Market Manipulation by a Monopsony Cartel: Evidence from the U.S. Meatpacking Industry

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Abstract

If a monopsony cartel manipulates market signals used by small sellers, it may lead to a larger welfare loss than standard models predict. This paper examines the U.S. meatpacking cartel from 1903 to 1917, during which government litigation disrupted the cartel's price manipulation. I quantify the welfare effects by comparing observed market outcomes under manipulation with model counterfactuals. Transitioning from manipulation to monopsony would increase wholesale cattle prices by 30.4 percent. This coincides with a minimal decrease in consumer welfare, with the average household spending $1.93 more per year on beef.

JEL Classifications: L12, L41, N61, N82

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1 Introduction

Can a monopsony cartel cause larger welfare loss by manipulating the market signals used by small sellers? While both antitrust agencies and empirical research call for more attention to the adverse effects of monopsony, economic theory provides a limited understanding of monopsonistic cartel strategies.[1] Contrary to the assumptions of the standard monopsony model, cartel buyers often possess more private information regarding market conditions than small sellers. When sellers make production or shipping choices, they rely on market signals that can be manipulated by the price-setting cartel. Without considering the impact of signal manipulation, the standard monopsony model may underestimate the welfare loss caused by a monopsony cartel.

This paper examines the impact of signal manipulation by the U.S. meatpacking cartel on both the input market (cattle) and the product market (beef). In the early 20th century, five meatpackers formed one of the largest manufacturing cartels in American history. The cartel dominated wholesale cattle and beef markets, purchasing 95 percent of the cattle sold at the 10 largest stockyards and producing more than 80 percent of refrigerated beef for urban markets. During an era of weak antitrust enforcement, they openly colluded to manipulate the wholesale cattle market from 1893 to 1920 (Yeager, 1981).

Two factors make this historical case particularly suitable for examining the effect of cartel manipulation. First, because the cartel was eventually challenged in court, the resulting litigation generated detailed documentation on how the cartel manipulated market prices. The court found that cartel members were guilty of "bidding up through their agents, the prices of livestock for a few days at a time, to induce large shipments, and then ceasing from bids, to obtain livestock thus shipped at prices much less than it would bring in the regular way."[2] Second, in 1913, in exchange for the Department of Justice to drop pending cases, cartel members stopped manipulating prices and switched to a standard monopsony strategy with fixed market shares. As a result, I observe market outcomes with and without manipulation, allowing me to compare empirical outcomes under cartel manipulation to counterfactual measures based on the well-understood monopsony model.

I first characterize the cartel's manipulation strategy with a two-period game. Every period, the cartel observes the demand states (for beef), which are correlated over time. Cattle sellers are rational. They do not observe the demand state but can imperfectly infer it from observed cartel prices and quantities. By offering a higher first-period price, the cartel can shift sellers' beliefs about the demand state. This induces more sellers to arrive at the market, which increases the cartel's profit in the second period. Thus, the cartel can receive higher total profits compared to

[1] The Department of Justice challenged a merger on the grounds of increasing monopsony power in grain trade (Cargill and Continental Grain Company, 1999), health insurance (Anthem and Cigna, 2016), and book publishing (Penguin Random House and Simon & Schuster, 2022). In January 2022, the Federal Trade Commission (FTC) and the Department of Justice announced that they would broaden the scope of merger guidelines to address the potential impact of monopsony power. For empirical analyses of monopsony power, see Krueger and Ashenfelter (2022), Dube et al. (2020), Ashenfelter et al. (2010), and Manning (2003) on labor markets; Inderst and Mazzarotto (2008) on retail distribution; and Hemphill and Rose (2018) and Werden (2007) on antitrust enforcement.

[2] *Swift & Co. v. United States* (122 F. 529)

the standard monopsony model, despite deviating from the monopsony price strategy in the first period.

I compile a novel data set of weekly market information from 1903 to 1917 using primary sources, including annual reports of stockyard companies, merchant exchanges, and livestock trade journals. The data cover the four largest stockyards, which collectively produced more than 58 percent of U.S. refrigerated beef during the sample period. I use an event study to show that under manipulation, the cartel purchased 40.4 percent more cattle, yet the wholesale price was 4.4 percent lower. These lower prices reduced sellers' margin—defined as the difference between wholesale cattle prices and feed costs—by 24.1 percent.

To construct the counterfactual market outcomes absent of manipulation, I model the stockyard cattle supply with a discrete choice framework: at stockyard markets, sellers choose between the cartel and the outside competitive market. I estimate the model parameters using data after 1913, when the cartel followed the monopsony strategy. To address price endogeneity, I use prices of beef substitutes in the urban market (e.g., chicken) as an instrumental variable (IV) to estimate the spot-market cattle supply. The results suggest that the cartel held substantial market power over sellers, who received 60.3 percent of marginal revenue products.

I then use the estimated model primitives to quantify the effects of cartel manipulation on both the input and product markets. I consider two counterfactual scenarios: monopsony and oligopsony, and find three sets of results. First, in the wholesale cattle market, cartel manipulation causes more damage to small sellers than what the standard monopsony benchmark suggests. Without the manipulation, the average wholesale cattle price would increase by 30.4 percent, and the average total quantity purchased by the cartel would decrease by 19.7 percent, or about 15,000 fewer heads of cattle processed per week. Second, for urban consumers, the manipulation strategy created a small benefit by increasing the beef supply. However, the effects are much smaller: without cartel manipulation, higher beef prices would increase total household expenditure on beef by $1.93 annually. Finally, while disrupting the manipulation can recover some welfare loss, the improvement is relatively small compared to the case when the cartel would be dissolved. Under the oligopsony scenario, 21,500 more heads of cattle would be process per week and the wholesale cattle price would almost double the average price under manipulation.

This paper contributes to three strands of existing literature. First, it builds on empirical research examining the inner workings of cartels. Past research uses court filings and internal documents to analyze how cartel members communicate and coordinate market strategies (Byrne and De Roos, 2019; Harrington and Skrzypacz, 2011; Levenstein and Suslow, 2006). A related literature focuses on specific cartel strategies across different markets and regulatory environments (Byrne et al., 2023; Delabastita and Rubens, 2023; Röller and Steen, 2006; Genesove and Mullin, 2001). This paper uses a historical case to highlight that cartels can coordinate to manipulate market signals. The results show that the standard monopsony benchmark may underestimate the welfare loss, especially in the input market.

Second, this paper relates to the literature on the rise of industrial cartels and antitrust regulations in the early 20th century. The meatpacking cartel was one of the largest manufacturing cartels in U.S. history and was among the first to be challenged in court (Lamoreaux, 2019). Prior research has detailed the cartel's development (Chandler, 1993; Libecap, 1992; Lamoreaux, 1988) and how competition policies evolved in response to the rise of giant corporations (Lamoreaux, 2023; Aduddell and Cain, 1981). More broadly, recent empirical studies have used historical cases to understand the effects of market structure on efficiency (Donna and Espín-Sánchez, 2023). This paper contributes to the historical analyses by documenting and quantifying the effect of a specific cartel strategy. In addition, while previous research examines how firms adapt to new regulations, this paper focuses on how the cartel responded to antitrust agencies' enforcement choices. The empirical results show that, without going through a lengthy legal process to fully dissolve a cartel, antitrust agencies can recover a non-trivial amount of welfare loss for small sellers by disrupting the signal manipulation.

Finally, a growing literature on buyer power and imperfect competition in the agricultural markets finds that dominant buyers negatively affect input prices (Chatterjee, 2023; Rubens, 2023; Garrido et al., 2022). Recent research from legal and antitrust policy perspectives also call for more attention to the adverse effects of monopsony on both sellers and overall market efficiency (Hemphill and Rose, 2018; Blair and Harrison, 2010). By quantifying the cartel's effects on both the input and product markets, the results show that cartel manipulation can create substantial welfare loss to sellers with small benefits to downstream consumers. The results echo other works that highlight the limitation of focusing on consumer welfare when analyzing buyer power in input markets.

2 Historical Background of the Meatpacking Cartel

This section provides some historical background on the meatpacking industry and the government litigation against the cartel. I follow the convention in historical texts and use "meatpackers", "packers", and "cartel members" interchangeably.

2.1 Meatpacking Industry in the Early 20th Century

In the 1880s, Midwestern meatpackers adopted mechanical refrigeration, creating the modern meatpacking industry (Anderson, 1953). While refrigeration substantially reduced the shipping cost of beef, the fixed cost of constructing specialized rail cars, ice plants, and refrigerated warehouses created high barriers to entry. By the early 20th century, five firms (the "Big Five") dominated the meatpacking industry. For example, in 1916, they slaughtered 6.5 million cattle, accounting for 82.2 percent of all wholesale refrigerated beef sold in interstate commerce (FTC, 1919). Refrigerated beef production was highly concentrated both across and within stockyard markets: the 10 largest stockyard markets produced near 80 percent of all the refrigerated beef. Within each market, the Big Five purchased almost all cattle sold at the stockyards.[3]

[3] Table A1 shows the relative market share for the top 10 stockyards.

It is worth noting that there was a large competitive outside market for cattle. Though the cartel dominated urban markets, less than half of the U.S. population lived in urban areas in the 1910s. Residents in small towns and rural areas created an alternative market for cattle, giving sellers the option to either sell to the cartel at the stockyards or to small retail butchers in this competitive market. In 1909, meatpacking establishments processed 59.6 percent of all cattle slaughtered for food in the United States, while the rest were processed on farms or by retail butchers.[4]

Cattle were slaughtered and processed by low-skilled manual labor. There was little productivity difference across firms as they drew from the same local labor market. The main variable cost of refrigerated beef production was the cost of cattle. According to the 1909 Census of Manufactures, non-fuel materials, primarily livestock, accounted for 90.7 percent of total production cost in the meatpacking sector, while wages accounted for only 5.4 percent.

3 Cartel History and Strategy

Between 1893 and 1918, the cartel controlled both the wholesale cattle and the wholesale beef markets. In 1913, government litigation forced the cartel to switch from a manipulation strategy to a standard monopsony strategy. Therefore, I divide the cartel strategy into two phases, before and after 1913.

Before 1913: Cartel Manipulation. In 1893, the Big Five formed a joint holding company in Chicago as a legal cover. They met "every Tuesday afternoon at 2 o'clock" under the guise of a board meeting of the holding company to collude and manipulate market price signals (FTC, 1919). Justice Oliver Wendell Holmes best summarizes the cartel's strategy when the U.S. Supreme Court unanimously upheld the lower court's ruling against the meatpackers (*Swift & Co. v. United States*, 196 U.S. 375):

> For the same purposes [to restrain competition], the defendants combine to bid up, through their agents, the prices of livestock for a few days at a time, so that the market reports will show prices much higher than the state of the trade will warrant, thereby inducing stock owners in other States to make large shipments to the stockyards, to their disadvantage.

While the court issued and upheld injunctions against the cartel's collusion, the early legal actions had little impact.[5] Both the lower court and the Supreme Court's decisions included specific qualifications that made it hard to enforce. The restrictive nature of the injunctions, together with the failed attempts to bring criminal cases against the top executives, provided no explicit threat to its continued operation. Cartel members continued to meet every week to discuss market strategies despite repeated legal challenges.

[4] United States Census Bureau (1913)

[5] Appendix A provides a chronicle of the government's litigation against the cartel.

After 1913: Standard Monopsony. The Department of Justice brought a new criminal case against the packers in 1911. Despite ample evidence documenting the collusive meetings, the jurors could not follow the technical details of the government's case and were reluctant to impose criminal penalties on the socially prominent defendants (Lamoreaux, 2019). As a results, the jury voted to acquit the packers on all the charges. Shortly after the packers were acquitted, the Department of Justice announced that it would file a civil case against the packers unless they dissolved the holding company where they meet as board members. Given the abundant evidence presented in court, "the packers did not wish to run the risk of another trial" for a civil case.[6] They quickly acquiesced and agreed to submit a dissolution plan to the Department of Justice.[7] By the end of January 1913, they finalized the dissolution and suspended their weekly meetings.

After 1913, the packers adopted the standard monopsony strategy in the cattle market: they maintained fixed market shares and purchased at the same monopsony price level. Because packers can directly observe the quantities and prices set by other firms at the stockyard, they can monitor compliance at little cost even without weekly meetings. Later investigations by the FTC uncovered internal documents showing that "each of the big packers maintains his relative percentage [...] fairly constantly even from week to week, more constantly from month to month, and almost exactly from year to year" (FTC, 1919). Stockyard data also show that the market share among the cartel members remained stable, suggesting no one deviated from the market share agreement after suspending the weekly meetings.[8]

4 Conceptual Framework

In this section, I use a two-period model to demonstrate the intuition for the cartel's manipulation strategy. The cartel observes the demand states, which are correlated over time. Sellers do not directly observe the demand state but can (imperfectly) infer some information about it through observed cartel prices. By manipulating market prices, the cartel can induce rational sellers to update their posterior beliefs about the state and attract more sellers to the market. While it is costly to lie and deviate from the monopsony price, the cartel can potentially receive higher total profit if it attracts sufficiently more sellers who otherwise would not come to the market.

The intuition behind the cartel strategy is similar to dynamic oligopoly games with asymmetric information. For example, in Mailath (1989) and Mester (1992), firms have private information about their costs and can infer other firms' cost types from observed market prices. In such cases, firms have incentive to manipulate others' beliefs by misrepresenting the cost types through pricing.

4.1 Setup and Timeline

The market operates for two periods. Cattle are identical, but sellers differ in their shipping cost θ to the stockyard. They can either sell to the competitive market with no cost (i.e., sell to local

[6] *The New York Times*, June 17, 1912, "Packers to Dissolve Trust Voluntarily"
[7] *The New York Times*, July 20, 1912, "Meat Packers' Trust Has Been Dissolved."
[8] Figure A1 shows the weekly market share for each cartel member.

butchers) or ship cattle to the stockyard. Every period, the cartel observes the beef demand state $\omega \in \{H, L\}$ in downstream urban markets. The demand states are correlated over time. Let $\rho(\omega_{t+1}|\omega_t)$ denote the transition probability. Sellers do not observe the state but share a common prior.

At $t = 1$, n_1 unit of cattle arrive at the stockyard. The cartel chooses a price strategy $c_1(\omega_1, n_1)$ given the demand state and the total number of cattle that arrived. For sellers at the stockyard, the shipping costs are sunk. They observe the cartel's price and can either sell to the cartel or leave and sell to the competitive market.

Before making the shipment decision for $t = 2$, sellers on the farm observe the stockyard outcomes, (n_1, c_1), update their beliefs about the state, and form an expected cartel price for the next period. They will ship to the stockyard if the expected cartel price net of shipping cost is higher than the competitive market price.

At $t = 2$, n_2 units of cattle arrive at the stockyard, the cartel reveals the price, c_2, and sellers choose whether to accept the cartel price or leave. The game ends after the second period.

Sellers' Choices. First, consider sellers on the farm. Normalize the competitive market price to 0. A seller with cost type θ would ship to the stockyard if he expects the cartel price net of shipping cost to be higher than the competitive price, or

$$\mathbb{E}[c_2] - \theta \geq 0. \tag{1}$$

Sellers form beliefs about $\mathbb{E}[c_2]$ after observing the market outcomes, (n_1, c_1), in the first period. Let $\mu(\omega_1|n_1, c_1)$ denote sellers' posterior beliefs about ω_1. The expected cartel price for the next period is

$$\mathbb{E}[c_2(\omega_2, n_2)] = \sum_{\omega_2} \sum_{\omega_1} \mu(\omega_1|n_1, c_1)\rho(\omega_2|\omega_1)c_2(n_2, \omega_2). \tag{2}$$

Equation (2) shows that sellers account for changes in aggregate supply, which affect the cartel prices. Let $F(.)$ denote the density of shipping cost θ and $\bar{N}$ denote the total number of cattle available for sale. In equilibrium, n_2 is determined by

$$n_2 = F(\mathbb{E}[c_2(n_2, \omega_2)]) \times \bar{N}. \tag{3}$$

Sellers at the stockyard choose between selling to the cartel or to the competitive market. The indirect utility of seller i selling to $j \in \{cartel, competitive\}$ is

$$u_{it} = \begin{cases} \gamma_c c_t + \epsilon_{i,cartel} & \text{sell to cartel} \\ \epsilon_{i,competitive} & \text{sell to competitive,} \end{cases} \tag{4}$$

where the mean utility from selling to the competitive market is normalized to 0 and c_t is the cartel price. ϵ_{ij} are unobserved iid idiosyncratic preferences of seller i for buyer j, which follows a type-I extreme value distribution. The quantity of cattle the cartel can acquire at the monopsony price c_t is therefore

$$q_t(c_t|n_t) = \frac{\exp(\gamma_c c_t)}{1+\exp(\gamma_c c_t)} \times n_t. \tag{5}$$

Equilibrium. The Bayesian Nash equilibrium includes the cartel's price functions, (c_1, c_2), and sellers' choices on the farm and at the stockyard such that

(1) sellers' shipment and sales decisions are optimal, given by equations (1) and (4);

(2) sellers' posterior beliefs $\mu(.)$ follow Bayes' rule and align with the cartel's strategy; and

(3) (c_1, c_2) maximize the (undiscounted) sum of expected profits:

$$\sum_{t=1,2} \mathbb{E}[\pi_t] = \pi_1(c_1;\omega_1,n_1) + \sum_{\omega_2} \rho(\omega_2|\omega_1)\pi_2(c_2;\omega_2,n_2), \tag{6}$$

where n_2 is determined by sellers' beliefs and optimal shipment decisions, as in equation (3).

4.2 Stylized Example.

Consider the following example. Suppose the cartel faces a linear inverse demand $D(q) = \omega - \frac{1}{2}q$, with $H = 10$ and $L = 5$. Let $\gamma_c = 1$ for sellers' utility defined in equation (4). In the first period, the cartel observes $n_1 = 1$ and $\omega_1 = L$. Sellers do not know the realized state but share the common prior that ω_1 is drawn with $\Pr(H) = 0.3$ and $\Pr(L) = 0.7$. The transition probabilities are $\rho(\omega'|\omega) = 0.7$ for $\omega' = \omega$ and 0.3 otherwise. In the second period, there are two potential sellers, one located at $\theta = 0$ and another at $\theta = 1$.

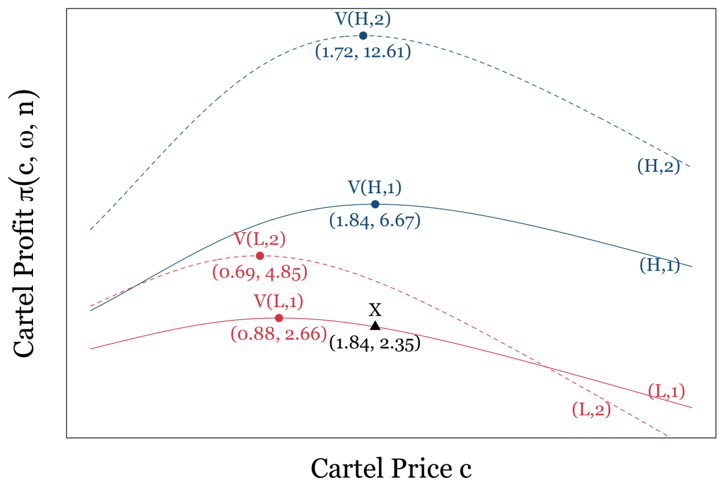
Figure 1 plots the cartel profit, $\pi(c;\omega,n)$, against the cartel prices, c, for each state-shipment combination. $V(\omega,n)$ are the maximum per-period monopsony outcomes, which are labeled by the optimal monopsony price, $c_\omega^n = \arg\max \pi(c;\omega,n)$, and the corresponding profits.

Second Period. Use backward induction to solve for the equilibrium. In the second period, the cartel faces a standard monopsony problem. After observing demand state ω_2 and total supply n_2, it will choose the monopsony prices and receive $V(\omega_2,n_2)$. Given the transition probability and that $\omega_1 = L$, the cartel's expected profit from $t = 2$ is

$$\mathbb{E}(\pi_2) = 0.3V(H,n_2) + 0.7V(L,n_2). \tag{7}$$

Note that the monopsony profit increases in n_2, the total number of sellers arriving at the stockyard. Therefore, the cartel has an incentive to manipulate the signal in the first period to induce a higher n_2 for the second period.

Figure 1: Stylized Example



Notes: The lines represent the cartel profits for each (ω, n) pair. The profit functions are calculated given the inverse demand $D(q) = \omega - \frac{1}{2}q$, with $H = 10, L = 5$, and stockyard logit supply $q(c, n) = \frac{\exp(c)}{1+\exp(c)} \times n$. $V(\omega, n)$ denote the maximum per-period monopsony profit. Point X represents the manipulation outcome when the cartel pays the optimal H state price c_H^1 even when the actual state is L.

First Period. At $t = 1$, the cartel observes $\omega_1 = L$ and $n_1 = 1$.

(1) *Without Manipulation*: The cartel follows the monopsony pricing strategy in the first period, choosing c_L^1 and receiving $V(L, 1)$.

Sellers can correctly infer the state $\omega_1 = L$ after observing c_L^1. Given the transition probabilities, the expected prices for the second period are

$$\mathbb{E}[c_2(\omega_2, 1)] = 0.3c(H, 1) + 0.7c(L, 1) = 1.17 > 0, \qquad \theta = 0 \text{ will ship}$$
$$\mathbb{E}[c_2(\omega_2, 2)] = 0.3c(H, 2) + 0.7c(L, 2) = 0.99 < 1, \qquad \theta = 1 \text{ not ship.}$$

Only type $\theta = 0$ ships to the stockyard and receives the cartel price of \$1.17 in expectation. The expected cartel quantity in the second period is

$$\mathbb{E}[q_2^{\text{truth}}] = 0.3q(c_H^1, 1) + 0.7q(c_L^1, 1) = 0.75.$$

The total cartel profit is

$$\sum_{t=1,2} \mathbb{E}[\pi_t^{\text{truth}}] = V(L, 1) + 0.3V(H, 1) + 0.7V(L, 1) = 6.5.$$

(2) *With Manipulation*: If the cartel manipulates the price in the first period by pretending to be in the H state, it needs to pay a higher price, c_H^1. This leads to a lower profit in the first period,

represented by point X in Figure 1.

Suppose the cartel manipulates the prices with the following probability:[9]

$$\begin{cases} \Pr(c_H^1|\omega_1 = H) = 1 \\ \Pr(c_L^1|\omega_1 = H) = 0 \end{cases} \qquad \begin{cases} \Pr(c_H^1|\omega_1 = L) = \frac{3}{7} \\ \Pr(c_L^1|\omega_1 = L) = \frac{4}{7} \end{cases} \tag{8}$$

In other words, the cartel is honest in the H state but lies and pays c_H^1 instead of c_L^1 with probability $3/7$ in the L state.

Knowing that the cartel may lie, sellers cannot be sure about current state after observing a high price in the first period. Instead, they will update their Bayesian posterior beliefs about the current state to be $\mu(\omega_1 = H|c_H^1) = \mu(\omega_1 = L|c_H^1) = 0.5$. This leads sellers to assign a higher probability on the H state in the second period, with $\Pr(\omega_2 = H) = 0.5$, instead of 0.3 when the cartel was telling the truth. The expected market price in the second period, given the posterior belief μ, is

$$\mathbb{E}_\mu[c_2(\omega_2, n_2)] = 0.5c(H, n_2) + 0.5c(L, n_2).$$

Prediction 1. *Under cartel manipulation, more cattle will be shipped to the stockyard market.*

The higher posterior belief on the H state in the second period leads to a higher expected price. Specifically,

$$\mathbb{E}_\mu[c_2(\omega_2, 1)] = 0.5c(H, 1) + 0.5c(L, 1) = 1.36 > 0 \qquad \theta = 0 \text{ will ship}$$
$$\mathbb{E}_\mu[c_2(\omega_2, 2)] = 0.5c(H, 2) + 0.5c(L, 2) = 1.21 > 1 \qquad \theta = 1 \text{ will ship.}$$

Both sellers will ship to the stockyard, $n_2 = 2$. This increases the cartel's profit in the second period under both states, which are represented by the dashed lines in Figure 1. The cartel's total profit under manipulation is

$$\sum_{t=1,2} \mathbb{E}[\pi_t^{\text{mani}}] = \pi(c_H^1, L, 1) + 0.3V(H, 2) + 0.7V(L, 2) = 9.5 > \sum_{t=1,2} \mathbb{E}[\pi_t^{\text{truth}}].$$

Thus, the cartel can achieve higher profits by manipulating the market price signals. While it is costly for the cartel to deviate from the monopsony price to signal a higher demand state, the additional profit generated by higher total shipment in the next period more than compensates the loss from lying about the state.

Prediction 2. *Under manipulation, the cartel purchases more cattle at the stockyard market.*

In the first period, the cartel purchased more cattle by paying a higher (manipulated) price. In

[9] Example adapted from Kamenica and Gentzkow (2011)

the second period, the cartel also acquires more cattle since

$$\mathbb{E}[q_2^{\text{mani}}] = 0.3q(c_H^2, 2) + 0.7q(c_L^2, 2) = 1.44 > \mathbb{E}[q_2^{\text{truth}}].$$

Prediction 3. *Under manipulation, sellers are worse off.*

The cartel manipulated sellers to assign a higher probability for the H state. As a result, at $t = 2$, while sellers *believe* the expected stockyard price to be $\mathbb{E}_\mu[c_2^{\text{mani}}] = 1.21$ when making their shipment decision, they will actually receive 0.99 at the stockyard in expectation. In comparison, without price manipulation, the stockyard price is $\mathbb{E}[c_2^{\text{truth}}] = 1.17$ in the second period, higher than in the manipulation case. The total surplus for sellers across the two period is 1.05 without manipulation, compared to 0.63 under manipulation, since the cartel attracted sellers with higher cost without increasing the prices.

Discussion. The stylized model supports the claims in the court documents that the cartel can manipulate the price signals in the wholesale cattle market to take advantage of small sellers. Because the cartel changed its strategy in 1913, I observe the market outcomes with and without manipulation. This allows me to construct the counterfactual outcomes for the manipulation period and to compare observed market outcomes with the model baseline. The primary advantage of this approach is to quantify the empirical damage created by cartel manipulation without imposing any assumptions on the demand states or sellers' beliefs.

5 Data

I collect weekly livestock market data from historical trade journals and stockyard annual reports. These data cover the four largest stockyards from 1903 to 1917. I combine the livestock market data with data on cattle production costs and urban wholesale market prices to analyze the decisions of both the cattle sellers and the cartel. Appendix B provides details on data sources as well as variable construction and validation.

Livestock Market Data. I compile weekly price and quantity data from 1903 to 1917 for the four largest stockyards: Chicago, Kansas City, Omaha, and St. Louis. These markets collectively processed more than 53 percent of cattle slaughtered for interstate trade in 1916 (FTC, 1919). Market information—including total shipment, cartel quantity, and market prices—were widely published. I collect weekly data on price and quantity from two trade journals, *The National Provisioner* and *The Drover's Journal*, and annual reports from the Chicago Union Stockyard Company, the Chicago Board of Trade, and the Merchants' Exchange of St. Louis. On average, more than 9,500 head of cattle were shipped to Chicago's Union Stock Yards every day, 63 percent of which were purchased by the cartel. The rest left the stockyard alive for the competitive market. The other three stockyards operated on a smaller scale but were all dominated by the cartel.[10]

[10] See Table A2 for summary statistics.

Cattle Production Cost and Weather. The main factors affecting cattle production are feed cost and weather conditions. To measure the fluctuations of these costs, I collect monthly wholesale prices of corn and hay in Chicago.[11] I use county-level historical weather data from Bleakley and Hong (2017) to construct monthly averages of temperature and precipitation for the feedlot cattle production region. Additionally, because local weather conditions can affect cattle sellers' decisions at the stockyard, I also collect weekly temperature and precipitation data from weather stations closest to each of the four stockyards, as reported by the National Oceanic and Atmospheric Administration.

Demand Instrument. Estimating the stockyard supply requires instrumenting for cartel prices. A natural choice for instruments is the prices of beef substitutes. To achieve this, I digitize the Bureau of Labor Statistics' *Wholesale Prices Series*. I discuss the IV selection in more detail in Section 7.

6 Descriptive Evidence

I first present descriptive evidence on the impact of cartel manipulation on the stockyard market. Because government litigation forced the cartel to stop manipulating prices, I can test the predictions generated by the stylized model in Section 4 by comparing the aggregate market outcomes with and without cartel manipulation. Specifically, I estimate the following regression:

$$y_{kt} = \alpha \mathbb{1}(\text{Manipulation}) + \beta_x X_t + \beta_k K_{kt} + \eta_{kw} + \tau_{ky} + \epsilon_{kt}, \tag{9}$$

where y_{kt} is an aggregate market outcome for stockyard k at time t. $\mathbb{1}(\text{Manipulation})$ is an indicator variable equal to 1 during the manipulation period (before 1913). The results control for shocks common to all markets, X_t, which includes four-month-lagged wholesale prices of corn and hay, and four-month-lagged monthly average temperature and precipitation in the cattle production region. K_{kt} represents local weather shocks at the stockyard, which includes minimum and maximum temperature and precipitation for stockyard k at time t. η_{kw} is a stockyard-by-week-of-year fixed effect, which captures the seasonality of the cattle market at each stockyard. τ_{ky} is the stockyard-specific time trend to account for market growth over this period. Standard errors are clustered by time, as the cartel coordinated prices across all markets. I use data before April 1917, when the United States entered World War I. Prior to 1917, robust export demand from Europe drove up grain prices, affecting cattle supply through the cost channel, which is controlled for in the analysis.

Table 1 reports the estimated results for α. Under cartel manipulation, 21.9 percent more cattle were shipped to the stockyards; cartel prices were 4.4 percent lower, while the cartel purchased 40.4 percent more cattle at lower average prices. These results are consistent with the model predictions from Section 4: the cartel manipulated the sellers to increase their posterior beliefs on higher states,

[11] Corn prices are available through the NBER Macro history database. I digitize the monthly No. 1 baled Timothy hay prices from the Department of Agriculture's Yearbook.

Table 1: Market Outcomes with and without Cartel Manipulation

	(1) Total Shipment	(2) Price	(3) Cartel Quantity	(4) Sellers' Margin
$\mathbb{1}$(Manipulation)	1.164***	-0.831***	1.239***	-1.231***
	(0.126)	(0.197)	(0.094)	(0.188)
Mean	5.31	18.74	3.06	5.11
% wrt Mean	21.92	4.43	40.45	24.10
Observations	2525	2439	2525	2439
Adjusted R-Squared	0.87	0.81	0.81	0.51

Note: "Sellers' Margin" is defined as the difference between cattle price and feed costs. Therefore, the estimations for sellers' margin (column 4) does not include the feed costs in the regression. "% wrt Mean" shows the estimated coefficient of the manipulation period dummy (first row) as a percentage of the variable's sample mean during the non-manipulation period. The number of observations differ due to missing data in cattle prices. Standard errors are clustered by (weekly) time to account for correlation across markets. * $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

leading to higher shipments to the stockyards and thus higher cartel quantities. I also compare sellers' margins over time. Sellers' margin is defined as the difference between stockyard cattle prices and feed costs. Column (4) shows that under cartel manipulation, their margin was 24.1 percent lower. Results in Table 1 suggest that, while the same cartel dominated the cattle market in both periods, price manipulation led to different aggregate market outcomes. Estimates for other control variables are reported in Table A3.

I conduct two robustness checks. First, I exclude Chicago, since it dominated all other markets in terms of scale. Second, because the cartel faced a prolonged public trial before suspending their collusive meetings, market outcomes during this period of legal uncertainty may not accurately reflect the cartel's typical strategies. Therefore, I exclude observations between December 1911, when the trial began, and January 1913, when the cartel finalized the joint holding company's dissolution. Table A4 and Table A5 show that excluding Chicago or the trial period does not change results.

7 Model and Estimation

In this section, I characterize and estimate the stockyard cattle supply. I use post-1913 data, when the cartel followed the standard monopsony strategy, to estimate the model primitives. The main goal is to quantify the effect of cartel manipulation by comparing observed market outcomes under manipulation with the model counterfactuals.

At the stockyards, sellers choose between the cartel and the competitive market, as described in equation (4). Following Berry (1994), this implies that

$$\ln(s_{ckt}) - \ln(s_{okt}) = \gamma_c c_{kt} + \gamma_x X_t + \gamma_k K_{kt} + \eta_{kw} + \xi_{kt}, \tag{10}$$

where s_{ckt} is the share of cattle at market k purchased by the cartel at time t, and s_{okt} is the share of cattle that left stockyard k alive to be sold to the competitive market. c_{kt} is the cartel price at market k at time t. X_t, K_{kt}, and η_{kw} are cost factors, stockyard weather conditions, and stockyard week-of-the-year fixed effects, as in equation (9). ξ_{kt} is the unobserved quality of cattle, such as weight, whether the steers were dehorned, and so on, which can be correlated with prices and create the typical endogeneity problem in demand estimation.

I use the prices of other perishable food items, which are uncorrelated with cattle supply but influences beef demand, as an instrument to identify γ_c. I collect weekly price data for chicken, eggs, and lard from the *Wholesale Prices Series*. The choice of price instrument is primarily driven by data availability, as only a few food items have weekly price data and were not produced by the meatpackers.[12]

Table 2: Spot-Market Supply

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		First Stages			IV	
Dependent Variable	$\ln(s_{ckt}) - \ln(s_{okt})$		Cattle Price			$\ln(s_{ckt}) - \ln(s_{okt})$	
Cattle Price	0.024				0.185*	0.224***	0.339*
	(0.018)				(0.101)	(0.081)	(0.175)
Chicken Price		0.098***					
		(0.025)					
Egg Price			-2.793***				
			(0.605)				
Lard Price				6.272***			
				(2.162)			
Observations	773	673	688	686	673	688	686
Instrument					Chicken	Egg	Lard
Kleibergen–Paap F-statistic					15.29	21.33	8.41
Elasticity					1.52	1.84	2.78
Markdown					1.66	1.54	1.36
Input Share of Revenue (%)					60.28	64.79	73.58

Note: The table shows the regression coefficient γ_c described in equation (10). Estimations include weather and cost controls as well as stockyard-by-week-of-year fixed effects. The number of observations differ between the OLS and IV results due to missing data in the instrument. Standard errors are clustered by time. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Column (1) in Table 2 reports the price coefficient for the logit model using ordinary least squares (OLS). As expected, without addressing price endogeneity, the price coefficient for the cattle supply cannot be properly recovered. Columns (2)–(4) report the first-stage results for the IV estimation, where the dependant variable is the cartel price. The results indicate that cartel prices are strongly correlated with the prices of other perishable animal products. Columns (5)–(7) report the price coefficient γ_c with the three different instruments. After accounting for price endogeneity, the estimations recover the positive price coefficient for the stockyard cattle supply. The IV results show similar estimates for the price coefficient despite using three different instruments.[13]

To interpret the coefficient, I calculate the stockyard cattle supply elasticity, markdown, and input share of revenue measures, all measured at the average price level. The bottom three rows in Table 2 present the estimates. When using chicken prices as an instrument, the estimates suggest

[12]The meatpackers also dominated cured meat production and livestock markets in urban centers. Thus, prices for fresh beef or other meat products are not suitable instruments

[13]Table A6 reports the estimates for other variables.

that the spot-market supply is elastic, with the average price elasticity around 1.5. This corresponds to a markdown value of 1.7, meaning sellers received 60.3 percent of what they would have in a competitive market. The results are similar with other instruments.

Based on the production process described in Section 2, I make two assumptions to connect cattle supply to the cartel's output. First, the cartel faced a Leontief production function, as one cannot substitute cattle with other variable inputs. Consequently, the quantity of output (beef) is directly proportional to the quantity of input (cattle). Second, because cattle accounted for more than 90 percent of the variable cost of production, I only consider the cost of cattle and ignore the other input costs such as fuel and labor. Given the two assumptions, the cartel's marginal cost can be written as $mc_t = c_t + \frac{1}{\gamma_c}\frac{1}{1-s_{ct}}$. In the product market, the cartel was also a monopoly seller of beef. The equilibrium monopoly pricing implies $\eta = \frac{p_t - mc_t}{p_t}$ where η is the monopoly markup.

I collect weekly wholesale prices, p_t, in New York City from *The National Provisioner* to calculate the markup for both periods. The estimated markup values are similar before and after 1913, at 32.5 percent and 31.7 percent, respectively. This is consistent with the narrative evidence that the cartel continued to operate as a monopoly in the wholesale beef market, even though it adopted different strategies in the cattle input markets.

8 Welfare Effects of Cartel Manipulation

I use the estimated parameters to construct counterfactual outcomes in both the input and output markets for the manipulation period, taking the observed cattle supply as given. I consider two hypothetical scenarios: standard monopsony and oligopsony. The standard monopsony benchmark measures the potential welfare loss that antitrust agencies can recover by disrupting the manipulation strategy. The oligopsony case assumes that the litigation had successfully broken up the cartel and the five packers compete with each other in both the wholesale cattle and beef markets.[14]

The top two rows in Table 3 present changes in the cattle markets. If the cartel switched to the monopsony strategy, it would purchase fewer cattle at higher prices. The average wholesale cattle price would increase by 30.4 percent, or be $4.74 higher. For small sellers, disrupting the manipulation would increase their profit margin by 60 percent. Meanwhile, the average daily quantity purchased by the cartel would decrease by 19.7 percent, or 2,500 fewer heads per day. In aggregate, this implies that, on average, the packers would process 15,000 fewer heads of cattle per week across the four stockyard markets. These changes in prices and cartel quantity align with the findings in Section 6, which show that price manipulation allowed the cartel to acquire more cattle at lower prices than in the standard monopsony case.

While disrupting cartel manipulation can recover some welfare loss, the improvement is much smaller compare to the case when the cartel is dissolved. If packers must compete in the input market (right panel in Table 3), they would process 28.1 percent, or 3,580 more heads of cattle

[14]The counterfactual measures provide a lower bound for the welfare loss, since the analysis uses the observed cattle shipment, which does not account for changes in aggregate supply.

Table 3: Changes in Market Outcomes

	Monopsony			Oligopoly		
	Mean	CI 5	CI 95	Mean	CI 5	CI 95
Δ Stockyard Cattle Price ($1920)	4.74	-0.84	9.30	14.37	7.88	19.38
Δ Cartel Quantity (000s)	-2.50	-7.98	0.91	3.58	0.74	7.71
Δ Beef Wholesale Price ($1920)	1.15	-0.74	2.99	-2.19	-4.83	-0.52

per day. The average wholesale cattle price would be $14.37 higher, almost double the average price under manipulation. The large difference also explains why cartel members quickly agreed to suspend their weekly collusive meetings, as described in Section 2: the gains from market manipulation are small compared to the litigation risk that may break up the cartel.

The welfare effects on urban consumers are much smaller. The bottom row in Table 3 shows that switching to a standard monopsony would increase beef prices by 4.9 percent, or $1.15 per 100 pounds. The change in consumer welfare is small compared to the additional cattle sales value: in 1917, an average urban household consumed 168 pounds of beef per year (Bureau of Labor Statistics, 1992). To maintain the same level of consumption, the average household would spend $1.93 more per year on beef. Compared to the manipulation case, breaking up the cartel would reduce the wholesale price by 9.4 percent, saving the average household $3.67 per year.

9 Conclusion

In this paper, I estimate the impact of signal manipulation by a monopsony cartel on the cattle market, focusing on the U.S. meatpacking cartel's case. I find that the manipulation strategy led to a larger welfare loss for price-taking cattle sellers than what a standard monopsony model would suggest. Without adopting new legislation or breaking up the cartel through forced divestiture, changes in antitrust enforcement forced the cartel to abandon the manipulation, which increased the profit margin for small cattle sellers at a relatively low cost to urban consumers.

The historical case has important implications for contemporary markets. Without contracts or futures markets, which is often the case in developing countries, small sellers usually rely on spot markets for sales. Insufficient oversight of dominant buyers can lead to substantial distortions in the input market where dominant buyers can manipulate market signals. Additionally, while cartel manipulation benefited consumers, these gains were outweighed by the losses to small sellers. Policies that primarily prioritize consumer welfare may hinder regulators' capacity to address the adverse effects of monopsony power on sellers.

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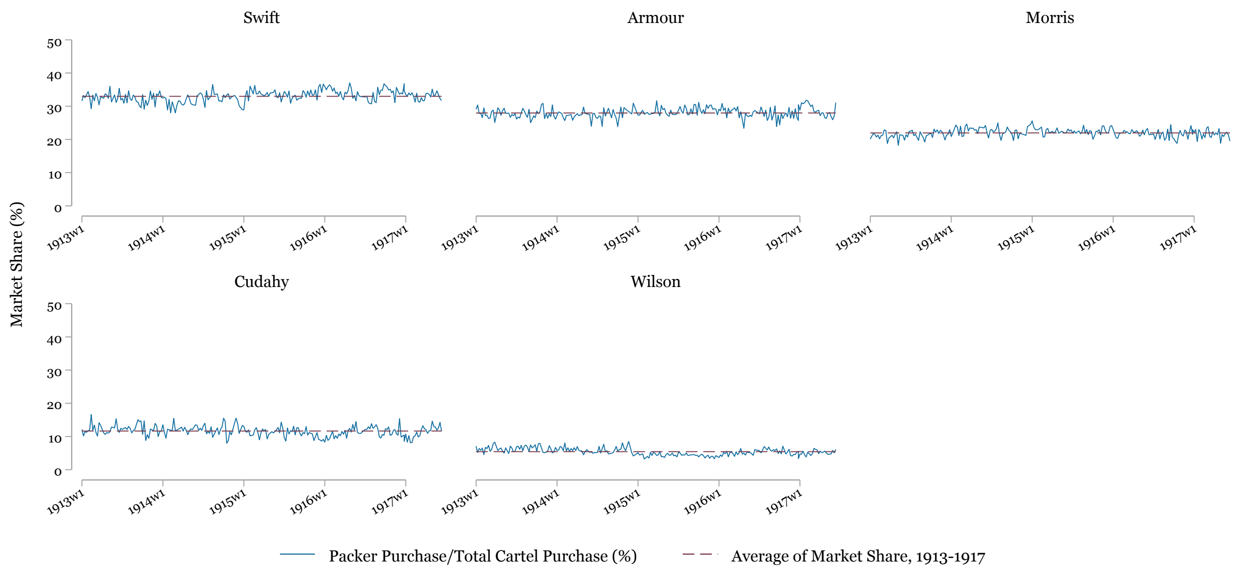
Supplemental Appendix

Figure A1: Aggregate Market Share for Each Cartel Member



Notes: The graph plots the market share of each cartel member as a percentage of total cartel purchases. Market share is defined as the total quantity of cattle purchased by a particular packer across all four stockyards (Chicago, Kansas City, St. Louis, and Omaha), as a percentage of the total purchase of all packers across all four stockyards. Note that packers colluded in *all* stockyard markets to maintain constant relative market share in total quantity purchased. However, due to data availability, I only calculate the relative market share using the quantity from the top four stockyards, which can explain some week-to-week variations.

Table A1: Concentration of Refrigerated Beef Production, 1916

	(1) Head Slaughtered	(2) "Big Five", %	(3) Interstate Slaughter, %
Chicago	1,949,735	87.1	24.5
Kansas City	1,169,658	99.6	14.7
Omaha	806,863	100.0	10.2
St Louis	694,715	89.2	8.7
New York City	409,917	97.7	5.2
St Joseph	311,848	99.4	3.9
Fort Worth	364,014	100.0	4.6
St Paul	230,452	100.0	2.9
Sioux	203,482	100.0	2.6
Oklahoma City	174,541	100.0	2.2
Top 10 Stockyard	6,315,225	94.6	79.5

Note: Data from FTC (1919). Total number of cattle slaughtered for interstate trade in 1916 was 7.9 million.

Table A2: Summary Statistics

	(1) Chicago	(2) Kansas City	(3) Omaha	(4) St. Louis	(5) Total
Cattle Price ($1920)	16.92	16.45	16.36	15.89	16.40
	(2.72)	(2.65)	(2.48)	(2.82)	(2.71)
Daily Average Shipment (000s)	9.53	6.63	3.44	3.98	6.07
	(2.24)	(2.82)	(1.31)	(1.55)	(3.22)
Daily Average Cartel Purchase (000s)	5.54	4.61	2.50	2.55	3.87
	(1.54)	(3.85)	(1.55)	(1.04)	(2.59)

Note: The table show average prices and quantities for the four stockyard markets. Standard deviations are in parentheses. See Appendix B for data sources.

Table A3: Market Outcomes With and Without Cartel Manipulation

	(1) Total Shipment	(2) Price	(3) Cartel Quantity	(4) Sellers' Margin
𝟙(Manipulation)	1.164***	-0.831***	1.239***	-1.231***
	(0.126)	(0.197)	(0.094)	(0.188)
Average Temperature, 4-Month Lag	0.003	-0.010	0.001	0.001
	(0.008)	(0.010)	(0.006)	(0.014)
Average Precipitation, 4-Month Lag	-0.110**	-0.205***	-0.012	-0.547***
	(0.051)	(0.068)	(0.035)	(0.096)
Min Temperature (F)	-0.011	-0.030**	-0.014**	-0.043**
	(0.010)	(0.012)	(0.007)	(0.018)
Max Temperateure (F)	0.008	0.023**	0.006	0.036**
	(0.008)	(0.010)	(0.006)	(0.015)
Precipitation (inch)	-0.332	0.355	-0.148	0.224
	(0.214)	(0.255)	(0.138)	(0.349)
Corn Price, 4-Month Lag ($1920)	-0.103***	0.445***	-0.071***	
	(0.019)	(0.027)	(0.014)	
Hay Price, 4-Month Lag ($1920)	-0.499***	0.580***	-0.362***	
	(0.066)	(0.081)	(0.045)	
Constant	-131.531***	-626.003***	-127.528***	-332.197***
	(34.465)	(50.615)	(25.614)	(37.566)
Mean	5.31	18.74	3.06	5.11
% wrt Mean	21.92	4.43	40.45	24.10
Observations	2525	2439	2525	2439
Adjusted R-Squared	0.87	0.81	0.81	0.51

Note: "Sellers' Margin" is defined as the difference between cattle price and feed costs. Therefore, the estimations for sellers' margin (column 4) does not include the feed costs in the regression. "% wrt Mean" shows the estimated coefficient of the manipulation period dummy (first row) as a percentage of the variable's sample mean during the non-manipulation period. The numbers of observations differ due to missing data in cattle prices. Standard errors are clustered by (weekly) time to account for correlation across markets. * $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

Table A4: Market Outcomes Excluding Chicago

	(1) Total Shipment	(2) Price	(3) Cartel Quantity	(4) Sellers' Margin
Cartel Manipulation	1.229***	-1.124***	1.118***	-1.459***
	(0.136)	(0.200)	(0.095)	(0.197)
Cost Controls	Yes	Yes	Yes	No
Mean	4.46	18.52	2.93	4.86
% wrt Mean	27.55	6.07	38.22	30.02
Observations	1820	1735	1820	1735
Adjusted R-Squared	0.82	0.81	0.74	0.51

Note: Sample excludes observations from Chicago Union Stockyard. Standard errors are clustered by week-of-year . * $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

Table A5: Market Outcomes Excluding Trial Period

	(1) Total Shipment	(2) Price	(3) Cartel Quantity	(4) Sellers' Margin
Cartel Manipulation	1.333***	-1.465***	1.178***	-2.382***
	(0.142)	(0.196)	(0.101)	(0.252)
Cost Controls	Yes	Yes	Yes	No
Mean	4.46	18.52	2.93	4.86
% wrt Mean	29.88	7.91	40.26	49.02
Observations	1653	1577	1653	1577
Adjusted R-Squared	0.82	0.82	0.74	0.55

Note: Sample excludes observations between December 1911, when the trial began, and January 1913, when the cartel finalized the dissolution of the joint holding company. Standard errors are clustered by week-of-year . * $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

Table A6: Detailed Estimates for Spot Market Supply Parameters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS		First Stages			IV	
Dependent Variable	$\ln(s_{ckt}) - \ln(s_{okt})$		Cattle Price			$\ln(s_{ckt}) - \ln(s_{okt})$	
Cattle Price	0.024				0.185*	0.224***	0.339*
	(0.018)				(0.101)	(0.081)	(0.175)
Average Temperature, 4-Month Lag	-0.000	0.031	0.036**	0.027	-0.004	-0.006	-0.009
	(0.005)	(0.022)	(0.018)	(0.021)	(0.008)	(0.008)	(0.010)
Average Precipitation, 4-Month Lag	-0.049	-0.147	-0.317***	-0.086	-0.030	-0.023	-0.001
	(0.033)	(0.122)	(0.120)	(0.129)	(0.047)	(0.048)	(0.063)
Min Temperature (F)	-0.002	-0.063***	-0.055**	-0.050**	0.008	0.010	0.018
	(0.007)	(0.022)	(0.024)	(0.022)	(0.011)	(0.012)	(0.014)
Max Temperateure (F)	0.001	0.036*	0.034	0.030	-0.006	-0.008	-0.013
	(0.006)	(0.020)	(0.021)	(0.020)	(0.009)	(0.009)	(0.011)
Precipitation (inch)	0.289*	0.124	-0.006	0.188	0.310	0.278	0.268
	(0.154)	(0.405)	(0.410)	(0.436)	(0.188)	(0.197)	(0.227)
Corn Price, 4-Month Lag ($1920)	0.037**	0.365***	0.219***	0.354***	-0.011	-0.024	-0.063
	(0.015)	(0.058)	(0.070)	(0.061)	(0.039)	(0.033)	(0.063)
Hay Price, 4-Month Lag ($1920)	-0.166***	0.008	-0.004	0.040	-0.203*	-0.197*	-0.203
	(0.060)	(0.318)	(0.364)	(0.318)	(0.111)	(0.116)	(0.148)
Chicken Price		0.098***					
		(0.025)					
Egg Price			-2.793***				
			(0.605)				
Lard Price				6.272***			
				(2.162)			
Constant	0.040						
	(0.500)						
Observations	773	673	688	686	673	688	686
Instrument					Chicken	Egg	Lard
Kleibergen–Paap F-statistic					15.29	21.33	8.41

Note: The table shows the regression coefficient γ_c described in equation (10). Estimations include weather and cost controls, as well as week-of-year by market fixed effects. The numbers of observations differ between the OLS and IV results due to missing data in the instrument. Standard errors are clustered by time. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A History of the Meatpacking Litigation

The table below summarizes the main events regarding the litigation process against the meat-packers. Dates and events are summarized from the materials presented at the House of Representatives debate on May 25,1912 (United States Congress, 1912) and various newspaper articles.

Meatpacking Litigation Time Line

Time		Event
1902	May	Government filed petition for an injunction against the Beef Trust
		Judge Grosscup issued temporary injunction
	August	Packers filed a demurrer against the injunction
1903	April	Judge Grosscup overruled packers' demurrer petition and the injunction remained in force(*Swift & Co. v. United States* (122 F. 529))
	May	Packers appeal to the Supreme Court against the injunction
1904	April	The Bureau of Corporations started an investigation in the meatpacking industry
1905	January	Supreme Court affirmed Judge Grosscup's injunction from 1903 (*Swift & Co. v. United States*, 196 U.S. 375)
	February	The government sought criminal indictment against the packers for antitrust violations
	July	Federal grand jury in Chicago indicted the Big Five and their top executives for violation of the Sherman Act
	October	Packers plead for immunity claiming that packers provided testimony for the Bureau of Corporation under compulsion
1906	March	Judge held that individuals were immune from the criminal prosecution, but indictment for the corporation stands
	October	Department of Justice decided to drop the case
1910	January	Department of Justice brought new charges against the packers
	March	Grand jury indicted the Big Five and their executives for violating the Sherman Act.
1911	December	Trial began
1912	March	Trial lasted three months. Jury found the packers not guilty of violating the criminal section of the Sherman Act.
	May	Attorney General announced that the government was prepared to file a civil suit against the packers
	June	Packers announced their intention to dissolve the joint holding company, National Packing Co.
	July	Packers submitted to the Department of Justice the dissolution plan
1913	January	Dissolution finalized

B Data Collection and Variable Construction

Cattle Market I collected the cattle shipment and price data from annual reports and trade journals. The table below listed the data sources for each market.

Stockyard Market Data Sources

Market	Shipment	Price
Chicago	Union Stockyard Annual Report	*The National Provisioner*,*Drover's Journal*, Chicago Board of Trade Annual Report
Kansas City	*The National Provisioner*	*The National Provisioner*
Omaha	*The National Provisioner*, *Nebraska Bee*	*The National Provisioner*, *Nebraska Bee*
St. Louis	Merchants' Exchange of St Louis *Annual Statement of the Trade and Commerce*	*Annual Statement of the Trade and Commerce*

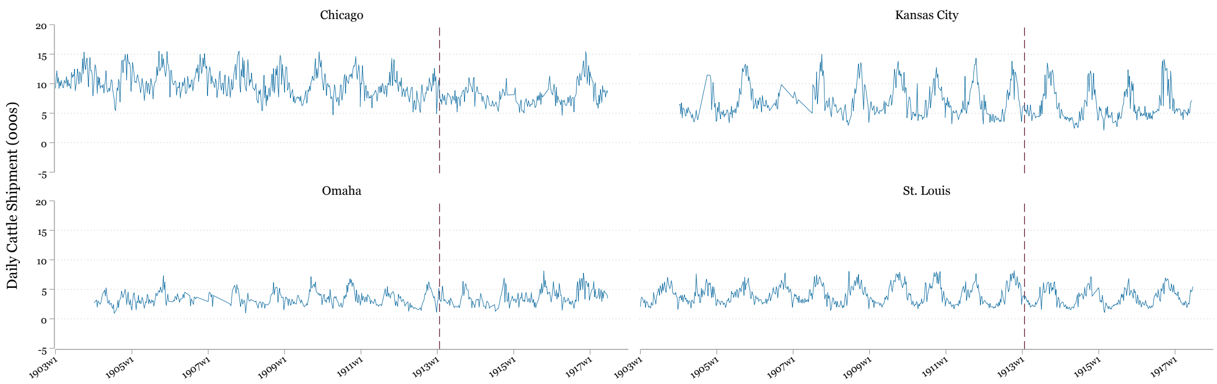
Though cattle prices are available by type and grade, I only use the average price for top-grade steers ("Prime" or "Choice") in the analysis for two reasons. First, the price for the top grade is the only category consistently reported over the whole time period. Second, refrigerated beef primarily came from the most heavy-weight ones and thus most relevant to the cartel manipulation. Bureau of Corporations (1905) reported that the average weight of cattle purchased a major packer in Chicago between 1902 and 1904 is 1,168 lbs, close to the average standard for "Choice" steer of 1,000 to 1,200 lbs. Heifers and bulls were either purchased by cattlemen for breeding or sold to local butchers since the smaller size does not justify being shipped afar as refrigerated beef.

For all the analysis, sample exclude periods when the stockyards were closed due to quarantine or extreme weather or when less than two days of trading data were reported. When estimating the logit model, I also exclude the top and bottom 1% of observations to avoid distortion of extreme values.

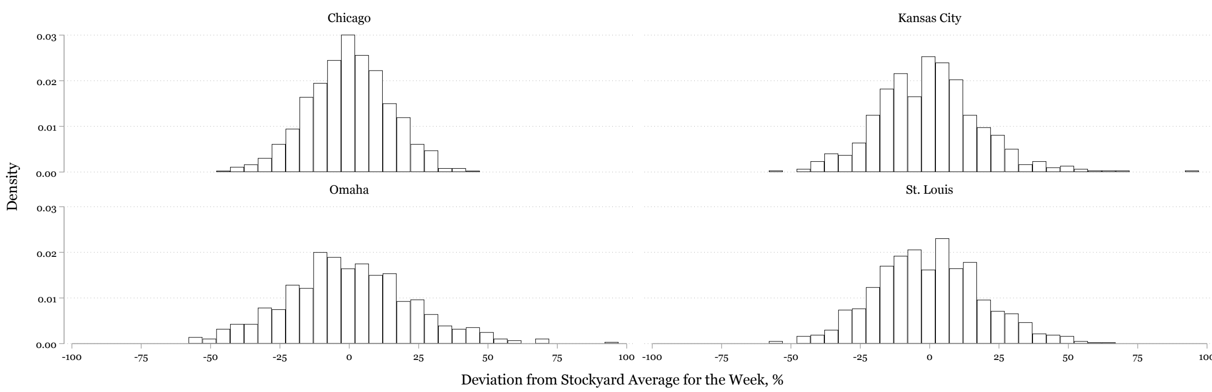
Cattle Production Cost and Weather Corn prices are available through the NBER Macro history database, series 04005, "U.S. Wholesale Price of Corn, Chicago." I digitize the monthly No. 1 baled Timothy hay prices from the Department of Agriculture's Yearbook.

I also construct monthly averages of temperature and precipitation for the feedlot cattle production region, using county-level historical weather data from Bleakley and Hong (2017). The averages are weighted by county areas. The sample includes the following key states in feedlot cattle production: Colorado, Iowa, Kansas, Minnesota, Missouri, North Dakota, New Mexico, Nebraska, Oklahoma, and South Dakota. Local weather data for each stockyarad were accessed through the NOAA past weather website.

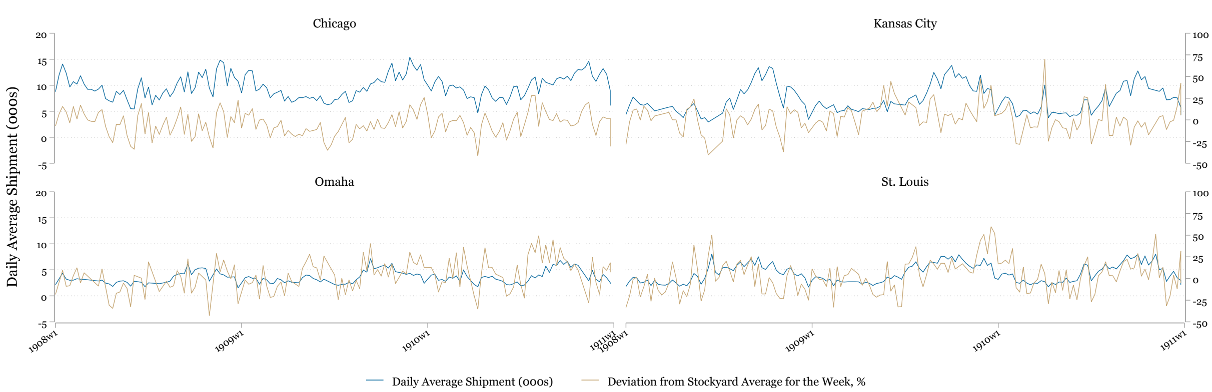
Figure A2: Shipment into Stockyard Markets



(a) Average Daily Shipment into the Stockyards,1903-1917



(b) Distribution of Deviation from Week-of-Year Average



(c) Example of Deviation from Week-of-Year Average,1908-1910

Notes: Deviation is the percentage difference between the shipment and the week-of-year averages. The week-of-year average shipment is calculated separately for each stockyard, with and without manipulation.