Firm-to-firm Price Rigidity within a Network

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The views expressed are those of the author and do not necessarily represent the views of the International Monetary Fund, the Central Bank of Chile or its board members

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Question

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Answer

- Bilateral market shares and firms' size are important determinants of the
  - Probability of price adjustment and its asymmetry ($|up| > |down|$)
  - Implications for theory: Kimball (1995) + menu costs at the firm-to-firm relationships

Idea in one slide

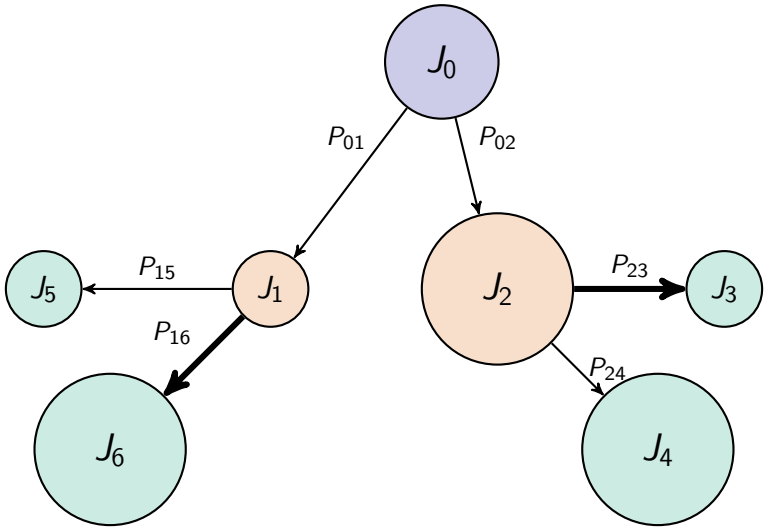


Figure: Network graph of an oil supplier. J_0 is the oil producer/importer. J_1 and J_2 are customers of J_0, while J_3 and J_4 are customers of J_2.

Related literature

1. Micro origins of price stickiness
   - Bils and Klenow (2004), Nakamura and Steinsson (2008), Goldberg and Hellerstein (2011), Bhattara and Schoenle (2014), Midrigan, (2011); Eichenbaum, Jaimovich, and Rebelo, (2011); Alvarez and Lippi (2014), Turen (2023), Afrouzi (2023)

   Contribution: using new data, confirm previous results and document the relevance of market structure and network structure

2. Monetary non-neutrality in multisector models with sticky prices
   - Nakamura and Steinsson (2010), Pasten et al. (2020), Rubbo (2023), Alvarez and Lippi (2014), Blanco et al. (2022), Mongey (2022), Ghassibe (2022), Minton and Wheaton (2023)

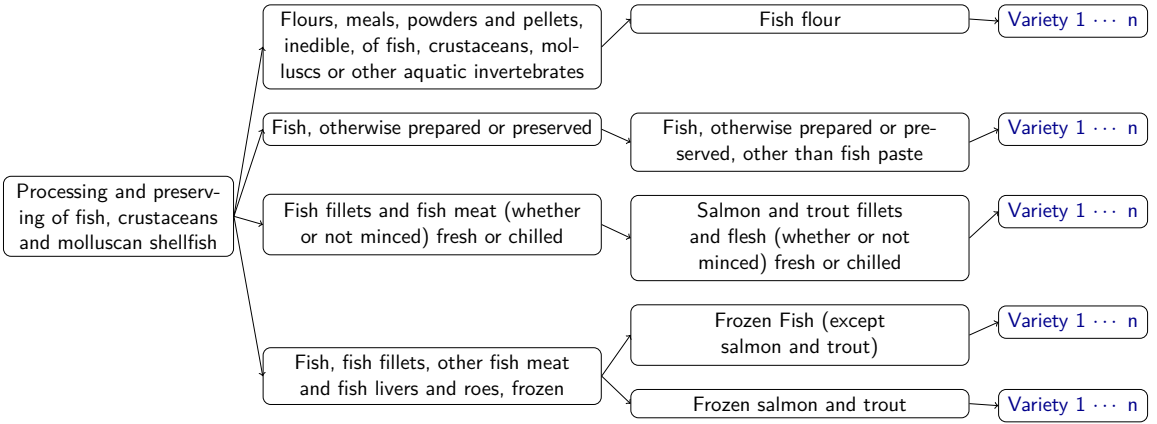
   Contribution: highlight the role of market power in bilateral firm-to-firm relationships as a determinant of price rigidity and, therefore, shaping the amplification of cost-push shocks and monetary policy shocks

The data

The data

- Universe of **firm-to-firm** (seller-customer) transactions in Chile, from 2018-2023 at a **Daily** Frequency.
- Use Machine Learning tools to identify prices at the variety level, [Acevedo et.al. (2022)]
- The price "triplet" p_{ijv}, i:*seller*, j: *buyer* and v: *variety*
  - Restrict varieties to be associated with products in the official CPI and PPI baskets.
  - Each variety must appear at least 24 times (for any supplier)
  - Drop change in prices ($dln(p)$) for percentiles 1 and 99
- Balance Sheet information about **both** seller and client
  - Total Sales, employment, industries, input purchases

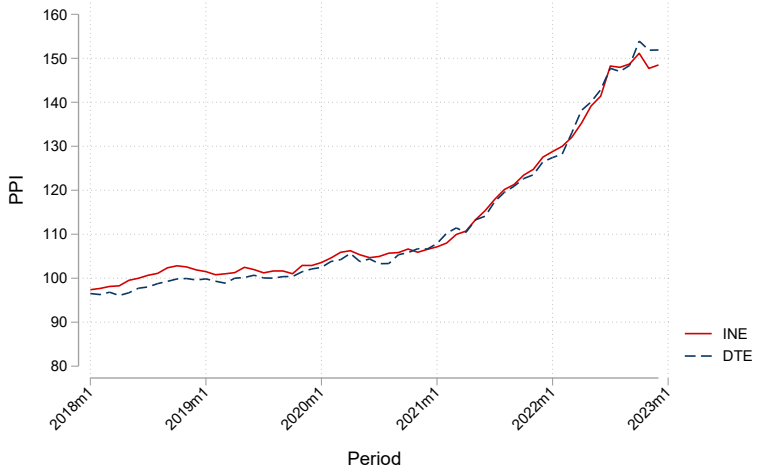
Example: Classes, Subclasses, Products, and varieties (INE-PPI)



- Varieties and subclasses relationship

Descriptive statistics

Representativeness of the data (PPI)



Note: The sum of weights is 0.97 of 100, and there are 165 of 173 products

Consistent with Acevedo et al. (2022) ▸ Additional validation

Descriptive statistics: supplier characteristics

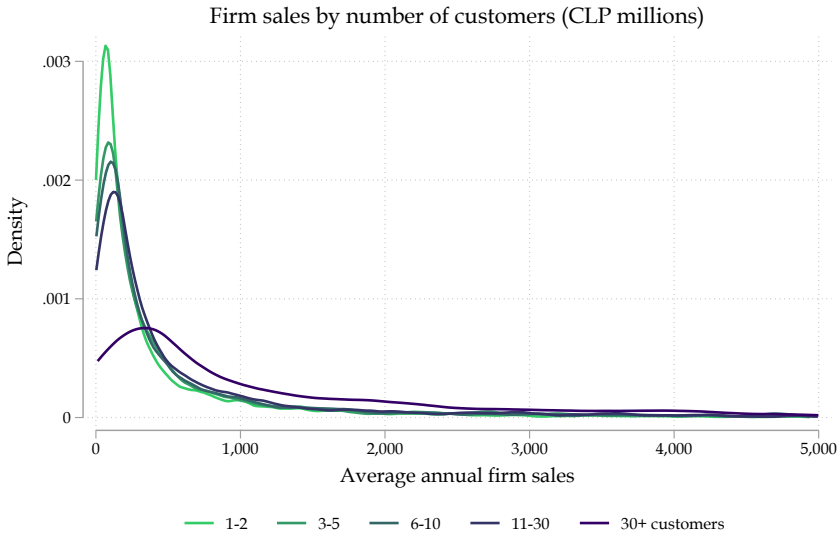
	Mean	Std. Dev.	p10	p25	p50	p75	p90	Obs.
Average sales (CLP millions)	6,825	129,685	34.6	85.3	244.4	860.9	3,603	15,369
Number of customers	46	972.9	1.0	1.4	3.3	11.5	35.8	15,369
Number of products sold	2.4	3.2	1.0	1.0	1.3	2.5	4.8	15,369

By sector

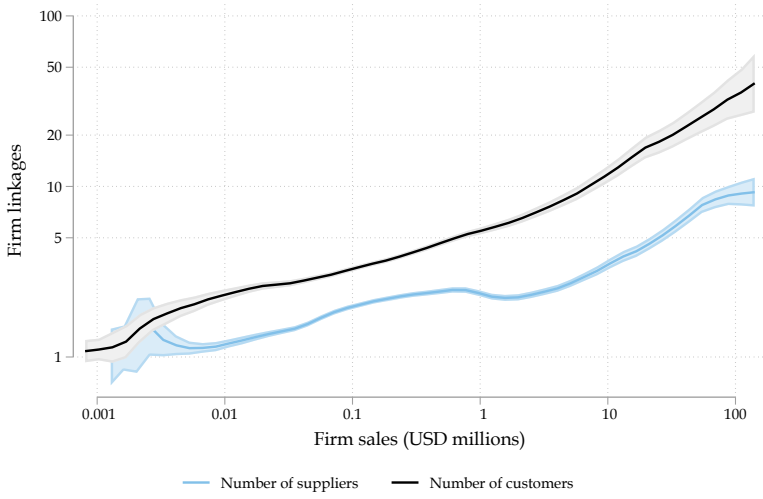
We have 15,369 firms and a total of 10,348,986 supplier-client-variety triplets. Average annual sales are 6825 million pesos ($\approx$ 7.5 million USD), median sales 244 million pesos (0.21 million USD)

▸ Size and subclasses

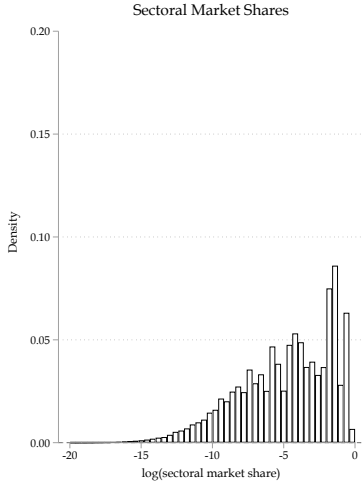
Descriptive statistics: size and downstream customers

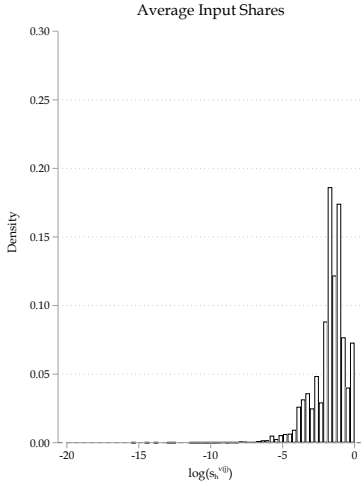


Large firms are more connected: up and downstream



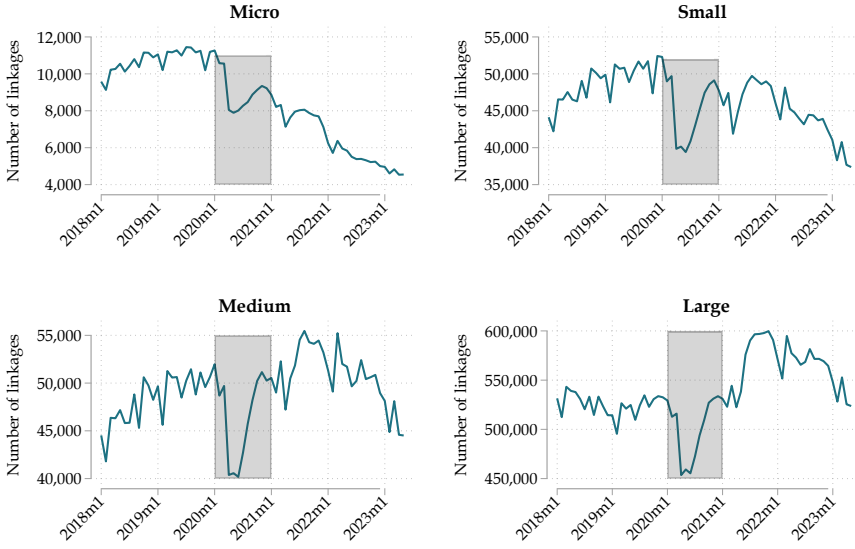
Market share vs supplier-client market share





- Correlation (binscatter)

Procyclical linkages and composition changes: fewer but better?



Frequency price change

Aggregate and sectoral desc. stats.

Frequency of price adjustment at supplier-client-variety level f_{ijv}

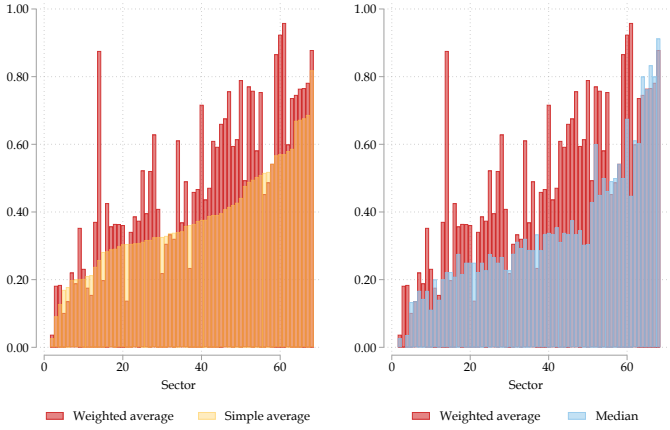
Table: Frequency price change at supplier-client-variety level f_{ijv}

	Mean	SD	P10	P25	P50	P75	P90	N
f_{ijv}	0.33	0.29	0.00	0.10	0.25	0.50	0.77	10,348,986
$dlogP_{ijv}$	0.31	0.26	0.00	0.12	0.25	0.45	0.71	8,014,515

Note: We obtain f_{ijv} as follows $f_{ijv} = \frac{\sum_{t=1}^{T_{ijv}} \mathbf{1}(\Delta \log P_{ijvt} > 0.005)}{T_{ijv}}$

- Average price frequency of f_i and f_{ijv} is 0.33 (price duration $\approx$ 3 months)
- Note the skewed distribution

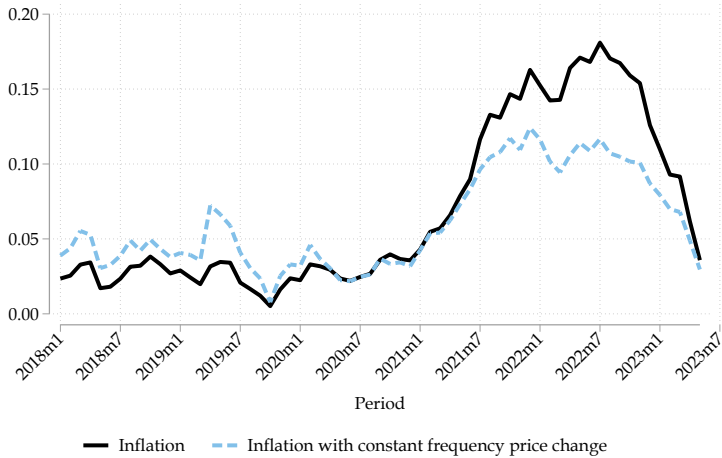
Sectoral frequency price change: median vs weighted average



- Significant price stickiness heterogeneity across sectors
- Consistent with evidence from the US, [Nakamura and Steinsson (2010)]

▸ Sector-to-sector heterogeneity

Decomposing inflation: intensive vs extensive margin



Economy-wide frequency of price adjustment increased during COVID-19

The transmission of oil price shocks

▸ Cross-sectional results

The network of an oil supplier

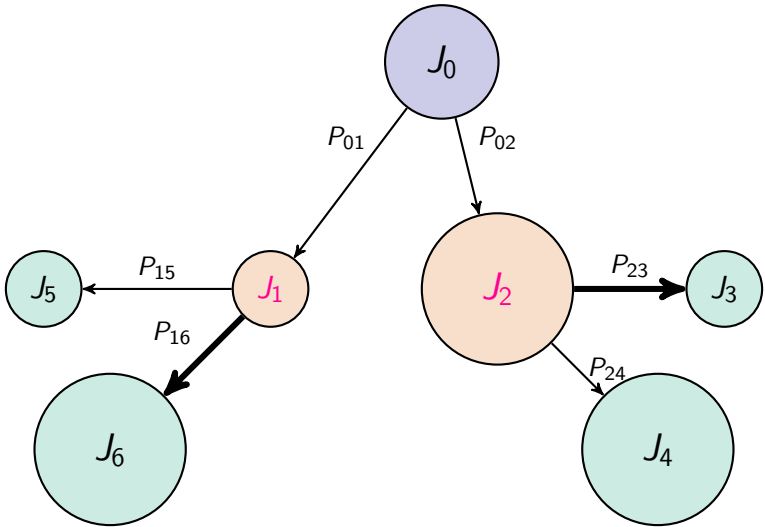


Figure: Network graph of an oil supplier (J_0).

Extensive Margin of Price Adjustments

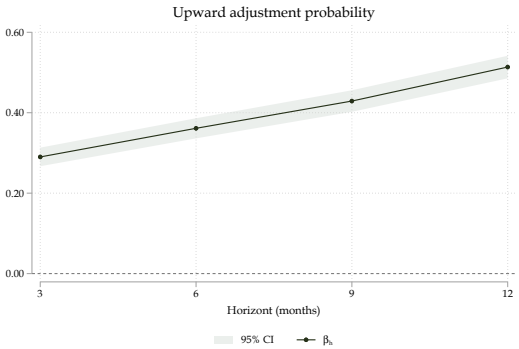
Adjustment probability

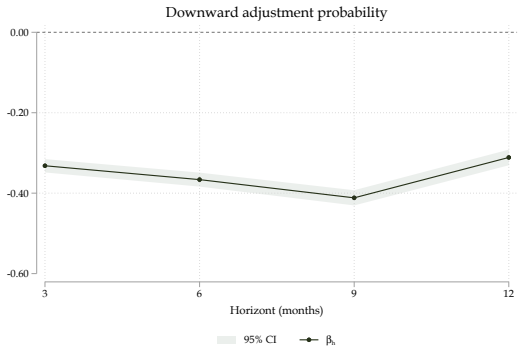
- We characterize the extensive margin adjustment of prices to changes in oil prices. The specification builds on Karadi et al. (2022):

$$I^{+,-}_{ijs,t+h} = \alpha_i + \alpha_j + \alpha_s + \beta_h(\Delta \tilde{P}^{oil}_t) + \gamma_h X_{ij} + \phi w_t + \epsilon_{ijs}, \quad (1)$$

- $I^{+,-}_{ijs,t+h}$: one if seller i changes the price charged to buyer j of subclass product s between month t and t + h, and zero otherwise.
- $\Delta \tilde{P}^{oil}_t = \Delta P^{oil}_t \cdot \text{exposure}_{i,oil}$, with P^{oil} change in the oil price, instrumented with Oil supply series, Baumeister and Hamilton (2019)
- X_{ij}: age of the price, competitor's price gap, # of products.
- Add subclass, month, supplier-industry, and customer-industry FE.
- Estimate at $h = 3, 6, 9, 12$

Probability of price adjustment (firms in J_1 and J_2)





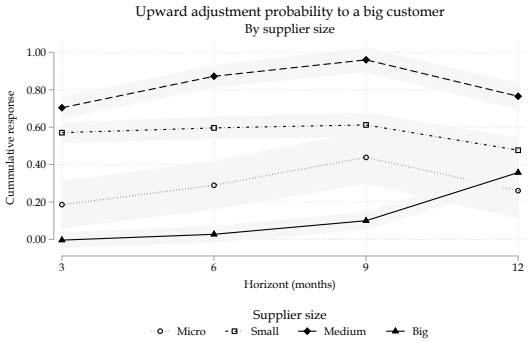
Heterogeneous adjustment probabilities

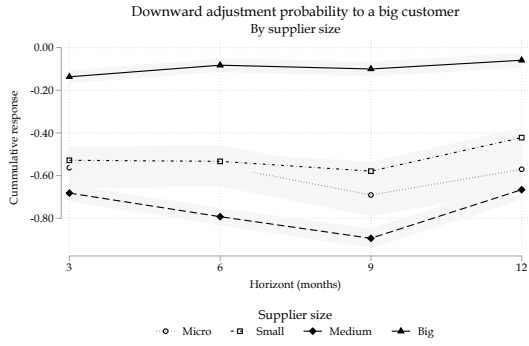
- We extend the previous specification to leverage the relative importance of the seller for the buyer.

$$I^{+,-}_{ijs,t+h} = \alpha_i + \alpha_j + \alpha_s + \beta_h(\Delta P^{oil}_t \times Z_{ij}) + \gamma_h X_{ij} + \phi w_t + \epsilon_{ijs}, \quad (2)$$

- Z_{ij}: size quintile of supplier i, size quintile of buyer j and the relative (Alviarez et al, 2023) importance of seller i for the buyer j (bilateral market share).
- Bilateral market share: Total purchases of j from seller i relative to total purchases of j within any year.

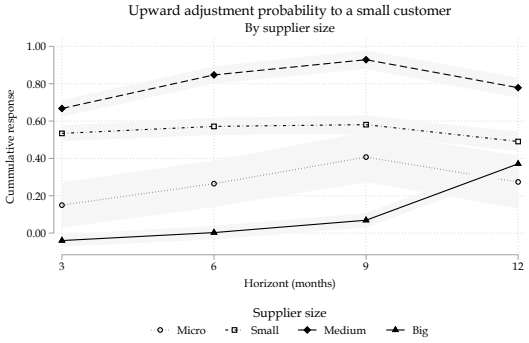
Price adjustment probability: supplier size for big customers

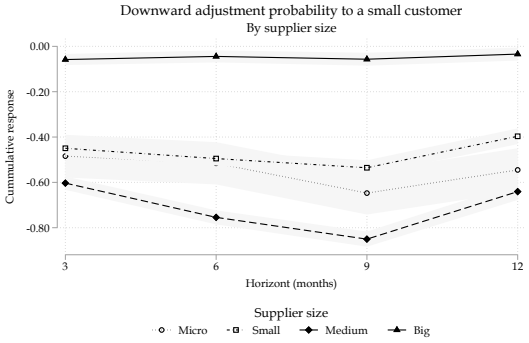




Upward adjustment probability increases in firm size, except for big firms. Mild asymmetry $Pr(I^{+}_{ijv,t+h}) > Pr(I^{-}_{ijv,t+h})$, except for micro firms.

Price adjustment probability: supplier size for small customers

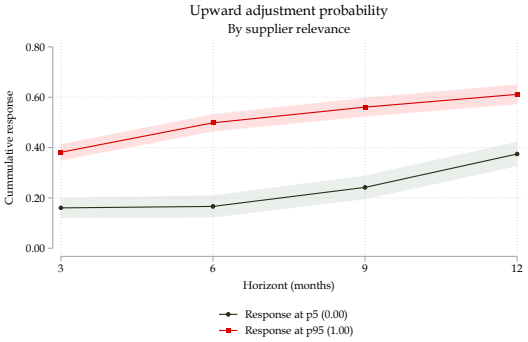


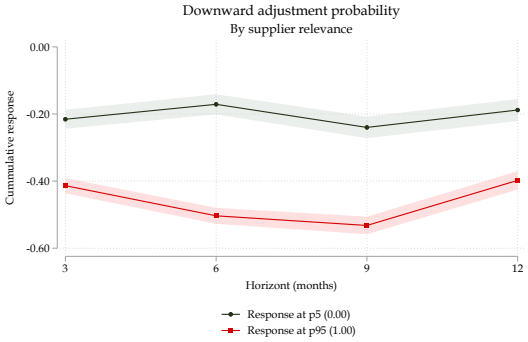


Upward adjustment probability increases in firm size, except for big firms. Significant asymmetry $Pr(I^{+}_{ijv,t+h}) > Pr(I^{-}_{ijv,t+h})$ for big firms.

▸ Customer size

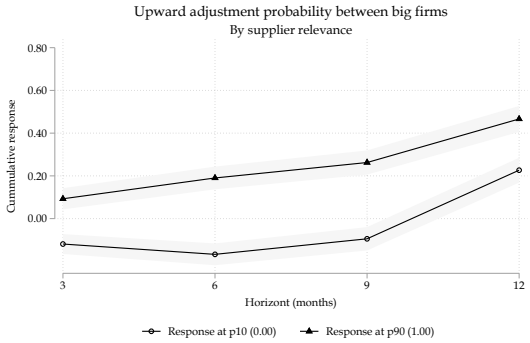
Price adjustment probability: supplier relevance (bilateral market share)

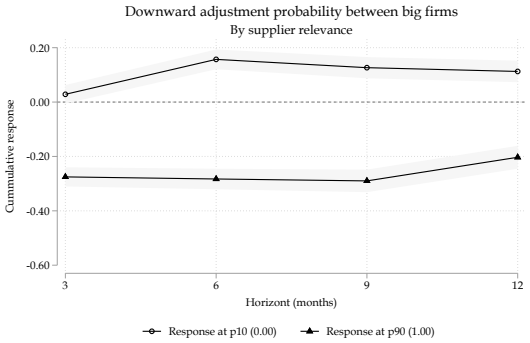




Probability of price adjustment is significantly larger for suppliers representing a large fraction of customers' purchases

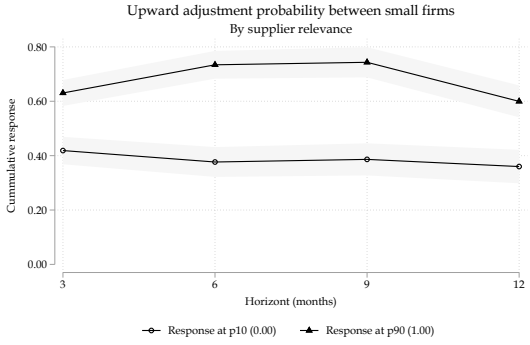
Price adjustment probability: supplier relevance (big firms)

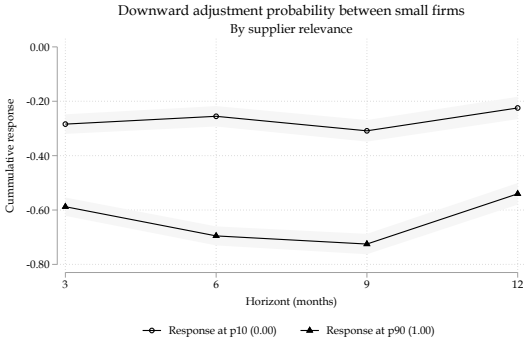




Probability of price adjustment is significantly larger for suppliers representing a large fraction of customers' purchases. Significant asymmetry for big suppliers with high bilateral market share

Price adjustment probability: supplier relevance (small firms)





Probability of price adjustment is significantly larger for suppliers representing a large fraction of customers' purchases. Mild asymmetry

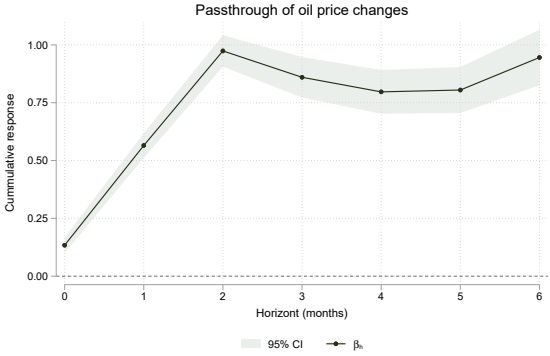
Cumulative price pass-through (intensive margin)

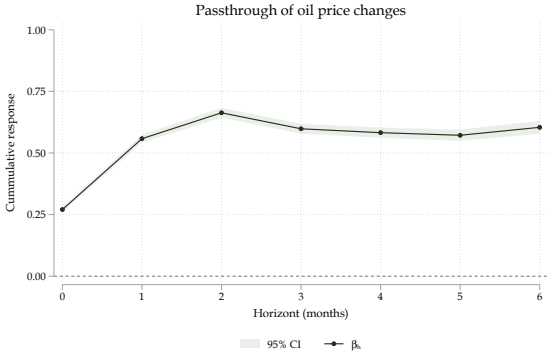
We estimate the following local projection regression

$$\pi^{K,ijv}_{t-1,t+h} = \alpha + \beta^K_h(\Delta \ln P_{c,t}) + \phi^K_h(\Delta \ln P_{c,t} \cdot Z_{ijt}) + \sum_{j=1}^{12} \delta^j \pi_{t-j} + \sum_{j=1}^{12} \gamma^j \Delta P_{c,t-j} + \psi X_t + \varepsilon_t,$$

where $\pi^{K,ijv}_{t-1,t+h}$ is the log change in $P^{K,ijv}$ between $t+h$ and $t-1$

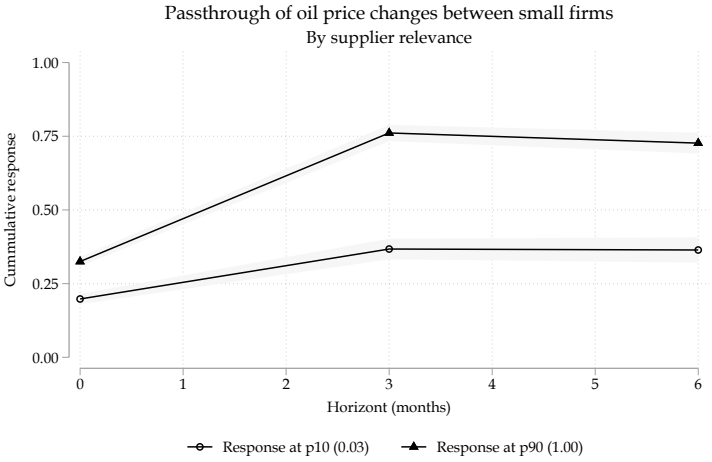
Pass-through at node 0 (oil extraction) and 1 (refinery industries)





Full pass-through, after two months, to firms in node 0

Passthrough to different customers (supplier importance)



Price passthrough increases with bilateral market share

▸ Supplier and customer size

Taking stock

- Larger firms, except for the very big firms, have higher probability of price adjustment
- Higher bilateral market share, especially for larger firms, increases the probability of price adjustments
- Price adjustment probability is asymmetric, especially for:
  - Suppliers with high bilateral market share
  - Big supplier selling to small clients
- Given the large heterogeneity in firm-to-firm relationships and the cyclical/compositional variation in firm-to-firm linkages, macroeconomic implications could be important
  - For example, the increase in the frequency of price adjustment during COVID-19 could be explained by changes in bilateral market structure and firm-to-firm linkages

Implications for theory

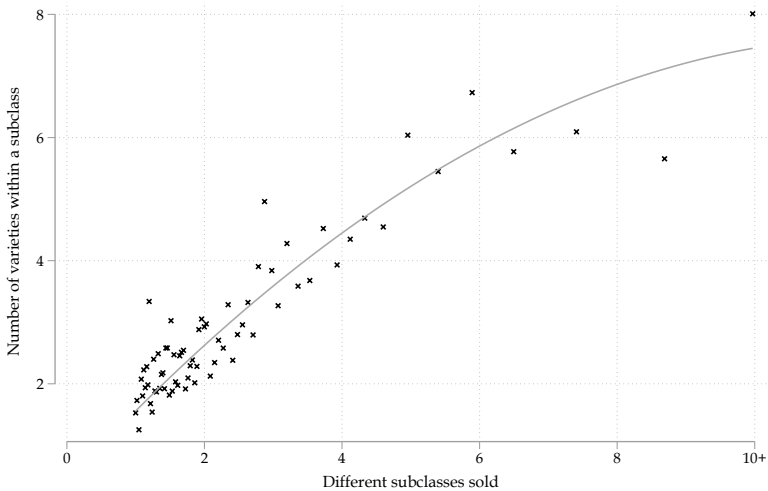
- Heterogeneity and asymmetry in price adjustment to cost-push shocks could be rationalized with
  - Kimball (1995) demand for intermediate varieties + menu costs (Klenow and Willis, 2016)
  - Smaller price adjustment compared to standard CES demand
  - Conditional on higher (bilateral) market share, larger upward adjustment and smaller downward adjustment

Conclusion

- Market structure and firm-to-firm network structure are relevant when thinking about price stickiness and monetary non-neutrality
- We have showed that price stickiness varies considerably across firms, but also within a firm
- Probability of price adjustment is significantly larger for suppliers with high bilateral market share
    - Significant asymmetry for big suppliers with high bilateral market share

Appendix

Product varieties and subclasses



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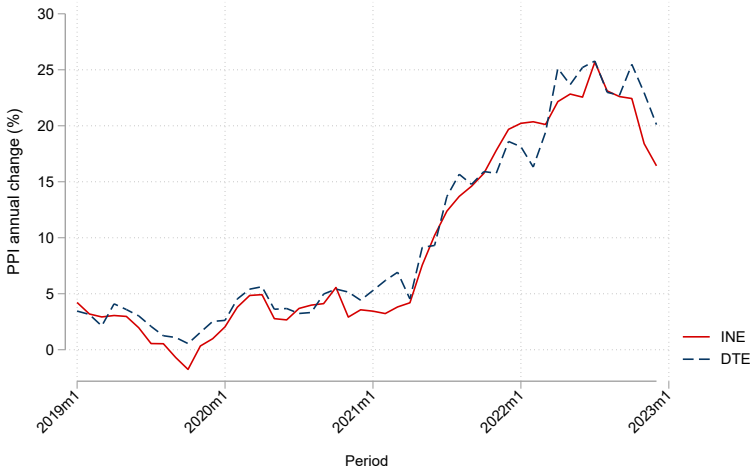
Representativeness of the data (PPI annual change)



Note: The sum of weights is 0.97 of 100, and there are 165 of 173 products

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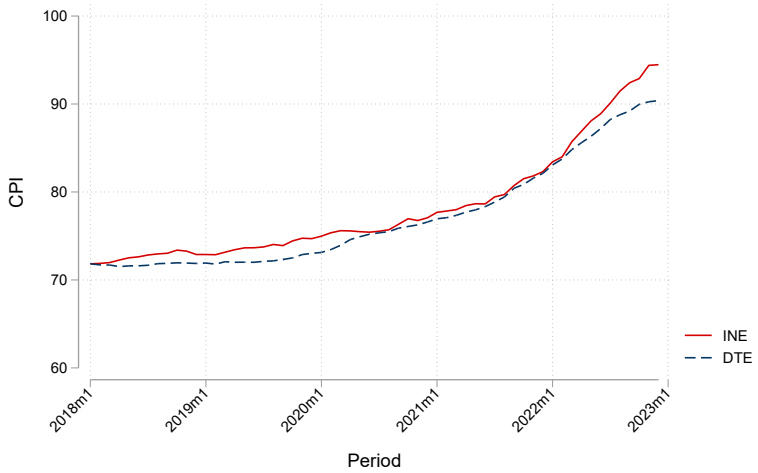
Representativeness of the data (CPI)



Note: The sum of weights is 71.83 of 100, and there are 254 of 303 products

Evolution frequency price change: CPI

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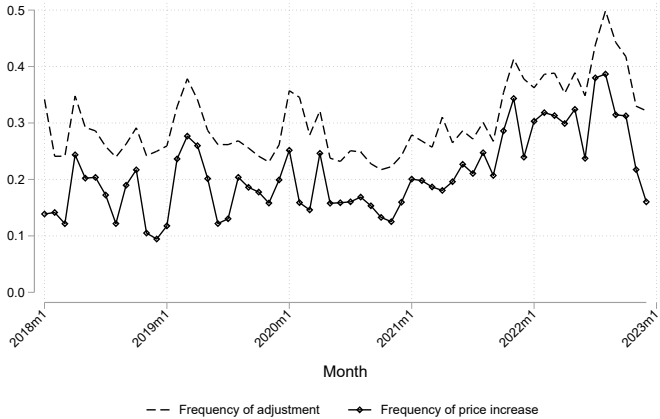
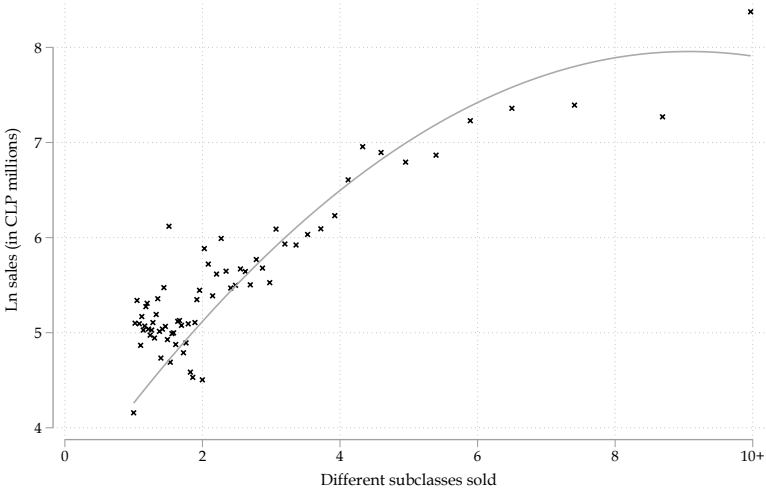


Size and subclasses



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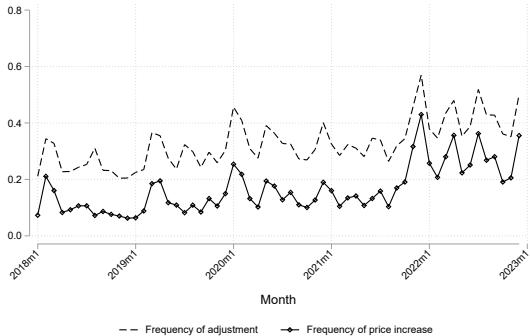
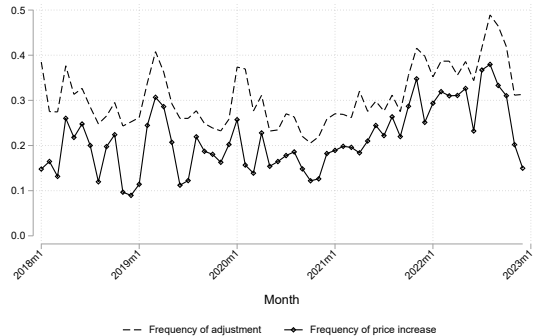
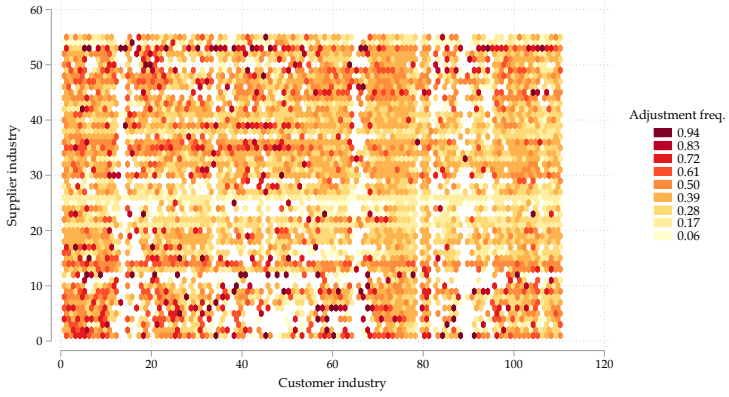
Evolution frequency price change: PPI and CPI frequent transactions

Figure: Frequency of price change (left) and CPI (right) frequent transactions





Sectoral frequency of price change f_{IJ} (Chilean firm-to-firm data)



f_{IJ}: monthly frequency of price IJ changes ($> 0.5\%$) for all IJ transactions (average across goods and time: 2018.m1-2023.m6)

For example, firms in the copper mining sector change prices 19% of the time to firms in the specialized construction activities sector but 50% of the time to firms in the retail sector.

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Competitor-price gap (strategic complementarities)

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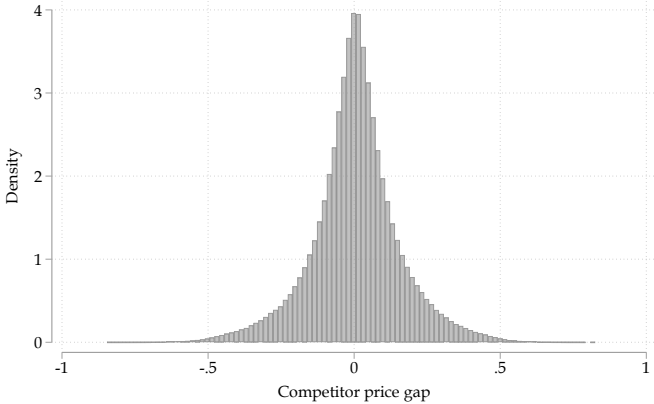
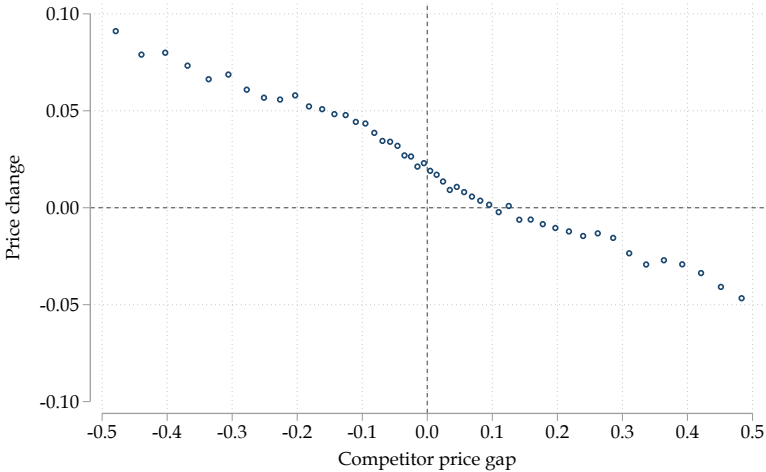


Filtered of supplier-product and month FE, using OLS (Karadi, Schoenle and Wursten (2022)). Using subclasses (bundling varieties, keeping constant number of varieties)

Magnitude of adjustment as function of competitor price gap

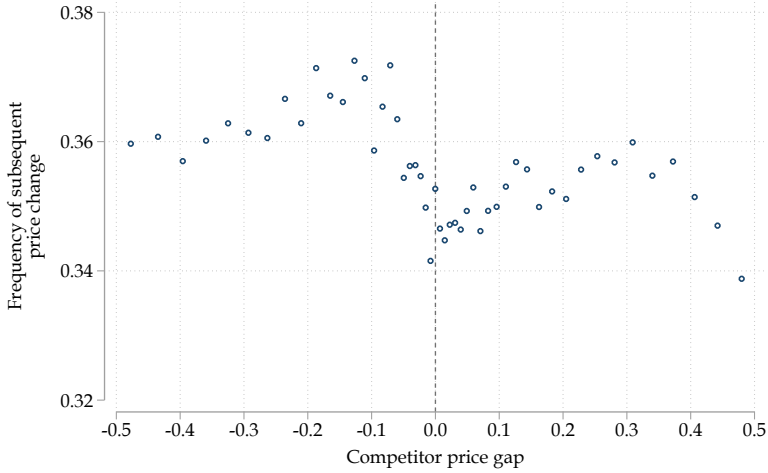
Figure: Magnitude of adjustment (t+1) as function of the gap



Note: competitor grap truncated at 50 percent

Frequency of adjustment (t+1) as function of competitor price gap

Figure: Magnitude of adjustment as function of the gap



Note: competitor grap truncated at 50 percent

Descriptive statistics (freq. price increases)

Table: Frequency of price increases

	Mean	SD	P10	P25	P50	P75	P90	N
CPI product	0.24	0.21	0.00	0.06	0.20	0.38	0.56	12,947,624
PPI product	0.17	0.17	0.00	0.00	0.13	0.27	0.42	10,007,004
Total	0.21	0.20	0.00	0.00	0.17	0.33	0.50	22,954,628

Descriptive statistics (share of price increases)

Table: Share of price increases

	Mean	SD	P10	P25	P50	P75	P90	N
CPI product	0.72	0.29	0.33	0.50	0.75	1.00	1.00	10,486,557
PPI product	0.83	0.26	0.50	0.67	1.00	1.00	1.00	7,121,443
Total	0.77	0.28	0.40	0.57	0.86	1.00	1.00	17,608,000

Descriptive statistics (supplier characteristics)

	Mean	Std. Dev.	p10	p25	p50	p75	p90	Obs.
Average sales (CLP millions)	3,903	92,937	8	23	92	381	1,714	25,078
Number of customers	24.6	699.6	1.0	1.1	1.8	5.2	17.2	25,078
Number of subclasses sold	1.6	1.9	1.0	1.0	1.0	1.5	2.7	25,078

By sector

We have 25,078 firms and a total of 22,954,628 supplier-client-variety triplets

Descriptive statistics (supplier characteristics by sector)

Table 2: Supplier characteristics by economic sector

	Mean	Std. Dev.	p10	p25	p50	p75	p90	Obs.
1								
Average sales (CLP millions)	951	14,948	7	20	85	335	1,247	7,454
Number of customers	3.1	11.5	1.0	1.0	1.1	2.1	5.1	7,454
Number of subclasses sold	1.3	1.3	1.0	1.0	1.0	1.0	1.8	7,454
2								
Average sales (CLP millions)	95,645	805,937	43	125	372	1,329	5,040	234
Number of customers	5.6	26.5	1.0	1.0	1.4	2.6	6.8	234
Number of subclasses sold	1.2	0.6	1.0	1.0	1.0	1.0	1.6	234
3								
Average sales (CLP millions)	3,926	60,147	8	25	96	402	2,013	16,864
Number of customers	34.9	852.9	1.0	1.3	2.5	7.5	23.9	16,864
Number of subclasses sold	1.8	2.1	1.0	1.0	1.0	1.7	3.1	16,864
4								
Average sales (CLP millions)	4,157	32,407	3	7	25	120	1,164	526
Number of customers	8.7	42.1	1.0	1.2	2.1	5.2	12.9	526
Number of subclasses sold	1.2	0.8	1.0	1.0	1.0	1.0	1.4	526
Total								
Average sales (CLP millions)	3902.6	92937.2	7.6	22.8	92.0	381.4	1714.4	25,078
Number of customers	24.6	699.6	1.0	1.1	1.8	5.2	17.2	25,078
Number of subclasses sold	1.6	1.9	1.0	1.0	1.0	1.5	2.7	25,078

Note: 1 “Agriculture” 2 “Minning” 3 “Manufacture” 4 “Utilities”

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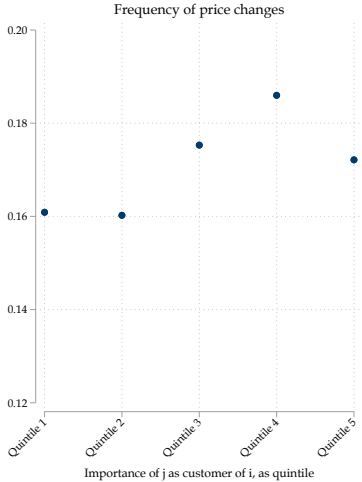
Descriptive statistics (supplier characteristics, subsample)

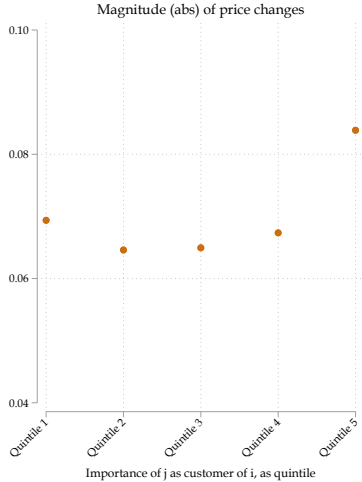
Table: Supplier characteristics - Subsample

	Mean	Std. Dev.	p10	p25	p50	p75	p90	Obs.
Average sales (CLP millions)	13,134	118,547	24	90	404	2,088	12,585	4,109
Number of customers	123.9	1724.5	1.5	3.1	8.4	25.0	75.1	4,109
Number of subclasses sold	4.3	3.6	2.1	2.4	3.1	4.7	7.7	4,109

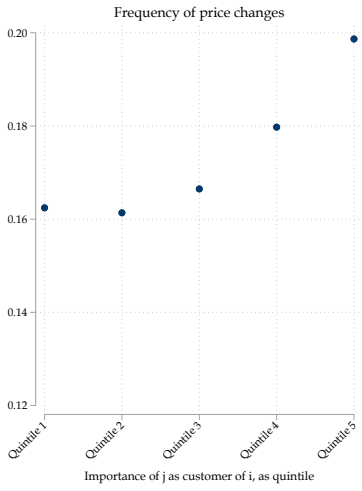
Firms selling more than one subclass

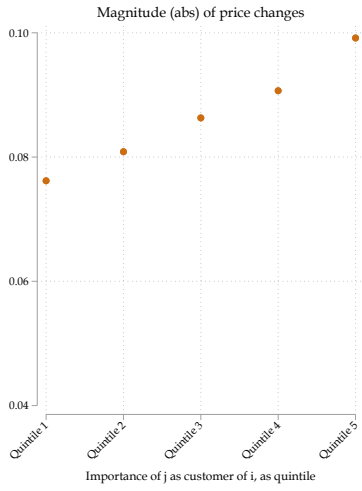
Frequency/magnitude price adj. and customer market share product level



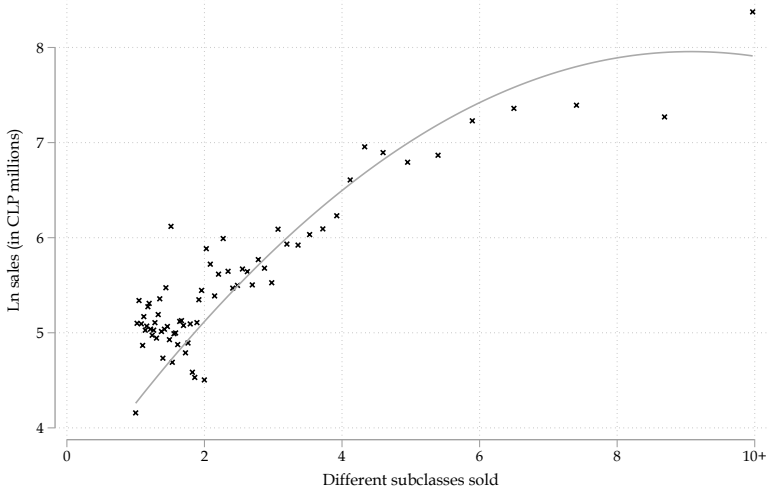


Frequency/magnitude price adj. and customer market share (product truncated)





Size and subclasses



Frequency and size (no controls)

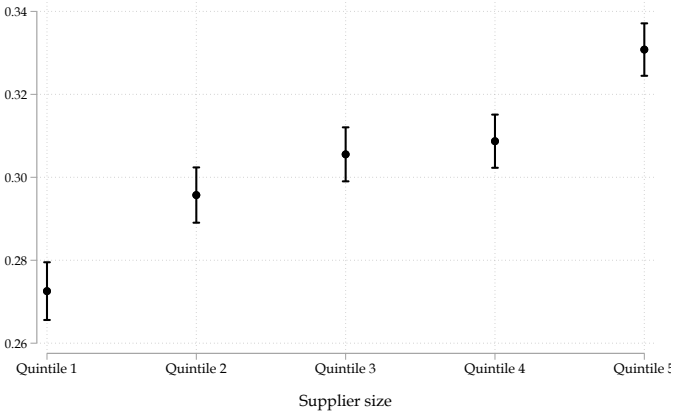


Figure: This figure plots the coefficients of a regression with frequency price adjustment, at the *ijs* level, as the dependent variable and size quintile dummies as independent variables.

Frequency and size (controlling for # products)

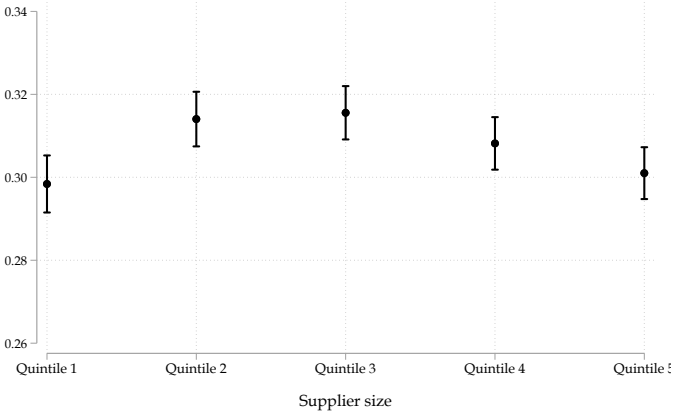
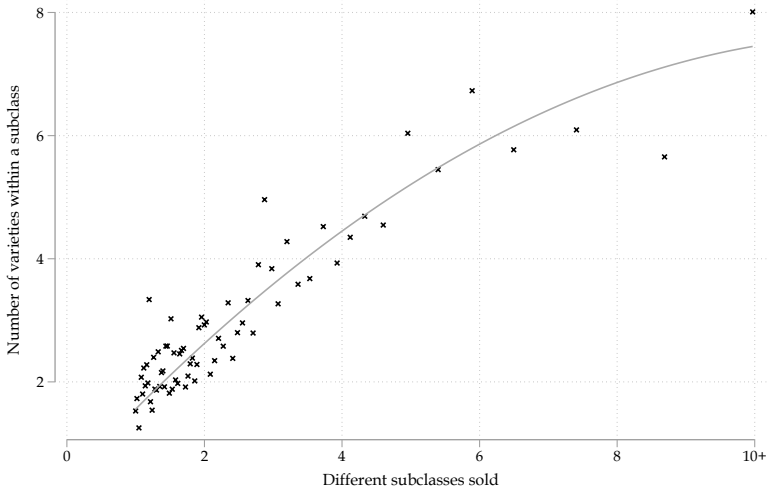
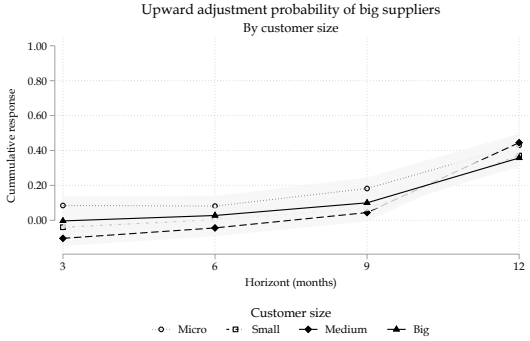


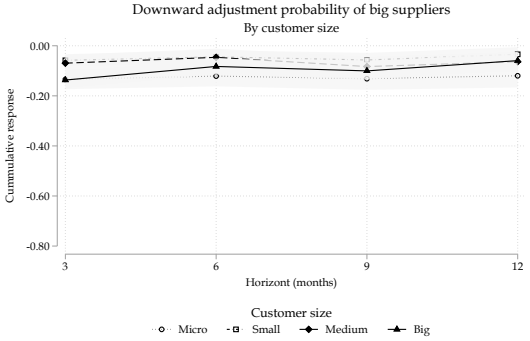
Figure: This figure plots the coefficients of a regression with frequency price adjustment, at the *ijs* level, as the dependent variable and size quintile dummies as independent variables.

Variety and subclasses

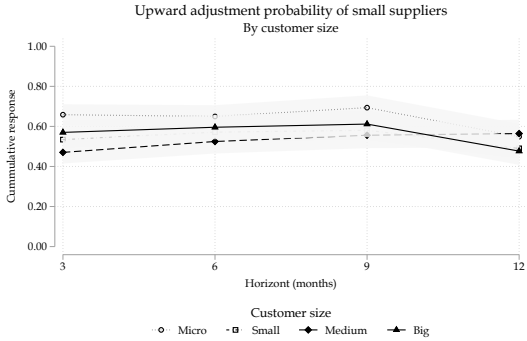


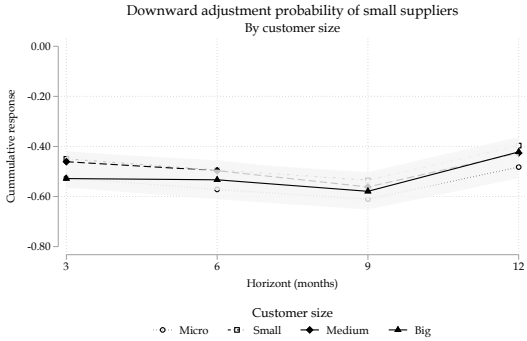
Customer size - big suppliers





Customer size - small suppliers





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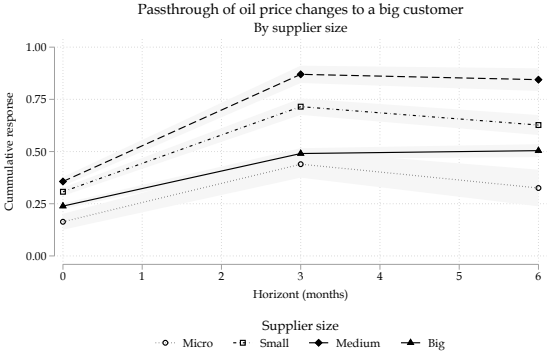
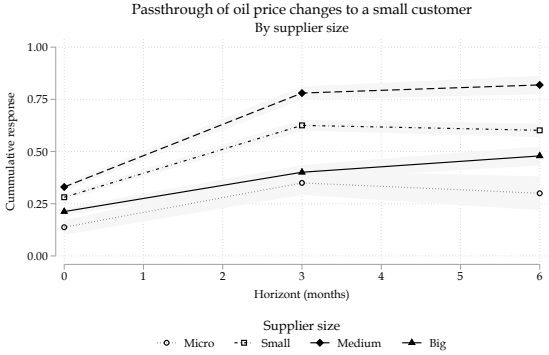
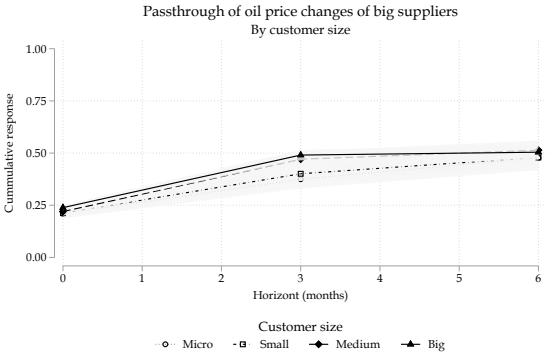
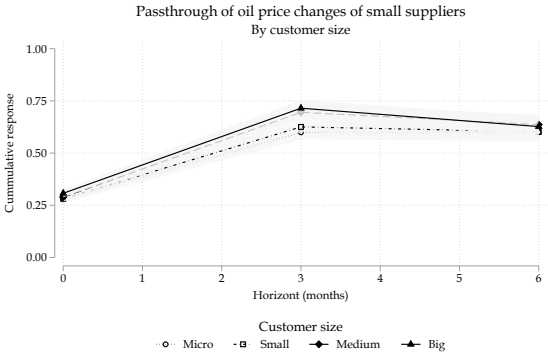
Price passthrough: supplier size





Price passthrough: customer size





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Cross-sectional heterogeneity in frequency/magnitude price change

role of supplier-client-product characteristics

Heterogeneity in unconditional frequency price change

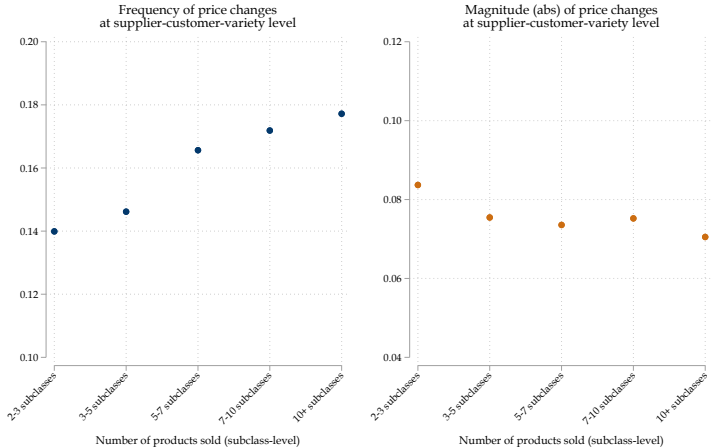
We assess the empirical relationship between firm-to-firm frequency/magnitude of price adjustment

$$y_{ijs} = \alpha \cdot \mathbf{X}_i + \beta \cdot \mathbf{Y}_j + \gamma \cdot \mathbf{Z}_{ij} + \epsilon_{ijs}$$

where y_{ijs} is *i*) the average frequency of price change of supplier i to client j in the subclass s, or *ii*) the average log change in the price of supplier i to client j in the subclass s.

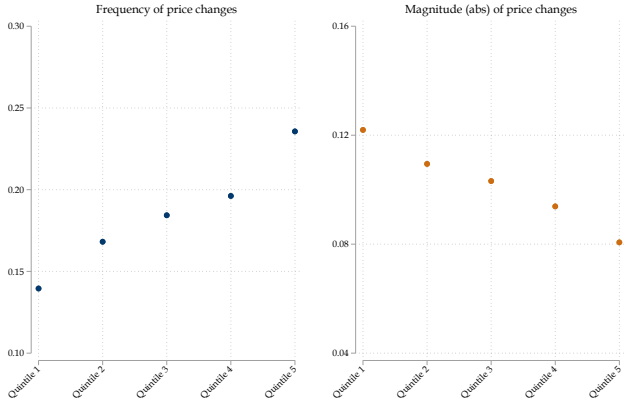
The vectors $\mathbf{X}, \mathbf{Y}, \mathbf{Z}$ contain supplier, client, and supplier-client characteristics, respectively.

Frequency/magnitude price adj. and # of products sold



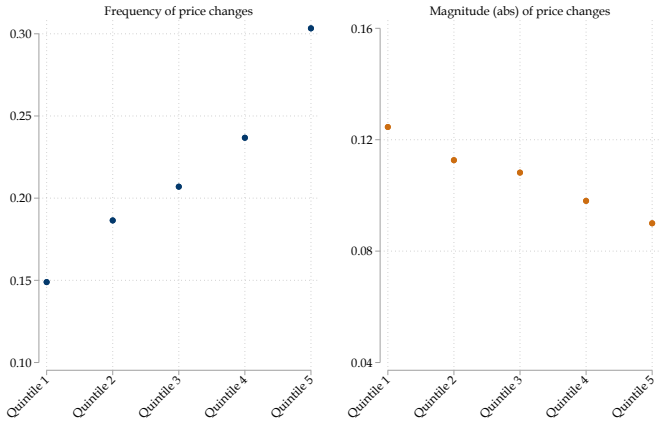
As in Bhattarai and Schoenle (2014): multiproduct firms adjust more frequently and in less magnitude (economies of scope in menu costs)

Frequency/magnitude price adj. and total sales



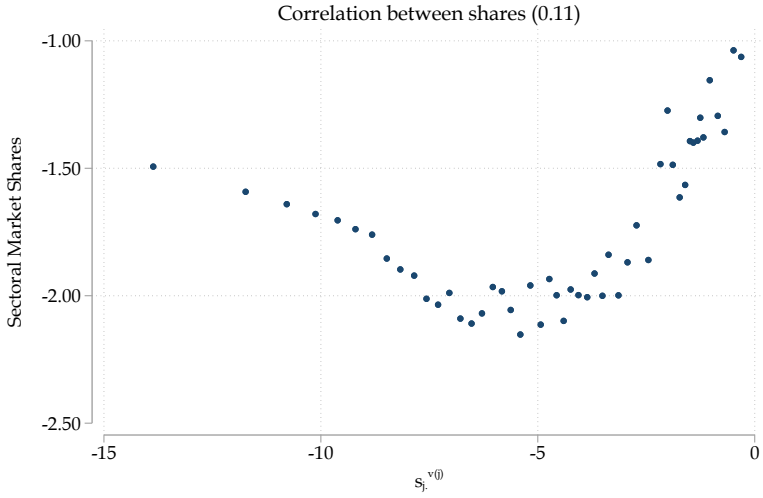
- As in Goldberg and Hellerstein (2011) large firms adjust more frequently and in smaller magnitude (e.g.,returns to scale in price setting or better information; Zbaracki et al., 2004)
- Similar when considering industry/product market share

Frequency/magnitude price adj. and sales (one-product firms)



Size matters beyond its association to multiproduct firms Back

Market share vs supplier-client market share



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