Law Enforcement and Bargaining over Illicit Drug Prices: Structural Evidence from a Gang's Ledger

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Motivation

- Drug-selling gangs create major negative externalities.
  - Significant resources are spent on policing this market.
- Different law enforcement methods can affect prices and quantities throughout the supply chain in different ways.
  - But we often lack good-quality data on prices and quantities *throughout* the supply chain to understand their effects.

This Paper

- We use unique and detailed accounting data kept by the Singaporean branch of a large transnational gang.
- We estimate a structural multiproduct bargaining model between the gang and 352 pushers.
- We use the model to perform two counterfactual experiments:

1. We estimate the effect of supply-targeted enforcement.
   - We do this by exploiting a large raid that increased the gang's costs.
2. We estimate the effect of targeting pushers.
   - We also identify which types of pushers are optimal to target.

Preview of Results

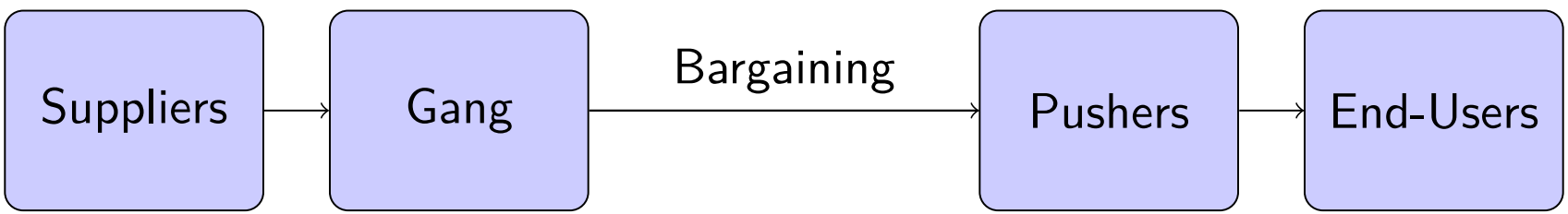
- The pushers with the least bargaining power are those with:
  - Drug addictions
  - Borrowing problems
  - No business connections
  - Shorter trade histories
- The supply raid that occurred during our sample period:
  - Increased marginal costs and wholesale prices, but
  - Had little effect on quantities.
- Targeting pushers is more effective at lowering the total quantity sold compared to targeting delivery routes.
  - Targeting those with nightclub connections is even more effective.

Related Literature

- *The effects of law enforcement in the illicit drug market*:
  - Dobkin and Nicosia (2009), Dobkin, Nicosia and Weinberg (2014), Dell (2015), Cunningham and Finlay (2016), Lindo and Padilla-Romo (2018), Gavrilova et al. (2019), Castillo et al. (2020)
- *Structural models of the illegal drug market*:
  - Jacobi and Sovinsky (2016), Galenianos and Gavazza (2017), Janetos and Tilly (2017)
- *Structural bargaining models*:
  - Ho (2009), Crawford and Yurukoglu (2012), Grennan (2013)
- *Internal finances of drug-selling gangs*:
  - Levitt and Venkatesh (2000), Lang et al. (2019)

Overview of the Supply Chain

- Drugs were transported from suppliers to the gang via *jockeys*.
- The gang sold drugs to *pushers*.
  - Pushers are independent operators.
  - They are not employees of the gang and do not receive wages.
- Pushers then sold drugs to end-users.



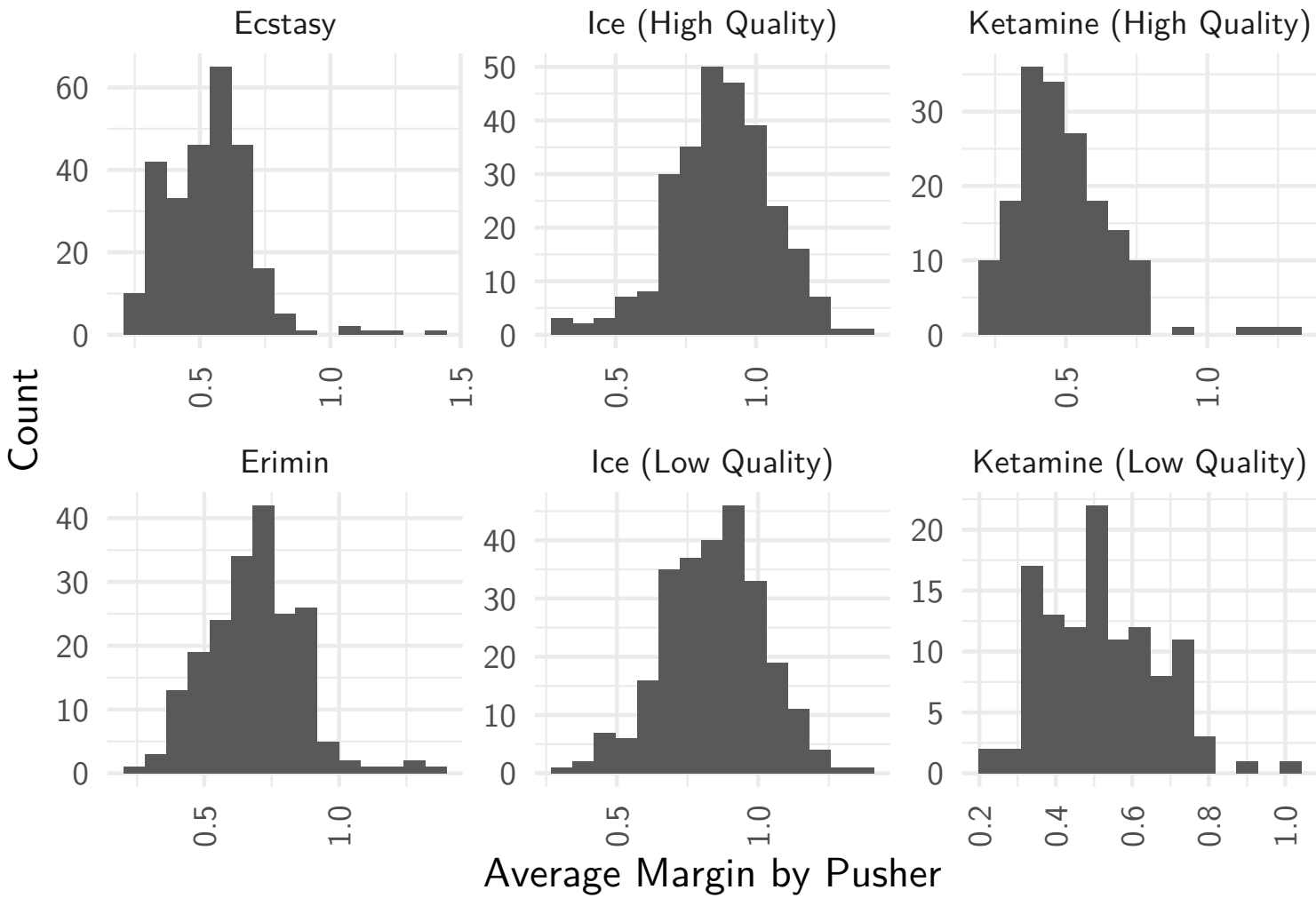
Data Overview

- In our data we observe 2,774 trades between the gang and 352 different pushers over 1 year.
- A trade can involve up to 4 drugs of varying quality levels.
  - Ecstasy, Erimin, Ice (Crystal Meth) and Ketamine.
- For each drug-quality pair in each trade, we observe:
  - The gang's unit cost.
  - The wholesale price paid by the pusher.
  - The number of units purchased.
- We observe a large number of characteristics for each pusher.
- We combine this with qualitative interviews and surveys with over 100 ex-drug offenders and users.
- From these interviews and official reports, we obtain end-user prices for each product during our sample period.

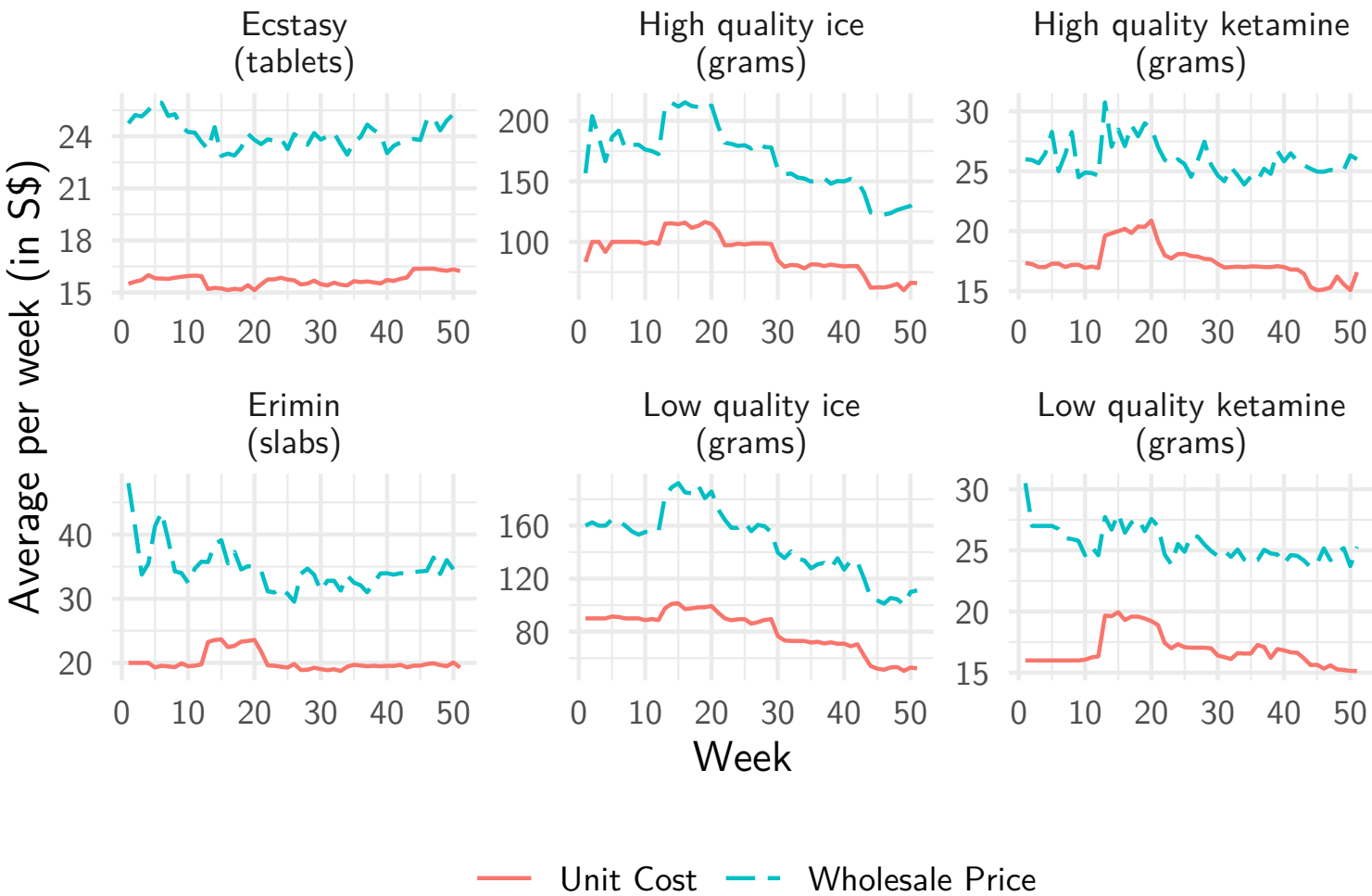
Pusher Summary Statistics

	N	Mean		N	Mean
Age	352	32.09	Monthly income (in $S)	350	858.86
Female	352	0.04	Been in prison	352	0.59
Married	352	0.12	Time spent in prison	352	2.03
Has children	352	0.27	Gang affiliation	352	0.66
Singaporean Chinese	352	0.88	Business connection with brothel	352	0.05
Malaysian Chinese	352	0.08	Business connection with KTV	352	0.38
Singapore Indian	352	0.04	Business connection with club/disco	352	0.24
Illiterate	352	0.06	Light drug addiction	352	0.39
Highest Education: Primary	352	0.38	Heavy drug addiction	352	0.30
Highest Education: Secondary	352	0.55	Been in rehab	241	0.43
Highest Education: Higher	352	0.01	Alcoholic	352	0.28
Unemployed	352	0.42	Gambling addiction	352	0.62
Employed part-time	352	0.12	Borrowing problem	352	0.58
Employed full-time	352	0.46			

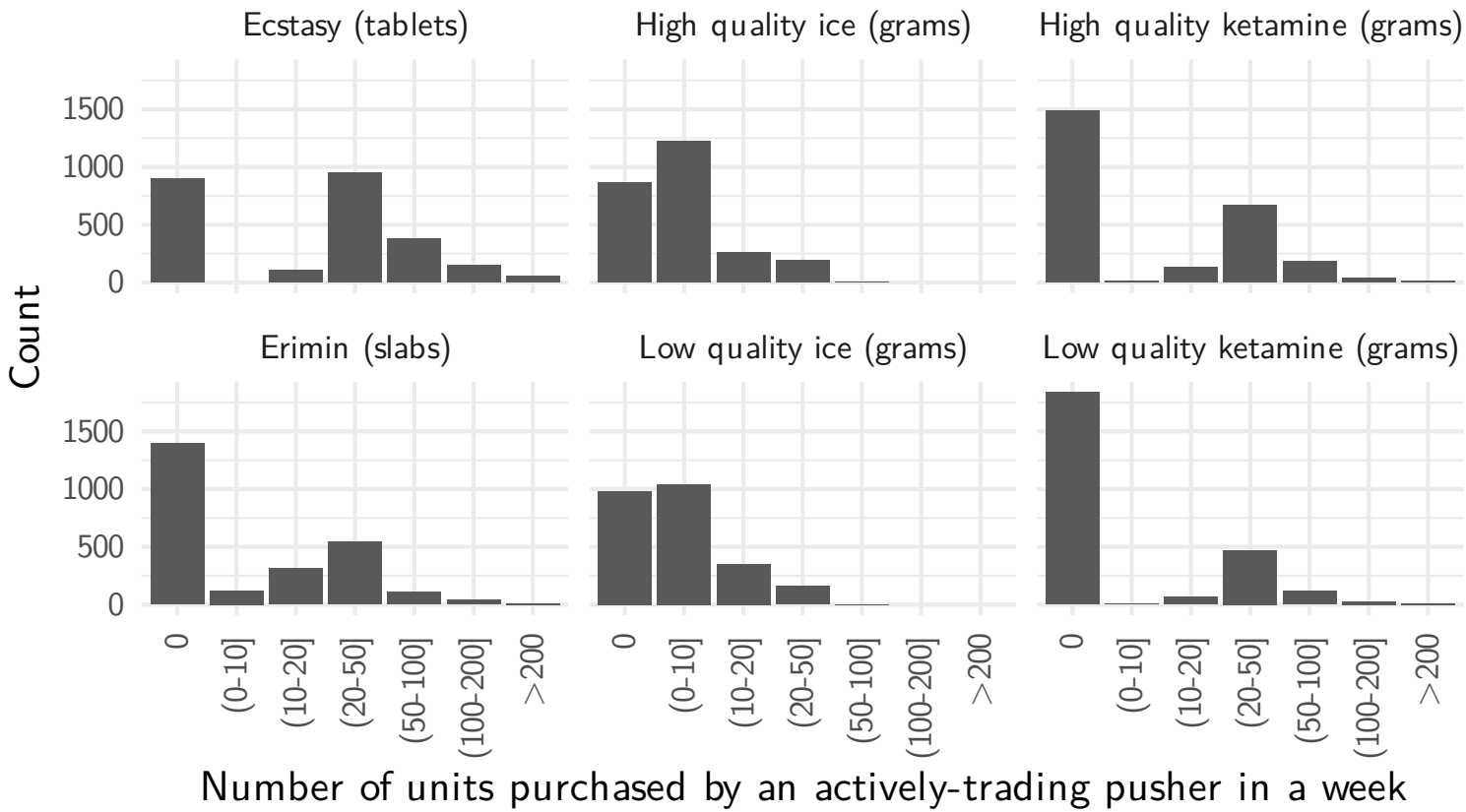
The Gang Charges Different Pushers Different Prices



Average Weekly Wholesale Prices and Unit Costs

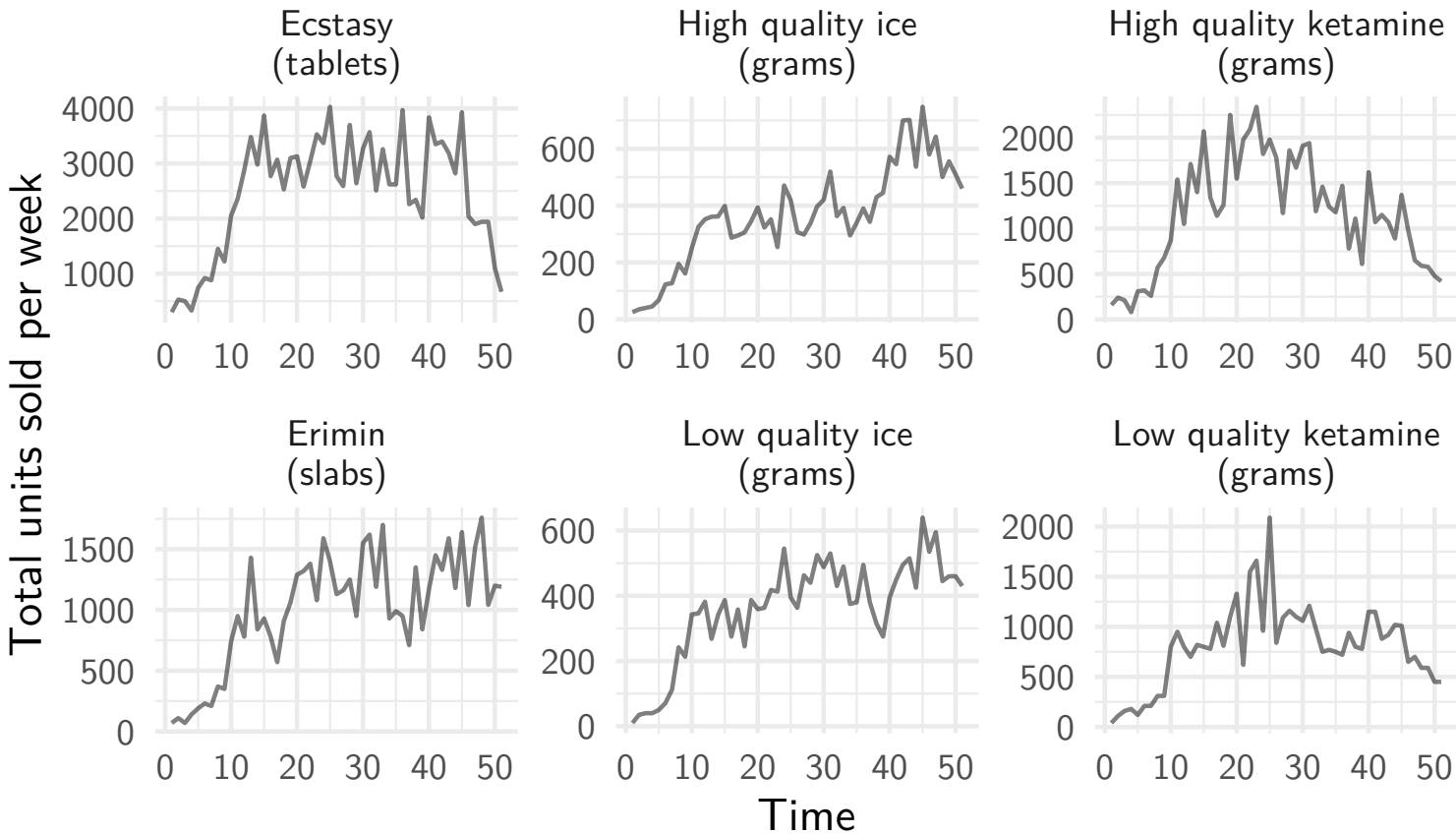


Pushers Usually Purchase Small Quantities Each Week



- Pushers only purchase a subset of all products.
- Penalties from arrest are increasing in the quantity sold.

Total Units Sold Per Week



End-User Market

- We do not observe the individual trades between pushers and end-users.
- However, from surveys and interviews, we have information about the structure of the end-user market.
- Most of the trading between pushers and end-users occurs in Geylang, Singapore's red light district:
  - Many pushers from at least 10 different gangs sell independently in different lanes of the district.
  - Very little price dispersion in the end-user market.
- We therefore assume pushers are price-takers.

Expected pusher payoffs

- Pusher i's expected payoff from purchasing quantities $\boldsymbol{q}_{it} \in \mathbb{R}_{+}^{J}$ from the gang at time t is:

$$u_i\left(\boldsymbol{q}_{it}\right) = \sum_{j=1}^{J}\left(p_{jt} - w_{ijt} - \xi_{ijt}\right) q_{ijt} - \alpha_t K_t\left(\boldsymbol{q}_{it}\right)$$

- p_{jt} is the end-user price (pusher is a price taker).
- w_{ijt} is the wholesale price.
- ξ_{ijt} are idiosyncratic cost shocks.
- α_t is the probability of arrest.
- $K_t\left(\boldsymbol{q}_{it}\right) = \frac{1}{2}\sum_{j=1}^{J} \kappa_{jt} q_{ijt}^2$ is the disutility from arrest.
- Pusher i's demand for product j is then:

$$q_{ijt}\left(\boldsymbol{w}_{it}\right) = \begin{cases} \frac{p_{jt} - w_{ijt} - \xi_{ijt}}{\alpha_t \kappa_{jt}} & \text{if } p_{jt} > w_{ijt} + \xi_{ijt} \\ 0 & \text{otherwise} \end{cases}$$

- p_{jt}, w_{ijt}, q_{ijt} are in our data.
- Parameters over ξ_{ijt} and $\alpha_t \kappa_{jt}$ are estimated.

Gang payoffs

- The gang's surplus from trading with pusher i is:

$$\pi_{it}\left(\boldsymbol{w}_{it}\right) = \sum_{j=1}^{J}\left(w_{ijt} - c_{jt}\right) q_{ijt}\left(\boldsymbol{w}_{it}\right)$$

- We use the observed unit costs for c_{jt}.
- w_{ijt}, c_{jt} and q_{ijt} are in our data.

Nash Bargaining

- Let $v_{it}(\boldsymbol{w}_{it})$ be pusher i's surplus from trading.
- The wholesale prices $\boldsymbol{w}_{it}$ are the result of Nash bargaining:

$$\boldsymbol{w}_{it} = \underset{\widetilde{\boldsymbol{w}}_{it} \in \mathcal{W}_{it}}{\arg\max} \left[\pi_{it}(\widetilde{\boldsymbol{w}}_{it})\right]^{1-\beta_{it}} \left[v_{it}(\widetilde{\boldsymbol{w}}_{it})\right]^{\beta_{it}}$$

where:

  - β_{it} is the pusher's relative bargaining weight, and
  - $\mathcal{W}_{it}$ is the set of possible wholesale prices.

- We model β_{it} as a function of pusher characteristics:

$$\beta_{it} = \Phi\left(\boldsymbol{x}_{it}'\boldsymbol{\theta}_{\beta}\right)$$

Estimation

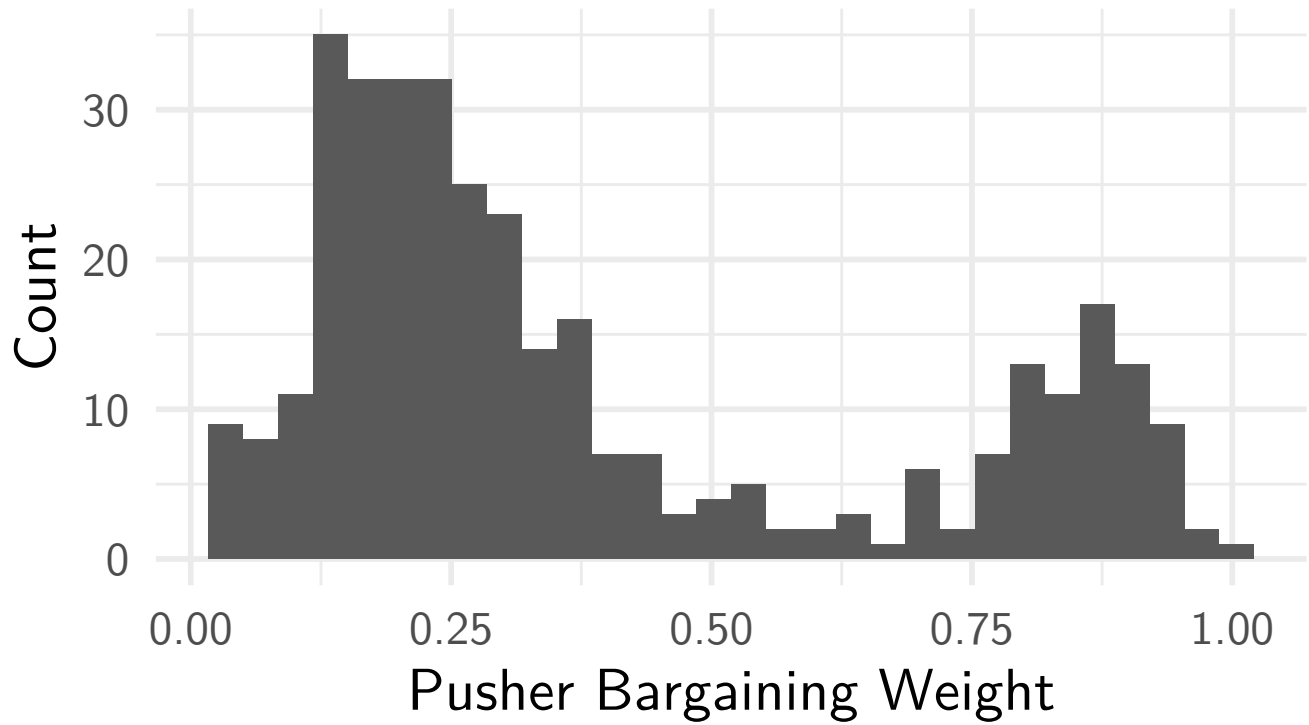
- We estimate the parameters $\boldsymbol{\theta}$ via simulated method of moments.
- For each guess $\boldsymbol{\theta}$, we draw ns paths of the cost shocks ξ_{ijt} and compute:
  - Optimal wholesale prices from Nash bargaining
  - Pusher demanded quantities
- We choose $\boldsymbol{\theta}$ to match (for each product-week combination):
  - The average wholesale price
  - The average quantity
  - The pusher participation probability

Pusher Bargaining Parameter Estimates, θ_β

Constant	−1.751	(0.080)	Club connection	1.836	(0.206)
Trade history	0.164	(0.018)	Unemployed	0.082	(0.037)
Heavy drug addict	−0.114	(0.041)	Age	0.013	(0.001)
Alcoholic	−0.055	(0.035)	Female	0.242	(0.190)
Gambling addict	0.019	(0.014)	Malaysian Chinese	−0.804	(0.233)
Borrowing problem	−0.110	(0.039)	Singapore Indian	0.098	(0.114)
Been in prison	−0.218	(0.050)	Married	−0.029	(0.042)
Gang affiliation	0.223	(0.053)	Has children	0.146	(0.059)
Brothel connection	0.807	(0.210)	Has primary education	0.070	(0.025)
KTV connection	0.157	(0.045)	Has secondary education	−0.108	(0.038)

Clustered standard errors in parentheses.

Histogram of Estimated Pusher Bargaining Weights

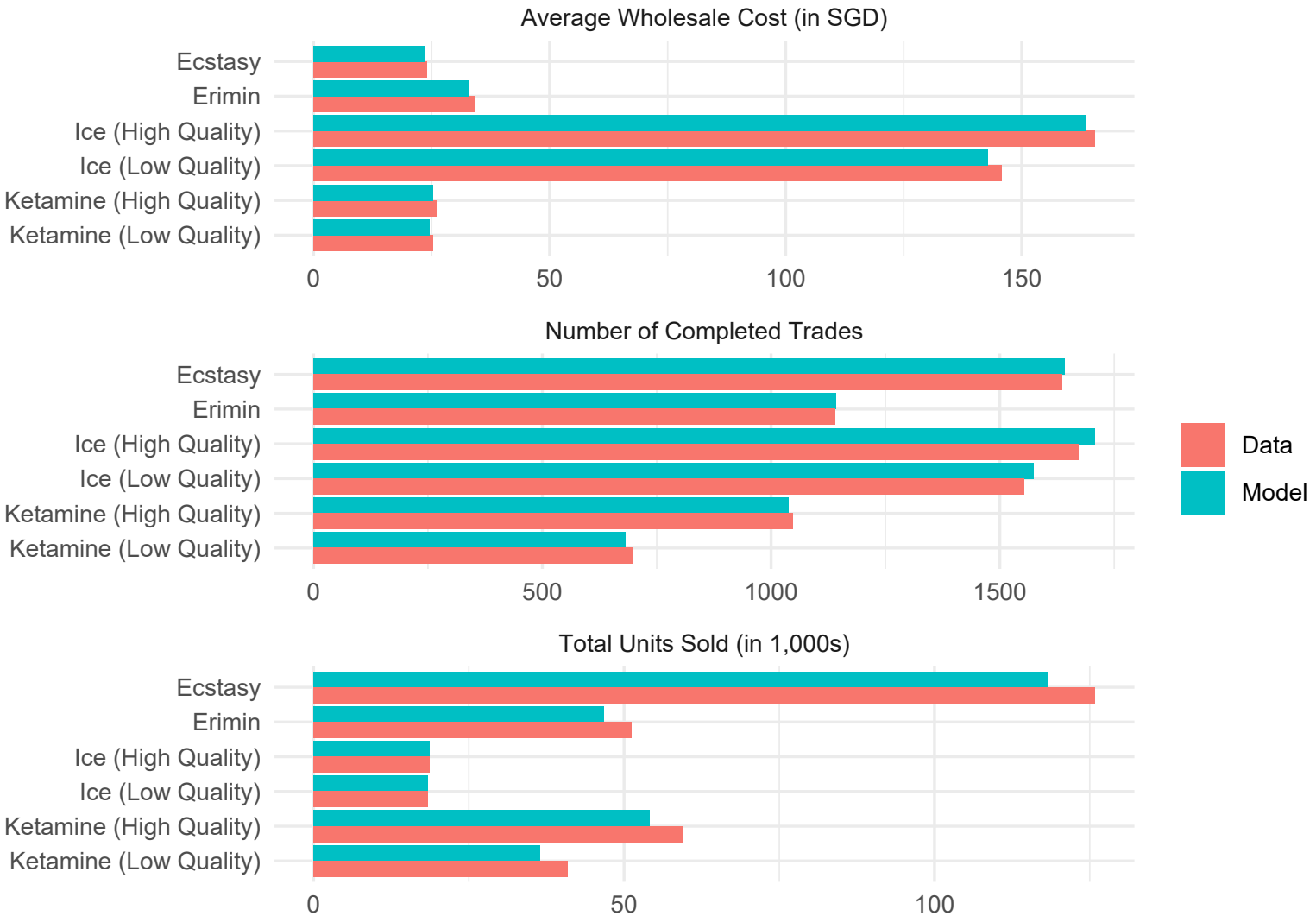


Demand Parameter Estimates

	Ecstasy	Erimin	High Quality Ice	Low Quality Ice	High Quality Ketamine	Low Quality Ketamine
Disutility κ_j	0.22	0.60	0.49	0.38	0.30	0.28
	(0.01)	(0.04)	(0.02)	(0.01)	(0.02)	(0.01)
Change during enforcement period κ_j^e	−0.03	0.01	0.17	0.21	−0.03	0.02
	(0.02)	(0.07)	(0.06)	(0.03)	(0.02)	(0.03)
Enforcement period price change θ_{ej}	−0.21	0.76	21.80	21.64	5.07	−0.17
	(0.34)	(2.19)	(1.57)	(0.63)	(0.80)	(1.37)
Pusher cost mean μ_j	10.04	57.05	20.35	21.58	32.90	40.57
	(0.08)	(0.35)	(0.36)	(0.15)	(0.12)	(0.08)
Pusher cost standard deviation σ_j	22.25	48.97	43.60	39.98	31.13	36.36
	(0.34)	(1.58)	(0.79)	(0.66)	(0.82)	(0.14)
Pusher cost autocorrelation ρ_j	0.44	0.14	0.09	0.10	0.19	0.20
	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Pusher cost correlations across products:						
Ecstasy	1.00	0.15	0.11	0.11	0.09	0.05
		(0.03)	(0.03)	(0.02)	(0.02)	(0.01)
Erimin	—	1.00	0.06	0.10	0.08	0.10
			(0.01)	(0.01)	(0.04)	(0.01)
High Quality Ice	—	—	1.00	0.19	0.13	0.12
				(0.01)	(0.04)	(0.01)
Low Quality Ice	—	—	—	1.00	0.09	0.10
					(0.01)	(0.00)
High Quality Ketamine	—	—	—	—	1.00	0.18
						(0.01)
Low Quality Ketamine	—	—	—	—	—	1.00

Clustered standard errors in parentheses

Model Fit


Average Wholesale Cost (in SGD)
Ecstasy
Erimin
Ice (High Quality)
Ice (Low Quality)
Ketamine (High Quality)
Ketamine (Low Quality)
0
50
100
150
Number of Completed Trades
Ecstasy
Erimin
Ice (High Quality)
Ice (Low Quality)
Ketamine (High Quality)
Ketamine (Low Quality)
0
500
1000
1500
Total Units Sold (in 1,000s)
Ecstasy
Erimin
Ice (High Quality)
Ice (Low Quality)
Ketamine (High Quality)
Ketamine (Low Quality)
0
50
100
Data
Model

Counterfactual I: No enforcement shock

- We simulate the trades that would have occurred if there was no supply raid:
  - Set marginal cost of affected drugs to pre-shock level.
  - No end-user price adjustment.
  - No pusher disutility adjustment.
- Total units sold in each product (in 1,000s):

	Ecstasy	Erimin	High Quality Ice	Low Quality Ice	High Quality Ketamine	Low Quality Ketamine
Enforcement shock (baseline)	118.29	46.77	18.67	18.42	54.07	36.43
No enforcement shock	115.00	47.49	18.23	18.13	52.15	37.77
Shock where only unit costs change	114.99	46.70	17.97	17.95	50.83	36.82
Shock with no end-user price adjustment	118.23	46.57	17.20	16.88	51.64	36.46

Counterfactual II: Targeting Pushers

- We suppose the authorities arrest 20 pushers in one week.
  - We choose week 26 as no other shocks occurred that week.
- We compare arresting 20 pushers randomly to arresting particular types of pushers:
  - Ex-convicts
  - Pushers with nightclub connections
- Total units sold in each product (in 1,000s):

	Ecstasy	Erimin	High Quality Ice	Low Quality Ice	High Quality Ketamine	Low Quality Ketamine
Baseline	118.29	46.77	18.67	18.42	54.07	36.43
Arrest 20 pushers randomly	114.29	45.10	18.06	17.82	52.33	35.16
Arrest 20 previously-convicted pushers	114.31	45.10	18.06	17.81	52.29	35.15
Gang hires back 20 pushers	118.16	46.71	18.65	18.40	54.01	36.39
Arrest 20 pushers with club connections	111.20	43.84	17.57	17.32	50.95	34.15
Gang hires back 20 pushers	115.59	45.70	18.26	18.02	52.88	35.62

Conclusion

- We estimate a structural bargaining model using unique accounting data kept by a large transnational gang.
- We find that a large bust in the gang's upstream delivery route:
  - Increased costs and wholesale prices, but
  - Had little effect on the total quantity sold in the market.
- In contrast, we find that targeting pushers has a larger effect on lowering the quantity sold.
  - This policy is also likely much cheaper to implement.