Minimum Wage Pass-through to Wholesale and Retail Prices: Evidence from Matched Scanner Data

Carl Hase

Goethe University Frankfurt
JGU Mainz

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Motivation

- The pass-through rate of costs to prices is a central parameter in evaluating 'who pays' for policies and cost shocks
- Examples include
  - Tax incidence (Marion and Muehlegger, 2011; Fabra and Reguant, 2014; Ganapati et al., 2020; Hollenbeck and Uetake, 2021)
  - Distributional impacts of trade policy (Amiti et al., 2019; Fajgelbaum et al., 2020)
  - Effects of labor market policies (Renkin et al., 2020; Leung, 2021; Harasztosi and Lindner, 2019)

Motivation

- Cost shocks often affect upstream *and* downstream firms (e.g. federal or state minimum wage laws, business taxes, energy cost shocks)
- There can be a compounding effect, with downstream firms subject to two shocks:
  1. **Direct cost shock**
  2. **Indirect cost shock** due to higher intermediate goods prices from upstream pass-through
- The scope of the direct and indirect cost shocks can diverge with implications for pass-through rates
- Little work exists on the transmission of vertical cost shocks and the implications for downstream pass-through

This paper

- **Investigate the impact of minimum wage increases on wholesale and retail prices in the legal recreational cannabis industry**
- Use scanner-level data on $6 billion of transactions from 1,192 producers and retailers in Washington state
- Exploit geographic variation in MW exposure across three predetermined MW hikes between 2018 and 2021
- Use DiD with continuous treatment framework to estimate effect of MW hikes on wholesale and retail prices
- Leverage a mismatch in the scope of the direct and indirect cost shocks downstream to investigate cost pass-through rates

Main findings

1. A 10% MW hike causes a 1.7% increase in wholesale prices
   - No substitution by retailers $\rightarrow$ confirms that retailers face an indirect cost shock from the MW hike
2. Retail prices increase by
   - 2.1% from the direct (i.e. labor) cost shock
   - 1.2% from the indirect (i.e. wholesale) cost shock
3. Strategic complementarity in prices drives a wedge between pass-through rates for the direct and indirect cost shocks
   - This reflects that the direct cost shock is an aggregate shock while the indirect shock is idiosyncratic to specific retailers

Cannabis industry

- Approx. 50% of US states have legal recreational cannabis markets, $25 billion in annual sales
- Washington state market established in 2014, now one of the largest agricultural products in the state
- 30-40% of adults in WA regularly consume cannabis (Washington State Department of Health, 2024)

Cannabis is an ideal laboratory

- Clearly defined vertical relationships between upstream producers and downstream retailers
  Supply chain
  - 508 cannabis retailers and 692 producers in WA
- High minimum wage exposure
- No cross-border trade e.g. to Oregon, California, Colorado, etc. $\rightarrow$ upstream and downstream firms subject to same MW hikes
- Rich scanner data provides a close-up of price dynamics for the universe of products **at both the wholesale and retail levels**

WA state minimum wage

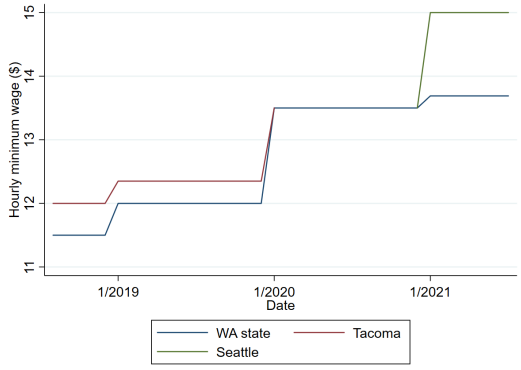


Figure 1: Minimum wage hikes in WA state, August 2018 - July 2021

Price data

- Source: Top Shelf Data, June 2018-August 2021
- At the transaction level, the scanner data contains:
  - The **price and quantity of each product sold by a producer to a retailer**
  - The subsequent **price and quantity of that very same product sold at the retail level**
- **Dependent variable**: establishment-level Young price index that aggregates price changes across product subcategories (see Renkin et al., 2020; Leung, 2021; Harasztosi and Lindner, 2019)

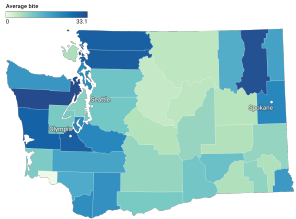
$$\pi_{j,t} = \ln I_{j,t}, \text{ with } I_{j,t} = \prod_{c} I_{c,j,t}^{\omega_{c,j,y(t)}} \tag{1}$$

- $\pi_{j,t}$: the month-over-month change in prices at a given store

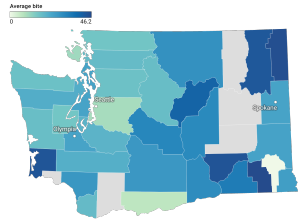
Sample overview

Continuous treatment variable

- Similar to Card (1992); Dustmann et al. (2022); Bossler and Schank (2022)
- **MW bite**: share of FTE workers earning below the new minimum wage two quarters before the hike, at the industry-by-county level



(a) NAICS 111 (crop production, incl. marijuana)



(b) NAICS 453 (misc. store retailers, incl. marijuana stores)

Figure 2: Avg. bite two quarters before MW hike

Notes: Data from Washington ESD, 2018-2021.

▸ Balance check ▸ Compliance

Strategic complementarity in prices

- In oligopolistic settings, the price a firm sets is a function of its own costs and the costs of its competitors

- Growing empirical literature finds rival costs are an important component of cost pass-through (Muehlegger and Sweeney, 2022; Amiti et al., 2019)

- Therefore, I assign a second treatment intensity variable equal to the average bite of competing stores within 30 miles (weighted by inverse distance)

Empirical strategy

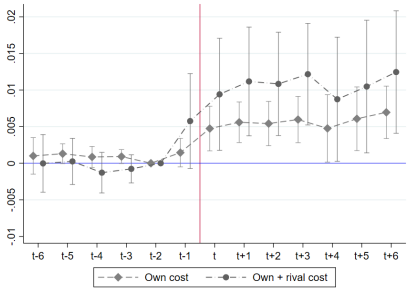
- DiD with continuous treatment (Bossler and Schank, 2022; Renkin et al., 2020)

$$\pi_{j,t} = \underbrace{\sum_{l=-5}^{6} \beta_l \Delta MW_{j,t-l} \times Bite_{k(j),t-l}}_{\text{Direct pass-through, own-cost}} + \underbrace{\sum_{l=-5}^{6} \delta_l \Delta MW^{n}_{j,t-l} \times Bite_{n(j),t-l}}_{\text{Direct pass-through, strategic}} + \gamma_t + \epsilon_{j,t} \quad (2)$$

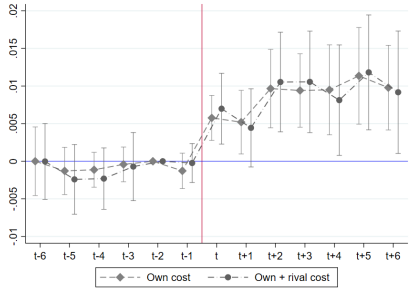
- $\beta_l + \delta_l$: own-cost pass-through + strategic complementarity in prices

- SE clustered by county to allow for autocorrelation in unobservables within counties

Main results - Direct effect



(a) Retail prices



(b) Wholesale prices

Notes: Both panels show cumulative price level effects E_L, relative to the normalized baseline period $t - 2$, with SE of the sums clustered at county level. Data: Top Shelf Data (August 2018-July 2021) and Washington ESD, 2018-2021.

Robustness checks

- Results are robust to extending the event window ▸ Extended window
- Robust to restricting to a balanced panel, accounting for outliers, alternative price index weights, seasonality, region x time FE, accounting for minimum wage compliance ▸ Whole table ▸ Retail table
- Robust to alternative rival specifications and weighting ▸ Rivals table

Taking stock

- Effect on wholesale prices entirely due to own-cost shock
  - Producers sell a tradable good and do not compete in local markets $\rightarrow$ MW hike is not a locally aggregate cost shock for producers
- Strategic complementarity in prices doubles the direct effect on retail prices
  - In line with Muehlegger and Sweeney (2022) and Amiti et al. (2019) who find that 50% of cost pass-through is from strategic complementarity in prices
  - Retailers compete in well-defined local markets $\rightarrow$ MW hike is an aggregate cost shock in these markets
  - Still does not account for indirect effect

Indirect effect

- Estimate product-level linear panel regression in logs (Hollenbeck and Uetake, 2021)

$$\Delta p_{i,j,t} = \alpha \Delta w_{i,j,t} + \sum_{r=1}^{R} \beta_r \Delta w_{i,r,t} + \gamma_t + \Delta \varepsilon_{i,j,t}. \tag{3}$$

Table 1: Wholesale cost pass-through rate

	(1) FD logs	(2) Logs	(3) FD dollars	(4) Dollars
Own wholesale cost	0.736***	0.762***	1.74***	1.11**
	(0.010)	(0.011)	(0.052)	(0.459)
Competitors' wholesale cost (0-30 miles)	0.016***	0.051**	0.073***	0.449***
	(0.006)	(0.020)	(0.025)	(0.139)
N	2,290,818	3,239,632	2,290,818	3,239,632

- Implied indirect pass-through elasticity of $0.74 \times 0.17 = 0.12$ (P-value: 0.002)
  - Similar results found with reduced-form shift-share instrument Shift share

Cost pass-through rates

- Taken alone, the pass-through elasticities are not informative about cost pass-through rates
- I derive MW-induced MC pass-through rates in three steps:

1. Extend general theoretical model from Renkin et al. (2020)
   - Illustrates the relationship between the MW elasticity of prices and the MW elasticity of MC at constant output
2. Empirically calibrate model using DiD estimates and cost shares
3. Derive implied cost pass-through rates for different components of MC

▸ Model ▸ Labor elasticity of cost ▸ COGS elasticity of cost

Cost pass-through rates

- MW-induced MC pass-through rate (COGS component of MC):

$$\hat{\rho}_{cogs} = \frac{\hat{\eta}^{p}_{cogs}}{\hat{\eta}^{mc}_{cogs}} = 0.99$$

- MW-induced MC pass-through rate (labor component of MC):

$$\begin{aligned} \hat{\rho}_{L} = \frac{\hat{\eta}^{p}_{L}}{\hat{\eta}^{mc}_{L}} &= 1.54 \quad \text{without strategic complementarity in prices} \\ &= 3.09 \quad \text{with strategic complementarity in prices} \end{aligned}$$

  - 3.09 is similar $\hat{\rho}_{L}$ to Renkin et al. (2020)

- **The difference between $\hat{\rho}_{cogs}$ and $\hat{\rho}_{L}$ reflects that the direct (i.e. labor cost) cost shock is an aggregate shock while the indirect (i.e. COGS) shock is idiosyncratic to individual retailers**

Conclusion and discussion

- A single policy (MW hike) induces multiple cost shocks for cannabis retailers
- Direct and indirect shocks differ in scope due to a mismatch in tradability upstream vs downstream
  - The direct cost shock is an aggregate shock $\rightarrow$ magnified by strategic complementarity in prices
  - The indirect cost shock is idiosyncratic to individual retailers $\rightarrow$ no strategic price effect
  - This gives rise to different pass-through rates for the different cost shocks
- **The vertical scope of a policy or cost shock affects the pass-through rate recovered**

Conclusion and discussion

- The implications of my findings extend beyond the context of this paper
  - High pass-through rates are observed in many settings (Leung, 2021; Renkin et al., 2020; Marion and Muehlegger, 2011; Conlon and Rao, 2020)
  - Differences in tradability upstream vs. downstream are common in many sectors
    - Interstate commodity flows dominate within-state flows in most manufacturing and wholesale trade sectors Commodity flows
    - 80% of retail sales are in brick-and-mortar stores (Statista, 2023)
- The cannabis industry similar to traditional retail sectors in terms of variable cost structure and (to a certain extent) demand elasticities (Hollenbeck and Uetake, 2021)

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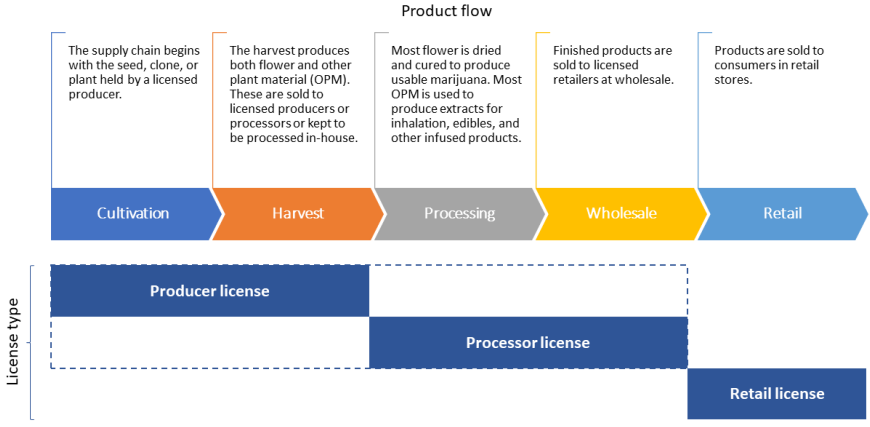

Figure 4: Cannabis supply chain and market structure in WA state

Table 2: Sample overview

	Retail	Wholesale
Establishments	508	692
Units sold	232,133,427	228,423,415+
Distinct products	172,688	147,273
Total revenue	$4.47 billion	$1.46 billion
Monthly revenue per establishment	$304,032	$106,634

Data source: Top Shelf Data (August 2018 - July 2021).

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Table 3: Market share by product category

	Retail	Wholesale
Usable marijuana	0.53	0.61
Concentrate for inhalation	0.31	0.28
Solid edible	0.07	0.03
Liquid edible	0.03	0.02
Infused mix	0.04	0.04
Other	0.02	0.02

Notes: This table shows market shares for the product categories defined by the LCB. Market shares are calculated using the estimation sample which runs from August 2018 through July 2021. "Other" includes any category with less than 1 percent market share. These are: topical, packaged marijuana mix, capsules, tinctures, transdermal patches, sample jar, and suppository. Sales from processor-only licenses are excluded. Sales between wholesalers are included. Data source: Top Shelf Data.

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Table 4: Pre-treatment summary statistics

	Retail		Producer-processor	
	(1) Low bite	(2) High bite	(3) Low bite	(4) High bite
Unit price (in dollars)	26.85	26.59	11.41	11.68
	(4.83)	(5.13)	(11.04)	(5.90)
Unit price growth (percent)	0.2	0.1	0.2	0.2
	(3.5)	(3.0)	(6.3)	(6.6)
Monthly revenue (in dollars)	223,571	254,589	76,305	81,795
	(258,136)	(245,064)	(215,746)	(238,092)
Unique products per month	381	410	62	45
	(316)	(345)	(170)	(127)

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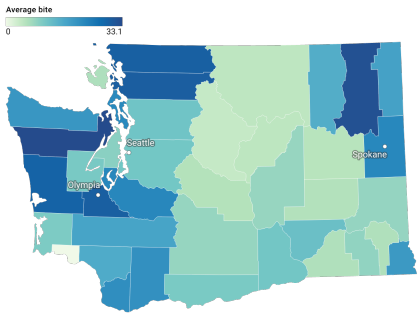
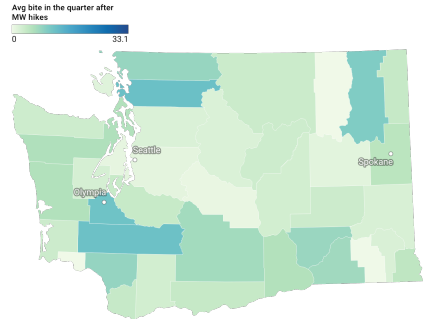


(a) Avg. bite two quarters before MW hikes



(b) Avg. bite in the quarter after MW hikes

Figure 5: Avg. bite for NAICS 111 (crop production subsector)

Notes: Data from Washington ESD, 2018-2021.

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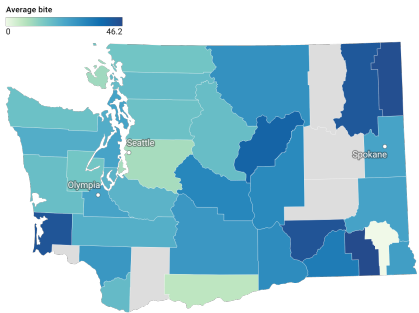

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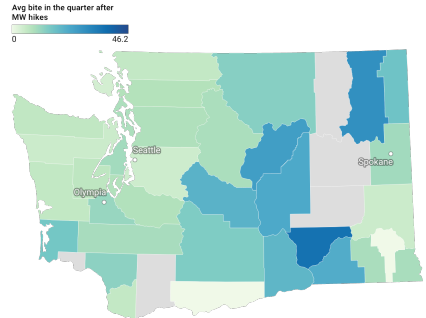

(b) Avg. bite in the quarter after MW hikes

Figure 6: Avg. bite for NAICS 453 (misc. store retailers)

Notes: Data from Washington ESD, 2018-2021.

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Table 5: Annual gross wages in the Washington state cannabis industry

Year	Wholesale			Retail			All private inds.	Min. wage
	Cannabis Wholesale	NAICS 111	NAICS 111419	Cannabis Retail	NAICS 453	NAICS 453998		
2018	$27,906	$28,804	$28,371	$26,126	$28,116	$31,848	$66,156	$23,920
2019	$29,713	$30,499	$30,417	$27,468	$29,798	$32,922	$57,185	$24,960
2020	$32,315	$33,026	$33,459	$29,534	$32,847	$34,847	$76,801	$28,080

Notes: This table compares average annual gross wage for workers at cannabis establishments for the years 2018-2020. Average annual gross wage is obtained by dividing total wages by average covered employment. Minimum wage is based on 2,080 hours per year. Data for 2021 is not available. Data from Washington state ESD.

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Table 6: COGS and the labor share of costs for cannabis retailers

	Average expenditure		Variable cost share	
Year	Labor	COGS	Labor	COGS
2018	$324,582	$702,358	0.32	0.68
2019	$370,897	$1,187,462	0.24	0.76
2020	$407,273	$1,584,301	0.20	0.80

Notes: This table compares average annual labor expenditure and COGS expenditure for cannabis retail establishments in Washington state for the years 2018-2020. Labor expenditure equals total wages divided by the number of active retail establishments. Establishments with missing UI data are excluded from total wages and establishment counts. COGS is the average annual wholesale expenditure for cannabis retailers in the estimation sample. Wholesale purchases from processor-only licenses are included. Data from Washington state ESD, Top Shelf Data, and High Peak Strategy (2018-2020).

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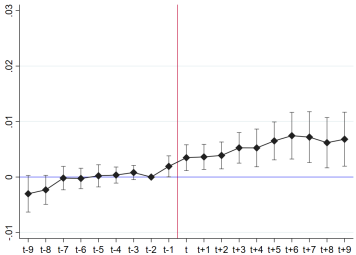
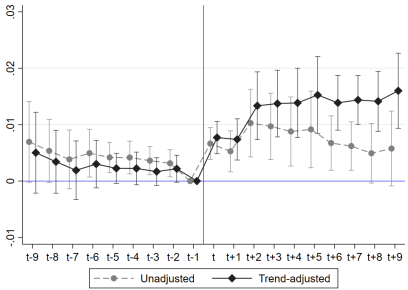


(a) Retail prices



(b) Wholesale prices

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Table 7: Wholesale prices

	Trend-adjusted						Unadjusted		
	(1) Baseline	(2) Controls	(3) County trends	(4) Wins-orized	(5) Outliers	(6) Trim-med bite	(7) Reg.-time FE	(8) Baseline	(9) t-1 base
E_0	0.006***	0.006***	0.004**	0.006***	0.005**	0.006***	0.006**	0.004**	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
E_2	0.010***	0.010***	0.006**	0.010***	0.010***	0.010***	0.009**	0.007**	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)
E_4	0.009***	0.010***	0.005	0.010***	0.010***	0.010***	0.006	0.005	0.007**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
$\sum$ Pre-event	1.0e-07	-2.0e-04	0.003	1.0e-07	2.0e-07	2.0e-07	1.0e-04	0.003	0.005*
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
N	14,777	14,777	14,777	14,932	14,932	14,735	14,777	14,777	14,777
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	NO	YES	YES	NO	NO	NO	YES	NO	NO

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data from Washington ESD and Top Shelf Data, July 2018-August 2021.

Table 8: Retail prices

	(1) Baseline	(2) Estab. trends	(3) Reg.-time FE	(4) Winsor-ized	(5) Outliers	(6) Trim-med bite
E_0	0.005**	0.005**	0.004**	0.003**	0.003**	0.005**
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
E_2	0.005***	0.006**	0.005**	0.003**	0.003**	0.005***
	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
E_4	0.005*	0.005	0.005	0.004**	0.003	0.004
	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)
$\sum$ Pre-event	0.001	0.001	0.001	-0.0002	0.0008	0.001
	(0.002)	(0.002)	(0.001)	(0.0009)	(0.001)	(0.002)
N	14,189	14,189	14,189	14,044	14,189	14,095

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data from Washington ESD and Top Shelf Data, July 2018-August 2021.

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Table 9: Alteriative specifications for rival bite

	Wholesale				Retail			
	(1) No rivals	(2) 30 miles, distance weights	(3) 30 miles, revenue weights	(4) Border counties	(5) No rivals	(6) 30 miles, distance weights	(7) 30 miles, revenue weights	(8) Border counties
$\sum$ Pre-event	1.02e-07	-2.42e-05	0.00225	0.00176	0.001	-0.00002	-0.0007	0.0006
	(0.00277)	(0.00306)	(0.00289)	(0.00425)	(0.002)	(0.002)	(0.003)	(0.002)
$E_0^o + E_0^r$	0.00576***	0.00699**	0.00654**	0.00281	0.005**	0.009**	0.01**	0.007**
	(0.00182)	(0.00286)	(0.00271)	(0.00207)	(0.002)	(0.005)	(0.005)	(0.003)
$E_2^o + E_2^r$	0.00966***	0.0105***	0.00851**	0.00519	0.005***	0.01**	0.01***	0.008***
	(0.00317)	(0.00403)	(0.00398)	(0.00401)	(0.002)	(0.004)	(0.004)	(0.003)
$E_4^o + E_4^r$	0.00950***	0.00813*	0.00629	0.00777	0.005*	0.009*	0.010*	0.009*
	((0.00364)	(0.00446)	(0.00509)	(0.00526)	(0.003)	(0.005)	(0.005)	(0.004)
N	14,777	13,621	13,601	14,741	14,189	13,632	12,432	13,997

Notes: Standard errors are clustered at the county level and are shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Data from Washington ESD and Top Shelf Data, July 2018-August 2021.

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Shift-share instrument

- Weighted avg. MW exposure of wholesalers that retailer r purchases from:

$$\pi_{r,t} = \sum_{l=-6}^{5} \beta_l \Delta MW_{r,t-l} \times Bite_{k(r),t-l} + \sum_{l=-6}^{5} \psi_l JB_{r,P,t-l} + X_{k(r),t} + \theta_{k(r)} + \gamma_t + \epsilon_{r,t} \quad (4)$$

where

$$JB_{r,P,t-l} = \sum_{p=s}^{S} \alpha_{r,p} \Delta MW_{p,t-l} \times \sum_{p=s}^{S} \alpha_{r,p} Bite_{k(p),t-l} \quad (5)$$

- $\alpha_{r,p}$: share of retailer r's wholesale expenditures going to wholesaler p from $t-4$ through $t-2$

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Shift-share instrument

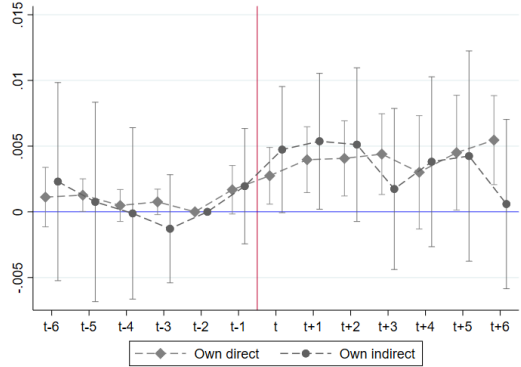

Figure 8: Indirect effect on retail prices

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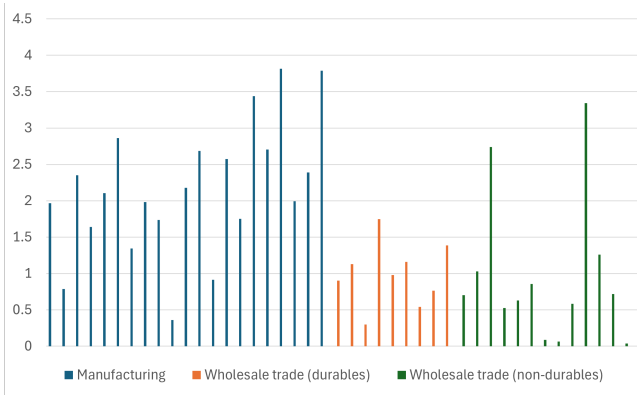

Figure 9: Ratio of out-of-state to within-state commodity flows in the 2017 Commodity Flow Survey

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Theoretical model

- Model similar to Renkin et al. (2020)
  - Homogeneous production function with competitive labor markets
  - Production technology $Q = F(L; X)$, $L = G(L_1, L_2, ..., L_N)$, $X = H(X_1, X_2, ..., X_N)$, with factor prices $P_1, P_2, ...P_N$ and $W_1, W_2, ...W_N$
  - F is homogeneous of degree h; G and H are linearly homogeneous

Estimating η_L^{mc}

- From FOCs of the firm cost minimization problem, I can derive elasticity of MC wrt MW keeping output constant
- Minimum wage elasticity of marginal cost (via labor cost):

$$\eta_L^{mc} = \frac{\partial MC}{\partial MW}\frac{MW}{MC} = \underbrace{\frac{\overline{W}L}{C}}_{(i)} \cdot \underbrace{\frac{\partial \overline{W}}{\partial MW}\frac{MW}{\overline{W}}}_{(ii)} \tag{6}$$

(i) Retailers' labor share of costs (equals 0.25)

(ii) MW elasticity of the average wage

- Estimate (ii) using TWFE as in (Renkin et al., 2020)

$$\Delta log\overline{W}_{c,q} = \beta \Delta MW \times Bite_{c,q} + \Delta\gamma_t + \Delta\epsilon_{c,q} \tag{7}$$

- $\hat{\beta} = 0.27$ (P-value: .001)

- $\hat{\eta}_L^{mc} = 0.25 \times 0.27 = 0.067$

Estimating η^{mc}_{cogs}

- Minimum wage elasticity of marginal cost (via COGS):

$$\eta^{mc}_{cogs} = \frac{\partial MC}{\partial MW}\frac{MW}{MC} = \underbrace{\frac{COGS}{C}}_{(i)} \cdot \underbrace{\frac{\partial P_w}{\partial MW}\frac{MW}{P_w}}_{(ii)} \tag{8}$$

(i) Retailers' COGS share of costs (equals 0.75)

(ii) MW elasticity of COGS $= 0.17$ (from main DiD analysis)

- $\hat{\eta}^{mc}_{cogs} = 0.75 \times 0.17 = 0.13$