indicates the nominal wages implied by the real wage and monthly inflation rate in each model. The level of the nominal wage is normalized such that the value of January equals to 100.

Model: Other Parameters

- Almost the same as Nakamura and Steinsson (2008)

	Parameters	Value
β	Subjective discount factor (monthly)	$0.96^{1/12}$
θ	Demand elasticity	4
C	Demand	1
ρ	Stickiness of idiosyncratic shocks	0.66
σ	Size of idiosyncratic shocks	0.0428