Regularization, Market Power and Collusion

in Iberian Electricity Wholesales Market 2003-2015

Xinyu Cao

June 2018

Abstract

De-regulation, market power exercises and cartel detection is one of the the key questions in industrial organization literature. This paper aims at understanding the decline of the price after de-regularization in Iberain market in period of 2003-2015. What's more, this paper tried to identify collusion using repeated game model to analyze the day-ahead market premium in the electricity market. However based on the second moment method, we do not find positive evidence to support the hypothesis of collusion, but rather testified the prediction Ito and Reguants (2016) made.

Contents

1 Introduction and Motivation

This paper aims at identify the the market power exercise and also collusive behavior in Iberian market in the decades between 2007-2013. Although in the literature, we already document the electricity regulation liberalization in the Iberian market and if there are collusive behavior, but there has not been a good identification of the how exactly those market power are exercised. Particularly, is there a cartel agreement and thus a collusion? Recent methodology advancement in industrial organization make it possible to make this identification.

The second of purpose of this research is to use the repeated game model of collusion to analyze the day-ahead market premium in the electricity market. In the literature, large number of goods are traded in a sequential market setup, such as bonds, stock, futures. For a simple economics model, we used to predict that the price will converge in discounted value. However in the empirical observation, there are large inconsistent with this prediction. For example decline price anomaly is documented in treasury bond market (Coutinho 2013),[1] mutual funds (Zitzewitz 2003)[2] and electricity markets (Borenstein et al 2008).[3]

Three potential explanations are discussed. First is related to behavior of consumers who are not rational or impatient (Coase 1972)[4] or clearance sale (Nocke and Peitz 2007).[5] Second is related to risk aversion (McAfee and Vincent 1993)[6] or asymmetric shocks (Bernhardt and Scoones 1994).[7] But even with those two constrains, if there are arbitrage, then the price must converge, therefore a literature on why there limitations to arbitrage on energy market are discussed (Borenstein et al 2008,[3] Jha and Wolak 2014[8]). Further Ito and Reguant (2016)[9] made a prediction that large firm that have incentive to deviate in the second stage of two stage game, this approach explained the declining price anomaly.

2 Literature Review

2.1 Sunk Cost Explanation of the Declining Price Anomaly

Ito and Reguant (2016) made a prediction that large firm that have incentive to deviate in the second stage of two stage game, this approach explained the declining price anomaly.

2.2 Collusion Theoretical models

The collusion in energy market is documented in Fabra, Toro (2005)[10] using Spanish electricity market. There are two types of imperfect competition model. The first of it is the Cournot Nash Equilibrium with entry deterrence (Allaz and Vila 1993).[11] The second is cooperative equilibrium in a repeated game.

2.2.1 Cournot Nash Equilibrium with Entry deterrence Models

The basic idea is that if there are limited number of firm, then the symmetric Nash equilibrium is a imperfect competition. Although this imperfect competition will converge to a perfect competition as number of the firm goes to infinite. However if there are large fixed costs or/and some punishment threats to entry to the market, then it's possible that there are equilibrium that deters potential competitor in the market.

2.2.2 Cooperative Equilibrium in a repeated game

In a repeated game set up, the basic idea is that if some player does not act according to the designed strategies of cooperative equilibrium, then other players are going to min-max punish the deviator, then by Folk theorem, any outcome that are above threats points are attainable. Although the electricity market is imperfectly monitored, but under suitable conditions then there are still Folk theorem holds.

2.3 Identifying Collusion in Electricity Market

Even with the theoretical prediction of cartel have been studied extensively, still we need to specific a model for empirical identifying the market power and mechanism for exercise the market power. For example Porter (1983a)[12] and Ellison(1994),[13] there is a rationale for looking for structural breaks which is that sharp changes in price. If there is a price war, then price is realized relative low and if not otherwise. Central to this approach is the structure placed on the stochastic process determining I_t. This branch of literature provide a way to identify regime switching that might occur when firms collude. They also finds persistence in regimes as the estimated probability of colluding tomorrow, given firms are colluding today is very high at .975, while the probability of colluding tomorrow, given firms are currently engaged in a price war is only .067. In sum, the evidence tends to support the Green-Porter model of collusion over standard non-collusive oligopolistic competition.

Another potential work frame is Baldwin, Marshall, and Richard (1997) where they want to determine a cartel exists in the Pacific Nrothewest over period of 1975-1981. This model gives two argument of why bidding is less aggressive (i.e. a bigger cartel) and a larger supply is being auctioned off. The set up make these two alternatives quite analogous in both unit of auctions and members of auctions. The mode use maximum likelihood estimation to specifies the behavior of bidding. The author conclude that collusion model is better than than Cornourt competition model.

The third branch of literature that I shall use in this paper is the second moment approach. In (Abrantes-Metz et.al. 2006),[14] they argued that due to Cater agreement, firms in Carter are harder to adjust the price, therefore if we could identify that firm with higher price have a lower volatility, then we are more confident to say there might be collusion. Therefore we could run a regression of the price compared to idiosyncratic shocks, price .

3 Data and Empirical Method

The method we use is that we use a perfect Cournot competition model and then put into a repeated game setting with punishment. The data I collect is the Iberian electricity bidding data. The data is open source regulator data from Iberia market, we have the hourly price and also producer and consumer's bid at each hour interval, therefore we indeed have both supply and demand of the market. In the mean time, we have the data of each firm's power plant's engineering data, such as technology type, fuel usage, and energy generation rate combined with fuel price, we could estimate a reasonable marginal cost data at firm level. Using both marginal cost and bidding price at firm level, we are able to identify the behavior of market power or collusion. The difficulty I currently encountered is that I need to build a structural econometric model to identify the structural model of price change relative to the marginal cost change, because since there are reserve for the firm, the marginal cost of the firm's production might not exactly the same as the current energy price, and

3.1 Sequential Markets in Iberian Electricity Market

In Iberian electricity market, there are the a day-ahead forward market and a real-time spot market. Most energy production is first allocated in the day-ahead market, the real-time market is used to balance the demand and supply. The market is scheduled as follows, first the auction started in the day-ahead market(t-1), supply side and demand side bidding for their desired price and quantity. Thus day-ahead market set up the baseline production according to the production forecast by demand side and also a regulator reserve for expected uncertainty.

3.1.1 The Correlation of Market Power Decline and Market Price Decline

The hypothesis is that the price is negatively correlated with the supply side market power and negatively correlated with demand side market power:

$$y_i = \beta \mathbf{X}_i + \gamma D_i + \varepsilon_i$$

where X is a vector of dependent variable, in model 1, we add the model of the measures of concentration: HHI index, the market share of four largest production firms. D is the log weekly demand of the electricity. This paper is based on the idea of orter (1983a)[12] and Ellison(1994).[13] The price is much correlated with market power both of supply side and demand side. In order to estimate if there are influence of the market power to the price in the market, we run a regression of price, share of four largest suppliers, share of four largest consumers, Herfindahl-Hirschman index of

3.2 Random Forest Estimation

In order to test for the robustness of the model, we extend our simple OLS model to a random forest to see what is the most important feature in the regression.

3.3 Second Order Method

Another potential extension is the second order method (Abrantes-Metz et.al. 2006).[14] Due to Cater agreement, firms in Carter are harder to adjust the price, therefore if we could identify that firm with higher price have a lower volatility, then we are more confident to say there might be collusion.

4 Summary Statistics

4.1 Hourly Market Price for Iberia Electricity Market

First, we plot some summary statistics of the hourly price of electricity in Iberian energy market from 2002 to 2015. We could see that the market is dominated by few strong outlier. This reflects three basic feature of the energy market. First of all, the demand of electricity market is highly uncertain and inelastic. Civilian energy price usage does not reflect the price change of the wholesale market, people usually receive a flat price over time. Because energy production investment is a long term effects, for producer. Utilizing the current capacity, it's either expensive to increase production after certain capacity or impossible to increase production. In the mean time, electricity is very expensive to store, therefore it's impossible for firm to arbitrage through peak and off-peak periods. Therefore we saw the hourly price fluctuated between 20 and 80 Euro per MWH, and in extreme cases to 0 and 100. However one of the feature of this data(figure 1) surprised me is that the price more frequently hit zero after 2010, it seems that the electricity market started to oversupply and this oversupply is consistent, and as a benchmark this is quite different the data from Nordic market(figure 2).

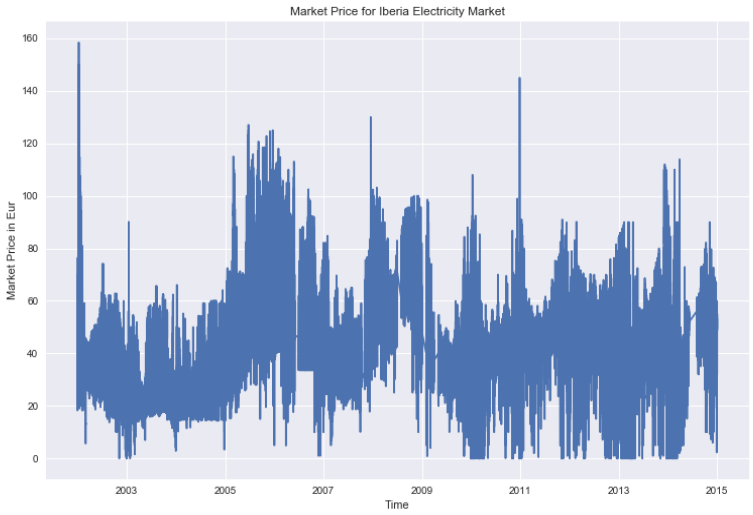

Figure 1: Hourly Market Price for Iberia Electricity Market

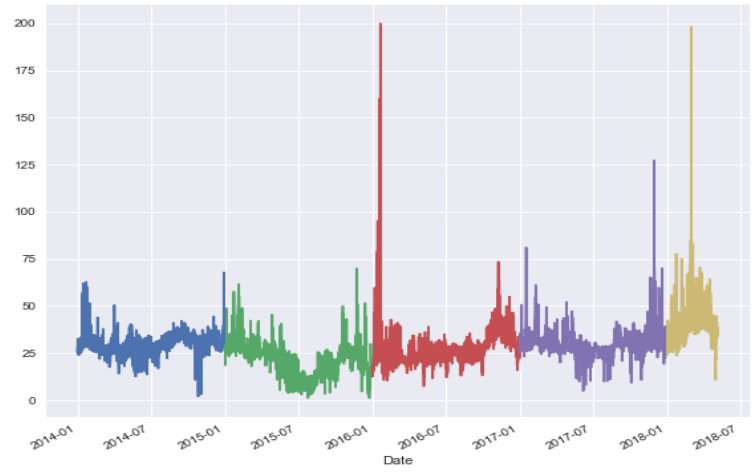

Figure 2: Hourly Market Price for Nordic Electricity Market

4.2 Market Share and Total Quantity

After we examined the price part of the data, we need to examine the quantity side of the data. In total, there are 2.77×10^8 mega watt hour(MWH) (10^6 watt) are traded in our data, while the actual energy production in this area is 2.74×10^2 tera watt hour(TWH) (10^{12} watt) and 49.1 TWH at Portugal. Our data actually captured the almost all electricity production and bidding in the market. There are 8 largest firms that have more than 1% of the total production, and 7 firms that have more than 1% of the total demand. While in the same time, 38 firms has more than 0.1% of the production and 26 of firms has more than 0.1% of the demand. In total there are 255 firms bid in the market, of which 69 are supplier and 186 are consumer.

As the following table showed to us the supply side of the market seems not similar with the actor in the competitive retail market. This already provide us evidence that wholesale market might have substantial market power, thus deterred the potential entrant, also the data we have in the price which seems much lower compared to the Nordic market also provide evidence that some new entrant deter actions have been taken.

Table 1: Summary of Market Share of 2013

Type of Firm	Significant ($> 10\%$)	Large ($1\%, 10\%$)	Medium ($0.1\%, 1\%$)	Small ($0.01\%, 0.1\%$)	Marginal ($< 0.01\%$)
Supply Side	3	10	28	19	12
Demand Side	4	7	19	39	121

4.3 The Decline of the Supply Concentration

In the relevant period 2007-2013, we see that there are a sharp decline of the supply side concentration and also a decline of supply side concentration. The HHI index of supply side drop from 0.28 to 0.20, in practices the regulatory authority view a index of more than 0.20 as a the highly concentrated market, and a sign for antitrust investigation, and a merge of 0.02 increase will be a concern for triggering a antitrust issue.

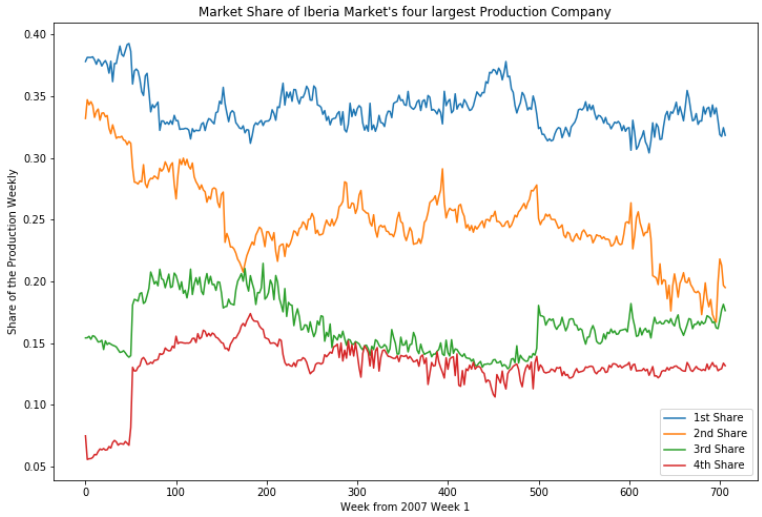

Figure 3: Largest Four Production Firm's Market Share

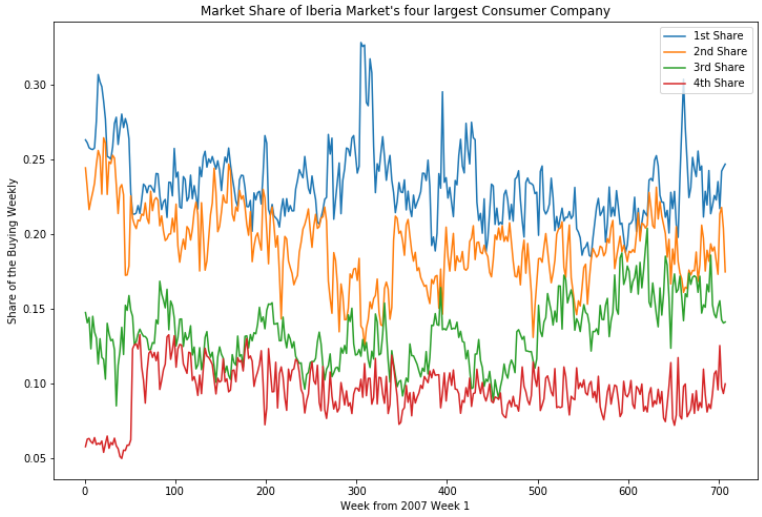

Figure 4: Largest Four Consumer Firm's Market Share

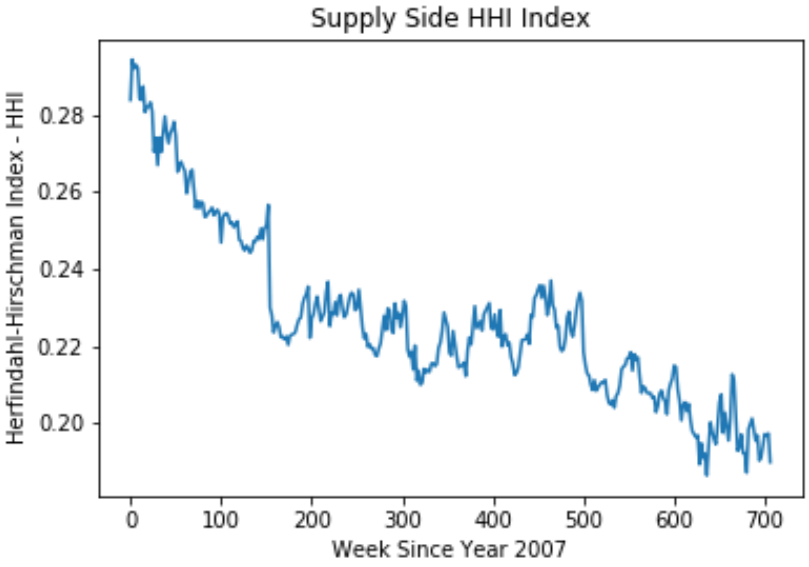

Figure 5: Supply's Concentration

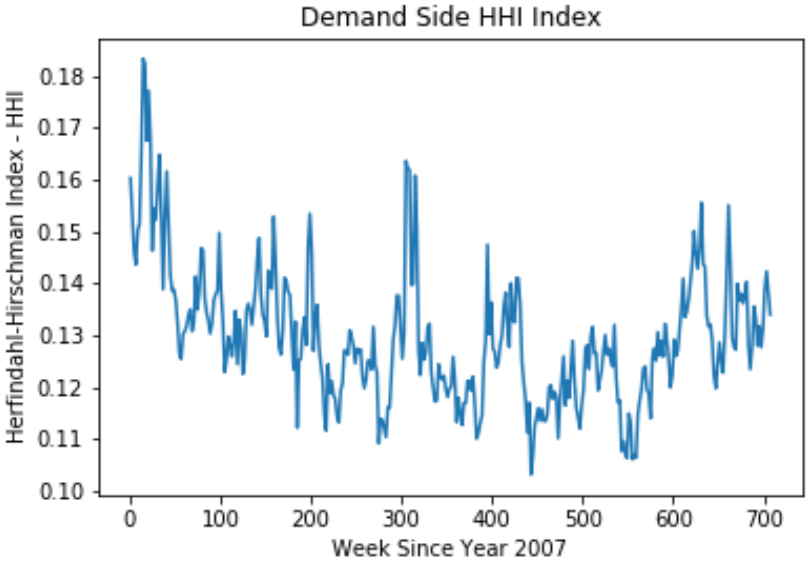

Figure 6: Demand's Concentration

5 Conclusion

In conclusion, from this long trend, we indeed see a decline of market power, therefore a decline of price. But the second moment estimation does not yield desired results of collusion. On the contrary we confirmed the two stage game model of Ito and Reguant (2016).[9]

5.1 OLS Results

Now I run three sets of OLS estimation, in those estimation I run as follow. In model 1, I add supply side measures of concentration, and in model 2 I add demand side measures of concentration, in model 3 I add both side measures. The table 2 showed our results. Our can see in our model, both the supply side market concentration and demand side market concentration matters. The demand side concentration

Table 2: The Regression Results

	Model 1	Model 2	Model 3
Demand_HHI		-43.69***	-44.48***
		(5.63)	(7.06)
Demand_perc_1_largest		15.69***	15.87***
		(2.60)	(3.29)
Demand_perc_2_largest		14.94***	15.30***
		(1.73)	(2.35)
Demand_perc_3_largest		9.69***	11.48***
		(1.48)	(1.88)
Demand_perc_4_largest		6.62***	5.88***
		(1.07)	(1.81)
HHI	6.92		15.03***
	(5.34)		(5.18)
lnQuant	0.19***	0.07**	0.18***
	(0.06)	(0.03)	(0.06)
perc_1_largest	-1.42		-8.67***
	(3.32)		(3.20)
perc_2_largest	-3.10		-5.77**
	(2.69)		(2.55)
perc_3_largest	0.22		-6.62***
	(2.12)		(2.43)
perc_4_largest	3.78***		1.52
	(1.21)		(1.48)

5.2 Random Forest

I run a random forest model, and showed that the indeed those features are both account for similar portion of the variance, therefore, it's important to keep track of all of them, and the results is robust.

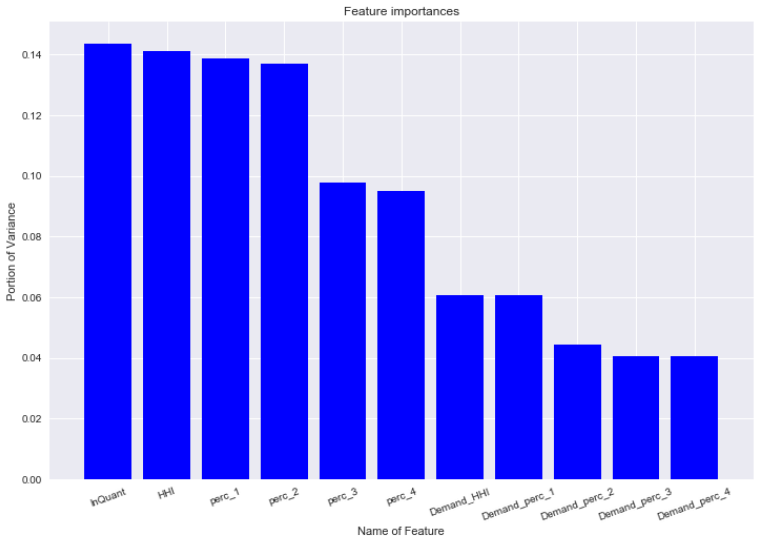

Figure 7: Feature Importance of Random Forest

5.3 Second Moment Results

I estimated the second moments and try to see if the firm's relative weekly price compare to the industry has a effects on the variance, i.e. the higher the idiosyncratic variance the more likely they are in a collusion agreement. However the result showed that it is unlikely the case, since this is less likely to be the case of the collusion. Rather we see a consistent effects, where large firm have lower price in this second stage market, because of the sunk cost in the first stage and deviation in the second stage where Ito and Reguant (2016)[9] identified in the their paper.

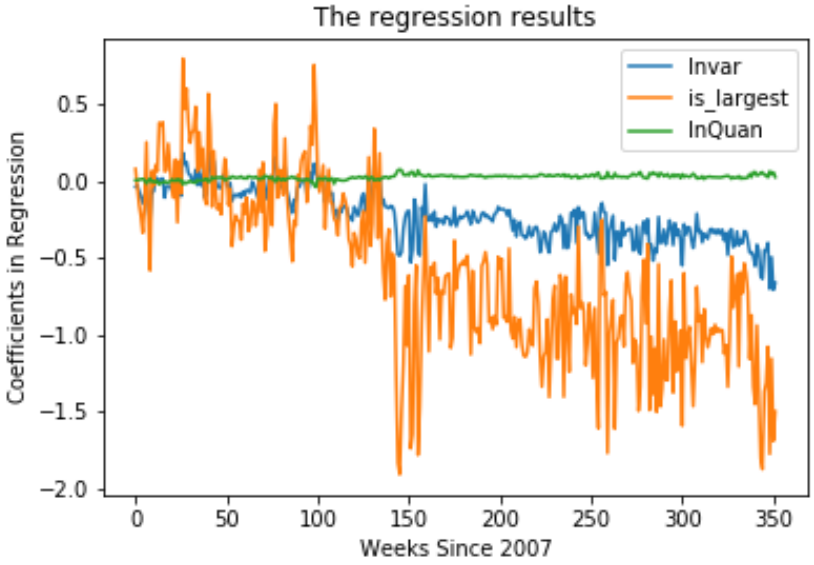

Figure 8: The Second Moment Results of Time Involving Windows

References

[1] Paulo Braulio Coutinho. When-issued markets and treasury auctions. 2013.

[2] Eric Zitzewitz. Who cares about shareholders? arbitrage-proofing mutual funds. *Journal of Law, Economics, and Organization*, 19(2):245–280, 2003.

[3] Severin Borenstein, James Bushnell, Christopher R Knittel, and Catherine Wolfram. Inefficiencies and market power in financial arbitrage: a study of california's electricity markets. *The Journal of Industrial Economics*, 56(2):347–378, 2008.

[4] Ronald H Coase. Durability and monopoly. *The Journal of Law and Economics*, 15(1):143–149, 1972.

[5] Volker Nocke and Martin Peitz. A theory of clearance sales. *The Economic Journal*, 117(522):964–990, 2007.

[6] R Preston McAfee and Daniel Vincent. The declining price anomaly. *Journal of Economic Theory*, 60(1):191–212, 1993.

[7] Dan Bernhardt and David Scoones. A note on sequential auctions. *The American economic review*, 84(3):653–657, 1994.

[8] Akshaya Jha and Frank A Wolak. Testing for market efficiency with transaction costs: An application to financial trading in wholesale electricity markets. Technical report, 2015.

[9] Koichiro Ito and Mar Reguant. Sequential markets, market power, and arbitrage. *American Economic Review*, 106(7):1921–57, 2016.

[10] Natalia Fabra and Juan Toro. Price wars and collusion in the spanish electricity market. *International Journal of Industrial Organization*, 23(3-4):155–181, 2005.

[11] Blaise Allaz and Jean-Luc Vila. Cournot competition, forward markets and efficiency. *Journal of Economic theory*, 59(1):1–16, 1993.

[12] Robert H Porter. A study of cartel stability: the joint executive committee, 1880-1886. *The Bell Journal of Economics*, pages 301–314, 1983.

[13] Glenn Ellison. Theories of cartel stability and the joint executive committee. *The Rand journal of economics*, pages 37–57, 1994.

[14] Rosa M Abrantes-Metz, Luke M Froeb, John Geweke, and Christopher T Taylor. A variance screen for collusion. *International Journal of Industrial Organization*, 24(3):467–486, 2006.