

Monopsony, Cartels, and Market Manipulation: Evidence from the U.S. Meatpacking Industry

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Abstract

This paper quantifies the effects of a dynamic monopsonistic cartel strategy on the market by examining the U.S. meatpacking cartel from 1903 to 1917. The analyses leverage changes in the legal environment that forced the cartel to switch from a dynamic to a static strategy. I quantify the welfare loss by comparing the observed market outcomes under the dynamic strategy with the static counterfactuals. Without the dynamic strategy, wholesale cattle prices would increase by 23% and 15,000 heads more cattle would be sold per week, while beef prices would be 6% lower and a household would save \$3.6 per year.

JEL Classifications: D22, L13, L66, N61, N82

Key Words: monopsony, cartel, meatpacking

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1 Introduction

Policymakers and academics are increasingly concerned about the anti-competitive effects of monopsony power in a wide range of industries.¹ However, despite recent policy efforts to address these adverse effects,² economic theory provides a limited understanding of monopsonistic cartel strategies. In particular, standard monopsony models focus primarily on static and immediate responses to cartel strategies. However, for markets with substantial time to ship or time to build, current market outcomes may influence future supply decisions and thus make sellers vulnerable to a more complex form of dynamic manipulation. Because sellers must make future production or shipment decisions based on current market information, they must commit to the market before observing the realized spot market price at the time of delivery.³ If a monopsonistic cartel incorporates the delayed supply responses in the collusive strategy, the canonical static model may fail to properly assess the cartel damage on the market.

This paper estimates the impact of a dynamic cartel strategy on both the input and product markets by analyzing the U.S. meatpacking cartel. In the early 20th century, five meatpackers formed one of the largest manufacturing cartels in American history. The cartel dominated both the input market (cattle) and product market (beef): the five packers purchased 95% of cattle sold at the ten largest stockyards and produced more than 80% of refrigerated beef for urban markets. In 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 well suited to examining the effect of a dynamic monopsonistic cartel strategy. First, because the cartel was eventually challenged in court, the resulting litigation created detailed documentation on the cartel's manipulation strategies. The court found that the 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."⁴ Second, exogenous changes in the regulatory environment forced the cartel to switch from the aforementioned dynamic strategy to a static fixed market share agreement in 1913, while other features of the market remained unchanged. Thus, I observe the market outcomes under both dynamic and static strategies but with the same market participants. This allows me to compare the empirical outcomes under the dynamic strategy to counterfactuals suggested by the well-understood static monopsony model.

¹In *The United States v. Apple*, 952 F. Supp. 2d 638, the court found "Apple orchestrated a price-fixing conspiracy with five major e-book publishers." In *Knevelbaard Dairies v. Kraft Foods, Inc.*, 232 F.3d 979, the court charged the manufacturer for unlawful manipulation of the cheese market. For empirical analyses of monopsony power, see Dube, Jacobs, Naidu, and Suri (2020), Ashenfelter, Farber, and Ransom (2010), and Manning (2003) on the labor market, Inderst and Mazzarotto (2008) on retail distribution, Morlacco (2019) on input trade, and Rubens (2021) and Chatterjee (2019) on agricultural products.

²The Department of Justice and the Federal Trade Commission issued guidelines in 2016 regarding no-poach and non-compete agreements. See also Senate Committee on the Judiciary (2004), Department of Justice (2012), and Council of Economic Advisors (2016).

³Jeon (2017), for example, describes the time-to-build feature in the container shipping industry.

⁴*United States v. Swift et al* (122 F 529).

I compiled high-frequency data from numerous primary sources for the empirical analysis. The main variables of interest are cattle shipment to the stockyards, spot market prices, and cartel quantities. The weekly data were compiled from the livestock trade journal, *The National Provisioner*, between 1903 and 1917 for the four largest stockyards, which collectively produced more than 58% of U.S. refrigerated beef. To control for input cost, I collected monthly wholesale corn and hay prices from the *Chicago Board of Trade Annual Report* and the *Department of Agriculture Yearbook*. I also collected wholesale prices of live hogs in New York City to construct the instrument variable for demand shocks.

The analysis consists of three main parts. I start by providing descriptive evidence on how dynamic manipulation affected the cattle wholesale market. I first show that such manipulation led to different aggregate market outcomes: under manipulation, 17% more cattle were shipped to the stockyards for sale, yet the cattle wholesale price was 4% lower. I also show that consistent with narrative evidence, the cartel successfully manipulated cattlemen's shipment decisions. Under cartel manipulation, higher shipment quantities did not correspond to higher realized prices. Without manipulation, however, more cattle were shipped when the market price was higher, suggesting that cattlemen could correctly predict market conditions once the cartel stopped their dynamic manipulation. Finally, I also show that no firm deviated from the static market share agreement after the packers suspended the weekly meeting. In other words, after 1913, the market outcomes are consistent with the static monopsony model.

However, the reduced-form results provide only limited information about the effects of the dynamic cartel strategy on the market. To measure the level of distortion created by the dynamic cartel strategy on both market price and quantity, I must construct the counterfactual market outcomes absent of cartel manipulation, which requires a structural model of static monopsony. Therefore, in the second part of the analysis, I construct and estimate a static model of the cattle wholesale market. The cartel chooses the price at the cattle market to maximize per-period profit given the cattle supply and beef demand. On the supply side, I use a discrete choice model with differentiated buyers (Berry, 1994): cattlemen either choose to sell to the cartel at the spot market price or try the competitive outside market. To address the price endogeneity issue, I use prices of a beef substitute in the urban market (i.e., live hogs) as an instrumental variable to trace out the spot market cattle supply curve. On the demand side, I use the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980) with two-stage budgeting to estimate urban households' demand for beef. Both the cattle supply and beef demand are estimated separately using data after 1913 when the cartel was forced to adopt the static strategy.

In the third part of the analysis, I use the estimated static model to solve for market outcomes for the dynamic period *before* 1913. Assuming that cattlemen and urban consumers behave in the same way as they did during the post-1913 static period, I recover the counterfactual cattle wholesale prices and cartel quantities as well as downstream wholesale beef prices. The difference between the observed market outcomes under the dynamic strategy and the counterfactuals suggested by the static model is therefore the "additional" damage of the dynamic cartel strategy

not captured by standard models.

I find two sets of key results. First, regarding the cattle wholesale market, the dynamic strategy causes more damage to small sellers than what is suggested by the standard model: without the cartel manipulation, the average cattle wholesale price would increase by 23.4%, which would increase the profit margin by 57% for the sellers. The average total quantity purchased by the cartel would also increase by 14%, or 15,000 more heads of cattle per week sold at the four stockyards. Second, regarding the downstream beef wholesale market, the dynamic strategy hurts urban consumers by reducing the beef supply and increasing household food expenditure. However, the effects are much smaller: without cartel manipulation, downstream wholesale beef prices would reduce by 6% and total household food expenditure would reduce by \$3.6 per year.

The main empirical strategy measures the effects of the dynamic cartel strategy by comparing the counterfactuals predicted by the static strategy with the observed market outcomes under the dynamic strategy. This approach exploits the unique data structure by taking the market outcomes under the dynamic cartel strategy as given. Though recent work provide insights into why individuals can make systematic mistakes, empirical analysis usually rely on specific and strong assumptions on preferences or beliefs.⁵ In contrast, this paper remains agnostic about agents' beliefs in the dynamic environment. Instead of imposing any specific belief structures on the agents, I focus on estimating the well-understood static model and quantify the aggregate impact of the dynamic strategy by comparing the observed market outcomes with the theoretical counterfactuals. In spirit, the analysis is similar to recent works that study market distortions in complicated economic or institutional environment by comparing empirical outcomes with model benchmarks.⁶

My research contributes to three strands of existing literature. First, it quantifies the effect of the monopsonistic cartel with dynamic seller responses on the input market. A growing literature on buyer power and imperfect competition in the agricultural markets ([Chatterjee, 2019](#); [Bergquist and Dinerstein, 2020](#); [Rubens, 2021](#)) documents the negative effect of dominant buyers on prices. In addition, recent research from legal and antitrust policy perspectives calls for more attention to monopsony's adverse effects on both sellers and overall market efficiency ([Blair and Harrison, 2010](#); [Hemphill and Rose, 2018](#); [Werden, 2007](#)). To my best knowledge, this paper is the first to consider the monopsony strategy under dynamic market responses. The results show that the canonical static model understates the welfare loss from monopsonistic market power. Moreover, the case of the meatpacking cartel shows that when a cartel dominates both the input and the product market, the dynamic manipulation can lead to welfare loss to both upstream sellers and downstream consumers.

Second, this paper is related to the literature on the rise of industrial cartels and antitrust regulations during the Progressive Era. The meatpacking cartel was one of the largest manufacturing cartels in U.S. history and was among the first to be challenged in court. Prior research has detailed

⁵See [Heidhues and Kőszegi \(2018\)](#) for a survey.

⁶See [Borenstein, Bushnell, and Wolak \(2002\)](#) on the California electricity market, [Asker, Collard-Wexler, and De Loecker \(2019\)](#) on OPEC oil production, and [Rafey \(2019\)](#) on the Australian water market.

the cartel's development (Yeager, 1981; Chandler, 1993; Libecap, 1992) and how competition policies evolved in response to the new market structure (Aduddell and Cain, 1981; Lamoreaux, 2019; Sawyer, 2019). I contribute to the historical analyses by documenting and quantifying the effect of a specific dynamic cartel strategy on the market. In addition, while previous research focuses on regulatory evolution, this paper leverages changes in the legal environment that were not created by new regulations. The results suggest that development in legal interpretation and antitrust enforcement can rein in certain anti-competitive behaviors and improve welfare under the existing legal framework.

Finally, this paper contributes to the literature on the inner workings of cartels. Past research dissects specific cartel strategies across different markets and regulatory environments (Marshall and Marx, 2012; Röller and Steen, 2006; Genesove and Mullin, 2001; Harrington and Skrzypacz, 2011). I present new evidence that a monopsonistic cartel can employ a more complicated dynamic strategy to manipulate the market. This paper provides a first-order estimate on the cartel damage and expands our understanding of the strategic toolkit available for cartels.

The rest of the paper is structured as follows. Section 2 describes the meatpacking industry and the cattle wholesale market. Section 3 introduces the data, and Section 4 presents descriptive evidence on the effectiveness of the dynamic strategy. Section 5 sets the analytical framework for the market under the static strategy. Section 6 discusses the identification of the model, and presents the estimation results. Section 7 presents the counterfactual analysis, and Section 8 concludes.

2 Historical Background of the Meatpacking Cartel

In this section, I offer some historical background on the meatpacking industry and the meatpacking cartel, and I describe the regulatory environment's evolution in the early twentieth century. The nature of the livestock market and the meatpacking industry provides the basis for the structural model I describe in Section 5. In addition, the changes in the regulatory environment described here allow me to identify key parameters for the model I describe in Section 6.

2.1 History of the Meatpacking Industry

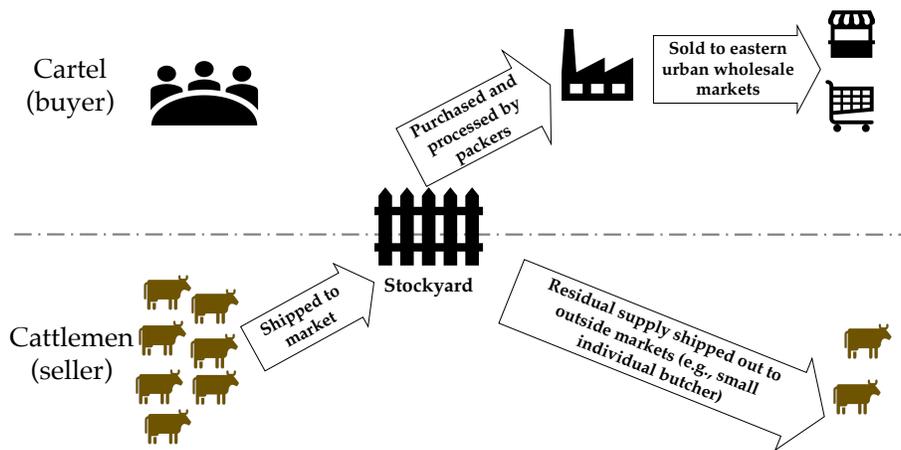
The introduction of mechanical refrigeration and the subsequent adoption of ice-refrigerated rail cars by Chicago meatpackers in the 1880s created the modern meatpacking industry (Anderson, 1953). Instead of shipping live cattle to eastern markets, packers could now ship just the carcasses in tightly packed refrigerated rail cars. On the one hand, refrigerated rail cars significantly reduced the shipping cost of beef: carcasses could be shipped for one-third the cost of shipping live cattle (Bureau of Animal Industry, 1884; Skaggs, 1986). On the other hand, the fixed cost of constructing specialized rail cars, ice plants, and refrigerated warehouses along the transportation lines created high barriers to entry.⁷ By the early 20th century, five firms (the "Big Five") had

⁷Appendix Figure ?? shows the specialized rail cars and ice manufacturing facilities along the rail lines.

come to dominate the meatpacking industry.

Figure 1 illustrates the meatpacking industry’s production chain. In the cattle market, the Big Five were the dominant buyers. In 1916, they slaughtered 6.5 million head of cattle, or 82.2% of all wholesale refrigerated beef sold in interstate commerce (Federal Trade Commission, 1919). Refrigerated beef production was highly concentrated both across and within stockyard markets: the ten largest stockyard markets contributed to almost 80% of all cattle slaughtered for interstate trade, with Chicago alone producing nearly a quarter of the cattle. Within each market, the Big Five accounted for almost all cattle slaughtered at the stockyards (see Appendix Table ??), and because they dominated the cattle purchase and refrigerated beef production, the Big Five naturally dominated the downstream beef wholesale market. By 1903, the packers furnished 75% of all beef consumed in New York City, 85% in Boston, 60% in Philadelphia, and 95% in Providence (Bureau of Corporations, 1905).

Figure 1: Meatpacking Industry Value Chain

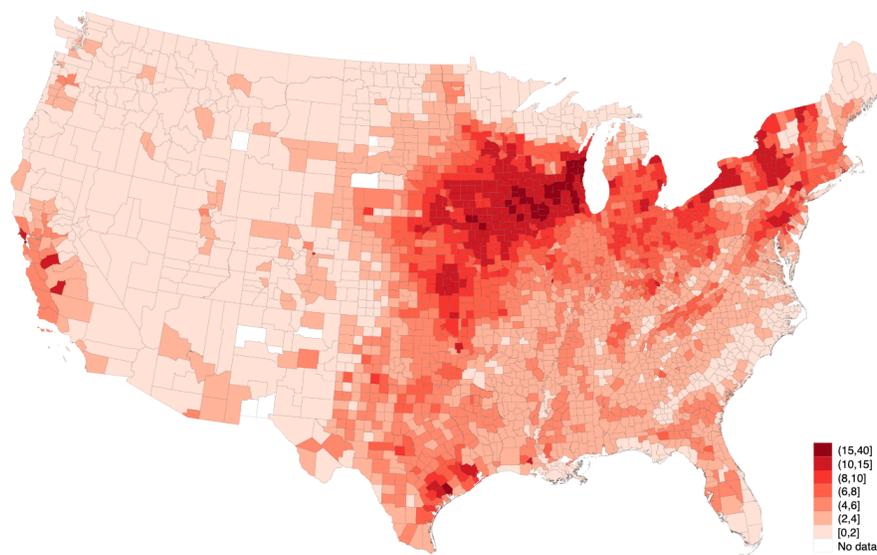


2.2 Cattle Production and the Stockyard Spot Market

Cattle production was concentrated in the Midwest in the early twentieth century. Figure 2 displays the spatial distribution of cattle in 1910. Illinois, Wisconsin, Iowa, and Kansas had the highest cattle density. Cattlemen fattened cattle on small feedlot farms with corn and hay, then shipped and sold their cattle at the stockyard spot markets. About 85% of cattle shipped to the Chicago stockyards were fattened on small feedlots in the “Corn Belt” (Clemen, 1923). Proximity to stockyards allowed cattlemen to respond quickly to price fluctuations when making their shipment decisions. For example, in a 1905 report, the Bureau of Corporations noted that “there is always a large potential supply of cattle ready or nearly ready for market compared with the amount actually shipped [...] and a large number, therefore, can be rushed to market at a day’s notice if the prices are sufficiently attractive” (Bureau of Corporations, 1905).

Cattlemen had long complained about the large supply and price variations at stockyard markets, and they attributed the fluctuations primarily to the meatpackers that dominated the stockyard markets. For example, the National Live Stock Association president highlighted the frustration against the packers at the association’s 1909 annual convention: “In the past we have witnessed many violent fluctuations in the value of live stock [...] the centralization of the meat packing industry in a few hands at those large markets has mainly been responsible for the uncertain and sudden changes in prices, creating a glut one week and a famine the next” ([American National Live Stock Association, 1909](#)). Nevertheless, without the cattle futures market, which was not introduced to the Chicago Mercantile Exchange until 1964, cattlemen lacked the financial tools necessary to hedge against the price fluctuations.

Figure 2: Cattle Density (per hundred acre), 1910



Note: Data from the 1910 Census of Agriculture ([Haines et al., 2018](#)). Values exclude milk cows and working oxen. The data are plotted with 1910 county boundaries.

The stockyard markets were composed of inelastic, price-taking sellers and the monopsonistic meatpacking cartel. Chicago’s Union Stock Yards, for example, received, on average, more than 9,000 cattle per day. The total number of cattle available for sale on the market dwarfed the capacity of any individual seller. Further, the high cost to ship live cattle led to inelastic supply decisions on the spot market. For example, in 1908, it cost between \$4.43 and \$8.03 to ship a steer from a feedlot in Kansas to Chicago ([Andrews, 1908](#)).⁸ Meanwhile the average profit per head was \$12.79 for the same year ([Skinner, 1909](#)). Therefore, cattlemen were reluctant to take their cattle off the market once they arrived at the stockyards.

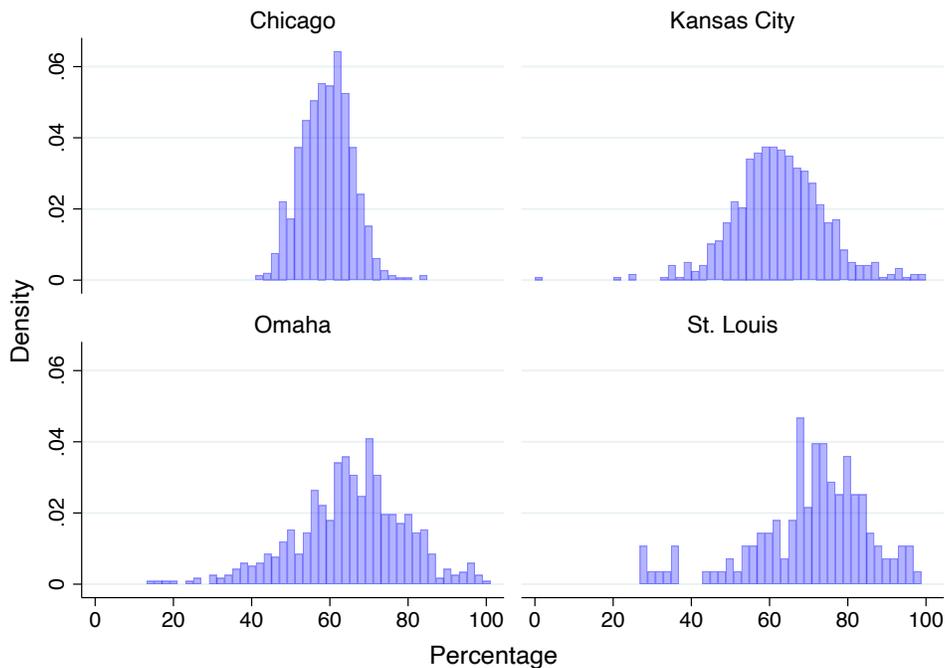
The spot market trading environment was conducive to collusion among the meatpackers.

⁸This cost covers the freight (\$0.25–\$0.55 per 100 pounds), as well as feed along the route, driving the cattle from the feedlot, and loading them onto rail cars ([Andrews, 1908](#)).

The meatpackers purchased cattle in the open market and immediately shipped the cattle to their packing plants adjacent to the stockyard for processing (see Appendix Figure ?? and Appendix Figure ??). Thus, the packers could directly observe the realized quantity and prices of other buyers. In other words, cartel members could easily monitor compliance with their collusive agreements at little cost.

There was a large alternative market for live cattle beyond the stockyards. Figure 3 plots the distribution of the share of cattle in stockyards purchased by the cartel. On average, 15% of the cattle shipped to the stockyards were not sold on the spot market and were instead sold in the outside market to small retail butchers. In 1909, slaughtering and meatpacking establishments processed 59.6% of all cattle slaughtered for food in the United States (1909 Census of Manufactures). The rest were processed on the farm or in retail slaughterhouses.⁹

Figure 3: Percentage of Cattle Purchased by the Big Five at Stockyard



Note: Data are from *The National Provisioner*.

2.3 Refrigerated Beef Production

Cattle were slaughtered and processed into large wholesale pieces, primarily by low-skilled manual labor (see Appendix Figure ??). There was little productivity difference across firms as they draw from the same local labor market. The main variable cost of refrigerated beef production was the cost of live cattle; labor and other variable costs were low. According to the 1909 Cen-

⁹Cities closer to the Corn Belt, such as Cleveland, Cincinnati, and Indianapolis, relied more on local slaughter for fresh, unrefrigerated beef. In these cities, packers contributed less than a third of the fresh beef supply (Bureau of Corporations, 1905).

sus of Manufactures, wages and salaries accounted for only 5.4% of total production cost in the slaughtering and meatpacking sector, while non-fuel materials, primarily livestock, accounted for 90.7% of production cost. In addition, labor was a perfect complement to the material input (cattle). Workers never secured a contract with fixed hours of work and instead received hourly wages to “work until the day’s killing is done” (Commons, 1904).

2.4 Cartel Structure and Strategy

Between 1893 and 1918, the Big Five formed a cartel that controlled both the live cattle market and the wholesale beef market. In 1913, changes in the regulatory environment forced the cartel to switch from a dynamic manipulation strategy to a static non-manipulation strategy.

[Appendix A](#) provides a chronological history of the meatpacking litigation from 1902 to 1913.

Phase 1: Cartel Uses Dynamic Strategy to Manipulate the Livestock Market

Between 1893 and 1912, the cartel used dynamic strategies to manipulate the livestock market. Though the Sherman Act was passed in 1890, enforcement against anti-competitive practices was lax.¹⁰

In the livestock wholesale market, the cartel not only fixed the market share and charged the same price but also used its market power to manipulate cattle prices to gain more than a monopsony. Circuit Judge Peter Grosscup best summarizes the strategy in a 1903 case:¹¹

That the defendants are engaged in an unlawful combination and conspiracy under the Sherman Act in (a) directing and requiring their purchasing agents at the markets where the livestock was customarily purchased, to refrain from bidding against each other when making such purchases; (b) *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*; (c) in agreeing at meetings between them upon prices to be adopted by all, and restriction upon the quantities of meat shipped. [emphasis added]

In 1905, in a unanimous decision, the U.S. Supreme Court upheld the lower court’s ruling (*Swift & Co. v. United States*, 196 U.S. 375). In the majority opinion, Justice Oliver Wendell Holmes wrote the following:

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*

¹⁰In the 1894 case *United States v. E.C. Knight Co.*, the Supreme Court ruling exempted manufacturing from “interstate commerce” restrictions, effectively barring the federal government from pursuing anti-trust action against manufacturing firms under the Sherman Act. In 1898, in *Hopkins v. the United States*, the court held that livestock trade occurring at the Kansas City stockyards did not constitute interstate commerce; this ruling further restricted application of the Sherman Act to the livestock market (Walker, 1910).

¹¹*United States v. Swift & Co.* (122 F 529).

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. [emphasis added]

Though courts issued injunctions against certain anti-competitive behaviors in the aforementioned cases, the injunctions were weakly enforced and had no explicit restriction against potential price manipulation. Eventually, despite abundant evidence on their collusive behavior, the grand jury found the packers and their executives not guilty of all criminal charges under the Sherman Act.¹²

Phase 2: Cartel Forced to Adopt Static Strategy

The packers, however, decided the weekly meetings had become too risky to continue given the new legal landscape. In particular, the landmark rulings against the Standard Oil Company and the American Tobacco Company made the packers legally more vulnerable in the ensuing civil cases (Yeager, 1981; Lamoreaux, 2019). To avoid future prosecutions, the packers decided to stop the dynamic manipulation. By the end of January 1913, after a few rounds of negotiation, the packers had agreed on the relative market share of cattle purchases and suspended the weekly meetings (Federal Trade Commission, 1919).¹³ Instead of manipulating the market prices from week to week to exploit the dynamic supply responses, the market share agreement intended to maximize static per-period profit, and thus is consistent with the standard static monopsony cartel model.¹⁴ In other words, the cartel followed the dynamic strategy until January 1913, after which it was forced to adopt the static strategy. This historical setting provides unique observations of the market outcomes with the same set of participants under different cartel strategies.

3 Data

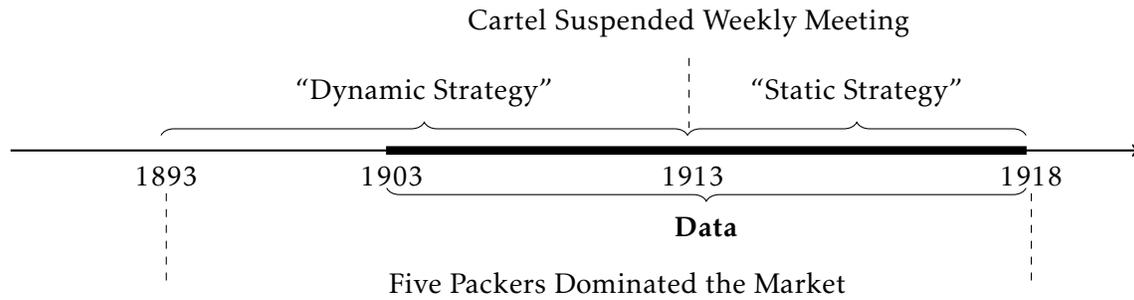
I collected weekly livestock market data from historical trade journals to quantify the effect of the dynamic cartel manipulation. These data cover the four largest stockyards from 1903 to 1917. Figure 4 shows where the data lie on the overall timeframe. Because the cartel was forced to switch from dynamic to static strategy in 1913, I can directly observe the market outcomes with the same cartel, market concentration, and production technology, but under different collusive strategies. I combined this livestock market data with information on input cost and downstream sales to analyze the decisions of both the cattlemen and the cartel.

¹²Evidence admitted by the court includes minutes of the weekly meetings showing the presence and participation of cartel executives as well as weekly telegraphs summarizing shipments and prices for every meeting (*The National Provisioner*, March 9, 1912.) The consensus among contemporary newspapers and historians later was that jurors were reluctant to impose criminal penalties upon the socially prominent defendants, whereas only civil charges were brought in the previous anti-trust cases against industry giants (Lamoreaux, 2019).

¹³The packers met under the cover of a “board meeting” for a joint holding company, the National Packing Company. In 1913, the packers dissolved the holding company and stopped the weekly “board meeting.”

¹⁴The packers maintained their market share agreement until 1920, when they were eventually forced to divest the production chain under a consent decree.

Figure 4: Event Timeline and Data Coverage



3.1 Livestock Market Data

I collected weekly cattle trade data from *The National Provisioner* from 1903 to 1917 for the four largest stockyards: Chicago, Kansas City, St. Louis, and Omaha. This trade journal published weekly data on the number of cattle shipped into the stockyards and the number of cattle that left the stockyards. The difference between the two is thus the number of cattle purchased and processed by the cartel. The weekly data also include wholesale cattle prices at the stockyard markets. These data allow me to directly measure cattlemen’s aggregate sales decisions and the cartel’s input quantity and price. The weekly publication also noted cases where transactions were affected by exogenous shocks such as disease quarantine or extreme weather. I exclude all such cases from my analysis. [Appendix B](#) provides details on variable construction and validation.

[Table 1](#) provides the stockyard markets’ summary statistics. On average, more than 9,000 head of cattle a day were shipped to Chicago’s Union Stock Yards, 60% of which were purchased in transactions valued at \$1 million. The other three stockyards operated on a smaller scale, but they were all dominated by the same packers.

Table 1: Summary Statistics

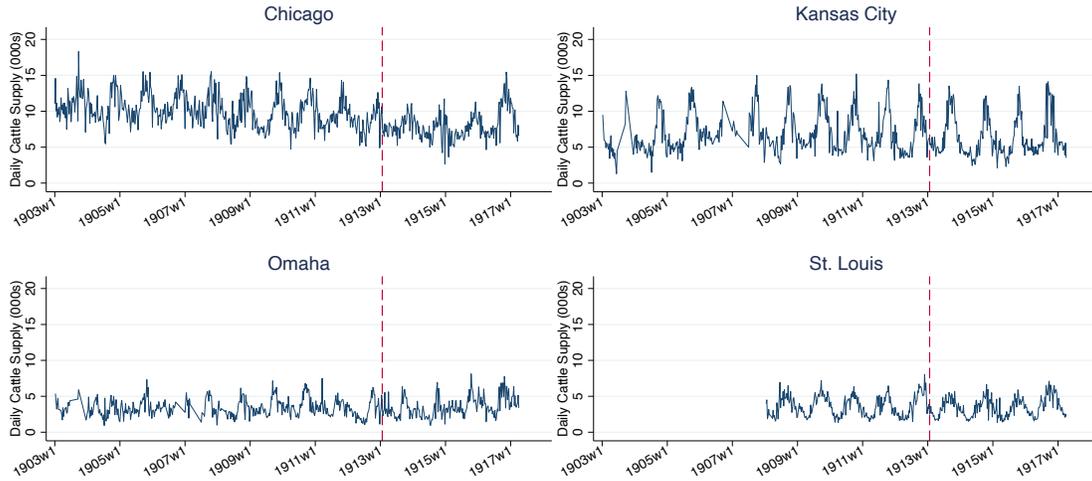
	(1) Chicago	(2) Kansas City	(3) Omaha	(4) St. Louis	(5) Total
Cattle Price in 1920\$	17.12 (2.63)	16.45 (2.62)	16.31 (2.45)	18.51 (1.79)	16.79 (2.59)
Daily Average Shipment (000s)	9.36 (2.27)	6.78 (2.72)	3.45 (1.29)	3.50 (1.47)	6.58 (3.27)
Daily Average Cartel Purchase (000s)	5.52 (1.44)	4.19 (1.55)	2.22 (0.82)	2.48 (1.13)	4.02 (1.89)

Note: Price and quantity data are from *The National Provisioner*.

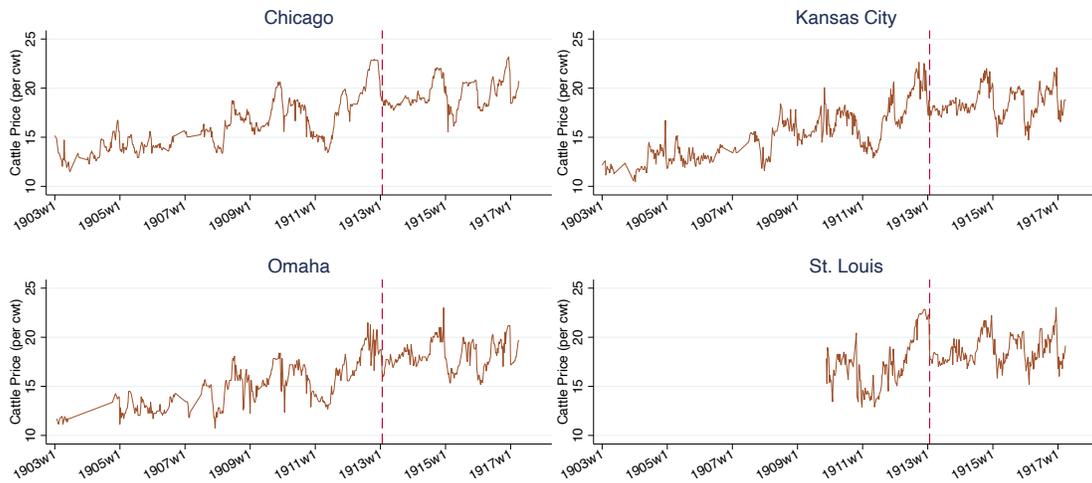
Cattle supply exhibits significant variations from week to week. [Figure 5a](#) displays the average daily shipment for each stockyard. The cattle supply exhibits obvious seasonality, driven by the natural production cycle of cattle. The aggregate supply at the stockyard spot market could be drastically different from one week to the next, even for cattle fattened over the same period with

similar feed costs.¹⁵ Spot market prices for cattle also varied dramatically from week to week (see Figure 5b). As a benchmark, the average profit margin per head of cattle is \$12.79 in 1909 (Skinner, 1909). Thus, a \$0.25 drop in the wholesale price would wipe out 30% of a cattleman's net profit.

Figure 5: Cattle Shipment and Prices



(a) Average Daily Shipment into the Stockyards



(b) Cattle Price by Stockyards

Note: Data are from *The National Provisioner*. Observations from weeks with less than two days of reported shipment information are excluded.

3.2 Auxiliary Data

I collected weekly wholesale prices of live hogs in New York City from the *The National Provisioner*. Live hogs were a close substitute for refrigerated beef and were not influenced by the

¹⁵The coefficient of deviation for the average shipment is 0.49.

cartel.¹⁶ The wholesale price of live hogs in the downstream urban market capture week-to-week consumer demand fluctuations faced by the cartel. Such prices would influence the cartel’s demand on the cattle market, and therefore I use them as instrumental variables to estimate the supply parameters.

To control for cost factors of cattle production, I collected monthly wholesale corn and hay prices from the *Chicago Board of Trade Annual Report* and the *Department of Agriculture Yearbook*.¹⁷ To measure weather shocks, I constructed the area-weighted average of monthly temperature and precipitation using county-level historical data from [Bleakley and Hong \(2017\)](#).

In addition, to estimate the retail demand for beef and other food items, I used the 1917–1919 cost of living survey,¹⁸ which is one of the earliest household consumption and expenditure surveys. It provides detailed household expenditure data on 12,817 families of wage earners or salaried workers in 99 U.S. cities, coinciding with the type of urban markets served by the cartel. In [Section 6.2](#), I discuss how I constructed the data for demand estimation.

4 Descriptive Evidence of the Dynamic Cartel Strategy

In this section, I provide reduced-form evidence on the effects of the dynamic cartel strategy on the cattle wholesale market. To do so, I first compare the aggregate market outcomes under the dynamic and static strategies. I then show that consistent with narrative evidence, the cartel successfully manipulated cattlemen’s prediction for market prices with the dynamic strategy.

4.1 Dynamic Manipulation is Effective

I first use an event study design to examine how the changes in cartel strategies influence aggregate market outcomes. Exogenous shifts in the external legal environment forced the cartel to adjust their market strategy while other aspects of the market remained the same. It is thus plausible to attribute the difference in aggregate outcomes to the changes in the cartel strategy.

Specifically, I estimate the event study regression

$$y_{kt} = \alpha_1 \mathbb{I}(\text{Dynamic Period}_{1903-1912}) + X_{kt} + \eta_{kw} + T + \epsilon_{kt}, \quad (1)$$

where y_{kt} is the outcome variable for stockyard k at time t ; η_{kw} is the stockyard-by-week-of-year fixed effect, which captures the seasonality of the cattle market at each stockyard; T is the yearly time trend; X_{kt} includes weather and cost controls. The weather controls include quarterly lagged weighted average temperature and rainfall, as well as the current temperature and rainfall in the counties where the stockyards were located. The cost controls include quarterly lagged corn and

¹⁶The cartel also produced cured meats as well as refrigerated (dressed) lamb, pork, etc. Though these animal products are close substitutes, their prices cannot be a plausible instrument.

¹⁷Specifically, I use the No. 2 corn from [Chicago Board of Trade \(various years\)](#) and No. 1 baled Timothy hay prices from [Department of Agriculture \(various years\)](#).

¹⁸[Bureau of Labor Statistics \(1992\)](#). The data are digitized by the Inter-university Consortium for Political and Social Research (ICPSR) and are available as ICPSR study 8299.

hay prices as cost controls. α_1 , the event study coefficient, represents the average difference of the outcome y_{kt} between the dynamic manipulation and static non-manipulation period. Because of the small number of stockyards, I follow [Bertrand, Duflo, and Mullainathan \(2004\)](#) and allow for the presence of arbitrary correlations within each market over time by clustering standard errors by stockyard.¹⁹

[Table 2](#) shows that market manipulation was effective. During the dynamic manipulation period, 17% more cattle were shipped to the stockyards, while the cartel price was 4% lower. Cattlemen’s margin, defined as the difference between the wholesale cattle and corn prices, was 24% lower.

Table 2: Price and Quantities during and after Manipulation

	(1) Total Shipment	(2) Price	(3) Cattlemen’s Margin
Dynamic Period Dummy (03/1903-01/1913)	0.920* (0.335)	-0.728* (0.264)	-1.128** (0.242)
Time Controls	Yes	Yes	Yes
Weather Controls	Yes	Yes	Yes
Cost Controls	Yes	Yes	No
Mean	5.30	18.66	4.72
% wrt Mean	17.34	3.90	23.89
Observations	2461	2103	2110
Adjusted R-Squared	0.85	0.75	0.35

Note: “Cattlemen’s Margin” is defined as the difference between cattle price and input cost, which is approximated by the three-month lagged corn price. “% 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. Standard errors are clustered by stockyard. * $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

One concern for this event study is the effect of World War I. To avoid this influence, I use only the data from before April 1917, when the United States joined the war, for my main analyses. Though WWI may have spurred agricultural production even before then,²⁰ the competitive structure at the wholesale livestock market remained unchanged. Therefore, I assume the market behaved the same during this period. Any potential influence of the war on cattle production, especially through the prices of corn and hay, affected the cattle market in the same way as before through the cost channel. In addition, column (3) of [Table 2](#) directly addresses the concern about rising price levels caused by the war. Though this is an event study, column (3) can also be seen as a difference-in-differences result, which compares the price of cattle with the price of corn and hay before and after the cartel meetings stopped. The result suggests that under cartel manip-

¹⁹One obvious alternative is block bootstrap. However, as noted in [Bertrand, Duflo, and Mullainathan \(2004\)](#), block bootstrap performs well when the number of groups is large. This paper uses data from only four stockyards (i.e. “group”), thus rendering block bootstrap ineffective.

²⁰Agricultural production increased steadily during the second half of the 1910s to satisfy robust export demand ([Henderson et al., 2011](#)).

ulation, cattle prices were lower compared to the price of corn and hay, which were traded in a competitive market throughout the whole period.

4.2 Cattlemen Behave Differently under Static and Dynamic Strategies

As the narrative evidence in [Section 2](#) suggests, the cartel benefited from manipulating the total supply of cattle at the stockyard from week to week. Because the weekly data contain both the total number of cattle shipped to the stockyards and the realized market price after their arrival, I can empirically document the cattlemen’s behavioral responses under different cartel strategies.

I estimate the relationship between the realized market price and total shipments into the stockyards, controlling for seasonality, production shocks, and general time trends. Specifically,

$$p_{kt} = \alpha_z Z_{kt} + X_{kt} + \eta_{kw} + \tau_y + \epsilon_{kt}, \quad (2)$$

where p_{kt} is the realized cattle price for the week t in stockyard k , Z_{kt} is the number of cattle shipped to the stockyard, η_{kw} is the stockyard-by-week-of-year fixed effect, and τ_y is the year fixed effect.²¹ X_{kt} include the same set of weather and cost controls as in [\(1\)](#). Note that cattlemen made the shipment decisions *before* they observed the market price for the week. Therefore, α_z captures whether cattlemen’s shipment decisions are “correct”: if they correctly predicted the market condition and shipped more cattle when the market price turned out to be high, one would expect α_z to be positive.²²

[Table 3](#) shows the estimation for α_z under different cartel strategies. The first two columns cover the dynamic manipulation period; the estimated coefficient suggests that the total number of cattle arriving at the stockyards during the dynamic manipulation period did not correlate with the realized market price. However, when the cartel stopped manipulating the price, more cattle were shipped to the stockyards when the realized price was high, as suggested by the positive and significant coefficient in columns (3) and (4).

I conduct two robustness checks to show that the results are not driven by learning or by changes in the available market outlet. One concern is that cattlemen may have learned more about the market over time, implying that the estimation using the whole dynamic manipulation period may be biased. The second concern is that, because some cattlemen could choose between the stockyards, they may have behaved differently when multiple stockyards were closed (due to animal quarantine or extreme weather). [Appendix Table ??](#) shows that cattlemen behaved the same in both the first and second half of the dynamic strategy period.²³ The results from the

²¹In the event study regression, I include only the year trend because of the dummy variable for the dynamic manipulation period. In regression [\(2\)](#), because I estimate the results for dynamic manipulation and static non-manipulation periods separately, I can include year fixed effects to control for potential non-linear changes in the trend.

²²Limited by the small sample size, I opt to compare the average values for the two periods rather than conduct an event study by year.

²³Given that the data cover the second half (1903–1912) of a two-decade-long manipulation scheme (1893–1912), this result is consistent with the assumption that the market should have arrived at an empirical equilibrium state after ten years.

main specification in [Table 3](#) are also robust to restricting the sample to cases with at least three operating stockyards.

Table 3: Price vs. Shipment

Dependant Variable: Price	Dynamic Strategy		Static Strategy	
	(1)	(2)	(3)	(4)
Daily Average Shipment (000s)	-0.007 (0.034)	0.042 (0.029)	0.100* (0.037)	0.097* (0.031)
Time Controls	Yes	Yes	Yes	Yes
Weather Controls	No	Yes	No	Yes
Cost Controls	No	Yes	No	Yes
Observations	1328	1320	787	780
Adjusted R-squared	0.75	0.78	0.56	0.63

Note: Weather controls include quarterly lagged weighted average temperature and rainfall as well as the current temperature and rainfall in the counties where the stockyards were located. The cost controls include quarterly lagged corn and hay prices. Standard errors are clustered by stockyard. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

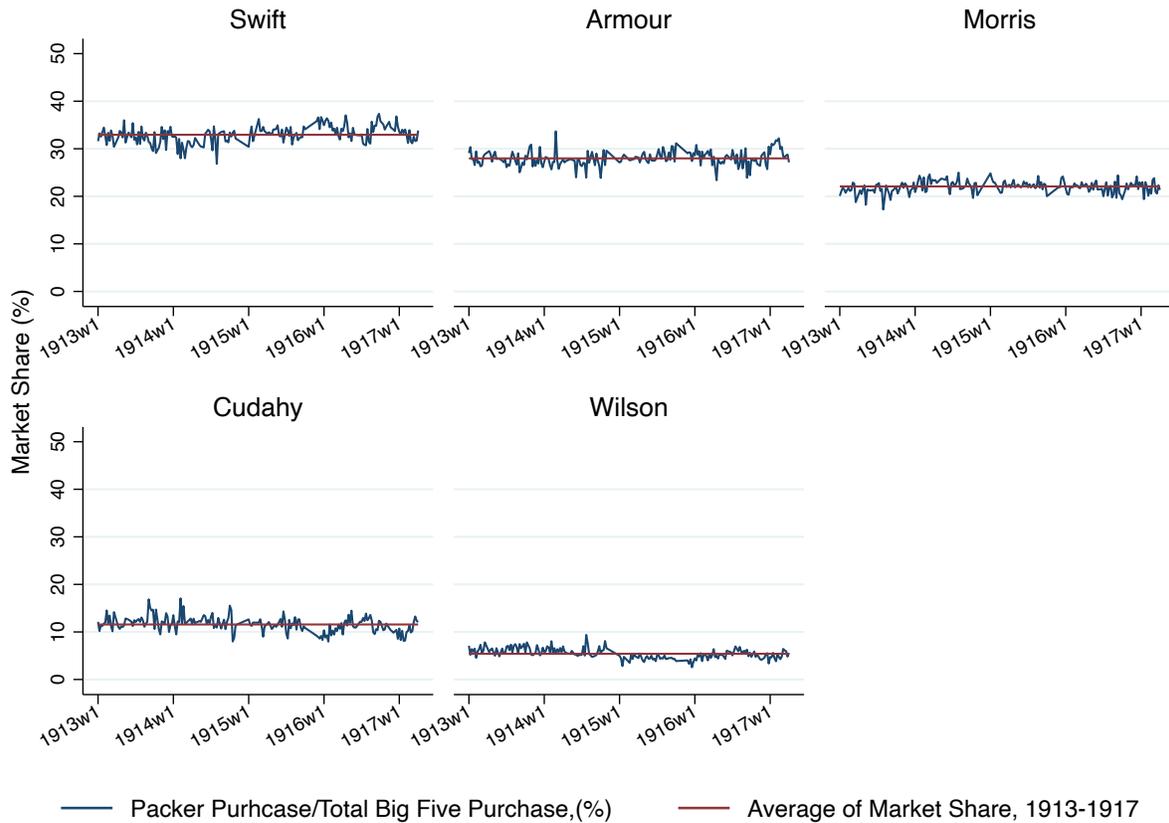
4.3 Cartel Members Did Not Deviate

The observed cartel outcomes during the static period would only coincide with the static monopsony model if cartel members did not cheat. Past research shows that cartels may have used frequent meetings to resolve other disagreements among members ([Genesove and Mullin, 2001](#)). Therefore, suspending the weekly meetings may have caused potential deviation from the collusive agreement and thus would not match the static monopsony model.

To show that cartel members did not deviate under the static strategy, I plot the aggregate market share for each of the packer after 1913. The market share is defined as the total quantity of cattle purchased by a particular packer across all four stockyards, as a percentage of the total purchase of all the Big Five across all the four stockyards.

As shown in [Figure 6](#), despite large week-to-week fluctuations in aggregate market supply, relative market share among the Big Five remained stable, suggesting cartel members did not deviate from their collusive market share agreement after suspending the weekly meetings. The result is also consistent with the narrative evidence described in [Section 2.2](#): the stockyard environment made it hard for cartel members to cheat even without frequent meetings as they could directly observe the quantity purchased by other packers and the price they paid.

Figure 6: Cartel Members Did Not Deviate



Note: The graph plots the market share of each packer as a percentage of total Big Five purchase.

In addition, the Federal Trade Commission also found evidence of stable market share among the packers in other stockyard markets under the static strategy. The FTC uncovered internal documents from the packers for 1916 and 1917, showing that they observed and recorded each others' market behaviors to monitor compliance. The FTC found that the packers collected weekly reports of "cattle purchases at a number of markets [...] which enables each to check the other's observance of the [market share] agreement." As a result, "each of the big packers maintains his relative percentage in the purchase of live stock at the different markets fairly constantly even from week to week, more constantly from month to month, and almost exactly from year to year" (Federal Trade Commission, 1919).

5 Analytical Framework of the Cattle Spot Market

This section presents a structural model of the cattle wholesale market under static monopsony. The main goal is to quantify the effect of dynamic cartel manipulation by comparing the empirical outcomes with the counterfactuals under the static cartel strategy. Though the results from the event study provide an arguably causal estimate on the effect of the dynamic cartel strategy on input market price and quantity, the estimate provides only limited information on the underlying

mechanism. In particular, it does not capture the counterfactual market outcome with both price and quantity changes, nor does it provide any information on the corresponding influence on welfare. Therefore, I develop the structural model to estimate what would happen during the dynamic period if the cartel adopted a static strategy.

Because the cartel dominated both the input (i.e., cattle) and product (i.e., refrigerated beef) markets, the cartel faced an upward-sloping cattle supply and a downward-sloping beef demand. On the supply side, cattlemen make spot market sales decisions following a discrete choice model: cattlemen choose between selling to the cartel and selling to the competitive market outside of the stockyard.²⁴ I use the standard logit choice model to capture cattlemen’s sales decisions. On the demand side, I estimate the downstream demand that the cartel faces with the the AIDS model. I then combine the spot market supply and downstream retail demand to characterize the cartel’s equilibrium static strategy.

This modeling choice is driven primarily by the historical setting. Regulatory changes forced packers to adopt the static strategy without changing any other aspects of the market, allowing me to directly estimate the static equilibrium with observed market outcomes under the static strategy. One intuitive alternative would be to specify the model under the dynamic strategy. However, the equilibrium solution under the dynamic strategy requires strong assumptions on how cattlemen and the cartel formed their expectations. Instead, leveraging the historical setting, I focus on solving the model under static conditions and use the estimated static model to derive the counterfactuals. This approach is effective for estimating the scope and severity of cartel damages, though it is less informative about the specific mechanism of cartel manipulation.

5.1 Cattlemen’s Spot Market Supply

Following [Berry \(1994\)](#), I use a logit discrete choice model with differentiated buyers to capture cattlemen’s spot market supply decisions. Cattleman i chooses between buyer j : $\mathcal{J} = \{\text{cartel}, \text{outside}\}$. As discussed in [Section 2.2](#), because of the high shipping cost, I assume that sellers cannot take the cattle off the market and have to sell to one of two buyers once they arrive at the stockyards.

The utility for cattleman i depends on price p_{jt} , cost factors \mathbf{X}_{jt} , latent buyer characteristics σ_{jt} , and an idiosyncratic utility shock ϵ_{ijt} . Cost factors \mathbf{X}_{jt} include lagged weather and feed price shocks common to all cattlemen, and stockyard-specific seasonality and weather conditions for time t . σ_{jt} represents unobserved (by econometrician) buyer characteristics, such as distance between the cattlemen and the buyer, or credit services provided by the buyer.²⁵ Finally, ϵ_{ijt} is a random utility shock identically and independently distributed across buyer-seller pairs and over time, so a seller may prefer a certain buyer today but this does not contain any information about the preference for the next period. This i.i.d assumption is reasonable for the static period, when

²⁴I assume the outside market to be perfectly competitive and thus do not consider the case of umbrella damage, where the outside non-cartel buyers adjust their pricing to the supra-competitive level set by the cartel at the stockyard. This is plausible given the large number of small buyers outside the stockyard who compete in prices.

²⁵For example, the meatpackers also operated cattle loan companies to provide credit for cattlemen to purchase calves and feed.

both the cartel and cattlemen were making decisions to maximize the static per-period gain and there was no long-term relationship between sellers and buyers. In other words, cattleman i 's utility when selling to buyer j is

$$U_{ijt} = \gamma_p p_{jt} + \mathbf{X}_{jt} \gamma_x + \sigma_{jt} + \epsilon_{ijt}. \quad (3)$$

Suppose that ϵ_{ijt} follow an extreme-value type-I distribution, and normalize the utility derived from the outside market to be zero. This generates the standard logit form of the market share expression

$$\ln(S_{cartel,t}) - \ln(S_{outside,t}) = \gamma_p p_{cartel,t} + \mathbf{X}_{cartel,t} \gamma_x + \sigma_{cartel,t}, \quad (4)$$

where $S_{cartel,t}$ is the share of cattle at the stockyard purchased by the cartel and $S_{outside,t}$ is the share of cattle that left the stockyard alive to be sold in an outside market. The supply side of the structural model characterized by equation (4) can be estimated using a simple instrument variable approach.

Of the Z_t cattle that arrived at the stockyard, the cartel can expect to purchase $q(p_{cartel,t})$ head at a given price $p_{cartel,t}$, where

$$q(p_{cartel,t}) = \frac{\exp(\gamma_p p_{cartel,t} + \mathbf{X}_{cartel,t} \gamma_x + \sigma_{cartel,t})}{1 + \exp(\gamma_p p_{cartel,t} + \mathbf{X}_{cartel,t} \gamma_x + \sigma_{cartel,t})} Z_t. \quad (5)$$

5.2 Cartel's Demand

Based on the production process described in [Section 2.3](#), I use three main assumptions to simplify the cartel's demand. First, there is no substitution between cattle and other variable inputs. This implies that the cartel faces a Leontief production function. A packer uses q_t head of cattle and v_t units of other variable inputs to produce m_t units of refrigerated beef, or

$$m_t = \min\{\theta_1 q_t, \theta_2 v_t\}. \quad (6)$$

I further assume there is no productivity difference across firms. Because the production process relied primarily on manual labor and all the packers drew from the same local labor market, it is likely that all firms share the same "conversion rate" between cattle and beef. In other words, all the cartel members share the same θ_1 .²⁶ Finally, because cattle accounted for more than 90% of the variable cost, the analysis focuses only on the cost of cattle and abstracts away from all other costs such as labor or fuel. With these two assumptions, the cartel's production cost when purchasing cattle at p_t is

$$c(p_t) = m(p_t) \times p_t,$$

²⁶For reference, a 1,200-pound steer yields a 750-pound carcass, or 63% of the input weight.

where $m(p_t) = \theta_1 q(p_t)$ and $q(\cdot)$ is the inverse spot market supply function from (5).

Because the cartel is also a monopoly seller of refrigerated beef, it faces a downward-sloping demand curve $D(\cdot)$. Therefore, under the static strategy, the cartel chooses optimal price p_t^* at the cattle wholesale market to maximize its per-period profit:

$$p_t^* = \arg \max_{p_t} D(m(p_t))m(p_t) - c(p_t). \quad (7)$$

5.3 Equilibrium

With the cattlemen's supply decision and the cartel's profit function, I can specify the market equilibrium:

Definition 1. The spot market equilibrium is the set of price and cartel quantities $\{p_t^*, q_t^*\}$ such that the quantity corresponds to the expected spot market supply given by (5) and the price solves the cartel's profit-maximization problem in (7).

5.4 Alternative Dynamic Model

The analysis abstracts from cattlemen's shipment decisions before they arrive at the stockyards and take the empirical aggregate market supply (i.e., the total number of cattle arrived at the stockyards) as given. One obvious alternative is to extend the supply side to incorporate cattlemen's dynamic shipment decisions, where the cattlemen observed past market information and decided whether to ship to the stockyard market for each period. However, two factors make this approach less desirable. First, to estimate the dynamic choice of cattlemen, one would need to observe the total number of cattle available for sales, the actual amount shipped to the stockyards, and the amount shipped to outside markets or held back for the next period. Other than the total shipment to stockyards, no other cattle production or sales data were available. Second, and more importantly, it requires an explicit belief structure to solve for the equilibrium under the dynamic cartel strategy. Section 4 suggests that cattlemen's behavior was not consistent with rational expectations, yet scant evidence exists to support any specific belief forms.

The historical setting allows me to analyze the effect of cartel manipulation without estimating the dynamic decisions on either the cattlemen or the cartel. The drawback of this approach is that the counterfactual results are of a partial equilibrium nature: they do not account for the changes in total supply to stockyards or aggregate cattle production under the static strategy. However, because the wholesale market price of cattle would be higher under the static cartel strategy, supply to the stockyards and aggregate production would both be higher than the observed value during the dynamic manipulation period. Therefore, the counterfactual results that take the empirical supply and production levels as given correspond to a lower bound of the effect of the cartel strategy on the input market.

6 Identification and Estimation

I start by estimating the supply function and calculating the input-price markdowns of the spot market cattle supply under different cartel strategies. I then estimate the demand for refrigerated beef and construct the cartel’s quantity decision given the cattle supply and beef demand. I use these results in the next section to simulate counterfactuals.

6.1 Spot Market Supply

As discussed in [Section 5.1](#), estimating spot market elasticity with observed market share and price data faces the typical simultaneity problem in industrial organization: the unobserved buyer characteristics σ_{jt} may influence both market price p_{jt} and demand. A demand shifter can be used as an instrument for cattle prices to identify the spot market supply function. Because the downstream demand for refrigerated beef influences the volume of cattle purchased by the cartel, I use the price of beef substitutes to instrument for the cattle price. Specifically, I use the lagged downstream wholesale price of live hogs as instruments for cattle prices at the stockyards.

Because the same cartel operated at all four markets, one may be concerned about the presence of correlations across markets, in addition to the serial correlation within a stockyard market. With such correlation, standard errors may be underestimated even with clustering. Instead, I used moving block bootstrap to calculate the standard errors while maintaining the correlation structures.²⁷

[Table 4](#) presents the estimated price coefficient γ_p , estimated separately for the dynamic and static period. During the dynamic period, because the cartel was not maximizing per-period profit, the static model does not match the actual cartel pricing strategy. As expected, columns (1) and (2) show that the estimated price coefficients are small and statistically insignificant under the dynamic strategy.²⁸ However, during the static period, cartel behavior matched the standard static model. After addressing the endogeneity issue with the instrument variable, column (4) shows that higher cattle prices indeed corresponded to a larger share of the total shipment bought by the cartel.

²⁷[Bertrand, Duflo, and Mullainathan \(2004\)](#) suggest using block bootstrap by re-sampling the groups of observation when the number of groups is large, yet the data contain only four stockyards (i.e., “groups”). More importantly, this method assumes independence across groups, which is less likely to hold in this scenario when the same cartel is making purchasing decisions simultaneously for all four stockyards.

²⁸This is driven by potential estimation bias for the dynamic period. As discussed in [Section 4.2](#), because the cartel used market prices to manipulate the sellers from week to week, the residuals are likely to be correlated across time and thus violate the independence assumption for the estimation.

Table 4: Spot Market Supply

	Dynamic Strategy		Static Strategy	
	(1) OLS	(2) IV	(3) OLS	(4) IV
Cattle Price	-0.02 (0.01)	0.01 (0.05)	-0.04 (0.04)	0.13** (0.07)
Observations	1087	644	610	492
First-Stage F-statistics		40.32		39.31

Note: The table shows the regression coefficient γ_p described in equation (4). All estimations include the same set of time, weather, and cost controls. Standard errors are bootstrapped with 100 iterations. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results highlight the importance of focusing the model estimation only on the static period. Consistent with previous evidence that the cartel successfully manipulated the sellers, the insignificant results suggest that the market had a different data-generating process during the dynamic period. By modeling the market under the static cartel strategy alone, this approach avoids specifying the complicated cartel manipulation while still providing a well-understood theoretical benchmark to quantify the effect of the dynamic cartel manipulation.

To interpret the results, I calculate the corresponding elasticity, markdown, and input share of revenue. Given the market share expression, the spot market price elasticity of cattle supply can be expressed as $e_s = \gamma_p p_{jt}(1 - S_{jt})$. Correspondingly, the cattle price markdown, ψ_s , can also be written as a function of price, market share, and the price coefficient, where $\psi_s = (\gamma_p p_{jt}(1 - S_{jt}))^{-1} + 1$. Input share of revenue is the inverse of markdown, or $\frac{1}{\psi_s}$. Since these statistics are non-linear in γ_p , I include the calculation of the three measures in the bootstrap process.

Table 5 presents selected moments for elasticity, markdown, and input share of revenue measures. The spot market supply is inelastic, with the average price elasticity as 0.94. This corresponds to the markdown value of 2.13, meaning cattlemen received 42% of their marginal contribution to manufacturing profits, on average. The results are consistent with the narrative evidence that the cartel had monopsony power on the cattle wholesale market.

Table 5: Elasticity, Markdown, and Input Share of Revenue

	Mean	SD	CI5	CI95
Elasticity	0.94	0.48	0.16	1.62
Markdown	2.13	1.37	1.51	3.98
Input Share of Revenue	0.42	0.35	0.14	0.62

Note: The table shows the estimated mean, standard deviation, and the 90% confidence intervals, calculated from the estimated regression coefficient γ_p described in equation (4). Results are bootstrapped with 100 iterations.

6.2 Cartel Demand

I estimate the demand for beef $D(\cdot)$ separately using the AIDS model (Deaton and Muellbauer, 1980) and the 1917–1919 cost of living survey (Bureau of Labor Statistics, 1992). The demand model corresponds to a two-stage budgeting process: at the higher level, households first choose to allocate expenditures across broad segments of food (meat, dairy, starch, vegetables). At the lower level, households allocate the expenditures for different products within the segment. In particular, given the expenditure on meat, a household may choose between beef, pork, poultry, and other meat products.²⁹ Appendix B reports the specific items included in each category.

This modeling choice is appropriate from both conceptual and practical perspectives. As a wholesaler, the cartel cared about the general demand for beef with respect to other food items such as pork. The AIDS model is a good first-order approximation for these broad product categories,³⁰ and it captures households' consumption behaviors and provides the basis for evaluating the counterfactuals in the downstream product market. The demand estimation thus plays a part first in solving for the cartel's problem and later in calculating the welfare effects of the dynamic strategy on urban consumers.

Table 6 summarizes the general household consumption pattern from the data. Among the 12,817 “families of wage earners or salaried workers” across 99 U.S. cities, the average household spent \$544 a year on food, which accounted for 38.4% of its total annual expenditure. The four main segments used in the demand estimation contributed to 58.7% of the food budget. Beef dominated other meat products in terms of quantity: an average household consumed 168 pounds of beef per year, four times the quantity of pork. For comparison, in 2017, Americans consumed 54 pounds of beef per person, or 216 pounds of beef per year for a family of four.³¹ Though the survey data contain household-level information, the reported prices on the household level exhibit little variation.³² Therefore, for my analysis, I aggregate the data at the city level. The empirical environment restricts me from using other demand models that are feasible only with high-quality microdata.

²⁹See Appendix C for details of the two-stage budgeting process for estimation.

³⁰The quadratic extension of AIDS, or QUAIDS, has been used to fit household consumption data. However, as noted by Banks, Blundell, and Lewbel (1997), the original AIDS model has proven to be a good fit for food items.

³¹U.S. Department of Agriculture “Food Availability and Consumption” data series. Accessed on October 7, 2020.

³²In many cases, the implied price of a certain product is identical across all households within a city. This suggests that the surveyor may have imputed total cost or quantity variables using a fixed price.

Table 6: Summary Statistics of Household Expenditure Survey

	Mean	SD
Annual Household Expenditure		
Main Food Groups (meat,dairy, starch, vegetables)	319.36	100.49
All food (includes coffee, candy, etc)	544.37	149.66
Total expenditure by the household	1419.45	394.84
Income		
Weekly Wage Rate of Husband	26.61	8.25
Household Total Earnings	1434.04	411.38
Annual Total Consumption (lbs.)		
Beef	168.11	108.38
Pork	41.37	54.73
Poultry	23.37	34.31

Note: Summary statistics are calculated from the 1917–1919 *Consumer Expenditure Survey* (Bureau of Labor Statistics, 1992). The values represent the average of 12,817 households in the survey.

Table 7 presents the summary statistics for price and expenditure share for the items I use in the estimation. Beef was the main source of meat consumption and contributed to half of the total household expenditure on meat products. Among the four food categories, households allocated 30% of their food expenditure to meat and dairy, 23% to starch (e.g., flour, rice, pasta), and 16% to vegetables (column (3)). Average prices from the survey are also comparable to values from contemporary market reports: for example, the wholesale price in New York City was 26 cents per pound for beef rib and 32 cents per pound for pork tenderloins.³³

³³*The National Provisioner*, April 6, 1918, page 44.

Table 7: Summary Statistics for Prices and Market Shares

	Price (\$/lb)		Expenditure Share (%)	
	Mean (1)	SD (2)	Mean (3)	SD (4)
Meat Products				
Beef	0.29	0.04	50.53	7.56
Pork	0.36	0.08	15.50	6.08
Poultry	0.35	0.04	8.65	2.39
Other (fish, cured meat)	0.36	0.07	25.32	6.36
Food Segments				
Meat	0.31	0.03	30.02	3.65
Dairy	0.21	0.03	30.89	5.59
Starch	0.09	0.01	23.41	3.87
Vegetable	0.05	0.01	15.68	1.91

Note: Prices are aggregated up to the city level by expenditure share weight. The upper panel shows the prices and expenditure of the products under the “meat” segment; the lower panel shows the prices and expenditures of the four segments in the food market.

Price endogeneity can be a threat to identification as in most demand estimations. In this case, beef prices were endogenously determined by the packers, who were monopolistic sellers on the market. Following [Hausman, Leonard, and Zona \(1994\)](#), I use the average price at the census region as an instrument for city-level prices to address the endogeneity concern in the lower-level estimation. Regional prices reflect local cost factors such as wages and transportation; they are correlated with city-level prices but are uncorrelated with unobserved demand shocks and can therefore be a valid instrument.³⁴ [Table 8](#) reports the estimated compensated own-price and cross-price elasticity for the lower-level.³⁵ The own-price elasticity for beef estimated at the mean is -1.42 , which is within the range of other own-price elasticities of beef from other studies.³⁶ Demand for other meat items appears to be more elastic, which may reflect a general preference for beef as households spent half of their meat budget on beef.

³⁴The survey questionnaire asked for the annual average quantity and cost on food. The survey was conducted in different months, and respondents might base their answers on recent purchases, but only a small fraction of the price variation can be explained by time. I report the analysis of variance of prices in [Appendix Table ??](#). As shown in columns (4) and (5), a significant fraction of the total price variance can be attributed to regional variation.

³⁵See [Appendix Table ??](#) for the elasticity estimation of the upper level.

³⁶Price elasticity ranges from -0.998 in the U.S. in 1993 ([Kinnucan, Xiao, and Hsia, 1996](#)) to -1.19 in the 1970s ([Eales and Unnevehr, 1993](#)), to -1.95 in post-WWII Australia ([Murray, 1984](#)).

Table 8: Lower-Level Price Elasticity

	(1) Beef	(2) Pork	(3) Poultry	(4) Other
Beef	-1.415*** (0.129)	0.940*** (0.102)	0.238*** (0.073)	0.237*** (0.068)
Pork	3.083*** (0.336)	-4.741*** (0.458)	-0.055 (0.222)	1.713*** (0.304)
Poultry	1.439*** (0.444)	-0.102 (0.411)	-1.691*** (0.392)	0.354** (0.172)
Other	0.485*** (0.140)	1.066*** (0.190)	0.119** (0.058)	-1.670*** (0.138)

Note: Standard errors are in parentheses. * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

6.3 Model Fit

Because I do not impose an equilibrium assumption of the cartel behavior for the estimation, one concern is that the cartel may not behave optimally during the static period so the observed market outcome may not match the model. Though there is no evidence of deviation on the input market after the cartel suspended the weekly collusive meetings, as discussed in [Section 4.3](#), there may be operation frictions or deviation on the beef wholesale market that prevented the packers from jointly maximizing their profit.

I examine the model fits by comparing the actual cartel quantity reported in the data with the model prediction for the static period. Appendix Figure ?? plots the predicted cartel quantity against the observed purchase. The predicted values largely replicate the distribution of the actual quantity observed in the data. In other words, the cartel's behavior after 1913 is consistent with the classic static model. There are a few cases where I observe more than 8,000 daily purchase and the model predicted a lower cartel quantity. These outliers all occurred at the Chicago stockyard during the winter months of 1916, suggesting that there were potential unobserved shocks in the market for this particular period that were not captured in the model.

7 Counterfactuals

In this section I use the estimated model to simulate counterfactual outcomes for the dynamic period, assuming the cattlemen and the cartel behaved the same way they did during the post-1913 static period. I first quantify the effects on the wholesale cattle market by comparing the observed market outcome under the dynamic cartel strategy with the counterfactuals under a static monopsony. In addition, from a policy perspective, antitrust regulators may also care about how disrupting cartel manipulation could influence downstream consumers. Therefore, I also calculate the counterfactual wholesale refrigerated beef prices and the corresponding changes in household expenditure. These two measures together allow me to evaluate the effect of cartel manipulation on both the aggregate market outcome and the distributional effect on individual

sellers and buyers.

7.1 Solving for Counterfactual Equilibrium

Following the equilibrium definition in [Section 5.3](#), I find the counterfactual equilibrium price by solving (7). The cartel’s optimal decisions are governed by the spot market supply of cattle and downstream demand for beef. On the demand side, I use the household price elasticity derived from the AIDS model to approximate the wholesale demand for beef. On the supply side, the inverse supply curve $q(p_t)$ requires two main components: the parameters γ_p and γ_x and the total supply of cattle at the market Z_t . γ_p and γ_x are estimated from the static period in [Section 6.1](#). I use the observed cattle shipment during the dynamic period for Z_t and solve for the optimal cartel price, as described in (7), by numerically finding the value that maximizes the profit function.³⁷ I then calculate the corresponding counterfactual cartel quantity using the inverse supply defined in (5).

This counterfactual is of partial equilibrium in nature since the model focuses primarily on the spot market and does not account for adjustment in aggregate cattle production or shipment. In particular, this calculation corresponds to a lower bound for the effect of the dynamic cartel strategy: absent cartel manipulation, the wholesale cattle price would be higher, which in turn would increase aggregate supply at the stockyard. The observed shipment I used for Z_t would be lower than the “true” counterfactual that allows for adjustment in cattle production. The results are thus lower bounds of the cartel effect.

This approach also implicitly allows for other frictions or inefficiencies that are hard to model or estimate. For example, litigation and public opinion pressure may discourage the cartel from capturing the full monopoly profit during the dynamic period. Past research also suggests that, even for legal cartels with no litigation threats, many cartels capture only part of the theoretical monopoly profits due to organizational frictions ([Röller and Steen, 2006](#); [Asker, Collard-Wexler, and De Loecker, 2019](#)). Therefore, instead of imposing strong equilibrium assumptions on the cartel, I compare the observed market outcomes under the complicated manipulation strategy with a simple and well-understood theoretical benchmark. The difference can be interpreted as the “empirical damage” to the market after incorporating all potential cartel inefficiencies.

7.2 The Livestock Market Suffered Larger Losses under Manipulation

The cartel’s dynamic manipulation strategy reduced the spot market price and the total quantity traded at the stockyards. [Figure 7](#) presents the distributions of observed and counterfactual wholesale cattle prices and quantities. Compared with the observed market price, the average cattle wholesale price would be 23.4% higher in the counterfactual scenario, or \$43.9 per head.³⁸ In

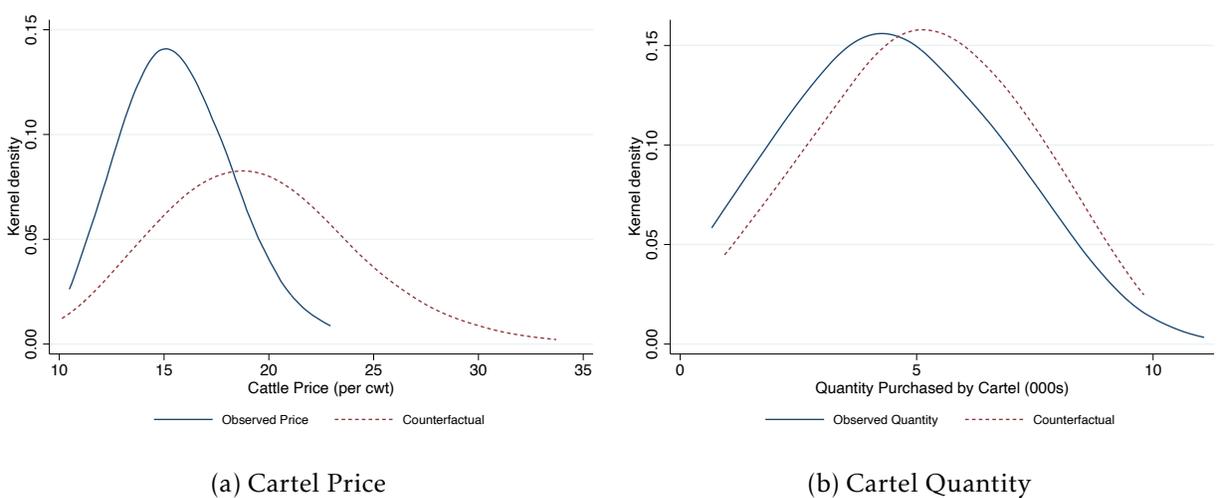
³⁷The average price for cattle was between \$10 and \$25 (see [Figure 5b](#)). For the solution, I use the interval (0,50) to search for the optimal price.

³⁸The average price is \$3.66 lower. For a 1,200-lb cattle, this implies a \$43.9 increase.

comparison, cattlemen’s average profit in 1909 was \$28.³⁹ Interrupting the dynamic manipulation would increase the profit margin by 57% for cattlemen.

Meanwhile, the average daily slaughter would increase by 14%, from 4,475 heads in the data to 5,097 heads per day in the counterfactual scenario. This adds up to about 15,000 more heads of cattle per week sold at the four stockyards. Assuming the urban beef supply adjusted by the same percentage and given that the average household consumed 168 pounds of beef per year (see Table 6), this increase also implies that the average household consumed 23.3 pounds more of beef per year absent of the cartel manipulation.

Figure 7: Counterfactual and Observed Cartel Prices and Quantities



7.3 Heterogeneity across Markets

The dynamic strategy has heterogeneous effects across markets. The difference is driven by the non-price elements of the supply curve, which are captured by the elements in X_{jt} , which includes local weather conditions and stockyard-by-week-of-year fixed effects. Differences in seasonality and weather patterns naturally influenced cattlemen’s sales decisions. In addition, stockyards have different unobserved features, such as proximity to input material markets or ease of out-bound transportation to the alternative market, which are all captured in the fixed effects.

Table 9 tabulates the observed and counterfactual average wholesale prices and quantities by stockyard. Larger stockyards such the Chicago Union Stock Yards were less influenced by the dynamic strategy. For example, on average, the observed price in Chicago is 93% of the counterfactuals, while the ratio is below 80% for the other three stockyards. Meanwhile, Chicago also has the smallest quantity changes under the counterfactual scenario.⁴⁰ Part of this could be due to the city being a major transit hub with easier transportation to outside markets and having a large

³⁹See Skinner (1909). All dollar values are adjusted to 1920 dollars.

⁴⁰Appendix Figure ?? and Appendix Figure ?? plot the complete distribution of counterfactual prices and quantities by stockyard.

number of feedlot farmers nearby (see [Figure 2](#)) who were less affected by the high shipping cost. These factors all limited the cartel’s market power over sellers and thus created less distortion.

Table 9: Empirical and Counterfactual Market Outcomes by Stockyard

	(1) Chicago	(2) Kansas City	(3) Omaha	(4) St. Louis	(5) Total
Cartel Quantity (000s)					
Observed	5.85 (1.39)	4.55 (1.47)	2.28 (0.62)	1.80 (0.66)	4.48 (1.92)
Counterfactual	6.57 (1.01)	5.08 (1.28)	2.87 (0.79)	2.14 (0.70)	5.10 (1.84)
Spot Market Price (per cwt)					
Observed	16.18 (2.44)	15.35 (2.46)	15.09 (2.12)	17.02 (1.71)	15.66 (2.41)
Counterfactual	17.06 (2.61)	19.08 (2.29)	23.26 (3.98)	21.28 (3.99)	19.32 (3.82)

Note: The table presents the average values by city. Standard deviations are in parentheses.

7.4 Manipulation Increased Beef Prices and Household Food Expenditure

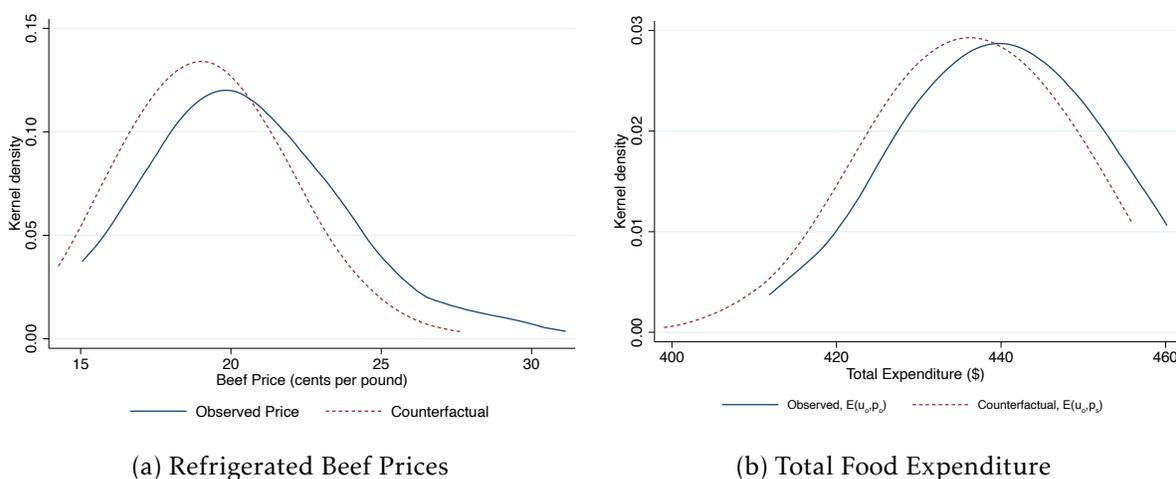
Next, I compare the effect of dynamic cartel manipulation in the cattle market on downstream wholesale refrigerated beef prices. Under a static strategy, the cartel purchased more cattle at the input market, which led to lower prices for refrigerated beef in the downstream market. I first compare the counterfactual wholesale beef prices with the observed weekly prices in New York City, collected from the Bureau of Labor Statistics’ *Wholesale Prices* series. [Figure 8a](#) shows the distribution of counterfactual and observed beef prices. If the cartel switched from the dynamic manipulation to the standard static strategy, the average downstream beef price would reduce by 6%, from 20.5 cents to 19.2 cents per pound. For an average household that consumed 168 pounds of beef per year, this price reduction would save the family \$2.1. However, this back-of-the-envelope calculation understates the influence on consumers since lower beef prices would induce households to consume more beef while also substituting away from other food items.

Next, I calculate the total food expenditures a household needs to achieve the same utility level as under the cartel manipulation. Specifically, let p_o and u_o denote the observed price vector and utility under the dynamic strategy, p_s the counterfactual prices under the static model, and $E(u, p)$ the total food expenditure. $E(u_o, p_o)$ represents the total food expenditure with observed beef prices, and $E(u_o, p_s)$ represents the expenditure with counterfactual beef prices.⁴¹ I assume perfect competition in other agricultural product markets so that their prices do not respond to changes in the cartel strategy. For the calculation, I use the reported New York City beef price in p_o and the simulated prices in p_s while holding the prices of other food items to be the same as reported in the cost of living survey.

⁴¹The difference between the two expenditures is the compensating variation (CV), defined as $CV = E(u_o, p_s) - E(u_o, p_o)$. Appendix Figure ?? shows the distribution of observed and counterfactual expenditures used to construct the compensating variation.

Figure 8b shows that, in the static counterfactual, the average household annual food expenditure would reduce by \$3.6, which is equivalent to 13.4% of the average weekly wage. Compared to the effects on cattle sellers, the cartel had a much smaller impact on downstream consumers. The difference is largely driven by the inelastic cattle supply and much more elastic demand for beef. Though the cartel dominated the refrigerated beef wholesale market, urban consumers can easily substitute beef with other food items and thus limiting the cartel’s ability to charge higher prices. The large damage on the upstream cattle market and the relatively small effect on downstream urban consumers also reflect the fact that the cattlemen actively pushed to regulate meatpackers’ market power, while consumers were largely absent in this policy discussion.⁴²

Figure 8: Counterfactual and Observed Beef Prices and Total Food Expenditure



8 Conclusion

In this paper, I estimate the effect of a dynamic cartel strategy on the market by analyzing the U.S. meatpacking cartel. The analyses leverage changes in the legal environment that forced the cartel to change from a dynamic strategy to a standard static strategy. I find that the dynamic strategy created larger welfare loss than what a typical static monopsony model would suggest. Under its dynamic manipulation strategy, the meatpacking cartel purchased fewer cattle at lower prices than it would have under a static strategy while also increasing downstream wholesale beef prices and total household expenditure on food. Without adopting new legislation or breaking up the cartel through forced divestiture, changes in legal interpretation and antitrust enforcement forced the cartel to abandon the dynamic manipulation and benefited both upstream cattlemen and downstream consumers.

The historical case has important implications for contemporary markets. Absent functioning

⁴²For example, in 1916, ten people in the business were invited to give statements at the U.S. House Judiciary Committee hearing on the investigation of the beef industry. Except for one trade journal editor, all the other nine witnesses were cattle ranchers or feedlot farmers ([House Committee on the Judiciary, 1916](#)).

contract or futures markets, which is often the case in developing countries, small sellers usually rely on spot markets for sales. Without adequate supervision over large buyers, the market can suffer significant distortions. My results also highlight the difficulties in regulating monopsony power. Though the cartel also harmed consumers, their losses were much smaller than those of the cattlemen. In other words, policies focusing primarily on consumer welfare may limit regulators' ability to address the adverse effects of monopsony power on small producers.

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Appendices

A Chronological History of the Meatpacking Litigation

The table below summarizes the main events regarding the litigation process against the meatpackers. Dates and events are summarized from the materials presented at the House of Representatives debate on May 25, 1912 ([United States Congress, 1912](#)).

Meatpacking Litigation Time Line

Date	Event
1902 May	Government filed petition for an injunction against the Beef Trust
	Judge Grosscup issued temporary injunction
Sep	Packers filed a demurrer against the injunction
1903 Feb	Judge Grosscup overruled the demurrer
May	Packers enter an appeal to the Supreme Court against the injunction
1904 July	President Roosevelt ordered the Department of Justice to advance the Beef Trust case to the calendar on the Supreme Court calendar
1905 Jan	Supreme Court sustained Judge Grosscup's injunction, clearing the way for the authorities to prosecute the packers who continue to defy the decree
Feb	Special Federal grand jury called in Chicago; the government sought criminal indictment of the packers for violation of antitrust laws

B Data Collection and Variable Construction

Cattle Market I collected the cattle shipment (including “receipts”, which is the total number of cattle arrived at the stockyards, and “shipment”, the number of cattle left the stockyards) and price data from *The National Provisioner*. Cattle market data from the trade journal is verified by checking the monthly and annual aggregates against *Chicago Union Stockyard Annual Report* during the same period.

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 standard for “Choice” steer of 1,100 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.

1917-1919 Cost of Living Survey The following table summarizes the food items included in each category for the demand estimation:

Variables Used in Aggregate Categories

Variable	Items
Meat Products	
Beef	Beef Steak, Beef Roast, Beef Stew
Pork	Pork
Poultry	Poultry Hens
Other	Fish, Seafood, Cured Meat
Food Segments	
Meat	Beef, Pork, Poultry, Other
Dairy	Whole Milk, Skimmed Milk, Condensed and Evaporated Milk, Buttermilk, Cream, Ice cream, American Cheese, Butter
Starch	Wheat Flour, Corn Meal, Grits, Corn Starch, Wheat Bread, Rolls and Buns, Crackers, Cake and Cookies, Pies, Pasta, Rice, Tapioca
Vegetable	Cabbage, Spinach, Peas, String Beans, Tomato, Onion, Corn, Lettuce, Celery, Navy Beans, Irish Potato, Sweet Potato, Canned Beans, Canned Peas, Canned Corn, Canned Tomatoes

C Demand Estimation

The lower-level demand of different meat products can be simplified by expressing the Marshallian demand as expenditure shares:

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln \left(\frac{X_s}{P_s} \right) + \varepsilon_i \quad (8)$$

where P_s is the Stone price index defined as

$$\ln P_s = \sum_i \omega_i \ln p_i \quad (9)$$

ω_i is the expenditure share of product i in the meat segment. X_s is the total expenditure on the meat segment, and the error term ε_i accounts for both measurement error and potential demand shocks.

Following the literature, I also impose the three sets of restrictions on the coefficients: Adding-up: the expenditure shares always sum up to 1, implying

$$\sum \alpha_i = 1; \sum \beta_i = 0; \sum_i \gamma_{ij} = 0 \quad \forall j \quad (10)$$

Homogeneity: Marshallian demand is homogeneous of degree zero in prices.

$$\sum \gamma_{ij} = 0 \quad \forall i \quad (11)$$

Symmetry: follows from Shepard's Lemma,

$$\gamma_{ij} = \gamma_{ji} \quad \forall i, j \quad (12)$$

At the higher-level, allocation of expenditure among broad food segments (meat, dairy, starch, etc.) follow the same structure:

$$\omega_S = \alpha_S + \sum_H \gamma_{SH} \ln p_S + \beta_S \ln\left(\frac{X}{P}\right) + \varepsilon_S \quad (13)$$

where all variables denoted by S refer segment rather than product level values. X is the total food spending, and P is the Stone price index at the segment level. The analogous restrictions of (10) to (12) also apply to the higher-level.

The estimated demand parameters allow me to calculate the unconditional elasticities for counterfactual analysis (Anderson and Blundell 1983). The own- and cross-price elasticities at the lower level are:

$$\epsilon_{ij} = -\delta_{ij} + \frac{1}{\omega_i} (\gamma_{ij} + \beta_i (\alpha_i + \sum_k \gamma_{kj} \ln p_k)) + \omega_j \left(1 + \frac{\beta_i}{\omega_i}\right) \quad (14)$$

where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ otherwise. The higher level has the analogous expression with parameters estimated from the segment level expenditure decisions.