Collusion in the Austro-Hungarian Sugar Industry 1889–1914

PhD Research Seminar in Microeconomics

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- **RQ2:** How much did stockpiling before known price increases limit the cartelists market power?

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  - created tax revenue especially through the excise tax on sugar
- The sugar industry is still prone to cartelisation nowadays[1]

[1] Recent cartels: KR 2007, AUT 2010, GER 2014

Related Literature

- **Estimation of conduct in homogeneous good industries:** Porter (1983)
- **In particular, in the (US) sugar industry:** Genesove and Mullin (1998)
- **Factors determining cartel success:** Levenstein and Suslow (2006)

  $\rightarrow$ *We estimate conduct taking into account stockpiling dynamics* (monthly data)

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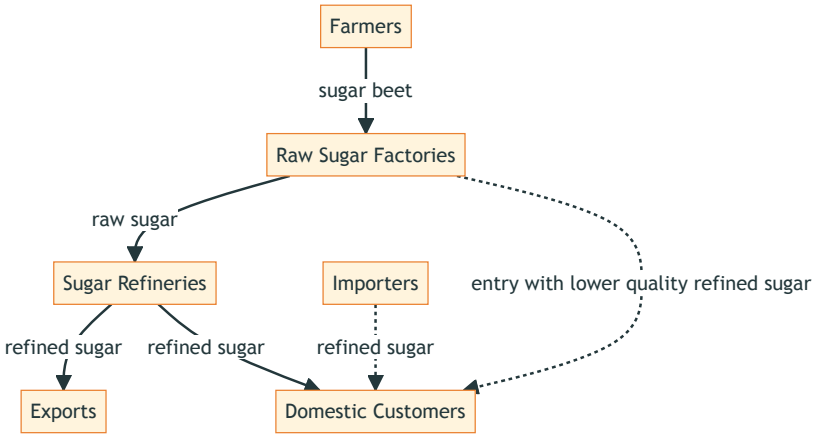
  - IV-estimates for a dynamic model of demand
- Next steps: refine cost, work on dynamic model, estimate counterfactuals

Austria-Hungary (Schober 1906)

Value Chain of the Sugar Industry



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- After the first cartels some raw sugar producers entered downstream market for refined sugar with lower quality sugar (crystal)

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- Refined sugar was storable by producers and consumers

Trade of Refined Sugar

- We consider the monarchy as a single market
- Limited competition between Cis- and Transleithania
- Transport cost small fraction of price (excl. tax, below 5%)
- Hardly any imports, but lots of export of refined sugar

Source: Schober (1906)

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- Austro-Hungarian raw sugar factories produced for the domestic market
- Raw sugar prices did not differ significantly across the empire
- World market price (as well as farmer cooperation) determined what Austro-Hungarian raw sugar producers received from refineries

Data

Industry Association

- monthly prices (raw)
- monthly prices (ref.)
- monthly quantities
- monthly Ex/Im

K. & K. Ministries

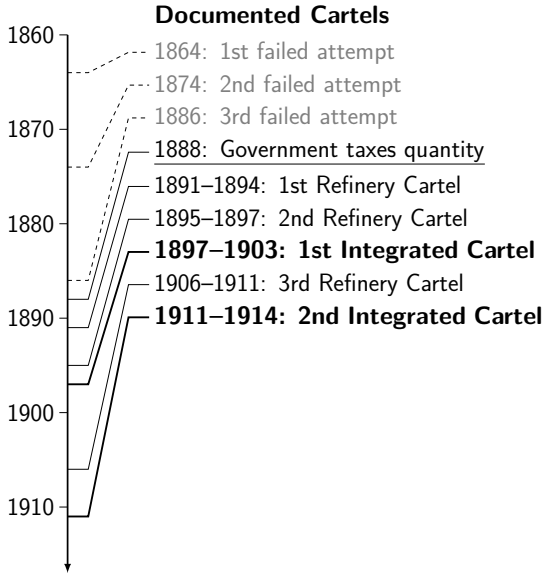
- sugar taxes
- import tariff
- export subsidy

Various

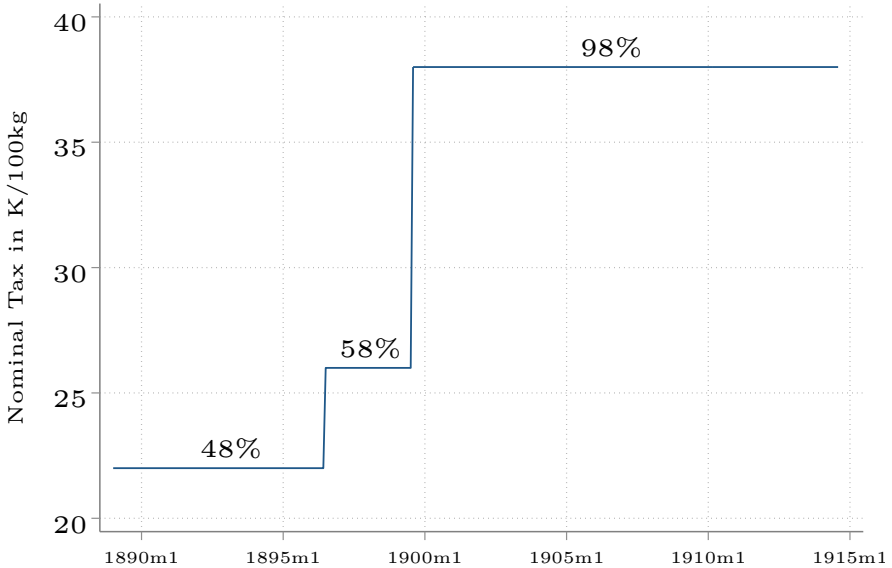
- pop: Schulze (2000)
- GDP: Schulze (2000)
- CPI: Mühlpeck et al. (1979)
- cartel periods: various

Timeline of Cartels (Fink 2016)

Cartel Agreement | Reasons for Start/End



Excise Tax for Sugar



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- Our data covers all five cartels periods

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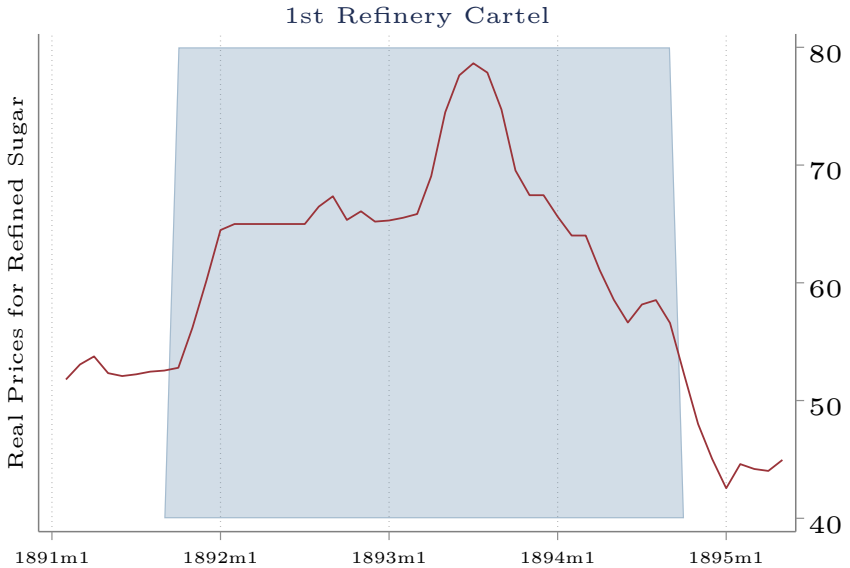
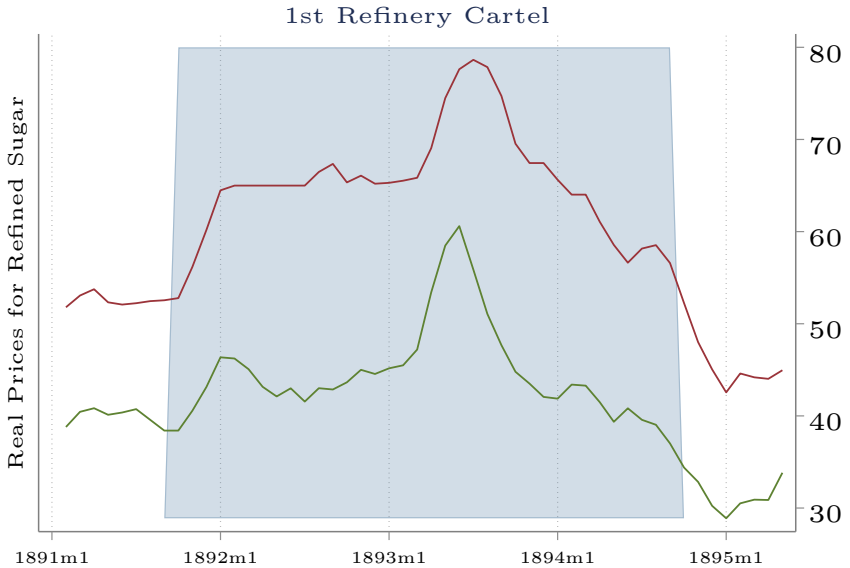
- We compare different measures of market power between cartel and non-cartel periods

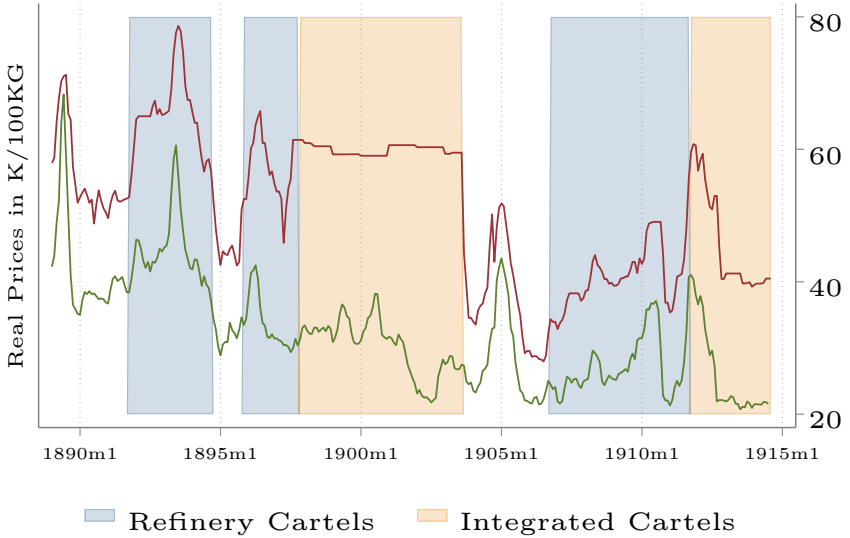
Prices - 1st Refinery Cartel



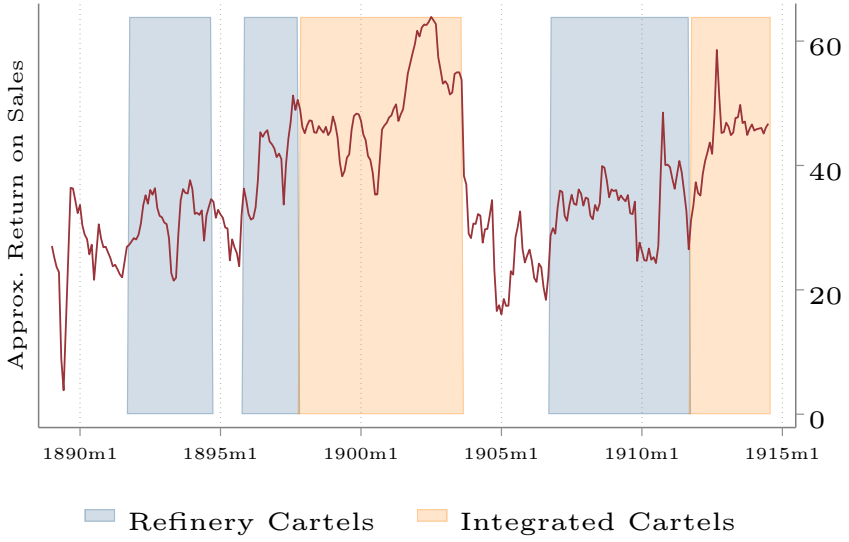
Input Prices - 1st Refinery Cartel



Input Prices - All Cartels



Approx. "Return on Sales" $\frac{P-MC}{P}$ over time



Average approx. "Return on Sales" $\frac{P-MC}{P}$

	$\frac{P-MC}{P}$
1873–1888 (note failed attempts)	31%
1889–1914 (non-cartel periods)	26%
1889–1914 (all cartel periods)	**40%**
– 1st Refinery Cartel	32%
– 2nd Refinery Cartel	41%
– 1st Integrated Cartel	49%
– 3rd Refinery Cartel	33%
– 2nd Integrated Cartel	44%

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  - Hints about level of c_0 from contemporaneous US industry

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  - $\theta = \frac{1}{N}$: symmetric Cournot with N firms

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  - Derive the corresponding pricing rule (FOC)
  - Plug in the estimated demand parameters
  - Estimate the pricing rule (supply equation)

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$$\text{Linear } (\gamma = 1) \qquad Q = \beta(\alpha - P) + \epsilon \tag{3}$$

$$\text{Log-Linear } (\alpha = 0) \qquad \ln Q = \ln(-\beta) + \gamma \ln(P) + \epsilon \tag{4}$$

$$\text{Exponential } (\gamma, \alpha \to \infty) \qquad \ln Q = \ln(\beta) + \frac{\gamma}{\alpha} P + \epsilon \tag{5}$$

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- We instrument price with raw sugar prices, taxes, and cartel dates

Implied Elasticities of Demand

Quadratic $(\gamma = 2)$	$\eta := \frac{\partial Q}{\partial P}\frac{P}{Q} = -2\frac{P}{\alpha - P}$
Linear $(\gamma = 1)$	$\eta := \frac{\partial Q}{\partial P}\frac{P}{Q} = -\beta\frac{P}{Q}$
Log-Linear $(\alpha = 0)$	$\eta := \frac{\partial Q}{\partial P}\frac{P}{Q} = \gamma$
Exponential $(\gamma, \alpha \to \infty)$	$\eta := \frac{\partial Q}{\partial P}\frac{P}{Q} = \frac{\gamma}{\alpha}P$

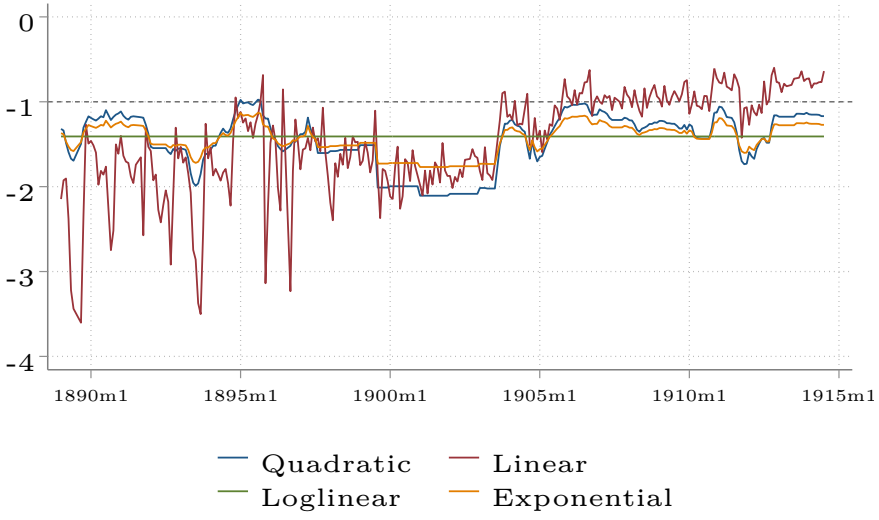
Results – Static Demand

	(1) Quadratic	(2) Linear	(3) Log-Linear	(4) Exponential
Ref. Sugar Price	214.02***	-4,784.21***	-1.41***	-0.02***
	(20.87)	(762.06)	(0.24)	(0.00)
Intercept	12.09***	621,501.59***	18.47***	13.58***
	(4.23)	(70531.29)	(1.08)	(0.26)
Year FE	Yes	Yes	Yes	Yes
Avg. Elasticity $\eta(\bar{Q}, \bar{P})$	-1.45	-1.51	-1.41	-1.44
F-Stat (MOP 2013)		136	174	136
Obs	302	302	302	302

Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

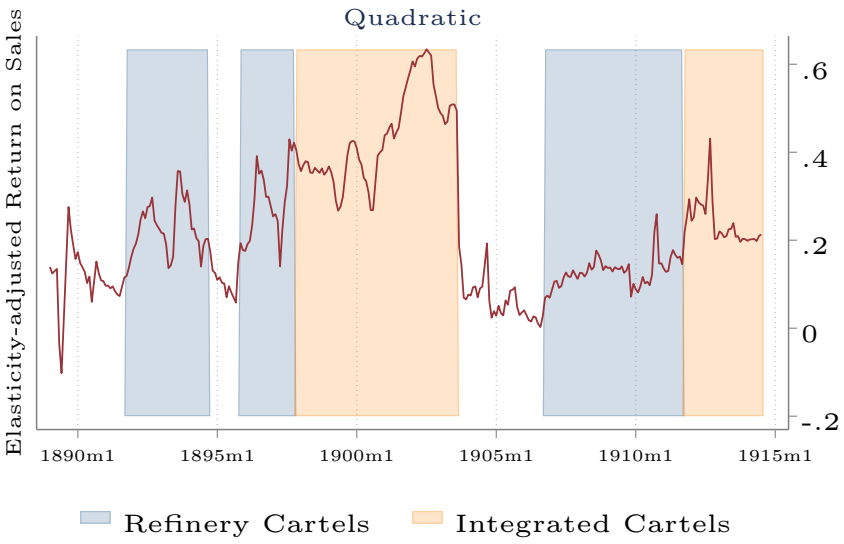
Estimates for η in line with the literature.

Elasticities over time



2 outliers removed (from linear model)

Elasticity-adjusted Return on Sales $|\eta|\frac{P-MC}{P}$



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- We allow for potentially time-varying conduct:

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- We estimate θ_0 and θ_1 with Non-linear Least Squares

Results – Conduct based on static demand results

	(1) Quadratic	(2) Linear	(3) Log-Linear	(4) Exponential
theta0				
	0.09***	0.12***	0.10***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
theta1				
	0.17***	0.28***	0.15***	0.16***
	(0.02)	(0.03)	(0.01)	(0.02)
Obs	302	302	302	302

Robust Standard errors in parenthesis (Newey-West, 2 Lags)

* p<0.1, ** p<0.05, *** p<0.01

- H0: $\theta_0 = 0$, H0: $\theta_1 = 0$, as well as H0: $\theta_0 = \theta_1$ are rejected

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- By comparison, Genesove and Mullin (1998) obtain $\widehat{\theta} = 0.038$ (SE of 0.024)

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- Reduced-form interpretation

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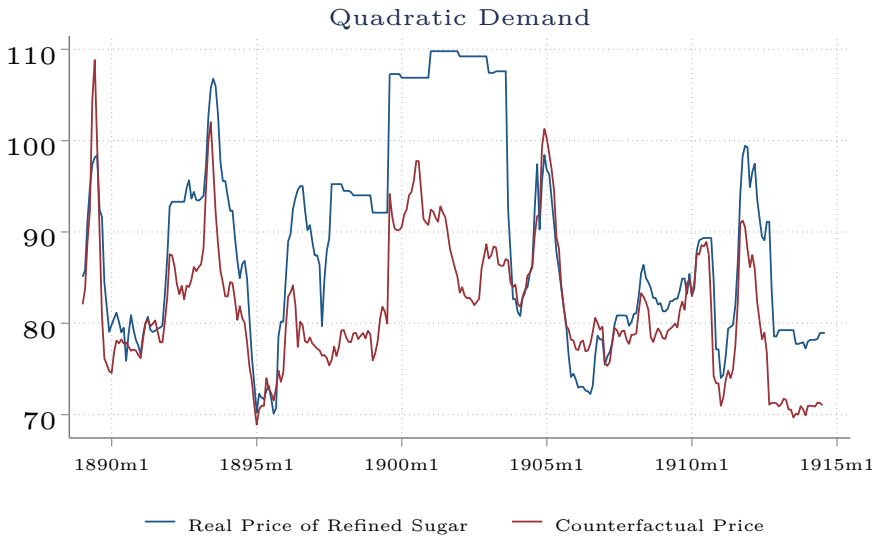
Counterfactual prices without cartels ($\theta_1 = 0$)



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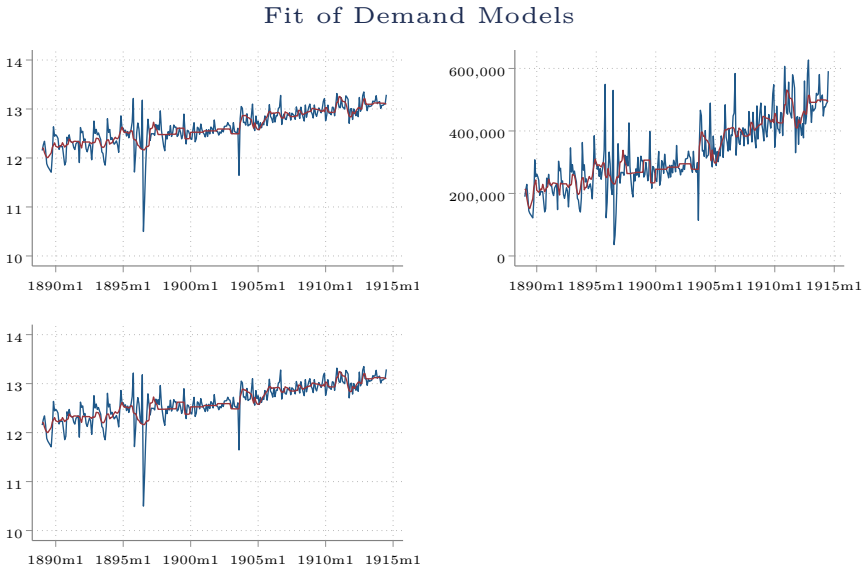
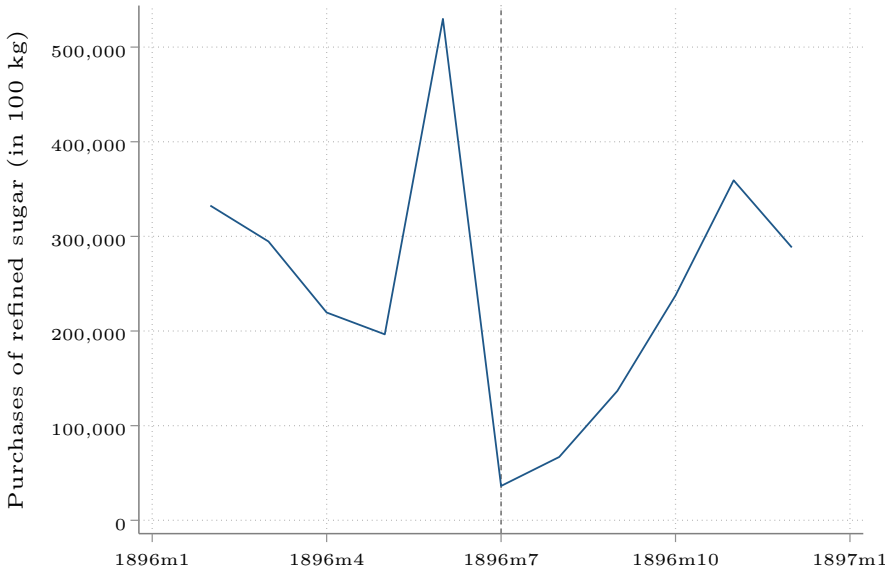
Appendix

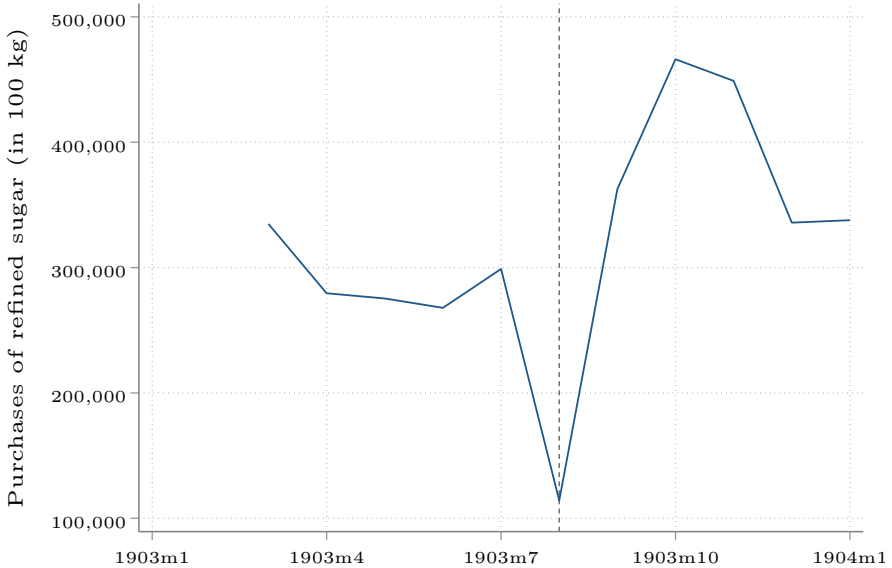
Fit of Demand Model: static



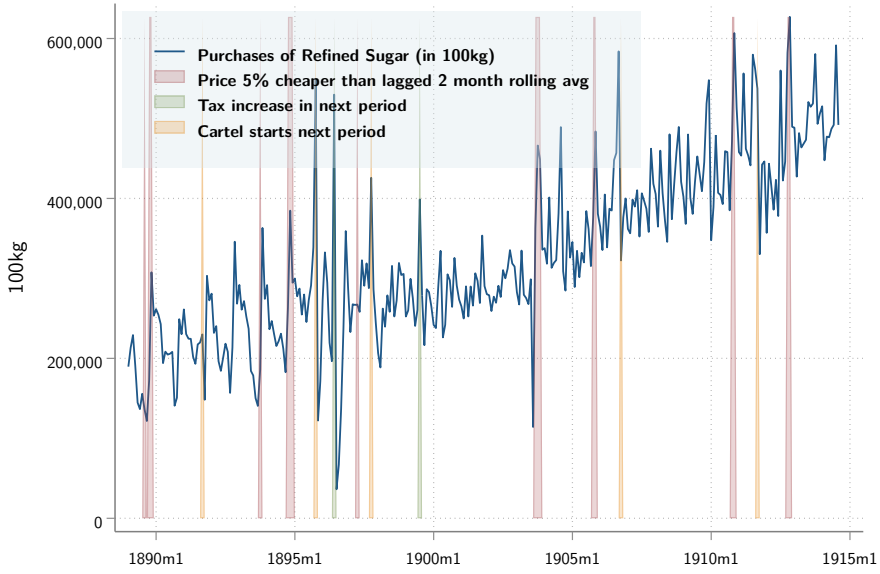
Hints of anticipating price increase before first tax increase



Hints of anticipating price decrease towards end of 1st integrated cartel



Cheap Periods



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- But storers can store at no cost for 1 period and know prices 1 period in advance
- Thus, they purchase more than their period consumption when prices are about to rise

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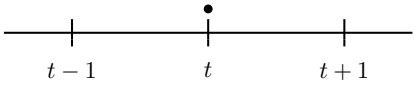
- This gives four states of the world $\{C, N\}^2 = \{(N,N), (C,N), (N,C), (C,C)\}$
- E.g., state (C, N) means that there was a sale at $t-1$, but no sale at t

Storers' Purchases

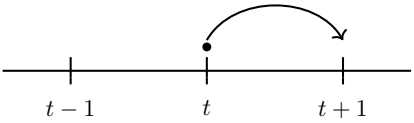
$$X_t^s(p_{t-1}, p_t, p_{t+1}) = \begin{cases} Q_t^s(p_t) & \text{NN} \\ Q_t^s(p_t) + Q_{t+1}^s(p_t) & \text{NC} \\ 0 & \text{CN} \\ Q_{t+1}^s(p_t) & \text{CC} \end{cases}$$

- Intuition for identification: purchases in each state can be expressed as linear combination of others

Storers' Purchases



NN



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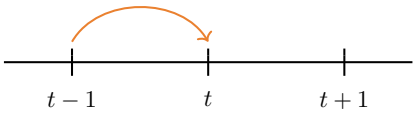
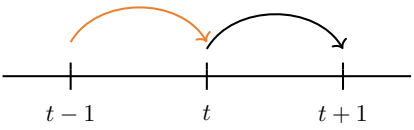


CN



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Estimating Equation: Dynamic Demand

$$X_t(P_t) = \omega X_t^N(P_t) + (1-\omega) X_t^S(P_t, S_t) + \varepsilon_t$$

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- As with static demand, we instrument price with raw sugar prices, cartel dates, and taxes

Results - Dynamic Demand

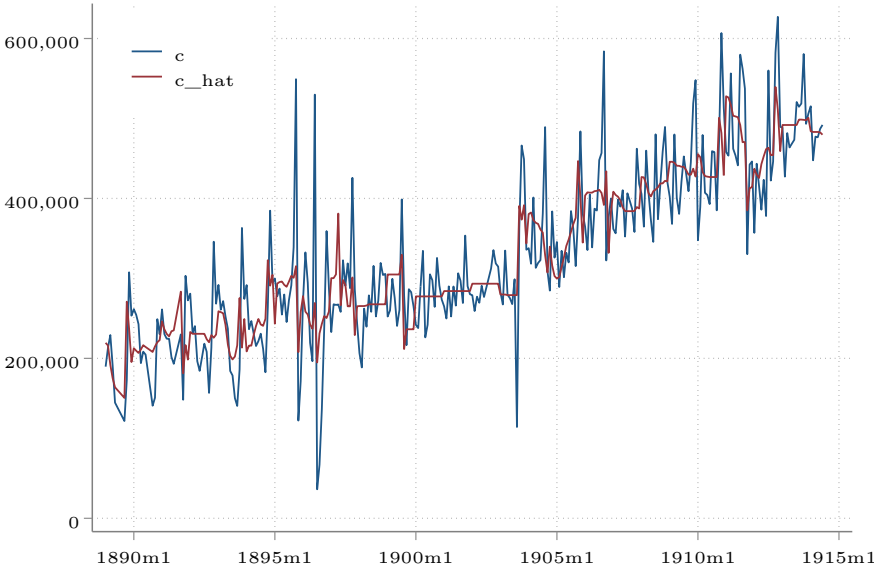
	Estimate	SE
α	134.75	8.59
β	4501	799.34
$\omega_{transform}$	1.3	0.84
ω	0.79	
Year FE	Yes	
$\eta(\bar{Q}, \bar{P})$ (average across states)	-1.38	
Obs	302	

State Specific Elasticities

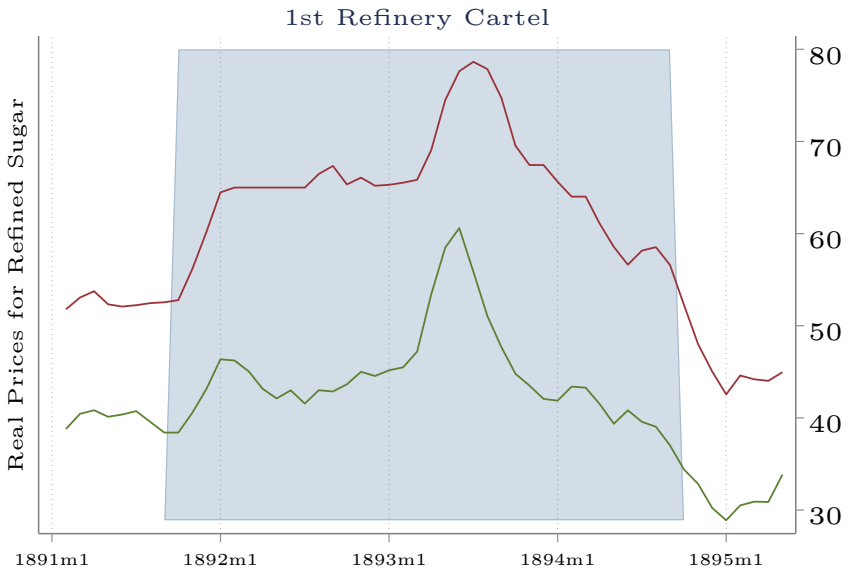
State	$\eta(\bar{Q}, \bar{P})$
NN	-1.40
NC	-1.18
CN	-1.72
CC	-.67

- Note: we mostly observe state NN in the data

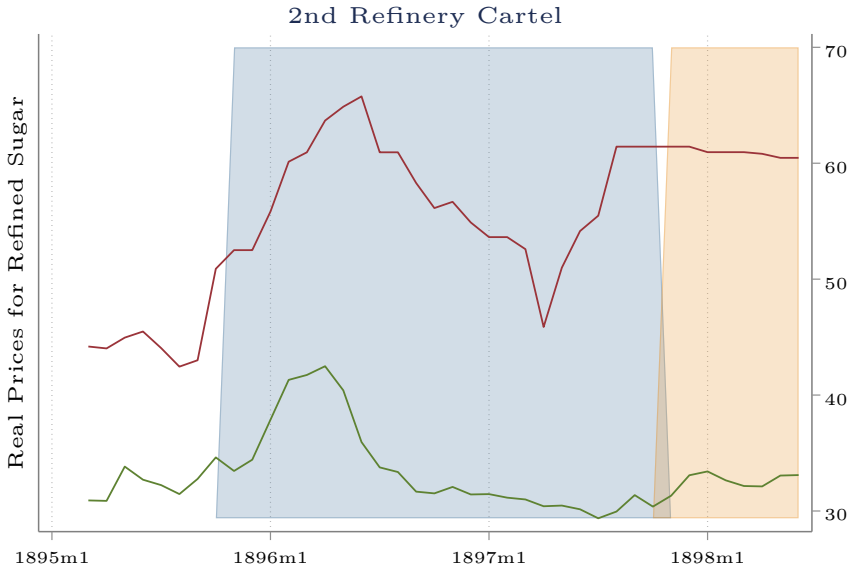
Fit of Demand model: dynamic



1st Refinery Cartel



2nd Refinery Cartel



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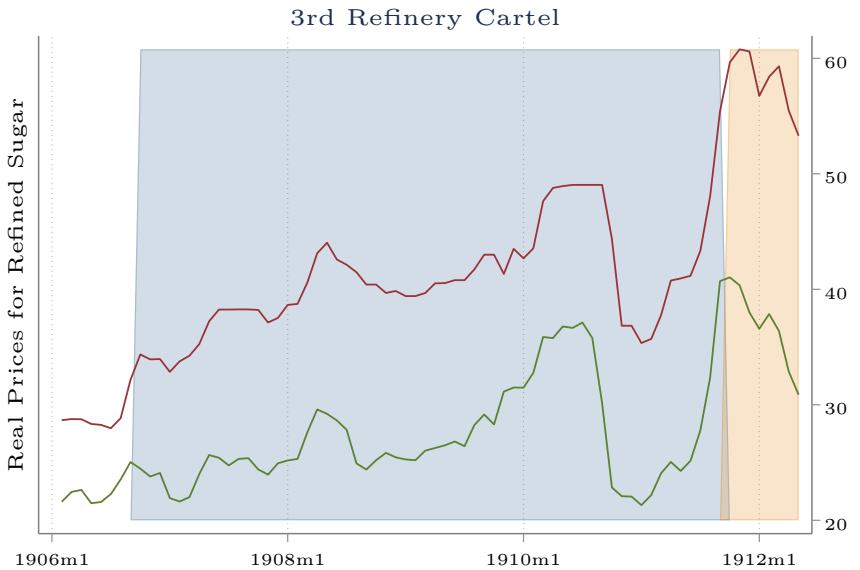
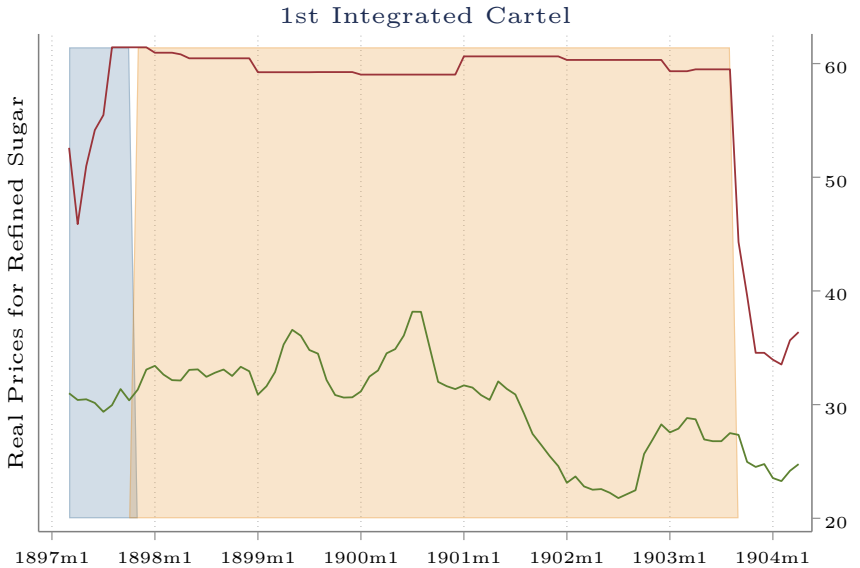


1st Integrated Cartel



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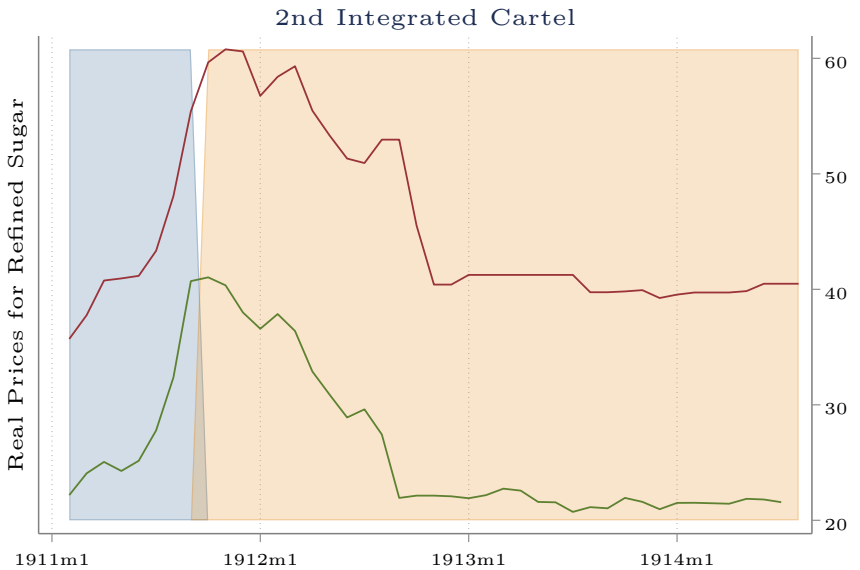

Current Quantities are a function of Previous Quantities

```
. reg c L.c L2.c //L3.c
```

Source	SS	df	MS	Number of obs	=	306
				F(2, 303)	=	223.37
Model	2.2028e+12	2	1.1014e+12	Prob > F	=	0.0000
Residual	1.4941e+12	303	4.9309e+09	R-squared	=	0.5959
				Adj R-squared	=	0.5932
Total	3.6969e+12	305	1.2121e+10	Root MSE	=	70220

c	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
c						
L1.	.5531197	.0553958	9.98	0.000	.4441104	.6621289
L2.	.2681282	.055781	4.81	0.000	.1583611	.3778953
_cons	59923.69	13463.93	4.45	0.000	33429.04	86418.35

Montiel Olea-Pfluegger (2013)

```
. weakivtest
(obs=302)

Montiel-Pflueger robust weak instrument test
------------------------------------------------------------------------------
Effective F statistic:      135.709
Confidence level alpha:          5%
------------------------------------------------------------------------------


------------------------------------------------------------------------------
Critical Values                TSLS       LIML
------------------------------------------------------------------------------
% of Worst Case Bias
tau=5%                       29.466     12.547
tau=10%                      17.193      8.028
tau=20%                      10.577      5.506
tau=30%                       8.189      4.570
------------------------------------------------------------------------------
```

Serial correlation in demand

```
. actest, lags(5) robust

Cumby-Huizinga test for autocorrelation
  H0: variable is MA process up to order q
  HA: serial correlation present at specified lags >q
```

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag-1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1 - 1	0.462	1	0.4966	1	0.462	1	0.4966
1 - 2	4.759	2	0.0926	2	7.995	1	0.0047
1 - 3	9.169	3	0.0271	3	2.406	1	0.1208
1 - 4	10.011	4	0.0402	4	0.526	1	0.4685
1 - 5	19.462	5	0.0016	5	2.598	1	0.1070

```
  Test allows predetermined regressors/instruments
  Test robust to heteroskedasticity
```

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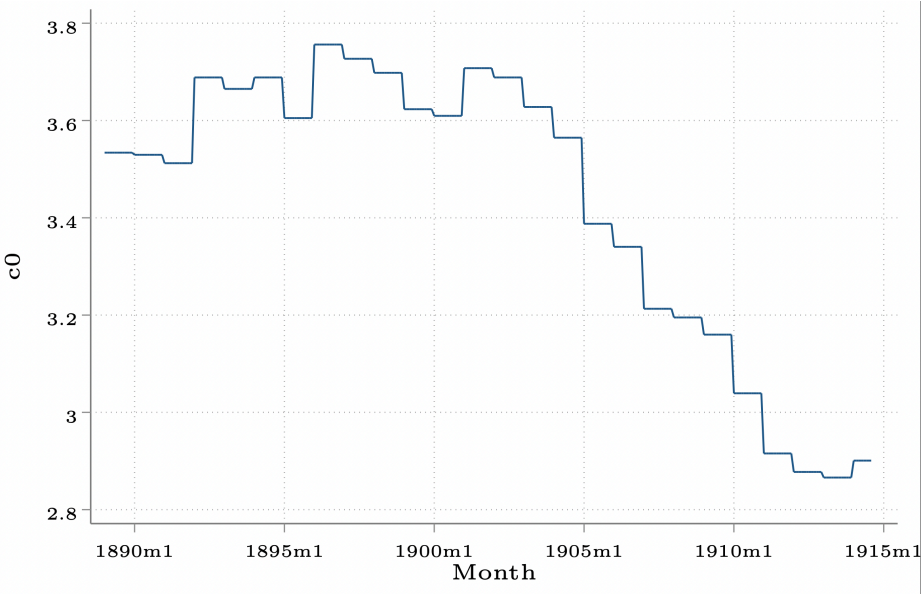
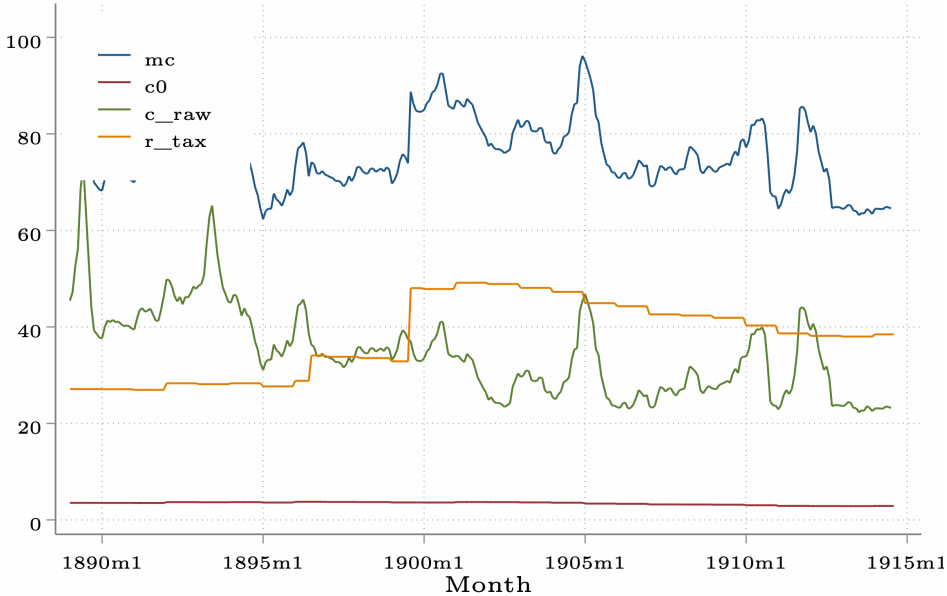
- adjustment with price index (real value)

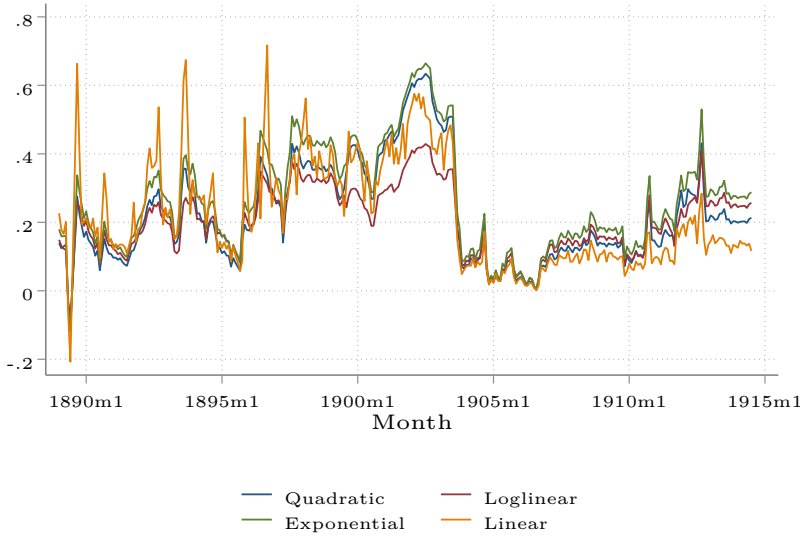
Marginal cost intercept over time



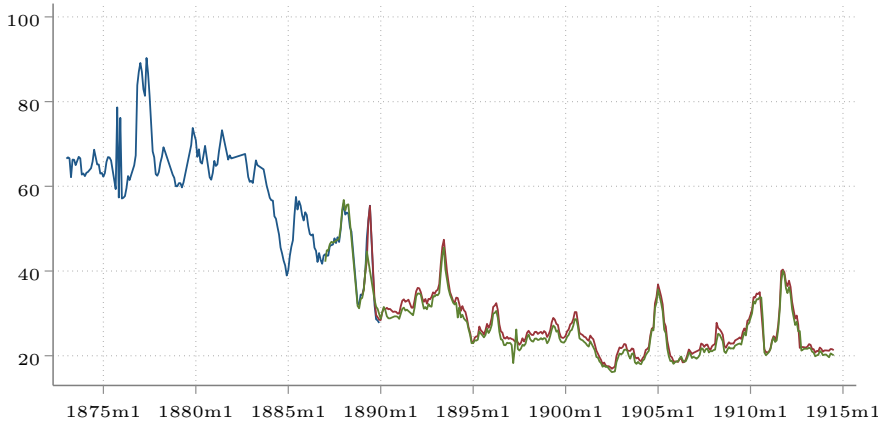
But marginal cost intercept is small part of overall marginal cost



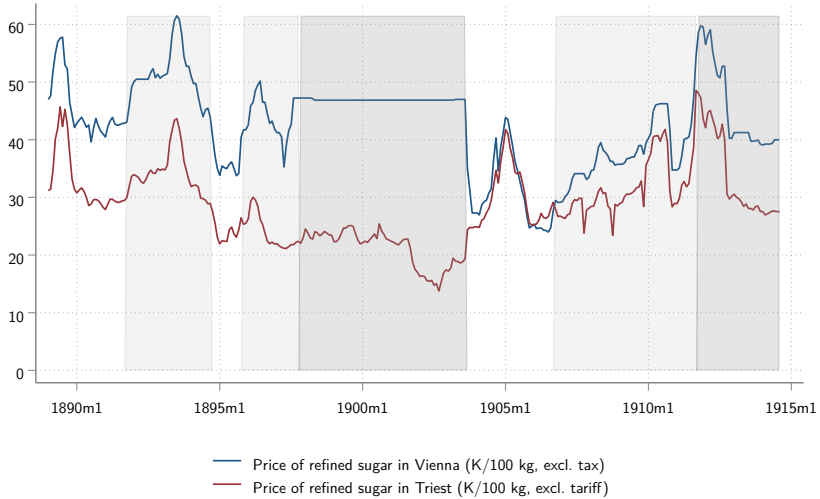
Elasticity-adjusted Return on Sales



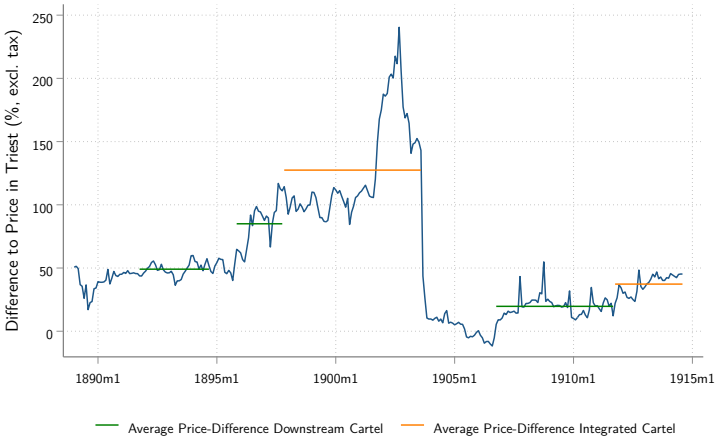
Raw Sugar Prices



Comparison with world market price (Triest)

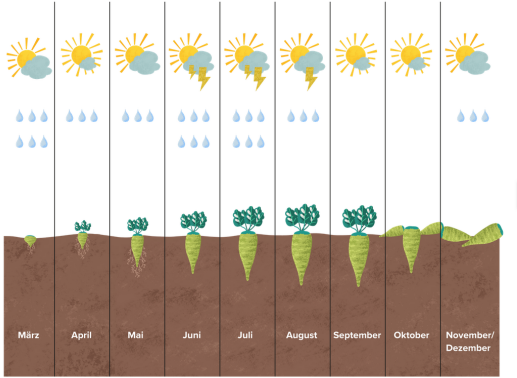


Average difference to world market price (Triest)



Season

- Sugar was produced and thus sold mainly during last quarter of calendar year



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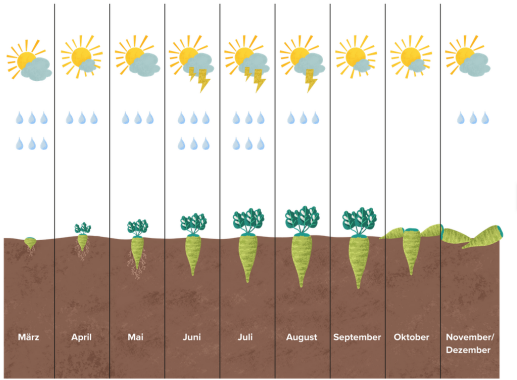
- “sugar year” lasting from Sept-Aug captures harvest period (“Kampagne”)



Reasons for Cartel Starts and Ends

Cartel	Duration	Reason for Start	Reason for End
1st refinery	1891m10-1894m9	Gov Tax	Looming entry from new refineries
2nd refinery	1895m11-1897m10	Include new refineries	Start of 1st integrated cartel
1st integrated	1897m11-1903m8	Include upstream to foreclose entry	International trade agreement
3rd refinery	1906m10-1911m9	Separate Austrian and Hungarian Agreement	Start of 2nd integrated cartel
2nd integrated	1911m10 -1914m8	Forbid entry from upstream (crystal)	World War I

Back

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  - also upstream factories committed not to sell to new entrants Back

References

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