The Role of Industrial Composition in Driving the Frequency of Price Change

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The views expressed here are our own and do not represent the views of the Federal Reserve System.

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- **Frequency of price change**: crucial parameter in monetary economics
  - Extent of transmission of nominal shocks to the real economy
  - Key **determinant of the slope** of the Phillips curve

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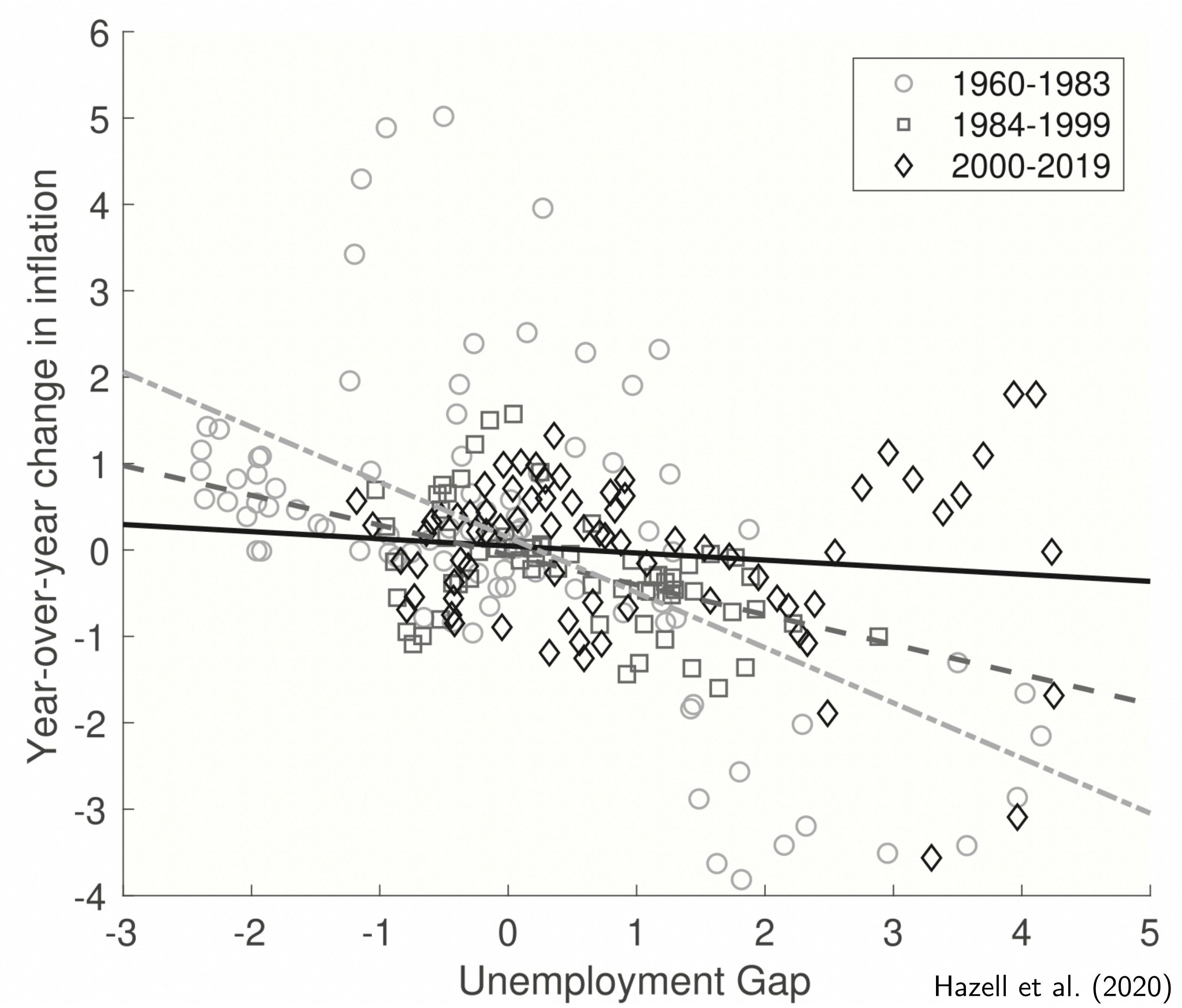

Hazell et al. (2020)

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- One potential reason for the slope decline: fall in the frequency of price change

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- **Long-term decline** in the slope of the Phillips curve in the United States (US)
- One potential reason for the slope decline: fall in the frequency of price change
- Natural candidate to explain the decline: **long-term structural changes**
  - **Changes in industrial composition**

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- Focus: US, 1947–2019
  - Methodology general and more broadly applicable
    - Other countries/time periods/price-change statistics

Related Literature

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Reasons for the decline in the slope of the Phillips curve

Del Negro et al. (2020), Mangiante (2022), Crump et al. (2019), Daly and Hobijn (2014), Moscarini and Postel-Vinay (2018), Daly and Hobijn (2014), Bernanke et al. (2010), Jørgensen and Lansing (2019), Borio and Filardo (2007), Iakova (2007), Rubbo (2020), Mangiante (2022), Kaihatsu, Katagiri, and Shiraki (2022)

This paper: simple explanation for why there has been a long-term decline in the slope from late 1940s–present

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Data

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Own algorithm based on:

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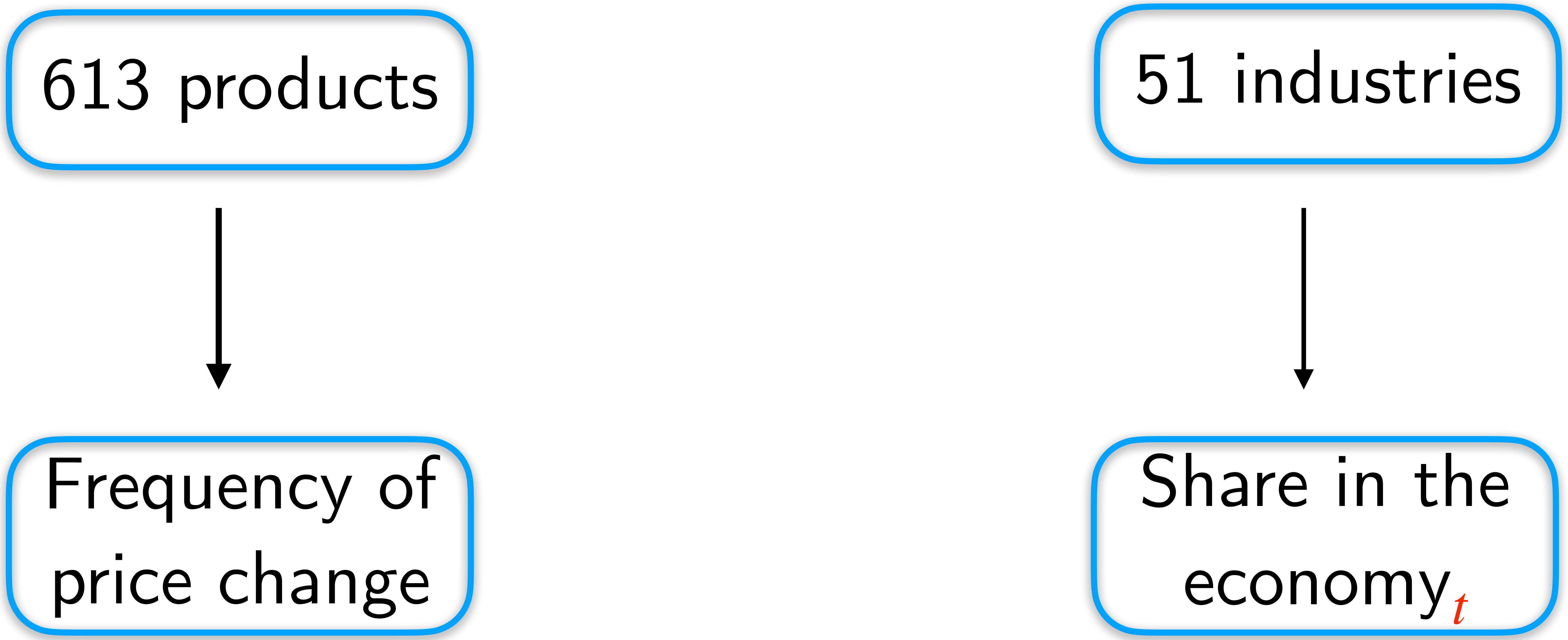

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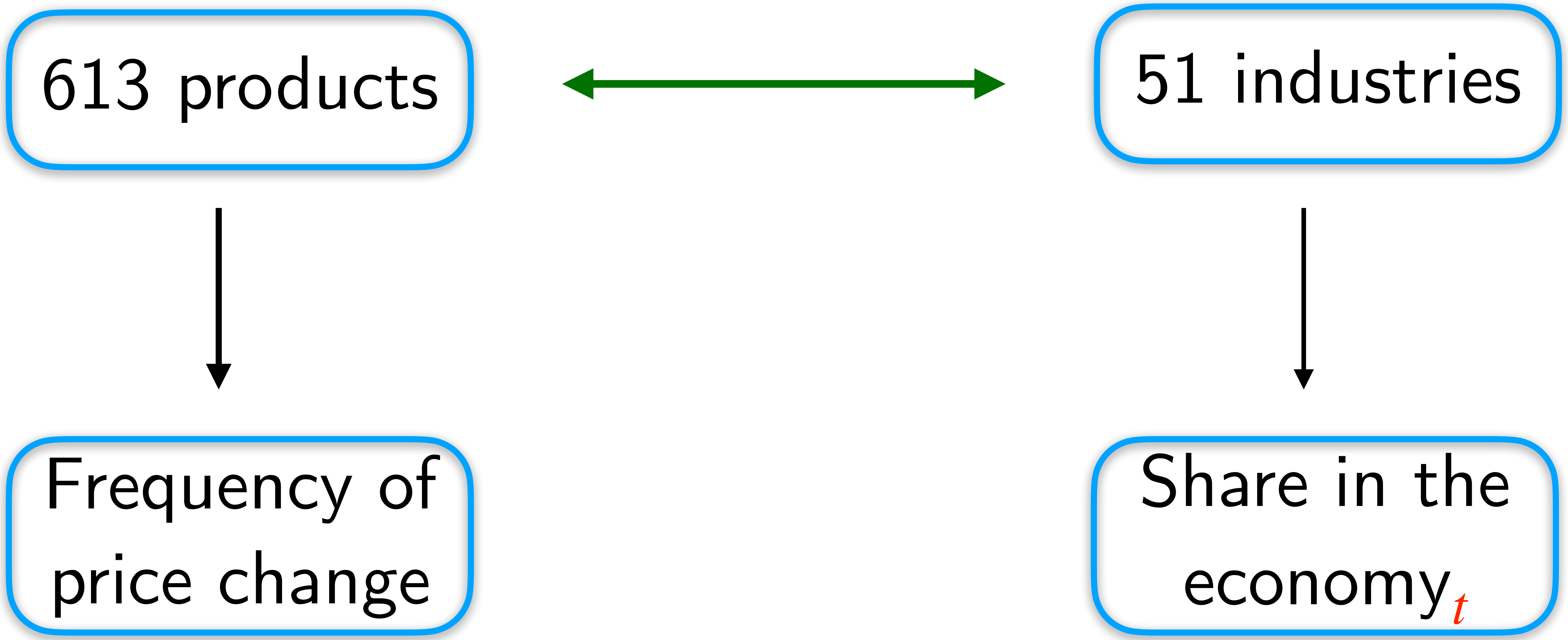

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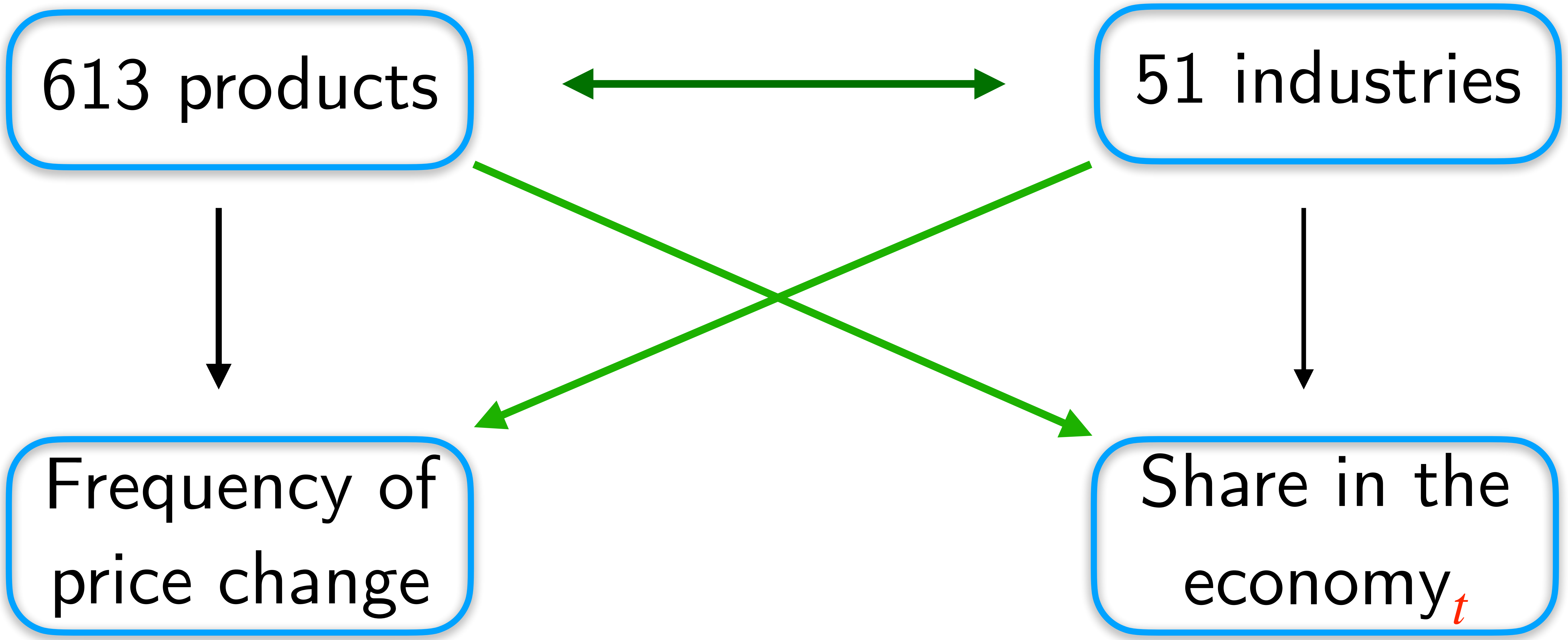

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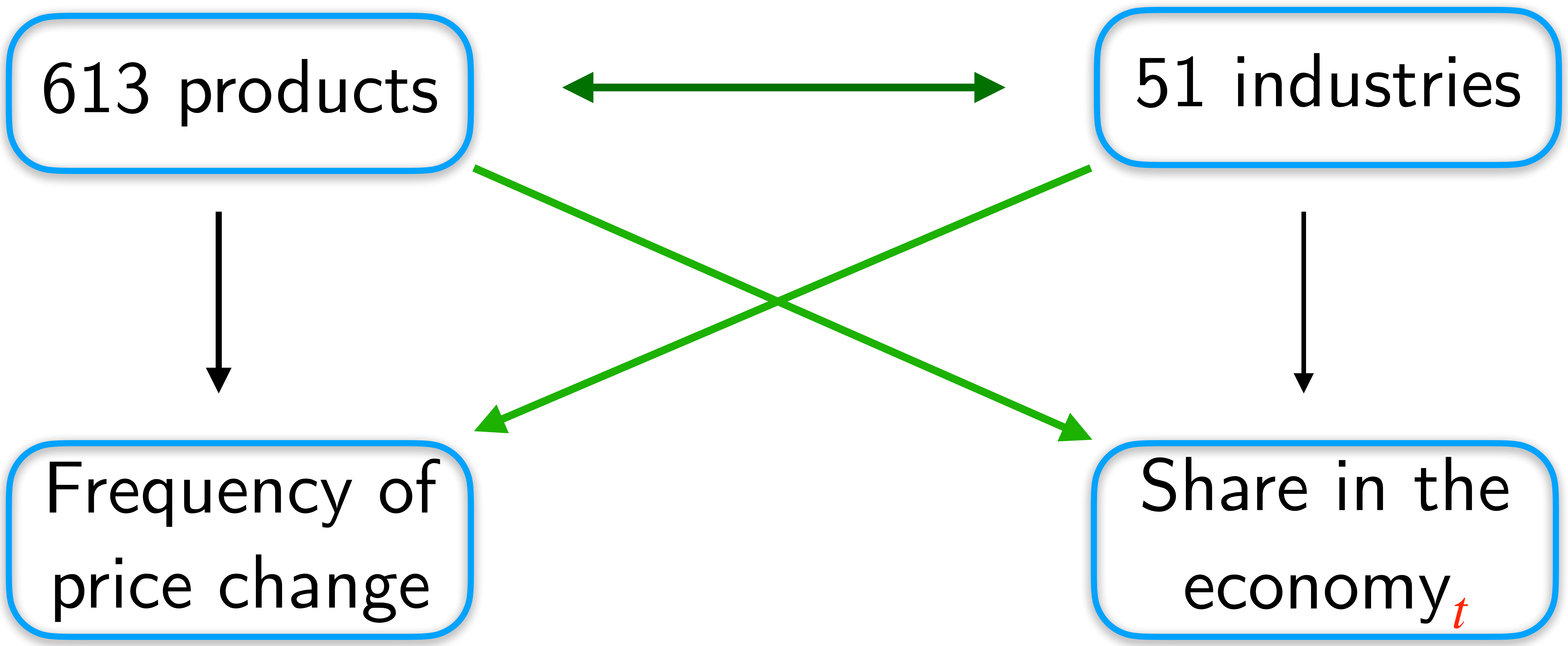

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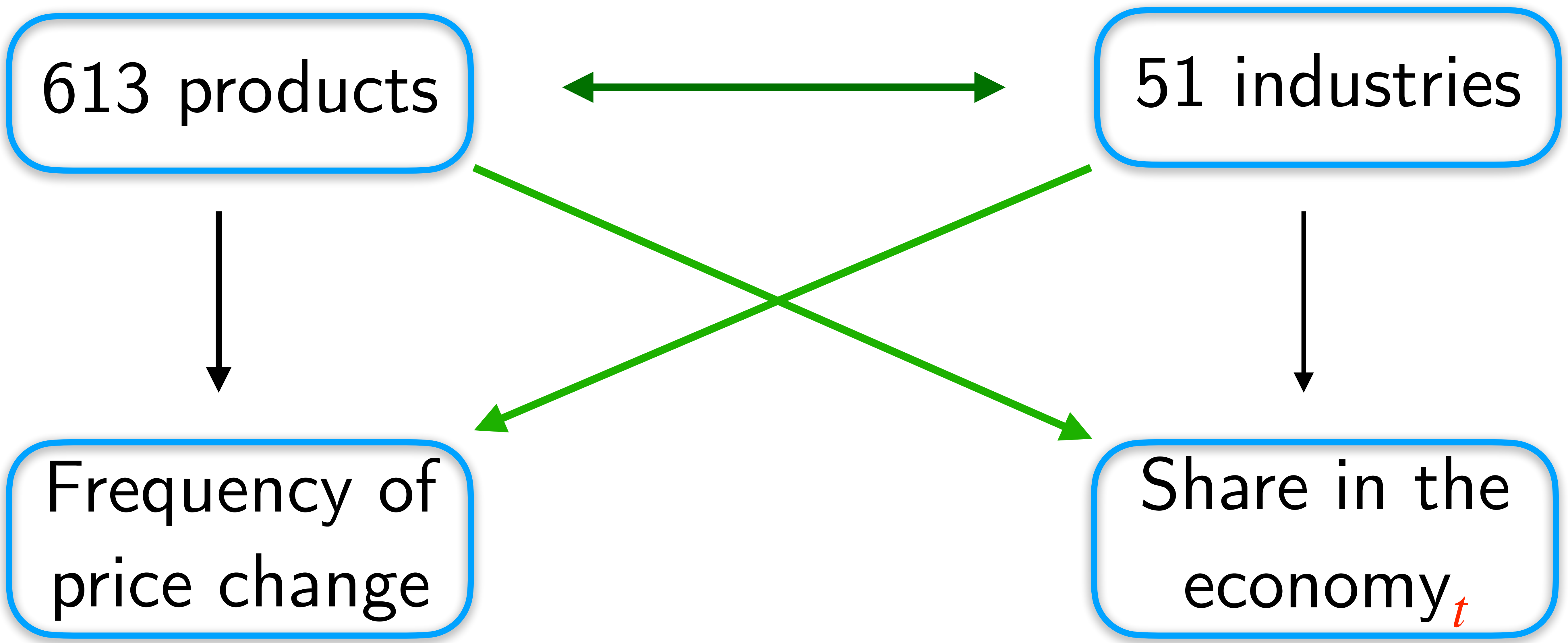

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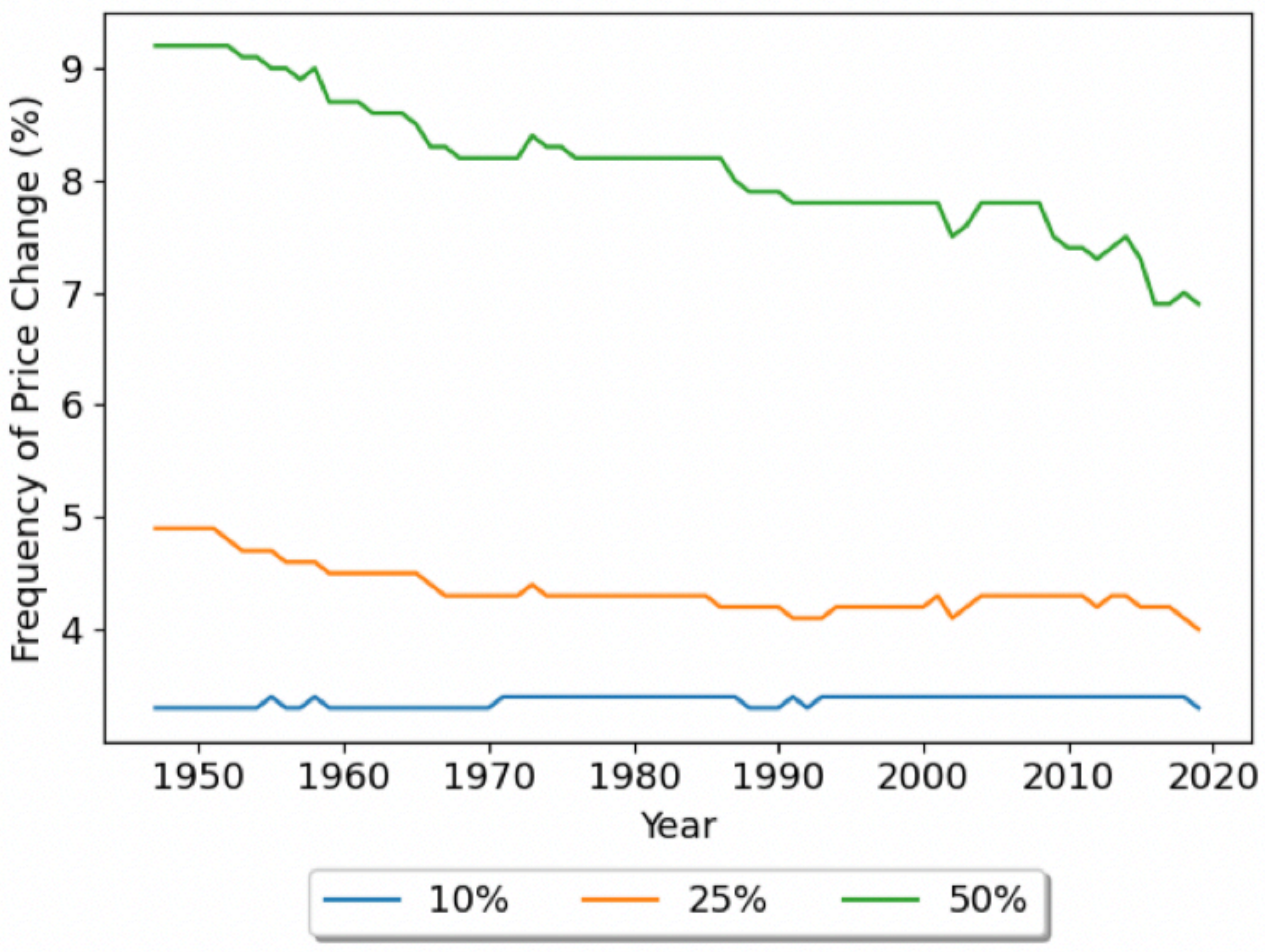
Distribution of any statistic of product$_t$ = F (Statistic of product$_i$, Share of product in economy$_{it}$)

Abs. size Prob. pos.

Result 1

- Changes in industrial composition have led to **large declines across the distribution of the frequency of price change** over the 1947–2019 period



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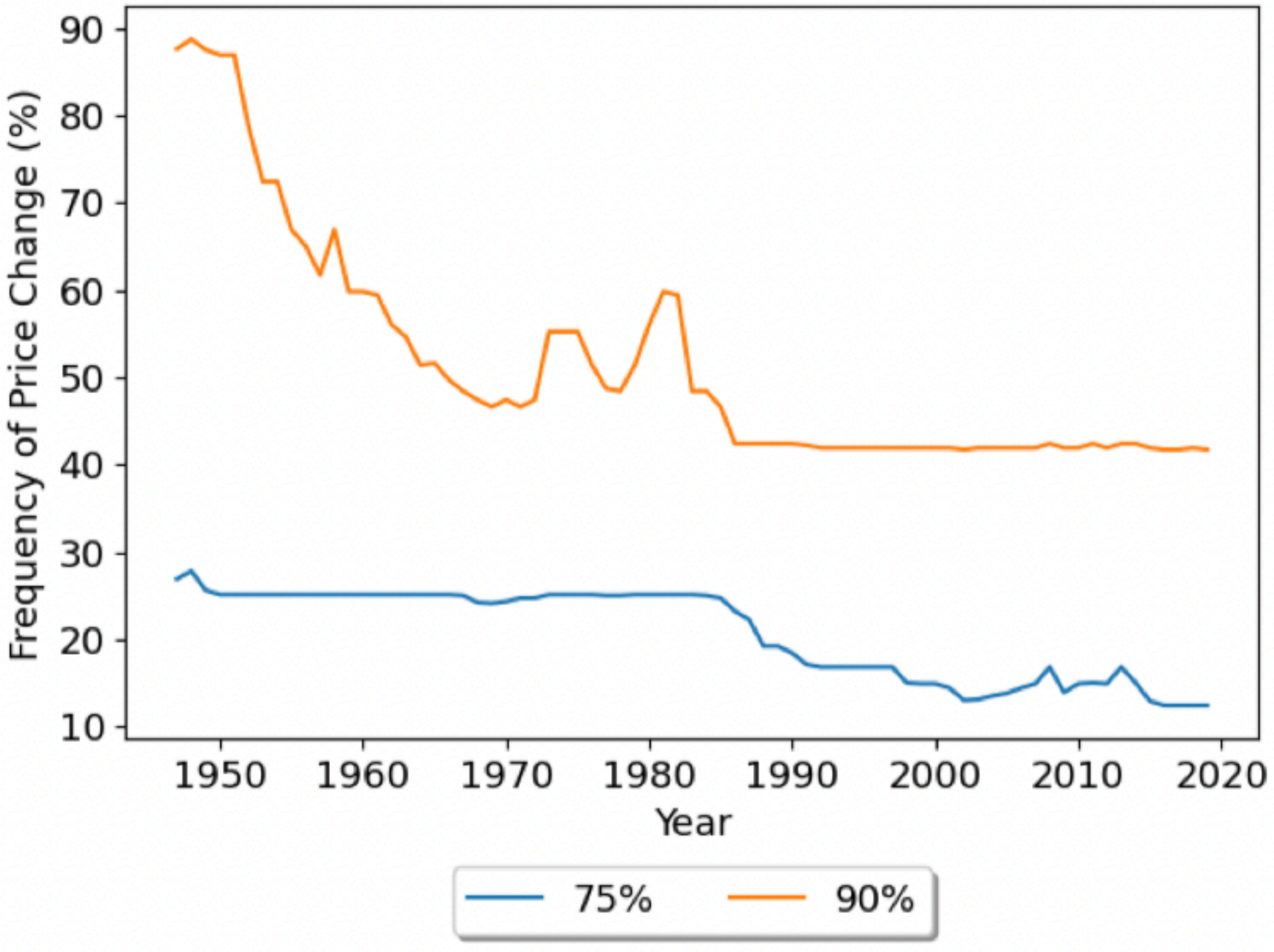

(b) For High Percentiles

Result 1

- Changes in industrial composition have led to **large declines across the distribution of the frequency of price change** over the 1947–2019 period

Year	10%	25%	50%	75%	90%
1947	3.3	4.9	9.2	26.9	87.6
1957	3.3	4.6	8.9	25.1	61.7
1967	3.3	4.3	8.3	25.0	48.4
1977	3.4	4.3	8.2	25.0	48.7
1987	3.4	4.2	8.0	22.2	42.4
1997	3.4	4.2	7.8	16.8	41.9
2007	3.4	4.3	7.8	14.9	41.9
2017	3.4	4.2	6.9	12.4	41.7
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Result 1

- Similar declines for other percentiles (except 10th) of the distribution of frequency of price change over the 1947–2019 period

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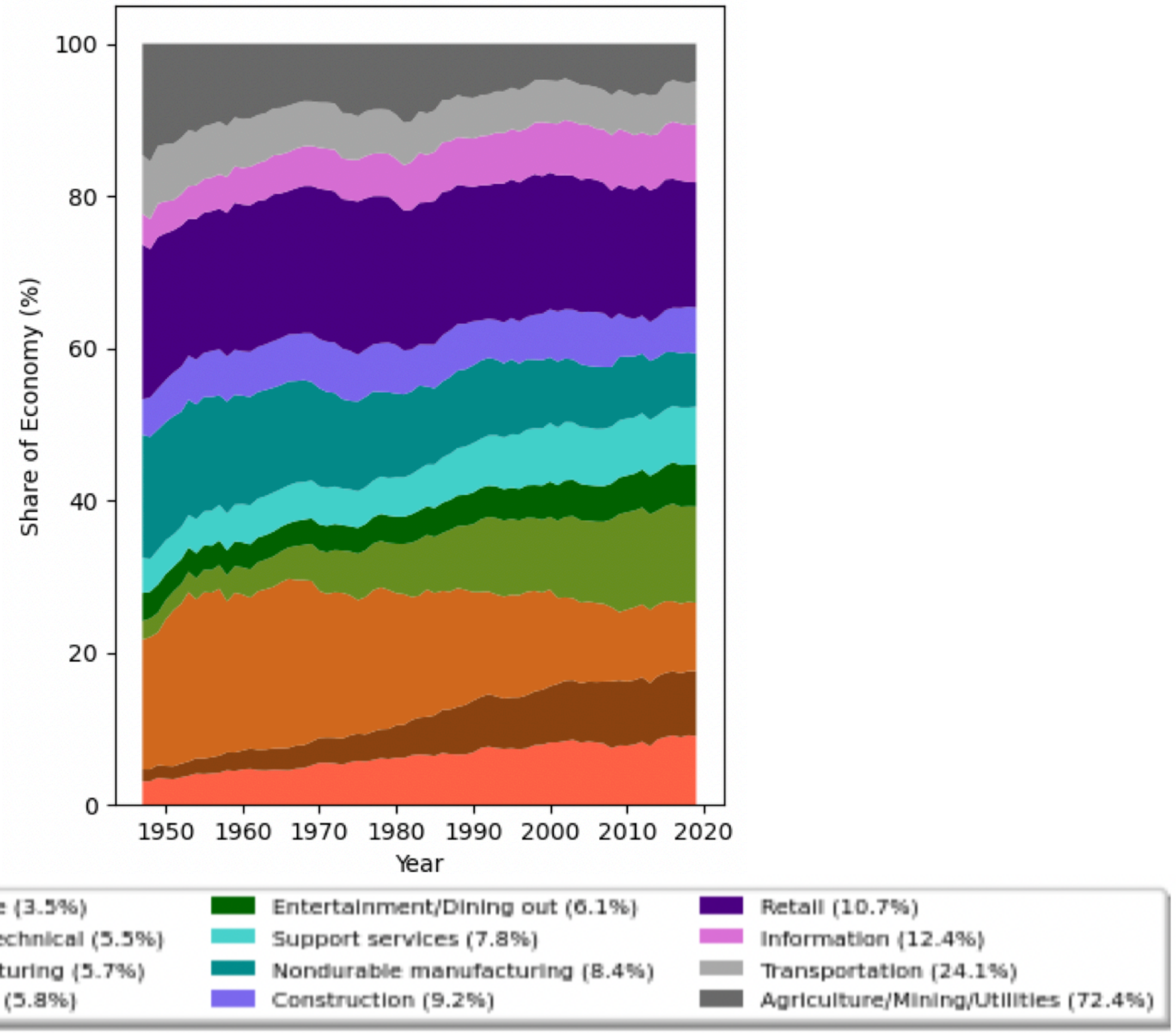
Robustness

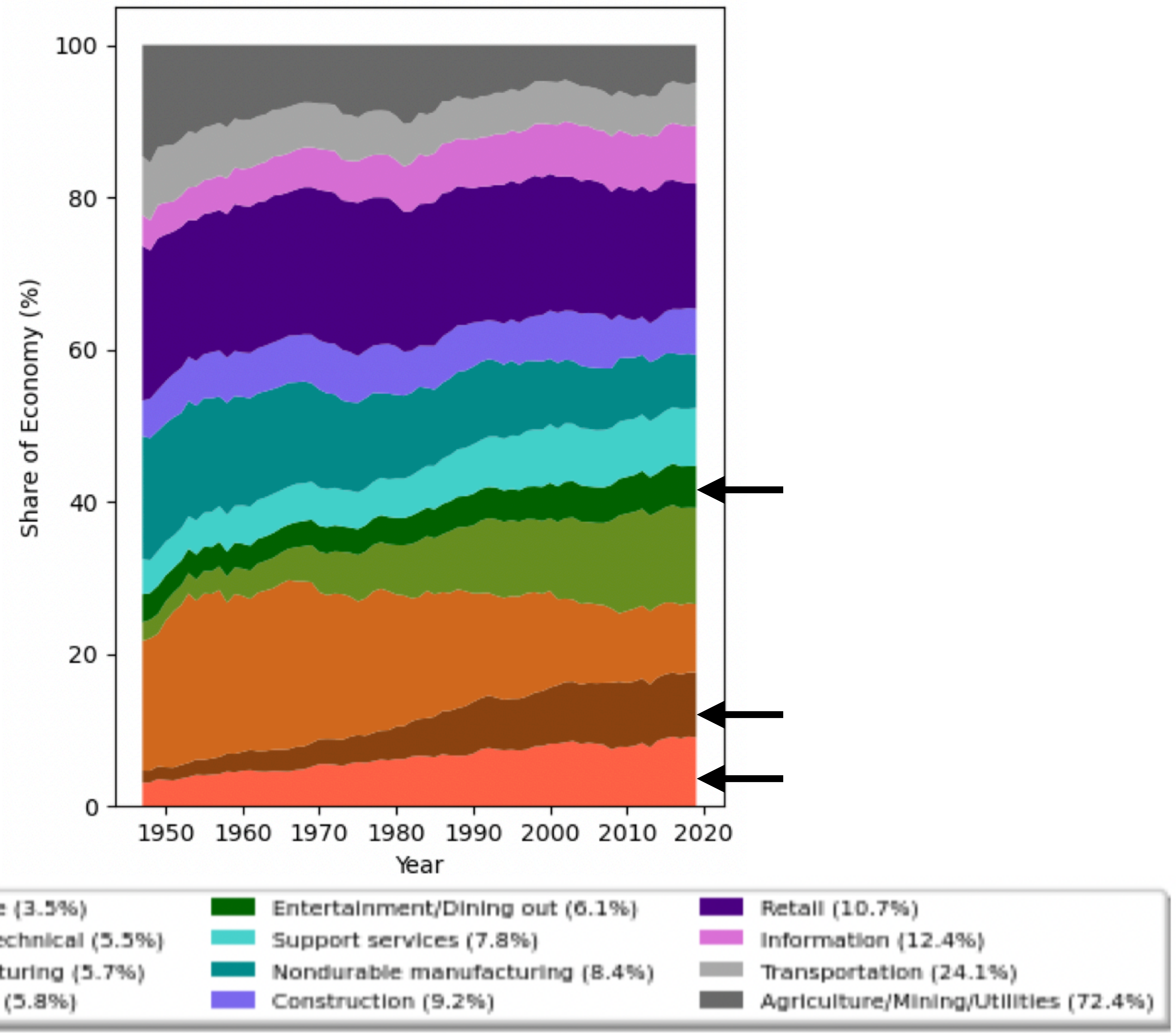
Result 2

- These declines across the distribution were driven by a **shift from primary and secondary industries to tertiary industries** over the 1947–2019 period



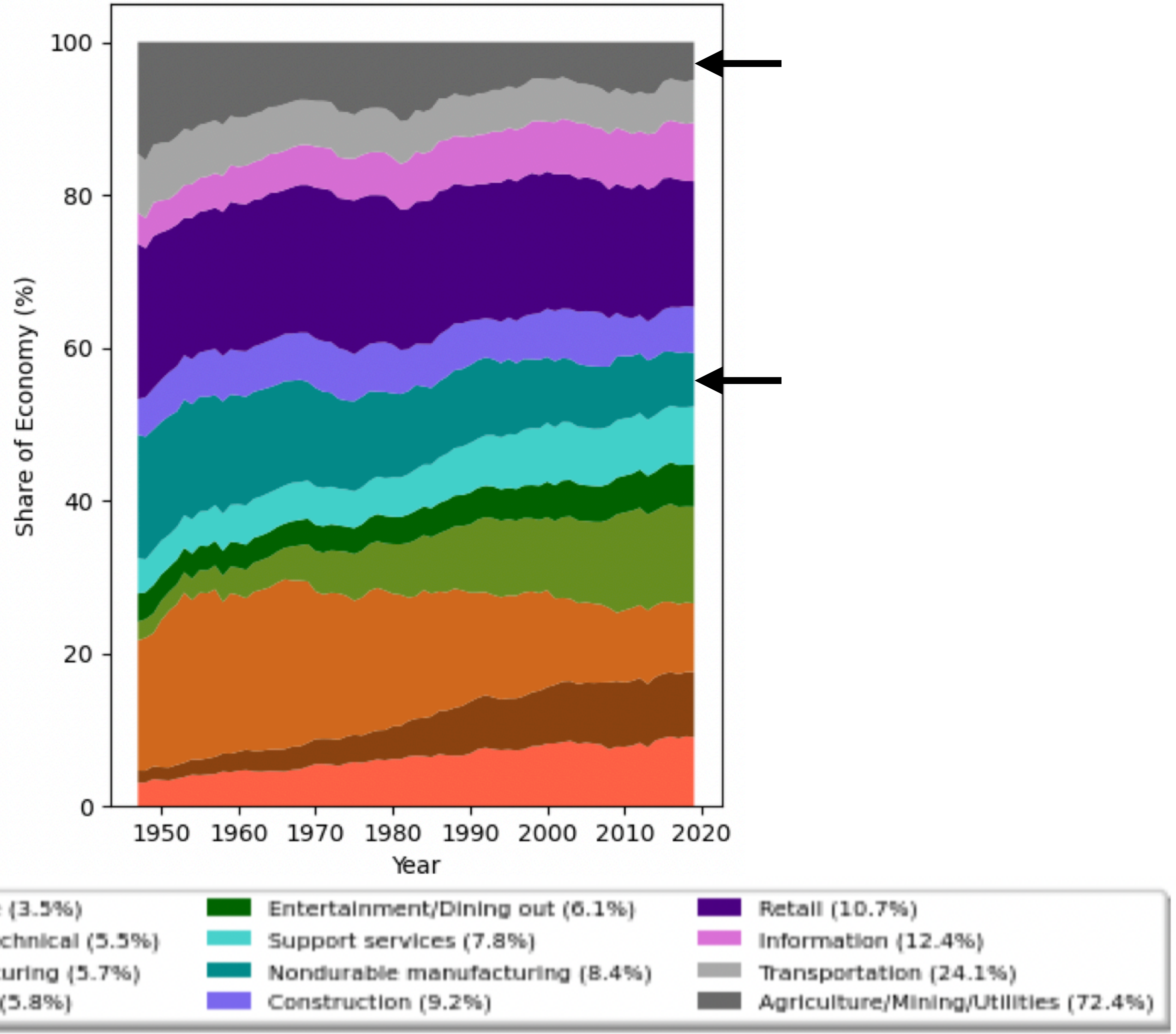
Result 2

- Finance/insurance, legal/scientific/technical, and education/health grew a lot
  - All have low frequencies of price change



Result 2

- Nondurable manufacturing and agriculture/mining/utilities shrunk a lot
  - Both have high frequencies of price change



Result 2

- All of the five industries that grew the most:
  - Show substantially lower frequencies of price change than industries that shrunk
  - Are tertiary (service) industries

Industries with the top 5 largest increases in share of the economy

Industry Name	Freq.	1947	1983	2019
Miscellaneous professional scientific and technical services	8.2	1.1	3.5	6.7
Ambulatory health care services	3.4	1.0	3.0	5.3
Hospitals Nursing and residential care facilities	6.3	0.9	3.1	4.6
Administrative and support services	4.3	0.5	1.8	4.1
Federal Reserve banks credit intermediation and related activities	3.5	1.7	3.9	4.8

Result 2

- Three of the five industries that shrunk the most:
  - Have relatively higher frequencies of price change
  - Are primary or secondary (that extract raw materials and those that process them, respectively) industries

Industries with the top 5 largest decreases in share of the economy

Industry Name	Freq.	1947	1983	2019
Farms	94.8	10.0	1.7	0.9
Retail Trade	10.7	12.2	9.9	7.9
Food and beverage and tobacco products	22.2	5.8	3.1	1.8
Rail transportation	24.1	4.0	0.8	0.3
Primary metals	34.8	2.8	1.2	0.4

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- The remaining two industries are associated with the sale and transportation of their goods

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  - Sector (j) : aggregated products (613 products $\rightarrow$ 14 sectors)

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  - Idiosyncratic productivity shocks → sector-specific distribution with std. dev. $\sigma_{\epsilon,j}$
  - Menu cost → sector-specific χ_j

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- Model solved for a **given distribution of sectors** (share of sector in the economy$_{jt}$)
- Simulate Phillips curve in response to **aggregate nominal demand shocks**

Details

Parameters

Calibration

Sector #	Target Moments: Price change		Weight (%)
	Frequency (%)	Absolute Size (%)	(1983)
1	2.34	13.59	7.93
2	3.34	14.16	3.72
3	3.64	17.54	11.24
4	4.39	9.94	6.03
5	5.34	8.54	6.74
6	6.15	10.92	7.27
7	7.59	6.44	8.97
8	8.99	9.31	9.64
9	10.11	8.38	3.02
10	13.25	6.75	7.15
11	22.34	13.93	3.18
12	30.23	8.71	11.60
13	49.61	7.78	6.16
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Calibration

Sector-specific menu cost

Sector #	Target Moments: Price change		Estimated Parameters		Weight (%)
	Frequency (%)	Absolute Size (%)	χ_j	$\sigma_{\epsilon,j}$	(1983)
1	2.34	13.59	0.0057	0.0685	7.93
2	3.34	14.16	0.0074	0.0824	3.72
3	3.64	17.54	0.0043	0.0877	11.24
4	4.39	9.94	0.0013	0.0471	6.03
5	5.34	8.54	0.0008	0.0403	6.74
6	6.15	10.92	0.0011	0.0531	7.27
7	7.59	6.44	0.0004	0.0306	8.97
8	8.99	9.31	0.0005	0.0377	9.64
9	10.11	8.38	0.0005	0.0396	3.02
10	13.25	6.75	0.0001	0.0242	7.15
11	22.34	13.93	0.0000	0.0195	3.18
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Sector-specific std. dev. of idiosyncratic productivity shock

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Robustness

Δ Industrial Composition $\implies$ Δ Phillips Curve

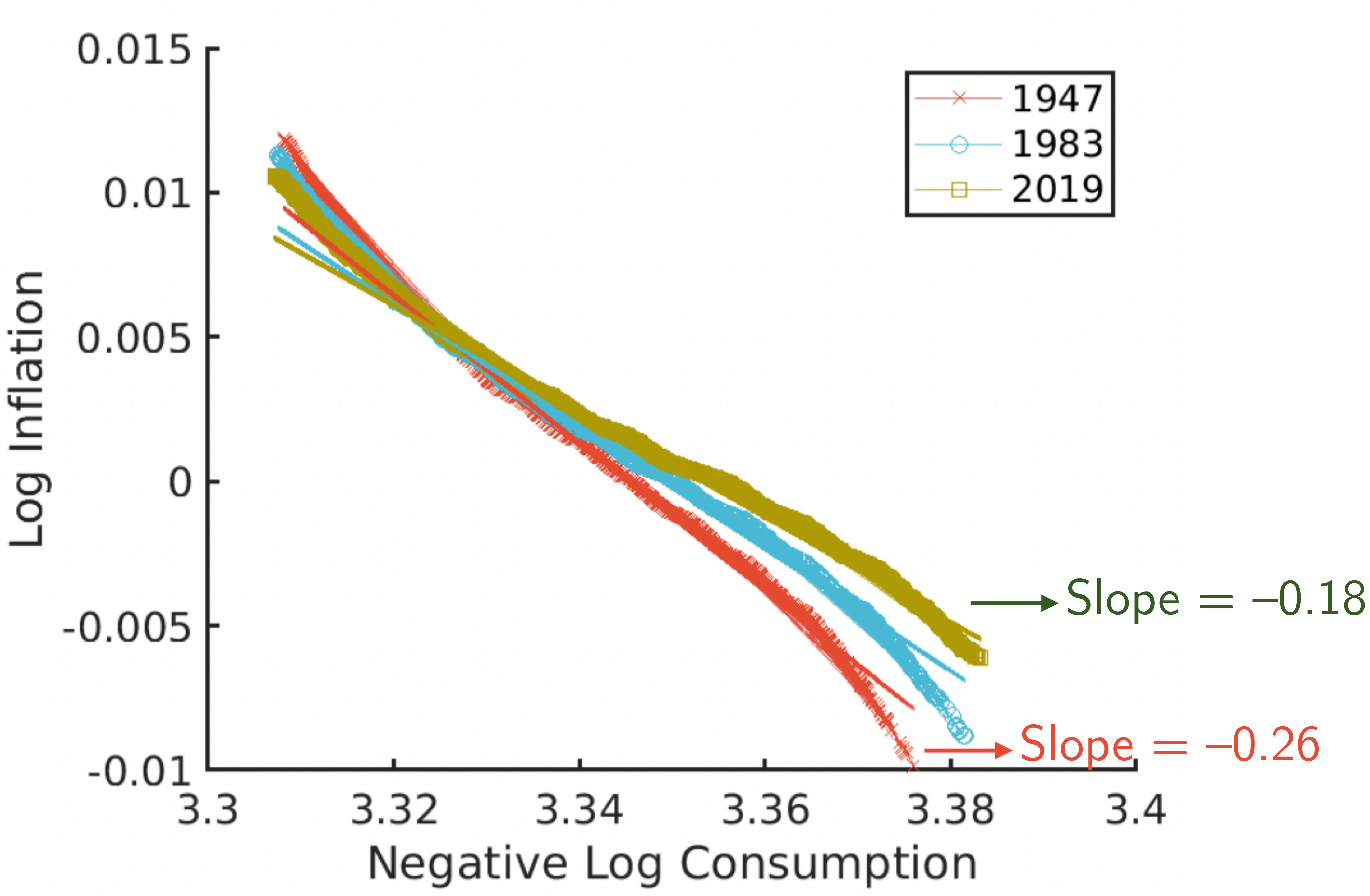
- Hold fixed:
  - Calibrated parameters
  - Nominal demand shocks

- **Change only share of sector in the economy**$_{jt}$
  - As implied by the share of product in the economy$_{it}$
    - As implied by the industrial composition of the economy for the given year

- **Simulate the Phillips curve given the new sector distribution**
  - One for each year: 1947–2019

Result 3

- These changes in the industrial composition have led to a **30.7 percent flattening** of the slope of the Phillips curve over the 1947–2019 period



Simple NK

Conclusion

- We isolated the impact of changes in industrial composition during 1947–2019 on:
  - the distribution of products in the US economy
  - consequently the distribution of the frequency of price change across the products
- We found: US economy exhibits greater price stickiness in 2019 compared to 1947
  - Median frequency of price change fallen from 9.2% to 6.9%
  - Mean frequency of price change fallen from 24.2% to 15.1%

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  - Median frequency of price change fallen from 9.2% to 6.9%
  - Mean frequency of price change fallen from 24.2% to 15.1%
- Then we analyzed the degree to which these distributional changes affected the slope of the Phillips curve over this period
- We found: US Phillips curve 30.7% flatter
  - Cause: long-term structural forces, unlikely to revert
  - Central banks should account for the flattening in their decisions

Thank you!

Algorithm

$$\text{Share of product in economy}_{it} = \sum_j \text{Share of industry in economy}_{jt} \times \text{Share of product in industry}_{ij}$$

Share of industry in economy:

- BEA and World KLEMS Initiative
- Available for 65 industries
- Dynamic: 1947–2019 annual data

1. 620 products (272 CPI + 348 PPI) mapped to one or more of 2017 6-digit NAICS industries (of which there are 65)
   - We are able to map 613 products to 51 industries
2. Aggregate industries to the BEA/KLEMS World-level for which we have industry-shares data
3. Compute the *share of product in industry*$_{ij}$ using:

i) set $a_{i,j} = 1$ if product i sold in industry j; zero otherwise

ii) compute raw weight of product i sold in industry j : $b_{i,j} = \dfrac{a_{i,j}}{\sum_j a_{i,j}}$

iii) compute proportion of industry j sold by product i : $c_{i,j} = \dfrac{\omega_i b_{i,j}}{\sum_i \omega_i b_{i,j}}$, where ω_i = expenditure weight*

* expenditure weight available for CPI products; for PPI products we set it to 1 divided by the total # of PPI products

Back

Robustness Checks

Method	1947 Median	1983 Median	2019 Median
A. Main	9.2	8.2	6.9
B. Any price change	11.5	8.7	7.8
C. One Klems	9.2	8.2	6.9
D. Same weight	9.1	8.0	7.2
E. No large products	9.4	7.8	6.9
F. Aggregate by Industry	10.7	8.4	8.2
G. CPI Only	9.2	8.2	6.9
H. PPI Only	9.7	7.4	7.2

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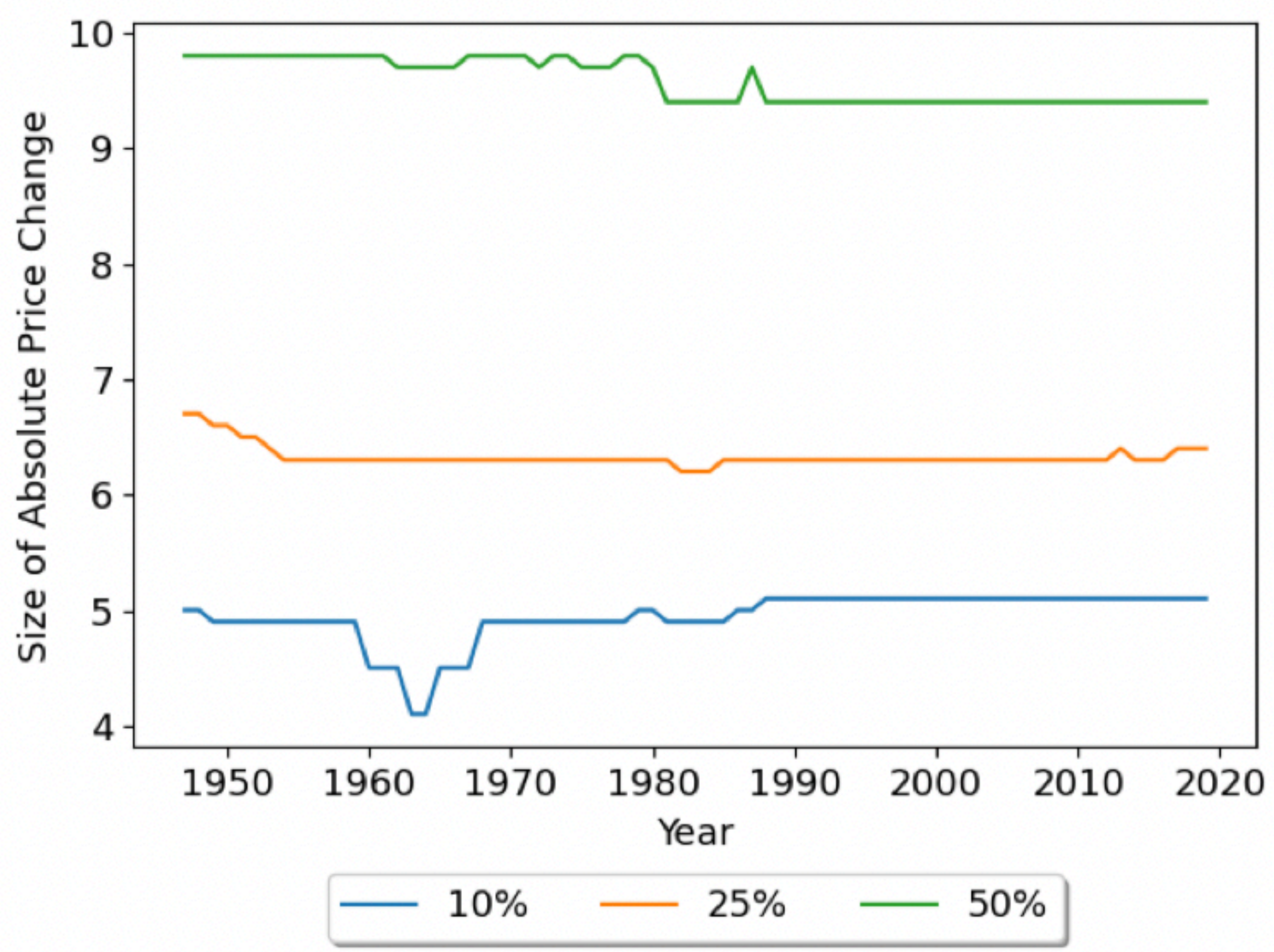
Distribution of absolute size of price change: 1947–2019



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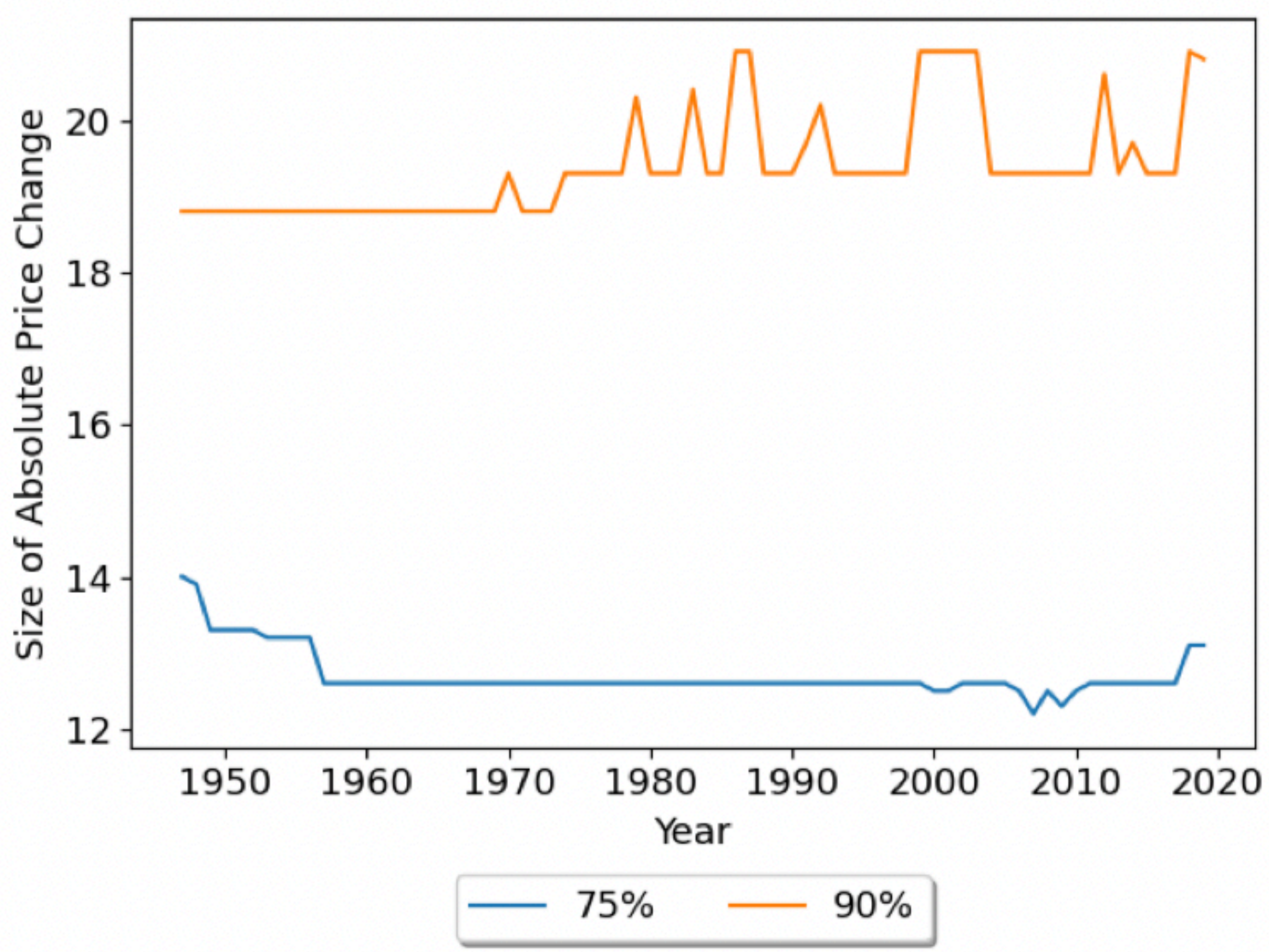
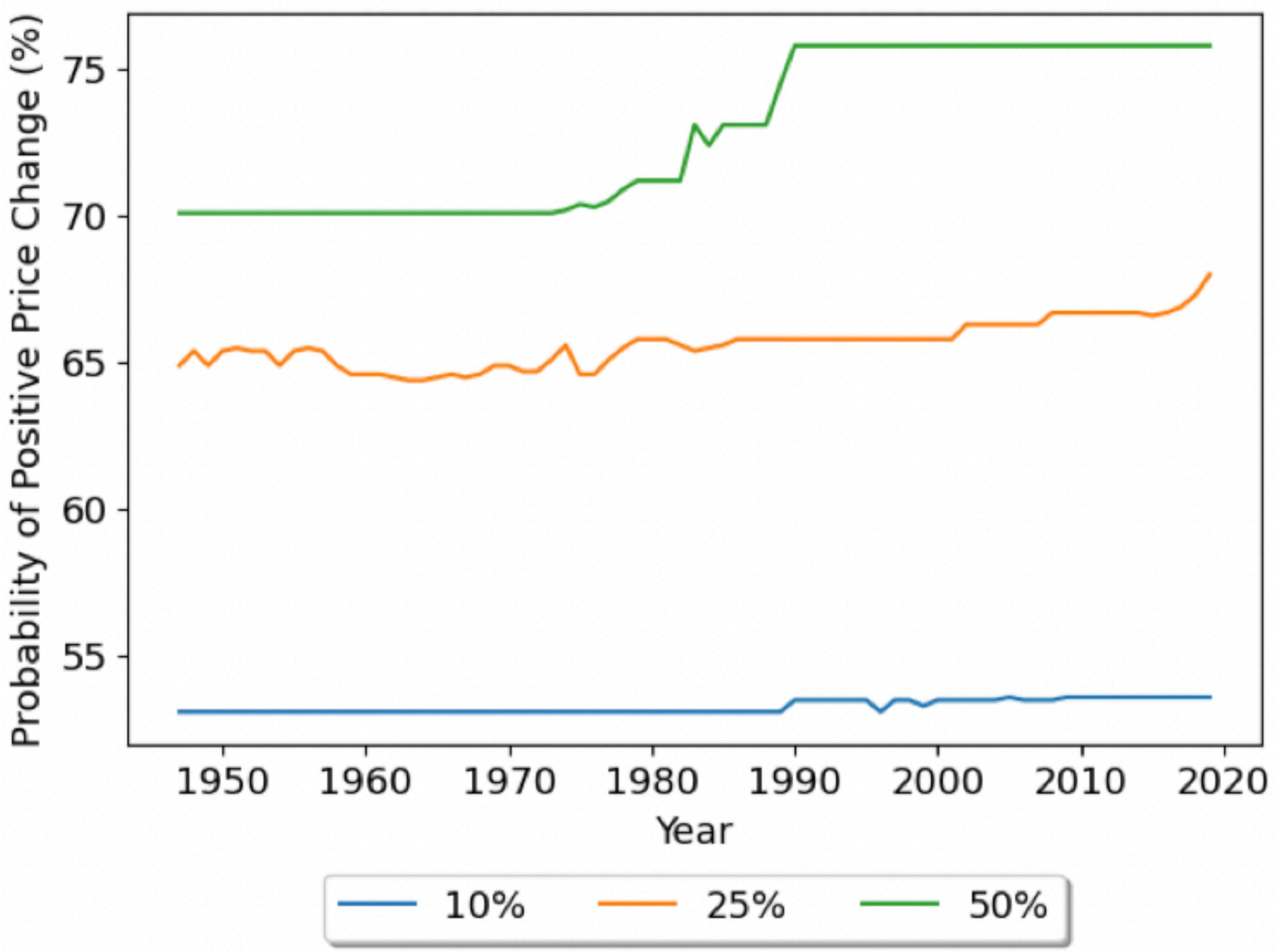


(b) For High Percentiles

- No systematic impact

Back

Distribution of probability of positive price change: 1947–2019



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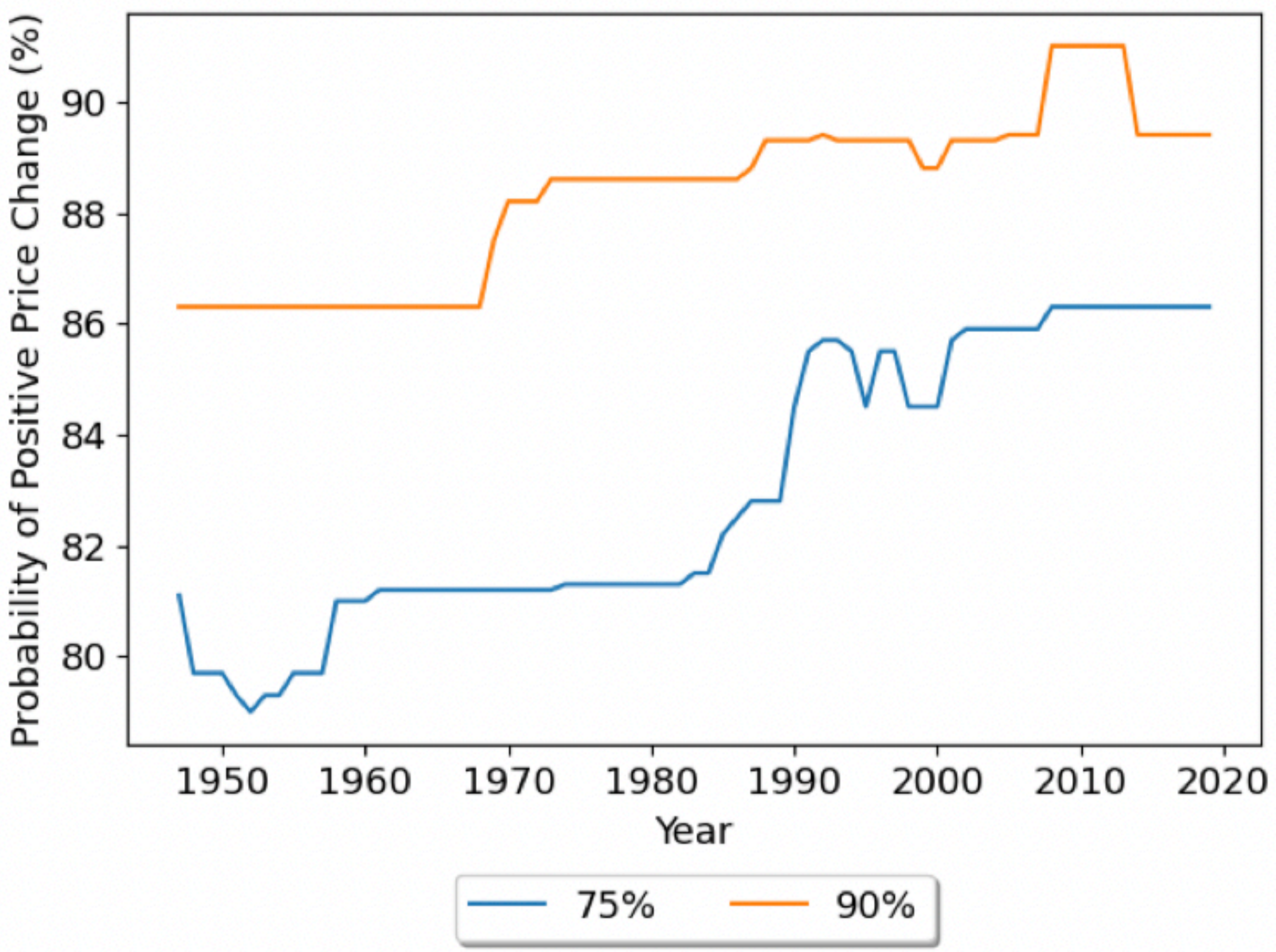

(b) For High Percentiles

- Shifted up

Back

Model Details

- 14 sectors
- Sector-specific:
  - Price stickiness in the form of menu costs χ_j
  - Standard deviation of firms' idiosyncratic productivity shocks $\sigma_{\epsilon,j}$
- Round-about production structure
  - Intermediate inputs as well as labor used in production
- Nominal target for monetary policy:
  - Nominal aggregate demand : $S_t = P_t C_t$
  - Monetary authority targets a path of S_t
- Idiosyncratic shocks to firms' productivity:

$$\log A_t(z) = \varrho \log A_{t-1}(z) + \epsilon_t(z) \text{ where } \epsilon_t \sim N(0,\sigma^2_{\epsilon,j}) \text{ are independent}$$

- Aggregate shocks to nominal demand:

$$\log S_t = \mu + \log S_{t-1} + \eta_t \text{ where } \mu \text{ represents trend inflation, } \eta_t \sim N(0,\sigma^2_\eta) \text{ are independent}$$

Back

Model Details

- Menu cost $\Longrightarrow$ Firms' optimal price-setting decision is dynamic
- Recursive formulation:

$$V\left(A_t(z), \frac{p_{t-1}(z)}{P_t}, \frac{S_t}{P_t}\right) = \max_{p_t(z)} \left\{ \Pi_t^R(z) + \mathbb{E}_t \left[D_{t,t+1}^R V\left(A_{t+1}(z), \frac{p_t(z)}{P_{t+1}}, \frac{S_{t+1}}{P_{t+1}}\right)\right]\right\}$$

- Solution: intractable because state space of the firm's problem includes the aggregate price level P_t, which is an infinite dimensional object
- Assumption to make the model tractable: price level perceived to evolve depending on only the nominal demand deflated by the preceding period's aggregate price level:

$$\frac{P_t}{P_{t-1}} = \Gamma\left(\frac{S_t}{P_{t-1}}\right)$$

  - P_{t-1}, though endogenous, is in the information's set at time t
  - S_t exogenous
- General equilibrium solution computed using Value Function Iteration on a discretized state space

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Calibration

Parameter	Description	Value
σ	Coefficient of relative risk aversion	1
ψ	Labor disutility convexity	0
β	Discount factor	$0.96^{\frac{1}{12}}$
θ	Elasticity of substitution	4
L	Steady-state labor supply	0.33
μ	Mean growth rate of nominal AD	0.0028
σ	Std. dev. of the growth of nominal AD	0.0065
s_m	Share of int. inputs in production	0/0.7
ρ	Persistence in firms' productivity	0.7

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Model Robustness

Year	Frequency (%)		Absolute Size (%)		Prob. Positive (%)	
	Data	Model	Data	Model	Data	Model
Panel A. *Mean*						
1947	24.2	24.0	10.8	9.4	70.2	71.2
1983	18.7	18.6	10.0	10.1	71.9	73.0
2019	15.1	15.0	10.3	10.3	74.9	75.0
Panel B. *Median*						
1947	9.2	9.2	9.8	8.6	70.1	70.5
1983	8.2	7.4	9.4	9.9	73.1	73.4
2019	6.9	7.3	9.4	9.9	75.8	73.6

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Basic New Keynesian Phillips Curve

$$\pi_t = \kappa mc_t + \beta \mathbb{E}_t \pi_{t+1}$$

Under log utility and linear labor disutility:

$$\pi_t = \kappa y_t + \beta \mathbb{E}_t \pi_{t+1}$$

where

$$\kappa = \frac{\lambda \left[1 - (1 - \lambda)\beta\right]}{1 - \lambda}$$

- Monthly parameters:
  - $\beta = 0.96^{\frac{1}{12}}$
  - λ = aggregate frequency of price change
    - Time-varying $\Longrightarrow \kappa_t$

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Basic New Keynesian Phillips Curve

$$\pi_t = \kappa_t y_t + \beta \mathbb{E}_t \pi_{t+1}$$

- $\lambda_{1947} = 9.2\% = 0.092$
- $\kappa_{1947} = 0.0096$
- Impact of known 1 p.p. rise in y_t for one year:
  - 12 months of high y_t
  - In earlier months, future inflation also rises
- Rise of 0.74 p.p. in inflation

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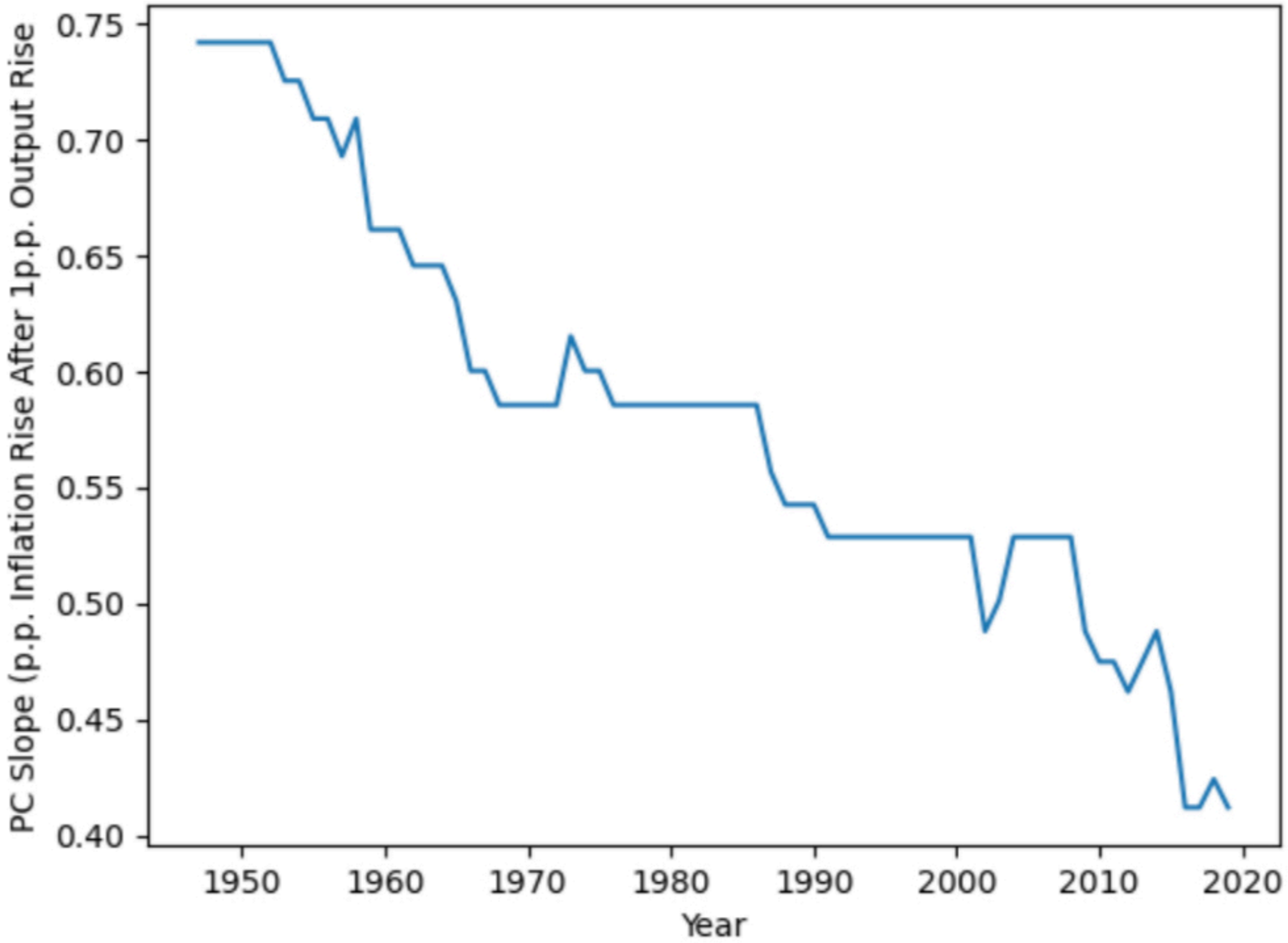
Basic New Keynesian Phillips Curve



- Slope declines from –0.74 in 1947 to –0.59 in 1983 to –0.41 in 2019
- Amount to a 44.5% flattening from 1947 to 2019

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