

Monopsony, Cartels, and Market Manipulation: Evidence from the U.S. Meatpacking Industry, 1903–1918

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June 1, 2021

Abstract

How does a monopsony influence market outcomes if future supplies are responsive to current prices? When neither production nor shipments coincide with spot-market sales, monopsonists can manipulate current prices to alter future supply, potentially achieving higher collusive profits. This dynamic strategy suggests that standard models may underestimate the effect of monopsonistic cartels on the input market. This paper examines the historical case of the U.S. meatpacking cartel, which manipulated market prices to attract large cattle shipments, then exploited the inelastic spot-market supply to obtain the input materials at lower prices. The analysis leverages exogenous regulatory changes that forced the cartel to switch from a dynamic to a static strategy. I develop and estimate a structural model of the wholesale cattle market. I then quantify the effect of dynamic cartel manipulation by comparing the empirical market outcomes with counterfactuals under the static model. I find that cartel manipulation harmed cattle sellers by enabling the cartel to buy fewer cattle at low prices than it would have under a static model. The manipulation strategy also harmed downstream consumers by increasing beef prices and thus total household food expenditures.

Key Words: monopsony, cartel, market manipulation, agriculture

JEL Classifications: D2, L1, L4, N6, L66

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1 Introduction

Policymakers and academics are increasingly concerned about the anticompetitive effects of monopsony power. Several recent court rulings in the United States highlight the prevalence of collusion among dominant buyers in industries ranging from digital publishing to dairy manufacturing,¹ and empirical research has documented monopsonies’ impact on a wide range of markets, including labor, retail distribution, input trade, and agricultural products.²

Though policymakers have tried to address monopsonies’ adverse effects through regulatory guidelines or legislative actions,³ economic theory provides limited understanding of monopsonistic cartel strategies and the resulting welfare losses. Standard monopsony models consider only static responses from the market. However, sales in many markets such as agricultural products can lag far behind production or shipment. Because sellers need to make decisions about future production or shipments based on current market information alone, they must commit to the market before observing the realized spot-market price at the time of delivery.⁴ Such markets can be vulnerable to a more complex form of dynamic manipulation: monopsonists can potentially manipulate current prices to influence future supply for higher collusive profits.

In this paper, I examine the U.S. meatpacking cartel to show that a monopsonistic cartel can obtain substantial markdowns by manipulating future supply responses. In the early 20th century, five meatpackers formed one of the largest manufacturing cartels in American history; collectively, they produced more than 80% of refrigerated beef. In an era of weak antitrust enforcement, they openly colluded to manipulate the wholesale cattle market from 1893 to 1920.⁵

Two factors make this historical case an ideal setting in which to analyze 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.”⁶ In addition, exogenous changes in the regulatory environment later forced the cartel to switch from the aforementioned dynamic strategy to a static fixed-market-share agreement, while other features

¹*United States v. Apple*, 952 F. Supp. 2d 638. The court found “Apple orchestrated a price-fixing conspiracy with five major e-book publishers.” *Knevelbaard Dairies v. Kraft Foods, Inc.*, 232 F.3d 979. The court charged the manufacturer for unlawful manipulation of the cheese market.

²See [Dube, Jacobs, Naidu, and Suri \(2020\)](#) and [Manning \(2003\)](#) for analysis on the labor market, [Inderst and Mazzarotto \(2008\)](#) on retail distribution, [Morlacco \(2019\)](#) on input trade, and [Blair and Harrison \(2010\)](#) and [Chatterjee \(2019\)](#) on agricultural products.

³The Department of Justice and the Federal Trade Commission issued guidelines to human resource professionals in 2016 regarding no-poach and non-compete agreements. See also [Senate Committee on the Judiciary \(2004\)](#); [Department of Justice \(2012\)](#); [Council of Economic Advisors \(2016\)](#).

⁴[Jeon \(2017\)](#), for example, describes the time-to-build feature in the container shipping industry.

⁵See [Yeager \(1981\)](#) for details on the evolution of the meatpacking cartel.

⁶*United States v. Swift et al* (122 F 529).

of the market remained unchanged. Thus, I observe the behaviors of the same cartel and sellers under both dynamic and static strategies. This allows me to compare the empirical outcomes under the dynamic strategy to counterfactuals suggested by the well-understood static monopsony model.

I collected weekly data from historical trade journals published between 1903 and 1918 for the four largest stockyards, which collectively produced more than 58% of U.S. refrigerated beef. These new data offer two advantages. First, given that the cartel set the dynamic strategies at weekly meetings, this high-frequency weekly data provides a good measure of the market under cartel manipulation. Second, the data cover both the dynamic and the static periods. I can thus quantify the impact of cartel manipulation by comparing the realized outcomes during the dynamic period to the benchmark measures suggested by a static monopsony model, which can be estimated using the data from the static period.

I start by providing descriptive evidence on how dynamic manipulation affects the cattle wholesale market. I first show that such manipulation led to different aggregate market outcomes: under manipulation, on average, 15.8% more cattle were shipped to the stockyards for sale, while the realized price was 35.5% lower. Then, I show that, consistent with narrative evidence, the cartel benefited from manipulating cattlemen’s shipment decisions. Under cartel manipulation, higher shipment quantities did not correspond to higher realized prices. In other words, cattlemen were “tricked” to believe that the market would be good when they made large shipments; once the cattle arrived at the stockyards, however, cattlemen ended up facing lower-than-expected spot-market prices. Without manipulation, however, more cattle were shipped when the market price was higher. This result suggests that cattlemen could correctly predict market conditions once the cartel stopped their dynamic manipulation.

Though the reduced-form results are informative, they provide only limited information about the dynamic strategy. To measure the level of distortion created by the dynamic cartel manipulation, I need to construct the market outcomes absent cartel manipulation. For this, a model of standard static monopsony is required.

The regulatory change provides observations under both dynamic and static strategies. I leverage this unique historical setting and start by constructing and estimating a structural model of spot-market cattle sales under the static monopsony. I then calculate the counterfactuals for the dynamic monopsony period. The difference between the observed market outcome under the dynamic strategy and the counterfactuals under the static strategy is, therefore, the effect of the dynamic monopsonistic cartel.

On the supply side, I model the cattlemen’s spot-market supply with a discrete choice model: sellers either choose to sell to the cartel at the spot-market price or to try the competitive outside market. To solve the standard price endogeneity problem, I use prices of downstream beef substitutes as instrumental variables. The estimated spot-market supply is more elastic under the static strategy. Intuitively, this is consistent with the cartel’s manipulation strategy, which was designed

to attract and exploit sellers more likely to accept the low spot-market price, that is, those with inelastic supplies. Markdown is 6.8 higher under dynamic manipulation strategy, meaning that cattlemen received 35.9% less of their marginal value of product.

On the demand side, I construct the cartel's profit function in terms of cattle supply and beef demand. The cartel chose the quantity of cattle to maximize profit, facing both an upward-sloping supply as a monopsony in the cattle market and downward-sloping demand as a monopoly in the refrigerated beef market. I use the standard Almost Ideal Demand System (Deaton and Muellbauer, 1980) to estimate the cartel's downstream demand. Combining the price elasticity of supply estimated before with the demand elasticity for the product, I then calculate the optimal cartel quantity and spot-market price under the static strategy.

I examine how cartel manipulation affected the input market by comparing the observed market outcomes under the dynamic strategy with the counterfactual outcome under the static cartel strategy. I first calculate the overall changes in wholesale cattle prices and quantities. Because antitrust regulators may care about the policy implications of disrupting cartel manipulation on downstream consumers, I also calculate the effect of the dynamic manipulation on downstream wholesale beef market. The results show that the dynamic cartel strategy hurt both small cattle sellers and urban beef consumers: compared to the static benchmark, the dynamic strategy reduced the number of cattle the cartel purchased by 13.8% and reduced cattle wholesale prices by 14.1%; meanwhile, it increased downstream wholesale prices by 10% and increased household food expenditure by 2%.

I exploit the unique data structure by taking the market outcomes under dynamic cartel strategy as given. This approach avoids specifying agent beliefs in the dynamic environment with complicated data generating processes while still effectively estimating the aggregate impact of dynamic cartel manipulation. In spirit, this approach is similar to a growing body of research that estimates market distortion in complicated economic and institutional environments. Instead of specifying intricate models to fit particular market settings, many empirical works focus on comparing the observed outcomes to some benchmark counterfactuals derived from classic theories.⁷

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 monopsony power (Chatterjee, 2019; Rubens, 2019) in the agricultural markets documents the negative effect of dominant buyers on prices. Similar works in labor markets (Ashenfelter, Farber, and Ransom, 2010; Azar, Berry, and Marinescu, 2019; Card, Cardoso, Heining, and Kline, 2018; Goolsbee and Syverson, 2019; Manning, 2003) also find that monopsonistic employers exert a negative effect on wages. 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

⁷For examples of measuring market distortion by comparing empirical outcomes with theoretical counterfactuals, see Asker, Collard-Wexler, and De Loecker (2019) on global oil production, Borenstein, Bushnell, and Wolak (2002) on the California electricity market, and Rafey (2019) on the Australian water market.

the first to consider the monopsony strategy under dynamic market responses. My results suggest that the static model understates the welfare loss from monopsonistic market power.

Second, this paper contributes to the literature on the inner workings of cartels. Past research dissects specific cartel strategies across different market and regulatory environments (Marshall and Marx, 2012; Röller and Steen, 2006). Some have emphasized the role of communication in sustaining collusion (Genesove and Mullin, 2001; Harrington and Skrzypacz, 2011). I present new evidence that a monopsony cartel can use frequent communication to 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 results also highlight the need for theoretical advances in monopsony collusion and coordinated market manipulation.

Finally, the analysis complements previous research on the meatpacking cartel by quantifying the effect of the manipulation strategy. 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 the impact of regulatory changes (Aduddell and Cain, 1981; Libecap, 1992), the evolution of the cartel (Yeager, 1981), and innovation in management (Chandler Jr., 1993). I extend the past narrative and reduced-form results by highlighting the excess welfare loss created by the dynamic manipulation strategy.

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. Section 4 presents descriptive evidence on the effectiveness of the dynamic strategy. Section 5 sets the analytical framework for the market under static strategy. Section 6 discusses identification of the spot-market supply and demand, and presents the estimation results. Section 7 presents the counterfactual analysis.

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 evolution of the regulatory environment between 1893 and 1918. The nature of the livestock market and the meatpacking industry provides the basis for the structural model I describe in Section 5. An exogenous regulatory change allows me to identify key parameters for the model I describe in Section 6.

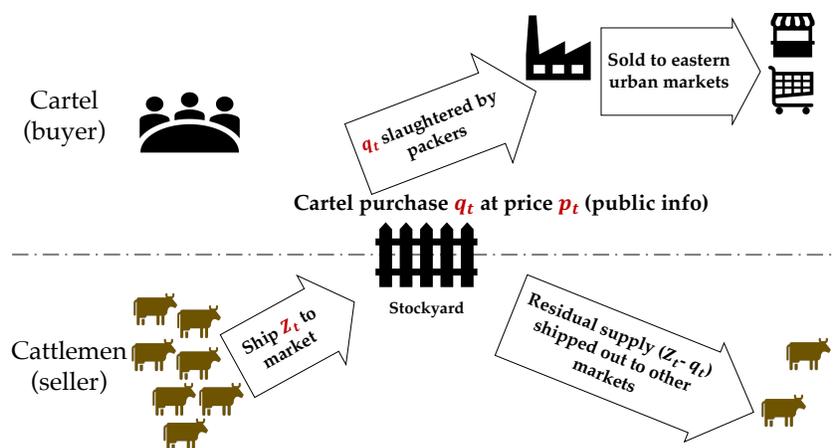
2.1 History of the Meatpacking Industry

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 greatly 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.⁸ By the early 20th century, five firms (the “Big Five”) had come to dominate the meatpacking industry.

Figure 1 illustrates the production chain of the meatpacking industry. The cartel dominated both the live-cattle wholesale market in the Midwestern stockyards and the refrigerated beef wholesale market in the urban centers of the eastern United States.

Figure 1: Meatpacking Industry Value Chain



Note: Cattle wholesale market data reported the variables in red: number shipped into the stockyard, market price, and number of cattle purchased/slaughtered by packers at the stockyard.

The Big Five dominated both the live cattle market and the urban wholesale beef market. On the cattle market, the Big Five were the dominant buyers. In 1916, they slaughtered 6.5 million head of cattle, generating 82.2% of all wholesale refrigerated beef sold in interstate commerce (Federal Trade Commission, 1919). They purchased most of the cattle shipped to the stockyards and accounted for almost all cattle slaughtered (see Table 1). On the downstream wholesale beef market, refrigerated beef constituted 75% of beef in New York City, 85% in Boston, 60% in Philadelphia, and 95% in Providence (Bureau of Corporations, 1905).

⁸Appendix Figure 3 shows the specialized rail cars and ice-manufacturing facilities along the rail lines.

Table 1: Concentration of Refrigerated Beef Production, 1916

Stockyard	Head Slaughtered	“Big Five”, %	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
NYC	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 City	203,482	100.0	2.6
Oklahoma City	174,541	100.0	2.2
Top 10 Stockyards	6,315,225	94.6	79.5
Total Interstate Slaughter	7,947,798		

Note: Data from the *FTC Report on the Meat Packing Industry*, Vol 1. The 10 largest packing centers are ordered in size.

2.2 Cattle Production and the Stockyard Spot-Market

Aggregate cattle supply at the stockyards responded to past prices. During this period, Cattle production was concentrated in the Midwest.⁹ Small feedlot farmers shipped live cattle to stockyards, where they were sold on the spot-market. Proximity to stockyards allowed these farmers to respond quickly to price fluctuations when making their shipment decisions. In a 1905 report, the Bureau of Corporations noted “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](#)).

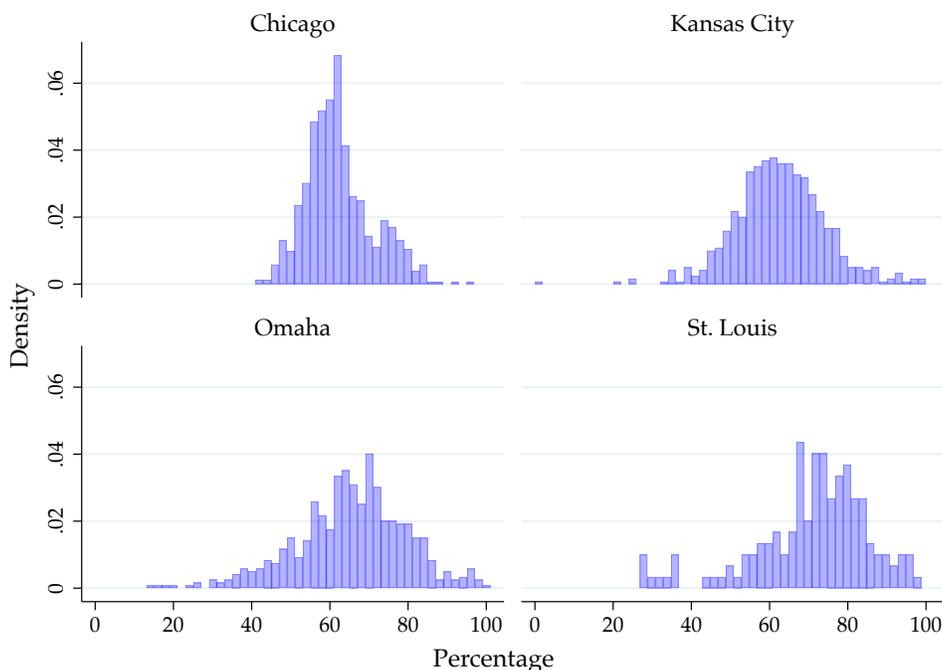
The stockyard markets were composed of inelastic, price-taking sellers and the monopsonistic meatpacking cartel. Chicago’s Union Stock Yards, for example, received on average nearly 10,000 cattle per day. The total number of cattle available for sale on the market dwarfed the capacity of any individual seller. Further, the high cost to ship live cattle led to inelastic supply decisions on the spot-market. It cost between \$4.43 and \$8.03 to ship a steer from a feedlot in Kansas to Chicago, while average profit per head was \$12.70 over the same period ([Skinner, 1912](#)).¹⁰ Therefore, cattlemen were reluctant to take their cattle off the market once they arrived at the stockyards.

⁹[Appendix Figure 1](#) displays the spatial distribution of cattle in 1910. Illinois, Wisconsin, Iowa, and Kansas had the highest cattle density. About 85 percent of beef steers shipped to Chicago stockyard were fattened by feedlot farmers in the “corn belt” ([Clemen, 1923](#)).

¹⁰This cost covers the freight (\$0.25-\$0.55 per 100 pounds), as well as feed along the route, driving the cattle from feedlot ,and loading them onto rail cars. [Andrews \(1908\)](#).

The spot-market trading environment was conducive to collusion among the meatpackers. Live-stock trading occurred in the open market, where packers could directly observe the realized quantity and prices of other buyers (see [Appendix Figure 4](#)).¹¹ In other words, cartel members could easily monitor compliance with their collusive agreements at little cost.

Figure 2: Percentage of Cattle Purchased by the Big Five



Note: Data are from *The National Provisioner*.

There *was* a large alternative market for live cattle beyond the stockyards. [Figure 2](#) plots the distribution of the share of cattle in the stockyards purchased by the cartel. On average, 15% of cattle shipped to the stockyards were not sold on the spot-market. Rather, cattlemen, unhappy with the spot-market conditions, would forward their livestock to be sold in the outside market. 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 in retail slaughterhouses near urban markets or on-farm. Cities 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](#)).

¹¹In fact, the quantity purchased by each packer was published in livestock trade journals (see [Appendix Figure 6](#)). Also, the meatpackers built their slaughtering and packing plants adjacent to the stockyard to minimize the travel distance from market to production line. [Appendix Figure 7](#) is a map of Chicago Union Stock Yards; it shows that all the major packing plants were located next to the stockyard.

2.3 Refrigerated Beef Production

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 Census of Manufactures, in the slaughtering and meatpacking sector, wages and salaries accounted for only 5.4% of total production cost, while nonfuel 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. Instead, they received hourly wages to “work until the day’s killing is done” (Commons, 1904).

2.4 The Meatpacking Cartel

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

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

Between May 1893 and July 1912, the cartel used dynamic strategies to manipulate the livestock market. Though the Sherman Act was passed in 1890, enforcement against anticompetitive practices was lax.¹²

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. The strategy is best summarized by Circuit Judge Peter Grosscup in a 1903 case¹³:

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]

¹²In 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 antitrust action against manufacturing firms under the Sherman Act. In 1898, in *Hopkins v. 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).

¹³*United States v. Swift & Co.* (122 F 529).

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)¹⁴. In the majority opinion, Justice Oliver Wendell Holmes wrote:

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.* [emphasis added]

The main intuition behind the cartel’s strategy was that it could exploit the highly responsive aggregate shipment to stockyards and the inelastic spot-market supply to “hold up” sellers.¹⁵

Though courts issued injunctions against certain anticompetitive behaviors in the aforementioned cases, the injunctions were weakly enforced and they had no explicit restriction against potential price manipulation. The Big Five continued to meet every week until July 1912, when the Department of Justice brought new charges against them. Despite abundant evidence on their collusive behavior, the grand jury found the packers and their executives not guilty for restraining trade under the Sherman Act.¹⁶

Phase 2: Cartel was Forced to Adopt Static Strategy

In 1913, after halting their weekly collusive meetings, the cartel resorted to a fixed-market-share agreement. The packers, though found not guilty in the 1912 case, decided the weekly meetings were too risky to continue. Though they had previously been challenged in court by state and federal authorities, their perception of their legal risk did not change until a couple of landmark cases in the 1910s. In particular, rulings against Standard Oil and American Tobacco made the packers legally more vulnerable in the ensuing civil case ([Federal Trade Commission, 1919](#)). The Big Five maintained their market-share agreement until 1920, when they were eventually forced to divest the production chain under a consent decree.

¹⁴Though the court never overruled the decision in *United States v. E.C. Knight*, here the court held that the federal government can regulate manufacturing when it affects interstate commerce.

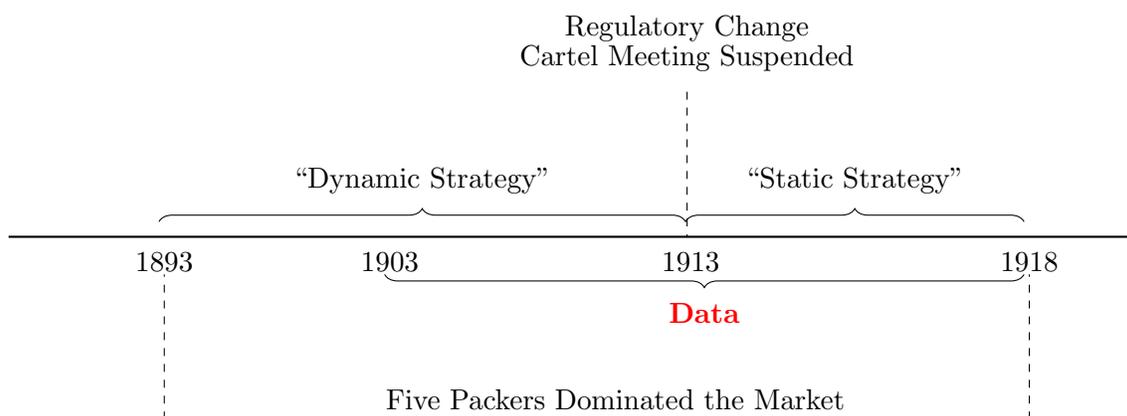
¹⁵[Appendix Figure 2](#) presents two numeric examples to show that manipulating the market created higher profits than the static monopsony strategy.

¹⁶Minutes of the weekly director meetings of the National Packing Company were admitted as evidence in court, showing the presence and participation of cartel executives. The court also admitted evidence of 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 antitrust cases against industry giants ([Lamoreaux, 2019](#)).

3 Data

I collected weekly livestock market data from historical trade journals to quantify the effect of market manipulation facilitated by weekly cartel meetings. These data cover the four largest stockyards from 1903 to 1918. [Figure 3](#) shows where the data lie on the overall time frame. To analyze the decisions of both the cattlemen and the cartel, I combined this livestock market data with information on input cost and downstream sales.

Figure 3: Event Timeline and Data Coverage



3.1 Livestock Market Data

I collected weekly cattle trade data from *The National Provisioner* for 1903 to 1918 on 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, the number of cattle slaughtered (i.e., purchased by the cartel), the number of cattle that left the stockyards, and wholesale cattle prices,¹⁷ as well as wholesale refrigerated beef prices in New York City. These data allow me to directly measure cattlemen’s aggregate shipment decision as well as the cartel’s input quantity and price. The weekly publication also noted cases in which transactions were affected by exogenous events such as disease quarantine or extreme weather. I exclude all such cases from my analysis. [Appendix A](#) provides details on variable construction and validation.

[Table 2](#) provides the summary statistics of the cattle market. On average, more than 9,000 head of cattle a day were shipped to the 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.

¹⁷[Appendix Figure 6](#) shows examples of the weekly publication.

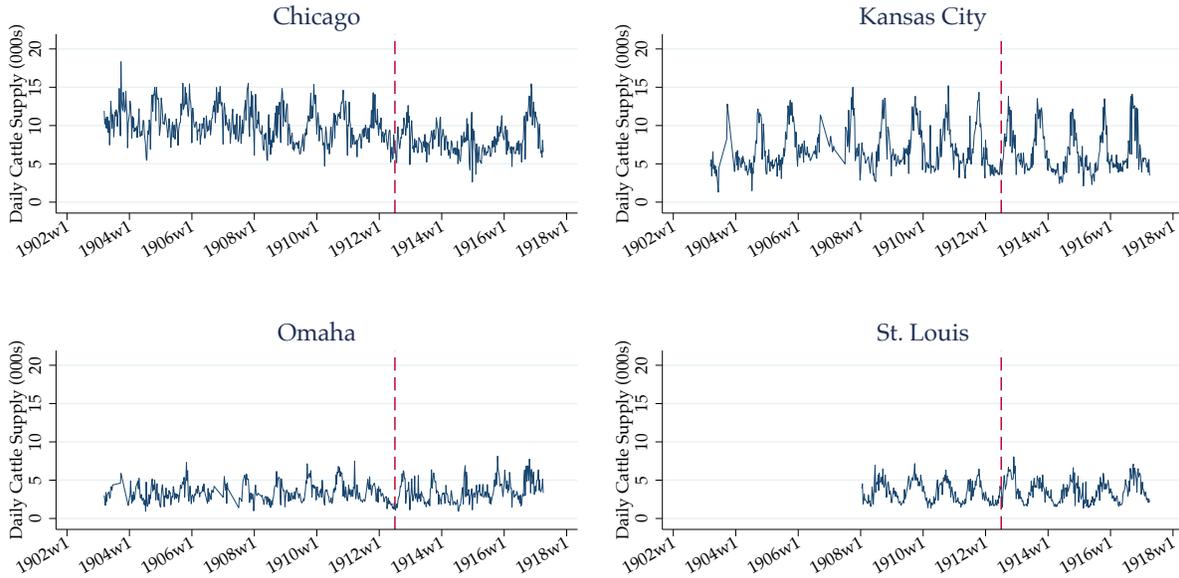
Table 2: Summary Statistics

	Chicago (1)	Kansas City (2)	Omaha (3)	St. Louis (4)	All Four Stockyards (5)
Cattle Price (per cwt, \$1920)	17.49 (3.03)	16.52 (2.65)	16.38 (2.49)	18.64 (1.78)	16.99 (2.78)
Average Daily Shipment (000s)	9.44 (2.35)	6.76 (2.71)	3.47 (1.28)	3.47 (1.44)	6.63 (3.31)
Share of Total Shipment Slaughtered (%)	62.53 (8.80)	64.50 (13.25)	72.41 (23.06)	73.56 (18.24)	66.50 (16.21)

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

Cattle supply exhibits large variations from week to week. Figure 4 displays the average daily shipment for each stockyard. The cattle supply exhibits obvious seasonality, driven by the natural production cycle of cattle. The supply also varied widely from week to week.¹⁸ In other words, the aggregate supply at the stockyard spot-market can be drastically different from one week to the next, even for cattle fattened over the same period with similar feed costs.

Figure 4: Average Daily Shipment Into the Stockyards



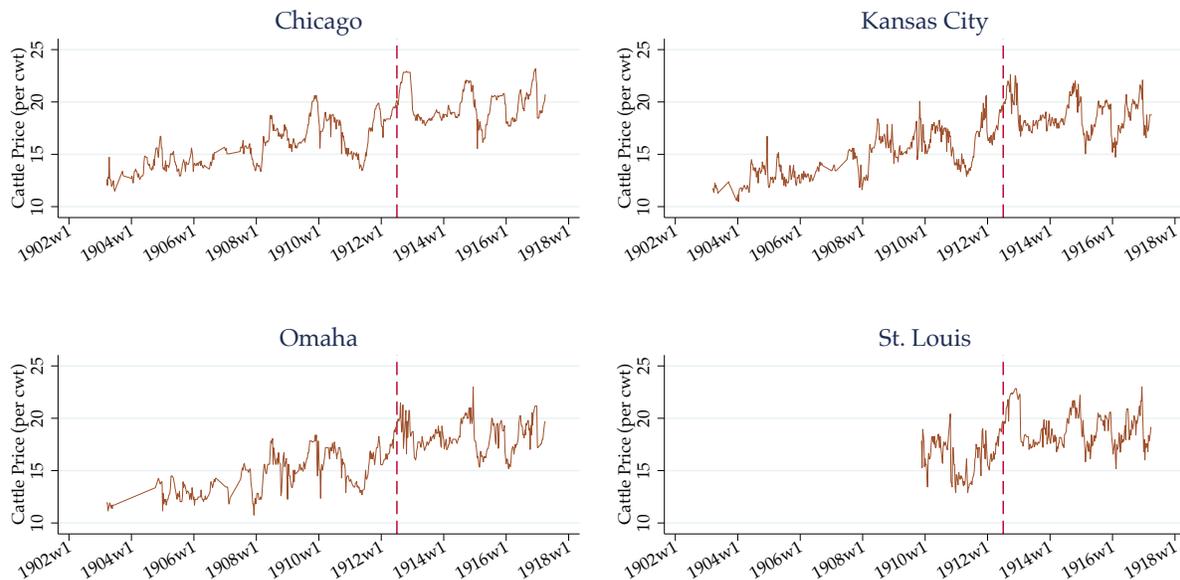
Note: Data are from *The National Provisioner*. The early reporting for Omaha and St. Louis, and occasionally for Kansas City, was irregular (e.g., not all days of the week were reported). For the analysis, I include only the weeks with more than two days of reported shipments. The plots only include data before the United States joined WWI on April 6, 1917.

Spot-market prices for cattle also varied dramatically from week to week (see Figure 5). As a benchmark, the average profit margin per head of cattle is \$12.80 in 1909 (University of Illinois at

¹⁸The coefficient of deviation for the average shipment is 0.49.

Urbana-Champaign Agricultural Experiment Station, 1912). Thus, a \$0.25 drop in the wholesale price would wipe out 30% of a cattleman’s net profit.

Figure 5: Cattle Price by Stockyards



Note: Data are from *The National Provisioner*. Cattle price is the weekly high top value for “Good to Prime” steers.

3.2 Auxiliary Data

I collected weekly wholesale prices in New York City for other animal products, such as eggs and lard, from the *Wholesale Price Bulletin*¹⁹ and prices for live hogs from the *The National Provisioner*. I consider these animal proteins as substitutes for refrigerated beef. Their wholesale prices 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; 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*.²⁰ To measure weather shocks, I constructed the area-weighted average of monthly temperature and precipitation using the county-level historical data from [Bleakley and Hong \(2017\)](#).

I used the 1917–1919 *Consumer Expenditure Survey*²¹ to estimate the retail demand for beef and other food items. This is the earliest household consumption and expenditure survey available. It provides detailed household expenditure data on 12,817 families of wage earners or salaried workers

¹⁹Bureau of Labor Statistics (various years), access through <https://fraser.stlouisfed.org/>

²⁰Specifically, I use the No.2 Corn and No.1 Baled Timothy Hay prices. ([Chicago Board of Trade, various years](#))

²¹Bureau of Labor Statistics (1992). The data is digitized by the Inter-university Consortium for Political and Social Research (ICPSR) and available as ICPSR study 8299.

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

Using high-frequency data covering the market with and without frequent cartel communication, I can empirically document the market outcomes under different cartel strategies. In this section, I first quantify the aggregate market effect of the manipulation coordinated through the weekly meetings. I then show that the main difference between the two periods is whether cattlemen could correctly predict market prices. This difference provides the basis for identification in [Section 6](#).

4.1 Dynamic Manipulation Is Effective

I first use an event-study design to examine how cartel manipulation influences aggregate market outcomes. Because the external legal environment forced the cartel to suspend market manipulation, without changing any other aspects of the market, it is plausible to attribute the changes in aggregate outcomes to frequent cartel communication.

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-the-year fixed effect, which captures the seasonality of the cattle market at each stockyard; T is the time trend; X_{kt} includes lagged weather shocks, lagged input prices, as well as the monthly temperature and precipitation of the counties where the stockyards were located. α_1 , the event-study coefficient, represents the average difference of the outcome y_{kt} between the dynamic manipulation and static non-manipulation period.

[Table 3](#) shows that market manipulation was effective. During the dynamic manipulation period (1903–1912), 18% more cattle were shipped to the stockyards, and the cartel purchased a smaller share (11.5 % lower) at a lower average price (5.6% lower). Cattlemen’s margin, defined as the difference between the wholesale cattle and corn prices, was 34% lower.

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,²² the competitive structure at the wholesale livestock market remained unchanged. Therefore, I assume the market

²²Agricultural production increased steadily during the second half of the 1910s to satisfy robust export demand ([Henderson et al., 2011](#)).

Table 3: Prices and Quantities During and After Manipulation

	Total Shipments (1)	% of Shipments Purchased (2)	Price (3)	Cattlemen’s Margin (4)
Dynamic Period Dummy (03/1903–06/1912)	1.080*** (0.123)	-7.392*** (2.266)	-1.064*** (0.144)	-1.529*** (0.134)
Time Controls	Yes	Yes	Yes	Yes
Weather Controls	Yes	Yes	Yes	Yes
Cost Controls	Yes	Yes	Yes	No
Observations	2469	2469	2110	2110
Adjusted R-squared	0.97	0.90	0.99	0.85
Mean	5.88	64.50	18.95	4.44
% wrt Mean	18.36	11.46	5.61	34.44

Note: “% of Shipment Purchased” is the share of total shipments into the stockyards purchased at the spot-market. “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 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 manipulation period covers March 1903 to June 1912. Time controls include stockyard-by-week fixed effects and year trend. 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 No.4 Corn and Hay prices at the Chicago Commodity Exchange. The data exclude period when the stockyards were closed due to quarantine or extreme weather. Standard errors are in parentheses.

* $p < 0.10$ **, $p < 0.05$, *** $p < 0.01$

behaved the same during this period.²³ Finally, column (4) of Table 3 directly addresses the concern about rising price levels caused by the war. Though this is an event study, column (4) can also be seen as a difference-in-differences result, which compares the price of cattle with the price of corn before and after the cartel meetings stopped. The result suggests that under cartel manipulation, cattle prices were lower compared to the price of corn, which was 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 trend. Specifically,

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

²³I explicitly control for the production cost of cattle. I use the price of corn and hay to approximate the input cost in cattle production. One can view this as an approximation for the actual cost of feed, or as the opportunity cost of raising cattle instead of growing grains.

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-the-year fixed effect, and τ_y is the year fixed effect.²⁴ 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.

Table 4 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. When the cartel stopped manipulating the price, however, 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).

Table 4: Prices vs. Shipments

Dependent variable: Cattle Price	Manipulation		Non-Manipulation	
	(1)	(2)	(3)	(4)
Daily Average Shipment	-0.010 (0.030)	0.040 (0.029)	0.102*** (0.037)	0.115*** (0.035)
Time Controls	Yes	Yes	Yes	Yes
Lagged Corn Price	No	Yes	No	Yes
Weather Controls	No	Yes	No	Yes
Observations	1317	1309	798	798
R-squared	0.79	0.81	0.65	0.70

Note: The table shows the regression coefficients α_z of price on average daily shipment, $p_{kt} = \alpha_z Z_{kt} + X_{kt} + \eta_{kw} + \tau_y + \epsilon_{kt}$. 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 No.4 Corn and Hay prices at the Chicago Commodity Exchange. The data exclude period when the stockyards were closed due to quarantine or extreme weather. Columns (1) and (2) cover the whole manipulation period. The point estimates for the manipulation period are either negative or statistically zero, suggesting that total shipments are not positively related to the actual realized market price. Columns (3) and (4) show the results for the non-manipulation period, where shipments are positively correlated with realized price. In other words, cattlemen correctly predicted the market during the non-manipulation period, where larger shipments to the stockyard coincided with higher prices. Standard errors are in parentheses.

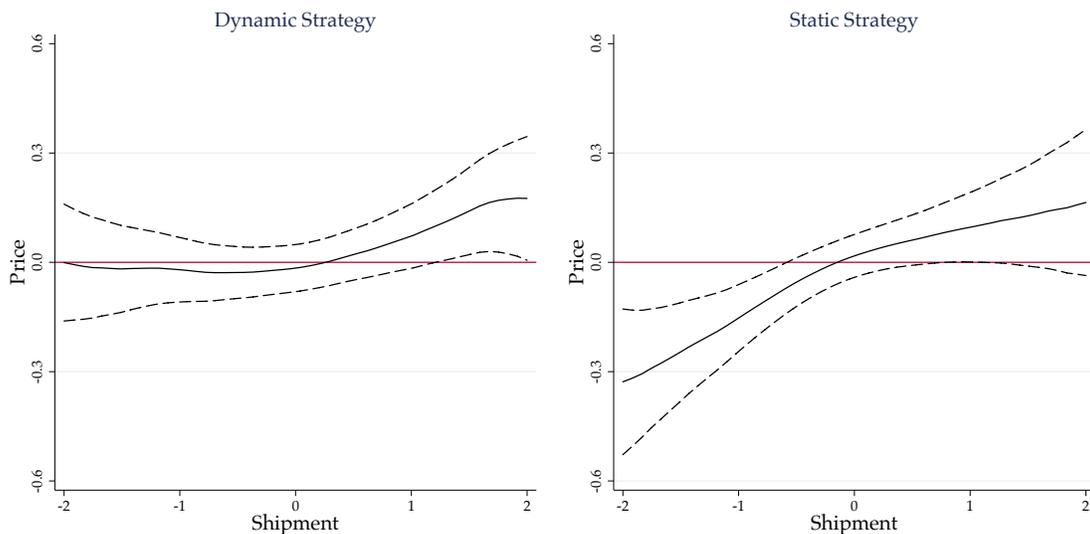
$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 6 depicts the estimation for (2), plotting the flexible local linear regression with the full set of controls (columns (2) and (4) in Table 4). During the dynamic manipulation period (left panel), no obvious relationship exists between total shipment and realized price. In other words, when cattlemen shipped a large number of cattle to the market, they may not have received

²⁴In the event-study regression, I include only the year trend because of the dummy variable for the dynamic manipulation period. In (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 nonlinear changes in the trend.

favorable prices. When the cartel stopped manipulating the market price, however, the relationship between price and total shipment resembles a typical supply curve, where larger total shipments into the stockyard correspond to higher prices.

Figure 6: Prices vs. Shipments



Note: The solid line is a local linear regression of cattle price on daily average shipment, where both values are residualized using week fixed effects, year trend, one-quarter lagged average temperature and precipitation, and up to one-year quarterly lagged corn price. The dash lines are 95% confidence intervals.

I conduct two main 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 marginal cattlemen could have shipped to either one of the stockyards, they may have behaved differently when multiple stockyards were closed (due to animal quarantine or extreme weather). [Appendix Table 1](#) presents the estimations for the two robustness checks. Results in columns (1) and (2) show that cattlemen behaved the same in both the early and late halves of the dynamic manipulation period.²⁵ Columns (3) to (6) show that results from the main specification in [Table 4](#) still hold after restricting the sample to only the periods with data from at least three stockyards.

²⁵Given 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.

4.3 Cartel Members Did Not Deviate

The observed cartel outcome during the static period coincides with the optimal cartel strategy only if cartel members did not cheat. Past research shows that cartels may have used frequent meetings also to resolve other disagreements among the members (Genesove and Mullin, 2001). Therefore, suspending the weekly meetings may cause potential deviation from the collusive agreement and thus sub-optimal cartel outcomes.

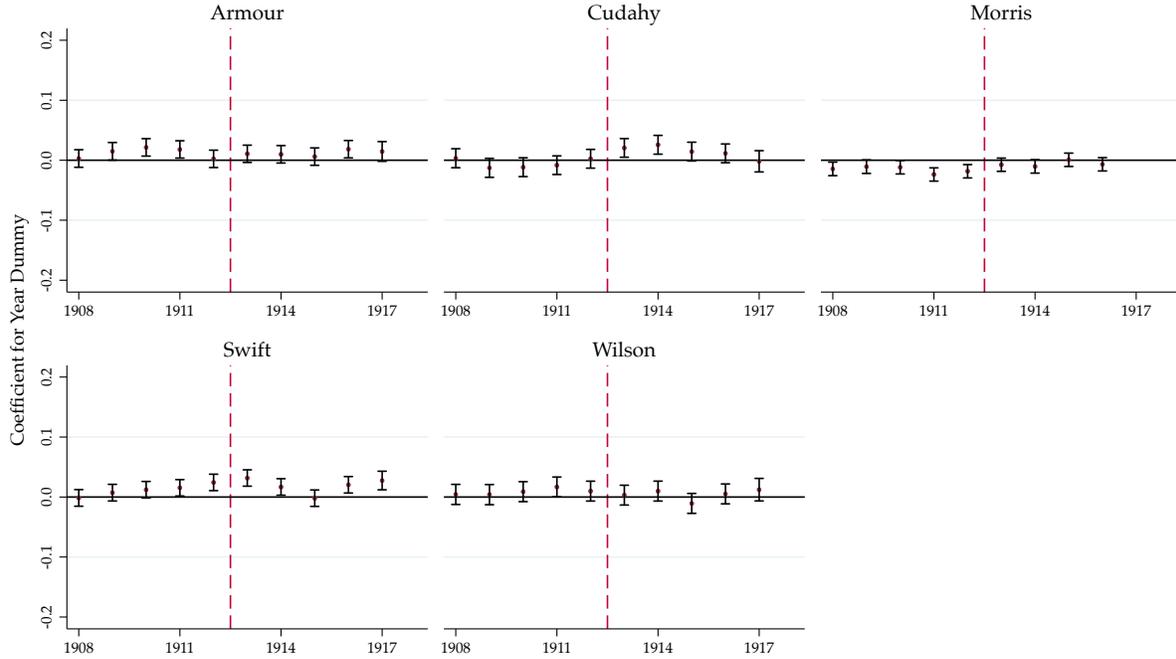
To show that cartel members did not deviate under the static strategy, I test whether the observed market share among the packers remained unchanged during the non-manipulation period. Specifically, I estimate the coefficients for the year dummies α_y in

$$s_{ft} = \sum_{y=1905}^{1917} \alpha_y \mathbb{I}(Year = y) + \epsilon_{ft}$$

where s_{ft} is the market share of firm f .

Figure 7 plots the estimated coefficient. Despite large week-to-week fluctuations in aggregate market supply, relative market share among the Big Five remained constant throughout the whole period. This suggests that cartel members did not deviate from their collusive market-share agreement after they suspended the weekly meetings. This is 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. Cartel members could directly observe the quantity purchased by other packers and the price they paid.

Figure 7: Cartel Members Did Not Deviate



Note: The graph plots the coefficient for year dummies in the regression $s_{ft} = \sum \alpha_y \mathbb{I}(Year = y)$, where s_{ft} is the market share of firm f . This analysis uses data of cattle purchases by each cartel in the Kansas City Stockyard, which has the longest data series of firm purchases and covers both the manipulation and the non-manipulation periods.

5 Analytical Framework of the Cattle Spot-Market

In this section, I present a structural model of spot-market cattle supply and cartel demand. Though results from the event study provide an arguably causal estimate on the effect of the dynamic cartel strategy on input market price and quantity, it 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 the markdown. Therefore, I developed the structural model to estimate what would happen during the dynamic period if the cartel were to adopt a static strategy. The main goal is to quantify the effect of dynamic cartel manipulation by comparing the empirical outcomes with the counterfactuals under static cartel strategy.

On the supply side, cattlemen make spot-market supply decisions following a discrete choice model: cattlemen choose between selling to the cartel and selling to the competitive market outside the stockyard. I use the standard logit choice model to capture cattlemen’s sales decisions. On the demand side, I specify the static cartel problem: the cartel chooses the quantity of cattle, facing both upward-sloping input supply and downward-sloping demand, as it was also the monopoly seller of refrigerated beef.

I estimate downstream demand faced by the cartel separately, with the Almost Ideal Demand System. I then combine the spot-market supply and downstream retail demand to characterize the cartel’s equilibrium static strategy for counterfactuals.

This modeling choice is driven primarily by the historical market setting. Regulatory changes forced packers to adopt the static strategy, without changing any other aspects of the market. This allows 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 on the future market. 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 the cartel manipulation.

5.1 Cattlemen’s Spot-Market Supply

Following [Berry \(1994\)](#), I use a logit discrete choice model to capture cattlemen’s spot-market supply decisions. For cattleman i , he can sell to buyer j : $\mathcal{J} = \{\text{cartel}, \text{outside}\}$. As in [Section 2.2](#), because of the high shipping cost, I assume that sellers cannot take the cattle off the market and have to either sell to the cartel at the stockyard or forward the cattle farther east to an outside market.

The utility for cattleman i depends on price p_{jt} , time-invariant characteristics of the buyer γ_j , and the error term ξ_{ijt} . Specifically, γ_j is an indicator variable for the cartel. This includes features such as auxiliary services like cattle loan company managed by the packers at the stockyards. I also control for other factors that may influence cattle supply, such as seasonality, with X_t . Therefore,

$$U_{ijt} = \gamma_p p_{jt} + \gamma_x X_t + \gamma_j + \sigma_{jt} + \epsilon_{ijt} \quad (3)$$

where the idiosyncratic preference ϵ_{ijt} follows the type-I extreme value distribution; σ_{jt} is the unobserved time-varying characteristics of the buyer that may enter cattlemen’s utility (e.g., railroad accidents or strikes). I further normalize the utility of selling to non-cartel buyers to be zero, or $U_{i,\text{outside},t} = 0$.

Following the standard logit form, [\(3\)](#) leads to the market-share expression

$$\ln(S_{\text{cartel},t}) - \ln(S_{\text{outside},t}) = \gamma_p p_{\text{cartel},t} + \gamma_x X_t + \gamma_j + \sigma_{jt} \quad (4)$$

where $S_{\text{cartel},t}$ is the share of cattle purchased by the meatpacking cartel, and $S_{\text{outside},t}$ is the

share transported out of the stockyard to an outside market.

Given the market-share expression, the spot-market price elasticity of cattle supply can be expressed as

$$e_s = \gamma_p p_{jt}(1 - S_{jt}) \quad (5)$$

In a market with Z_t cattle arrived at the stockyard, the cartel can expect to purchase q_t^* head at a given price p_t , where

$$q_t^* = \frac{\exp(\gamma_p p_t^* + \gamma_x X_t + \gamma_j)}{1 + \exp(\gamma_p p_t^* + \gamma_x X_t + \gamma_j)} Z_t \quad (6)$$

5.2 Cartel's Demand

Based on the production process described in [Section 2.3](#), I assume that (1) there is no substitution between cattle and other variable inputs and (2) all inputs can be adjusted without cost. The two assumptions lead to a Leontief production function for the cartel:

$$m_t = \min\{\theta_1 q_t, \theta_2 v_t\}$$

A packer uses q_t head of cattle and v_t units of other variable inputs to produce m_t units of refrigerated beef. For reference, a 1,200-pound steer yields a 750-pound carcass, or 63% of the input weight. Because the cost of cattle constitutes more than 90% of variable cost, I consider only the cost of cattle in the cartel's cost function:²⁶

$$c(m_t) = c(\theta_1 q_t) = p(q_t) \times q_t$$

where $p(\cdot)$ is the spot-market supply function determined by cattlemen's choices.

Because the cartel is also a monopolist seller of refrigerated beef, it faces a downward-sloping demand curve $D(m_t) = D(\theta_1 q_t)$. Therefore, under the static strategy, the cartel chooses optimal quantity q_t^* to maximize per-period profit:

²⁶According to the 1909 Census of Manufactures, for the whole slaughtering and meatpacking sector, non-fuel material (cattle) accounted for 90.8% of production expenses; wages (excluding officials and clerks) accounted for 3.9%.

$$\begin{aligned}
q_t^* &= \arg \max_{q_t} \Pi(q_t) \\
&= \arg \max_{q_t} D(m_t)m_t - p(q_t)q_t \\
\text{s.t. } m_t &\leq \min\{\theta_1 q_t, \theta_2 v_t\}
\end{aligned} \tag{7}$$

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

Definition 1. 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 (6), and the quantity also solves the cartel’s profit-maximization problem in (7).

In particular, the cartel’s first-order condition implies

$$\left(\frac{1}{e_D(m_t^*)} + 1\right)\theta_1 D(m_t^*) = \left(\frac{1}{e_s(q_t^*)} + 1\right)p_t^* \tag{8}$$

where $e_D(\cdot)$ is the beef demand elasticity and $e_s(\cdot)$ is the spot-market cattle supply elasticity.

5.3 Alternative Dynamic Model

The analysis focuses primarily on the spot-market, where cattlemen interacted with the cartel, and abstracts from discussing cattlemen’s shipment decisions. The primary goal is to quantify the distortion created by the dynamic cartel strategy, while taking the empirical aggregate market supply and spot-market elasticity as given. One obvious alternative is to extend the supply side to incorporate cattlemen’s shipment decisions with a dynamic discrete choice model and explicitly solve for the cartel’s dynamic strategy given cattlemen’s responses.

[Appendix C](#) presents the dynamic discrete choice model of cattle shipment. Every period, cattlemen decide whether to ship their cattle to the stockyards, given expected spot-market prices formed after observing the state of the market (the previous week’s price). This is analogous to the dynamic choice in job-search literature in which a worker chooses between accepting an offer or waiting for the next period. [Appendix D](#) discusses the dynamic cartel strategy when the cartel incorporates future supply responses in its decisions. This provides the intuition behind the manipulation: with elastic shipment decision and inelastic spot-market supply, the monopsonistic cartel can create a temporary glut and take advantage of the inelastic suppliers after they arrive at the spot-market.

However, two factors make this approach less desirable. First, estimating the dynamic discrete

choice of shipment decisions requires data on the relative market share of *shipment* to the stockyards and the outside competitive market, which is not available at the weekly level. Second, solving for the equilibrium under the dynamic cartel strategy requires an explicit belief structure. [Section 4](#) suggests that cattlemen’s behavior was not consistent with rational expectations. Meanwhile, 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 market shock σ_{jt} may influence both market price p_{jt} and cartel demand.²⁷ A demand shifter can be used as an instrument for price to identify the spot-market supply function. Because the volume of cattle purchased by the cartel is influenced by the downstream demand for refrigerated beef, I use the retail price of beef substitutes to instrument for the cattle price. Specifically, I use the lagged downstream price of eggs, lard, and live hogs as instruments for cattle prices at the stockyards.

I estimate (4) separately for the dynamic and static periods. As discussed in [Section 4.2](#), the marginal cattlemen on the market are different in the dynamic and static periods, and therefore need to be estimated separately to account for their potentially different sales decisions. [Table 5](#) presents the estimated coefficient for γ_p . Different price instruments generate similar point estimates for the

²⁷One example of such shocks is railroad accidents, which influence both shipment of live cattle to outside markets and the cartel’s productivity.

coefficient.

Table 5: Spot-Market Supply

	Dynamic Manipulation			Static Non-manipulation		
	(1)	(2)	(3)	(4)	(5)	(6)
Cattle Price (1920\$)	-0.114 (0.069)	0.023 (0.027)	-0.049 (0.035)	0.118** (0.054)	0.136** (0.061)	0.096* (0.050)
Instrument Price	Egg	Lard	Live Hog	Egg	Lard	Live Hog
Average Elasticity	-0.65	0.13	-0.28	0.80	0.93	0.65
Observations	876	876	578	507	507	443
R-squared	0.46	0.52	0.57	0.58	0.58	0.65
First-stage F-statistic	4.33	28.46	19.33	19.74	14.89	24.63

Note: The table shows the regression coefficient γ_p in equation (4). The dependent variable is $\ln(S_{cartel,kt}) - \ln(S_{outside,kt})$. All estimations control for stockyard-by-week fixed effects, year fixed effects, one-quarter lagged average temperature and precipitation, and one-quarter lagged corn price. The sample excludes the top and bottom 5% of observations. Average elasticity is calculated as the average of estimated elasticity $e_s = \hat{\gamma}_p p(1 - \hat{S})$, where $\hat{\gamma}_p$ is the estimated coefficient for price and \hat{S} is the estimated cartel market share. Instrument prices are from the *BLS Wholesale Price Bulletin*. Standard errors are in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To interpret the result, I calculate the corresponding elasticity following (5). The spot-market supply was inelastic when the cartel adopted the static strategy: for example, when using live hogs as an instrument, a 10% reduction in price would lower the cartel market share by 6.5%. Meanwhile, the estimated coefficient is not statistically different from zero under dynamic manipulation, which implies an even more inelastic spot-market supply. Estimations support the narrative evidence that the cartel manipulated the market to benefit from the inelastic spot-market supply.

I compare the effect of dynamic versus static cartel strategies on the input market with the same event study as before:

$$y_{kt} = \alpha_1 \mathbb{I}(\text{manipulation}_{1903-1912}) + X_{kt} + \epsilon_{kt} \quad (9)$$

where y_{kt} are the elasticity, markdown, and the corresponding cattlemen's share of marginal product at stockyard k . Table 6 summarizes the results. Compared to the market under the static strategy, the cattle price markdown is on average 6.2 higher, which implies that the cattlemen received 27.5% less of their marginal contribution to marginal product.

Table 6: Effects of Dynamic Manipulation on the Input Market

	Supply Elasticity (1)	Markdown (2)	Input Share of Marginal Product (3)
Dummy for Dynamic Period	-0.529*** (0.005)	6.204*** (0.069)	-0.275*** (0.002)
Time Controls	Yes	Yes	Yes
Weather Controls	Yes	Yes	Yes
Cost Controls	Yes	Yes	Yes
Observations	1319	1319	1319
Adjusted R-squared	0.93	0.92	0.96

Note: The dynamic period covers March 1903 to June 1912. Input market outcome measures (elasticity, markdown, input share of marginal products) are calculated using the estimation with Live Hog as the instrument. Time controls include stockyard-by-week fixed effects and year trend. 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. Cost controls include quarterly lagged No.4 Corn and Hay prices at the Chicago Commodity Exchange. The data exclude period when the stockyards were closed due to quarantine or extreme weather. Standard errors are in parentheses.

$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Spot-market supply is more elastic in larger stockyards. [Table 7](#) tabulates the elasticity, markdown, and corresponding cattlemen’s share of marginal product, by stockyard. The top panel summarizes the results for the dynamic manipulation period; the bottom panel for the static non-manipulation period. The supply-elasticity measures are slightly larger in Chicago and Kansas City. Intuitively, the larger stockyards were situated in major railroad hubs. This provided cattlemen with easier access to outside markets, and thus relatively more elastic spot-market supply.

Table 7: Average Spot-Market Estimation by Stockyard

		(1) Chicago	(2) Kansas City	(3) Omaha	(4) St. Louis	(5) Total
Dynamic Manipulation	Supply Elasticity	0.15 (0.02)	0.13 (0.02)	0.11 (0.03)	0.12 (0.02)	0.13 (0.03)
	Markdown	7.63 (0.89)	9.09 (1.53)	10.84 (2.37)	9.35 (1.02)	8.95 (2.04)
	Input share of marginal output	0.13 (0.02)	0.11 (0.02)	0.10 (0.02)	0.11 (0.01)	0.12 (0.02)
Static Non-manipulation	Supply Elasticity	0.57 (0.09)	0.73 (0.14)	0.70 (0.17)	0.49 (0.18)	0.65 (0.16)
	Markdown	2.80 (0.30)	2.41 (0.25)	2.53 (0.44)	3.32 (0.86)	2.64 (0.49)
	Input share of marginal output	0.36 (0.04)	0.42 (0.04)	0.41 (0.06)	0.32 (0.08)	0.39 (0.06)

Note: The table shows the average estimated elasticity, markdown, and cattlemen’s share of marginal output, by stockyard.

6.2 Cartel Demand

I estimate the demand for beef $D(\cdot)$ separately using the Almost Ideal Demand System (Deaton and Muellbauer, 1980) and the 1917–1919 Consumer Expenditure Survey. 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 in each segment. For example, given the expenditure on meat, a household may choose between beef, pork, mutton, and poultry. Appendix B describes the two-stage budgeting process for estimation.

The survey samples 12,817 “families of wage earners or salaried workers” in 99 U.S. cities. The average household spent \$544 a year on food, 38.4% of its total annual expenditure. The average household consumed 183 pounds of beef per year (see Table 8). For comparison, in 2017, Americans consumed 54 pounds of beef per person, or 216 pounds of beef per year for a family of four.²⁸

Table 8: Summary Statistics for Household Income and Expenditure

	Mean	SD
Annual Household Expenditure		
Main Food Groups (meat, dairy, starch, vegetables)	303.37	34.55
All Food (includes coffee, candy, etc.)	544.37	149.66
Total Expenditure	1419.45	394.84
Income		
Weekly Wage Rate of Husband	26.61	8.25
Annual Household Total Income	1434.04	411.38
Annual Total Consumption (lbs.)		
Beef	183.95	113.47
Pork	41.37	54.73
Starch	1562.62	686.53
Dairy	506.53	285.83

Note: Summary statistics calculated from the 1917–1919 Consumer Expenditure Survey (Bureau of Labor Statistics, 1992). Values represent the average of 12,817 households in the survey. “Starch” products includes wheat and corn flour, rice, pasta, and other carbohydrates. “Dairy” products include milk, cream, butter, and cheese, etc.

This modeling choice is appropriate from both conceptual and practical perspectives. As a wholesaler, the cartel cared about the general demand for refrigerated beef with respect to other food items such as pork and vegetables. AIDS model is a good first-order approximation for these broad product categories. And though the consumer expenditure survey data contain household demographic and expenditure information, the reported prices on the household level exhibit little variation. In many cases, the implied price of a certain product is identical across all households

²⁸U.S. Department of Agriculture “Food Availability and Consumption” data series. Accessed on October 7, 2020.

within a city. This suggests that the surveyor may have imputed total cost or quantity variables using a fixed price. 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 micro data.

Table 9 presents the summary statistics for price and expenditure share for the items I use in the estimation. Beef contributed to 66% of total household expenditure on meat products. Among all food categories, households allocated more than a third of their food expenditure to dairy and starch (e.g., flour, rice, pasta), and 26.5% to meat.

Table 9: 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	66.17	7.08
Pork	0.34	0.03	19.07	7.94
Mutton	0.30	0.05	4.65	5.26
Poultry	0.35	0.04	10.10	3.29
Food Segments				
Meat	0.31	0.03	26.50	3.25
Dairy	0.31	0.04	32.61	5.45
Starch	0.09	0.01	32.12	4.52
Vegetable	0.18	0.05	8.77	1.49

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.

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 classic endogeneity problem in demand estimation. Suppose regional prices reflect local cost factors such as wages and transportation; they are correlated with city-level prices but uncorrelated with unobserved demand shocks and can therefore be a valid instrument. I report the analysis of variance of prices in Table 10. As shown in columns (4) and (5), a significant fraction of the total variance in prices can be attributed to regional variation.²⁹

²⁹The survey questionnaire asked for 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 variation in price can be explained by time.

Table 10: Analysis of Price Variance

Product group/segment	SS Region (1)	SS Month (2)	Total SS (3)	Percentage Explained by Region (4)	Percentage Explained by Time (5)
Meat Products					
Beef	0.079	0.002	0.147	54%	1%
Pork	0.019	0.007	0.104	18%	6%
Mutton	0.061	0.013	0.210	29%	6%
Poultry	0.042	0.003	0.163	26%	2%
Food Segments					
Meat	0.060	0.002	0.115	52%	2%
Dairy	0.061	0.007	0.133	46%	5%
Starch	0.002	0.000	0.007	27%	6%
Vegetable	0.123	0.004	0.203	60%	2%

Note: Prices are aggregated up to city level by expenditure share weight.

Table 11 reports the compensated own-price and cross-price elasticity for the lower-level.³⁰ The own-price elasticity for beef is -1.91.³¹ Demand for other meat items appears to be more elastic, which may reflect a general preference for beef, as households spent two-thirds of their meat budget on beef.

Table 11: Lower-Level Price Elasticity

	Price			
	(1) Beef	(2) Pork	(3) Mutton	(4) Poultry
Beef	-1.913*** (0.329)	0.998*** (0.289)	0.216 (0.180)	-0.300 (0.199)
Pork	5.782*** (1.680)	-2.285 (2.702)	-1.974* (1.120)	-1.522 (2.229)
Mutton	3.650 (3.024)	-5.759* (3.248)	-14.308*** (2.072)	16.417*** (2.421)
Poultry	-1.588 (1.047)	-1.390 (2.027)	5.136*** (0.760)	-2.158 (1.633)

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

³⁰Estimates for higher-level elasticities are in Appendix Table 2. Demand coefficients are reported in Appendix Table 3 and Appendix Table 4.

³¹Other researchers find that the own-price elasticity of beef 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).

7 Counterfactuals

To quantify the effect of dynamic monopsonistic market manipulation, I calculate counterfactual outcomes for the cattle spot-market and the downstream wholesale beef market by solving (8) for the dynamic period. I first quantify the effect on the wholesale cattle market price and quantity by comparing the observed market outcome under the dynamic cartel strategy with the simulated 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 price. 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. Because the manipulation was interrupted by regulatory enforcement, this result can also be seen as the economic benefit from regulating inter-firm communication.

As discussed in Section 5.3, this counterfactual is of partial equilibrium in nature: the model focuses primarily on the spot-market and does not account for adjustment in aggregate cattle production or supply to the spot-market. The result is, however, a lower bound for the effect of dynamic cartel manipulation, as the higher counterfactual price should lead to higher aggregate supply at the spot-market.

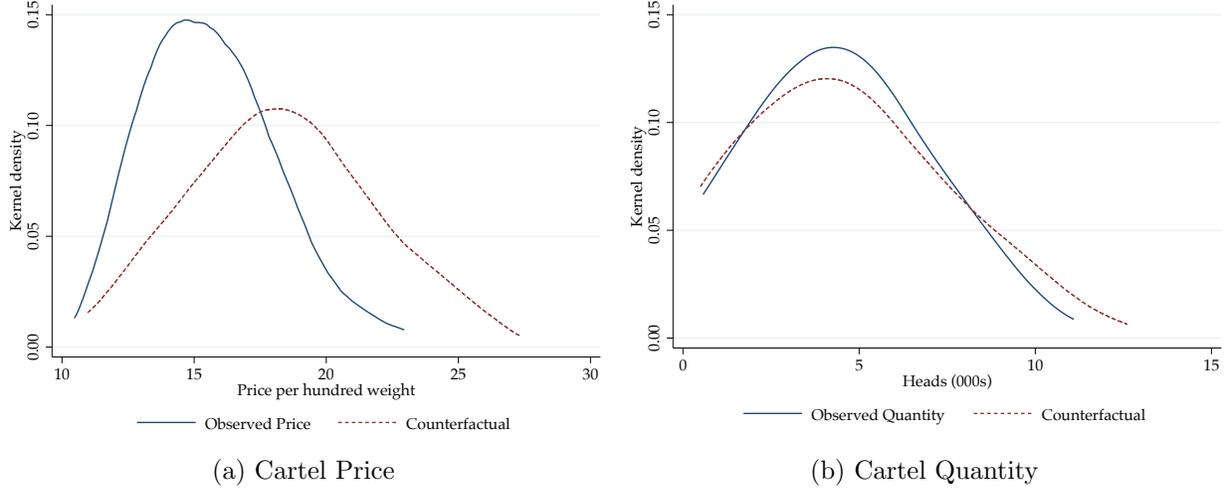
7.1 The Livestock Market Suffered Larger Losses Under Manipulation

The cartel's dynamic manipulation strategy reduced the spot-market price and the total quantity traded at the stockyards. Figure 8 presents the distribution of observed and counterfactual wholesale cattle prices and quantities at the stockyards. Under dynamic manipulation, cattlemen received on average 14.1% less than they would have under a static strategy, or \$32.4 per head.³² By comparison, cattlemen's average profit in 1909 was \$28.00 (in 1920 dollars). In other words, interrupting the dynamic manipulation can more than double the profit margin for cattlemen.

Meanwhile, 13.8% fewer cattle were traded at the stockyards. This is equivalent to 26 fewer pounds of beef consumed by an average urban household per year. For Chicago Union Stock Yards, the largest spot-market, this is equivalent to 10,440 fewer head of cattle purchased by the cartel per week.

³²Average spot-market price is \$2.7 lower (in 1920\$) per hundred weight. For an average cattle weighs 1,200 lb, this leads to $2.7 \times 12 = 32.4$ loss.

Figure 8: Distribution of Counterfactual and Observed Prices and Quantities



The dynamic strategy has heterogeneous effects across markets. [Table 12](#) tabulates the observed and counterfactual average wholesale prices and quantities by stockyard. Prices at the larger markets were less influenced by the dynamic strategy than prices at the smaller ones. Meanwhile, the larger stockyards, like Chicago, saw larger cartel quantity changes under the static counterfactual scenario. This is consistent with the elasticity estimates that the spot-market supply is more elastic in larger markets, and thus would experience both larger reduction in quantity and smaller price increases.³³

Table 12: Empirical and Counterfactual Market Outcomes by Stockyard

		(1)	(2)	(3)	(4)
		Chicago	Kansas City	Omaha	Total
Spot-market Price	Observed	15.8	15.1	14.9	15.4
		(2.37)	(2.53)	(2.21)	(2.46)
	Counterfactual	17.6	18.6	19.1	18.3
		(3.40)	(3.37)	(3.02)	(3.34)
	Observed/Counterfactual,%	91.9	82.8	79.0	85.9
Quantity Purchased by Cartel	Observed	5.98	4.37	2.21	4.39
		(1.36)	(1.47)	(0.61)	(1.97)
	Counterfactual	7.29	5.08	2.45	5.21
		(1.50)	(1.87)	(0.78)	(2.46)
	Observed/Counterfactual,%	81.8	86.9	91.6	86.2

Note: Price and quantity data are from *The National Provisioner* for the three stockyards. St. Louis is omitted for too few observations.

³³[Appendix Figure 8](#) and [Appendix Figure 9](#) show the distribution of price and quantity changes by stockyard.

7.2 Manipulation Increased Downstream Refrigerated Beef Prices

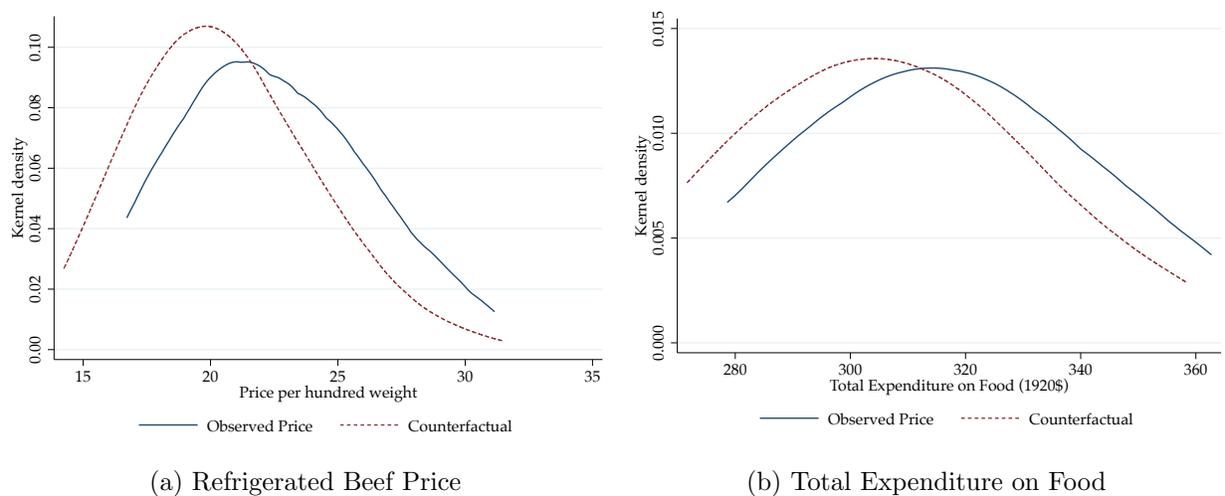
Next, I compare the effect of dynamic cartel manipulation in the cattle market on downstream wholesale refrigerated beef prices. Under a static strategy, the cartel purchased more cattle at the input market, which led to lower prices for refrigerated beef in the downstream market.

The left panel of [Figure 9](#) shows the distribution of observed and counterfactual downstream refrigerated beef prices in New York City. On average, the downstream beef price is 10% higher under the dynamic strategy, or \$1.98 per hundred weight.

I measure the changes in consumer welfare by the compensating variation (CV), defined as the additional expenditure a household needs in order to achieve the same utility level as under the static monopsony strategy. This calculation hold the prices of other food items constant, implicitly assuming perfect competition in other agricultural product markets. The changes in total household food expenditure is driven partly by the higher beef prices and partly by the substitution effect.

The right panel of [Figure 9](#) shows that, under dynamic cartel manipulation, average household total food expenditure on the four main food groups increased by \$7.34, or 2%. Though the change is small in absolute scale, this is equivalent to 50% of annual household savings³⁴. It is also comparable to the inflation rate for the same period.³⁵

Figure 9: Distribution of Counterfactual and Observed Beef Price and Household Food Expenditure



³⁴As shown in [Table 8](#), average household income is \$1434, while average total expenditure is \$1419.5. This leads to \$14.59 in savings.

³⁵Consumer price index changed by 2.4% from 1912 to 1913. Historical inflation data from the Federal Reserve Bank of Minneapolis, <https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1800-> (Access September 30, 2020).

8 Conclusion

In this paper, I study the effect of dynamic monopsonistic cartel manipulation on the input market. My results show that the dynamic cartel 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 and at lower prices than it would have under a static strategy, while also increasing downstream wholesale beef prices and total household expenditure on food. Regulatory changes imposed on the cartel benefited both upstream cattlemen and downstream consumers, even without breaking up the cartel through forced divestiture.

The historical case has important implications for contemporary markets. Without a functioning contract market, which is often the case in developing countries, small sellers usually rely on spot markets for sales ([Chatterjee, 2019](#)). Without effective 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. For policymakers focus primarily on consumer welfare, this can imply low political will to regulate the market.

Finally, by documenting a manipulation strategy that lasted for decades, this paper provides new evidence to support regulations against coordinated market manipulation. Given the prevalence of such behavior ([Shiller, 1990](#); [Assenza, Bao, Hommes, and Massaro, 2014](#)), this gap between policy and empirical evidence has significant legal and economic implications. Further research into the prevalence of such manipulation is needed to properly assess cartel damages.

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Appendices

A Data Collection

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.

Number of cattle shipped into and out of Chicago excludes calves. Though cattle prices are available by type and grade (see [Appendix Figure 6](#)), 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. The Commissioner of Corporation reported in 1905 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. Few Texas cattle were sold in Chicago market, and would either be bought as feeders or as low-quality local butcher meat.

B Demand Estimation

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

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{X_s}{P_s}\right) + \varepsilon_i \quad (10)$$

where P_s is the Stone price index defined as

$$\ln P_s = \sum_i \omega_i \ln p_i \quad (11)$$

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

$$\sum \alpha_i = 1; \sum \beta_i = 0; \sum_i \gamma_{ij} = 0 \quad \forall j \quad (12)$$

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

$$\sum \gamma_{ij} = 0 \quad \forall i \quad (13)$$

Symmetry: follows from Shepard’s Lemma,

$$\gamma_{ij} = \gamma_{ji} \quad \forall i, j \quad (14)$$

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

$$\omega_S = \alpha_S + \Sigma_H \gamma_{SH} \ln p_S + \beta_S \ln\left(\frac{X}{P}\right) + \varepsilon_S \quad (15)$$

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 (12) to (14) 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:

$$\epsilon_{ij} = -\delta_{ij} + \frac{1}{\omega_i}(\gamma_{ij} + \beta_i(\alpha_i + \Sigma_k \gamma_{kj} \ln p_k)) + \omega_j(1 + \frac{\beta_i}{\omega_i}) \quad (16)$$

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.

C Dynamic Discrete Choice Model for Cattle Shipment

Every period, cattlemen observe the state of the stockyard market (last week’s price), ω_t , and decide whether to ship the cattle to the stockyard, $i \in \{-1, 0, 1\}$.

$$i = \begin{cases} -1 & \text{outside market} \\ 0 & \text{wait} \\ 1 & \text{ship to stockyard} \end{cases}$$

Assumption: (Small seller, competitive outside market.) Individual sellers are price takers, and their shipment decisions do not affect the stockyard market state; i.e. $G(\omega_{t+1}|\omega_t, i) = G(\omega_{t+1}|\omega_t)$ for all i . The outside market is competitive, where the price is determined only by the average input factors X_t such as feed prices and seasonality, or $b(X_t)$.

The payoff of choice i is:

$$u(i, \omega_t, \nu_{it}; \theta) = \begin{cases} b(X_t; \theta_0) + \xi_{it}(\omega_t) + \nu_{it} & i = -1 \\ 0 & i = 0 \\ \mathbb{E}(p_t|\omega_t; \theta_1) + \xi_{it}(\omega_t) + \nu_{it} & i = 1 \end{cases} \quad (17)$$

where $\mathbb{E}(p_t|\omega_t)$ is the expected price at the stockyard market conditional on the observed state ω_t .

$\xi_{it}(\omega_t)$ is the unobserved shocks to the utility and potential source of endogeneity. Note here that $i = 1$ is the absorbing state: the cattlemen can only sell the livestock once.

The Bellman equation can then be written as:

$$V(\omega, \nu) = \max_{i=-1,0,1} \{u(i, \omega, \nu_i; \theta) + \beta \mathbb{E}[V(\omega', \nu')]\} \quad (18)$$

$$= \max\{u(-1, \omega, \nu_i; \theta); \beta \mathbb{E}[V(\omega', \nu')]; u(1, \omega, \nu_i; \theta)\} \quad (19)$$

$$= \max\{\tilde{V}(\omega, \nu, -1); \tilde{V}(\omega, \nu, 0); \tilde{V}(\omega, \nu, 1)\} \quad (20)$$

Assume that ν_{it} is the i.i.d idiosyncratic shocks that follow a Type-I extreme value distribution, then the probability of choosing i is

$$\Pr(i|\omega; \theta) = \frac{\exp(\tilde{V}(\omega, \nu, i))}{\sum_i \exp(\tilde{V}(\omega, \nu, i))} \quad (21)$$

which can be estimated through a nested fixed-point algorithm, given observed choices. However, except for the aggregate shipment to stockyards, there is not historical records on either the total number of cattle available or the number of cattle sold in local markets.

D Cartel's Dynamic Strategy

Consider the case when cartel incorporates the dynamic supply response. I omit the stockyard k notation for simplicity.

Every week, the cartel chooses q_t , the amount of cattle to purchase in the market. Given the total shipment Z_t and cartel's quantity decision q_t , the spot-market supply curve $p(\cdot)$ determines the realized market price

$$p_t = p(q_t, Z_b(p_{t-1}, X_t)) \quad (22)$$

Under the Leontief production function assumption, the per-period profit can be simplified only in terms of input cattle quantity q_t :

$$\Pi(q_t, \omega_t) = D(q_t, \omega_t)q_t - p_t q_t \quad (23)$$

where $D(\cdot)$ is the demand for beef and ω_t is exogenous demand shocks revealed to the cartel before the market decisions; p_t is the realized cattle price at the stock yard.³⁶

³⁶Technically p_t includes the price of other inputs V . Because cost of other inputs were considered exogenous, assuming $p(\cdot)$ to be linear, it will be absorbed in the constant term.

Cartel makes quantity decisions to maximize the long-run total profit. In recursive form, we have

$$\begin{aligned}
V(p_{t-1}, \omega_t) &= \max_{q_t} \Pi(q_t, \omega_t) + \beta \mathbb{E}[V(p_t, \omega_{t+1})] \\
&= \max_{q_t} D(q_t, \omega_t)q_t - p_t q_t + \beta \mathbb{E}[V(p_t, \omega_{t+1})] \\
\text{s.t. } \Pi(q_t, \omega_t) &= D(q_t, \omega_t)q_t - p_t q_t \\
\text{total shipment to stockyard } Z_t &= Z(p_{t-1}) \\
\text{spot-market supply: } p_t &= \Gamma(q_t, Z(p_{t-1})) \\
\omega_{t+1} &= \rho_0 + \rho_1 \omega_t + \varepsilon_t \\
\varepsilon_t &\sim \text{i.i.d } N(0, \sigma_z^2)
\end{aligned} \tag{24}$$

$\Gamma(\cdot)$ is the mapping across states.³⁷ Suppose the law of motion of the state, $\Gamma(\cdot)$ is invertible, such that $q_t = \gamma(p_t, Z(p_{t-1}))$. Then

$$V(p_{t-1}, \omega_t) = \max_{p_t} \Pi(\gamma(p_t, Z(p_{t-1})), z_t) + \beta \mathbb{E}[V(p_t, \omega_{t+1})]$$

The Euler equation for cartel is:³⁸

$$\underbrace{\frac{\partial \pi_t}{\partial \gamma_t} \frac{\partial \gamma_t}{\partial p_t}}_{\text{(A) direct effect of } p_t} + \beta \mathbb{E} \left[\underbrace{\frac{\partial \Pi_{t+1}}{\partial \gamma_{t+1}} \frac{\partial \gamma_{t+1}}{\partial Z_{t+1}} \frac{\partial Z_{t+1}}{\partial p_t}}_{\text{(B) effect of } p_t \text{ on next period}} \right] = 0 \tag{25}$$

When the cartel is making the quantity decision at t , sellers' response to the realized market price p_t created the inter-temporal trade-off. If sellers are not responsive to past price, then $\frac{\partial Z_{t+1}}{\partial p_t} = 0$, and cartel's problem becomes the static monopsony case.

Suppose the cartel increases the price today by purchasing more of the cattle in the stock yard. (A) captures the direct effect as it changes the marginal profit scaled by the marginal supply on the spot-market, $\frac{\partial \gamma_t}{\partial p_t}$; meanwhile, sellers respond to higher price now by shipping more cattle to the stock yard next period by $\frac{\partial Z_{t+1}}{\partial p_t}$ and change the profit next period represented by (B).

The difference between the spot-market elasticity and shipment elasticity to past price determines how much the cartel can manipulate the market. To see this, first define

$$\begin{aligned}
e_s &= \frac{\partial q_t}{\partial p_t} \frac{p_t}{q_t}, \text{ spot-market price elasticity} \\
e_l &= \frac{\partial Z_{t+1}}{\partial p_t} \frac{p_t}{Z_{t+1}}, \text{ shipment elasticity to past price} \\
e_q &= \frac{\partial q_t}{\partial Z_t} \frac{Z_t}{q_t}, \text{ elasticity of purchase to shipment}
\end{aligned} \tag{26}$$

³⁷The expression is re-organized from (22).

³⁸To simplify the expression, $\gamma_t = \gamma(p_t, Z(p_{t-1}), \omega_t)$, $Z_t = Z(p_{t-1})$

Euler equation (25) can be written in terms of elasticities:

$$\frac{\partial \pi_t}{\partial q_t} q_t + \beta \left[\frac{\partial \pi_{t+1}}{\partial q_{t+1}} q_{t+1} \right] \frac{e_l}{e_s} e_q = 0 \quad (27)$$

The larger the shipment elasticity is to the spot-market elasticity (higher e_l/e_s ratio), the higher the effect of p_t is on the next period. This leaves more room for the cartel to manipulate in the current market. Cartel can reduce the price paid for cattle under the dynamic scenario. This effect can be captured by the “markdown”, or the wedge between marginal revenue of product and the input price. Under static monopsony case, cartel’s profit maximization problem leads to the expression:

$$\begin{aligned} MR &= \left(\frac{\partial p(q)}{\partial q} \frac{q}{p(q)} + 1 \right) p(q) \\ &= (\tilde{\varphi}_s + 1)p \end{aligned} \quad (28)$$

where $\tilde{\varphi}$ is the (inverse) spot-market elasticity.

Under the dynamic scenario, the “markdown” changed into:

$$\begin{aligned} MR_t + \beta \mathbb{E} \left[\frac{\partial V(p_t)}{\partial p_t} \frac{\partial p_t}{\partial q_t} \right] &= \left(\frac{\partial p(q_t)}{\partial q_t} \frac{q_t}{p(q_t)} + 1 \right) p_t(q_t) \\ &= (\varphi_s + 1)p_t \end{aligned} \quad (29)$$

Compared to the static case, if the cartel faces a smaller spot-market elasticity by manipulating the total shipment, or $\varphi_s > \tilde{\varphi}_s$, the markdown will be larger under manipulation. In other words, the cartel can potentially outperform a static monopsonistic pricing strategy by manipulating the market. In practice, cartel manipulated price signals to attract more cattle to the stock yard. The marginal ones being manipulated are the cattlemen further away (higher cost) that would not have made the shipment decision without the falsely high prices. Such cattlemen are therefore more constrained on their choices of taking the cattle off the market, making the the spot-market supply less elastic under manipulation.

E Appendix Table

Appendix Table 1: Robustness-Test, Prices vs. Shipments, With Different Samples

Dependent variable: Cattle Price	Early and Later Dynamic Manipulation Period		Panel with data from ≥ 3 stockyards			
	1903–1907 (1)	1908–1912 (2)	Dynamic (3) (4)		Static (5) (6)	
Daily Average Shipment	0.017 (0.037)	0.003 (0.043)	-0.031 (0.036)	0.028 (0.034)	0.100*** (0.036)	0.111*** (0.035)
Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Cost Controls	Yes	Yes	No	Yes	No	Yes
Weather Controls	Yes	Yes	No	Yes	No	Yes
Observations	453	844	1113	1109	789	789
R-squared	0.69	0.77	0.78	0.81	0.65	0.70

Note: The table shows the regression coefficients α_z of price on average daily shipment, $p_{kt} = \alpha_z Z_{kt} + X_{kt} + \eta_{kw} + \tau_y + \epsilon_{kt}$. 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 No.4 Corn and Hay prices at the Chicago Commodity Exchange. Data exclude period when the stockyards were closed due to quarantine or extreme weather. Columns (1) and (2) cover the first and second halves of the manipulation period. The point estimates for the manipulation period are both statistically zero. Columns (3) to (6) use only the sample with data from at least three stockyards. Results are consistent with the estimation in [Table 4](#). Standard errors are in parentheses.

$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 2: Higher-Level Price Elasticity

	Price			
	(1) Meat	(2) Dairy	(3) Starch	(4) Vegetable
Meat	-0.822 (0.646)	-0.075 (0.950)	0.831*** (0.197)	0.067 (0.210)
Dairy	-0.072 (0.916)	-0.614 (1.450)	0.236 (0.371)	0.451 (0.346)
Starch	0.733*** (0.175)	0.216 (0.341)	-0.839*** (0.165)	-0.111 (0.099)
Vegetable	0.203 (0.639)	1.417 (1.091)	-0.381 (0.339)	-1.239*** (0.322)

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

Appendix Table 3: Coefficient Estimates for Lower-Level AIDS System

Meat Products	Constant	Cross-Price Coefficient				Expenditure
		Beef	Pork	Mutton	Poultry	
	(1)	(2)	(3)	(4)	(5)	(6)
Beef	-2.363*** (0.388)	-1.275*** (0.356)	1.970*** (0.342)	0.202 (0.186)	-0.898 (0.232)	0.288*** (0.037)
Pork	5.060*** (0.499)	1.970*** (0.342)	-2.352*** (0.553)	-0.373 (0.229)	0.754* (0.452)	-0.464*** (0.049)
Mutton	0.268 (0.277)	0.202 (0.186)	-0.373 (0.229)	-0.563*** (0.096)	0.734*** (0.143)	-0.027 (0.026)
Poultry	-1.966*** (0.392)	-0.898*** (0.232)	0.754* (0.452)	0.734*** (0.143)	-0.590* (0.340)	0.203*** (0.038)

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

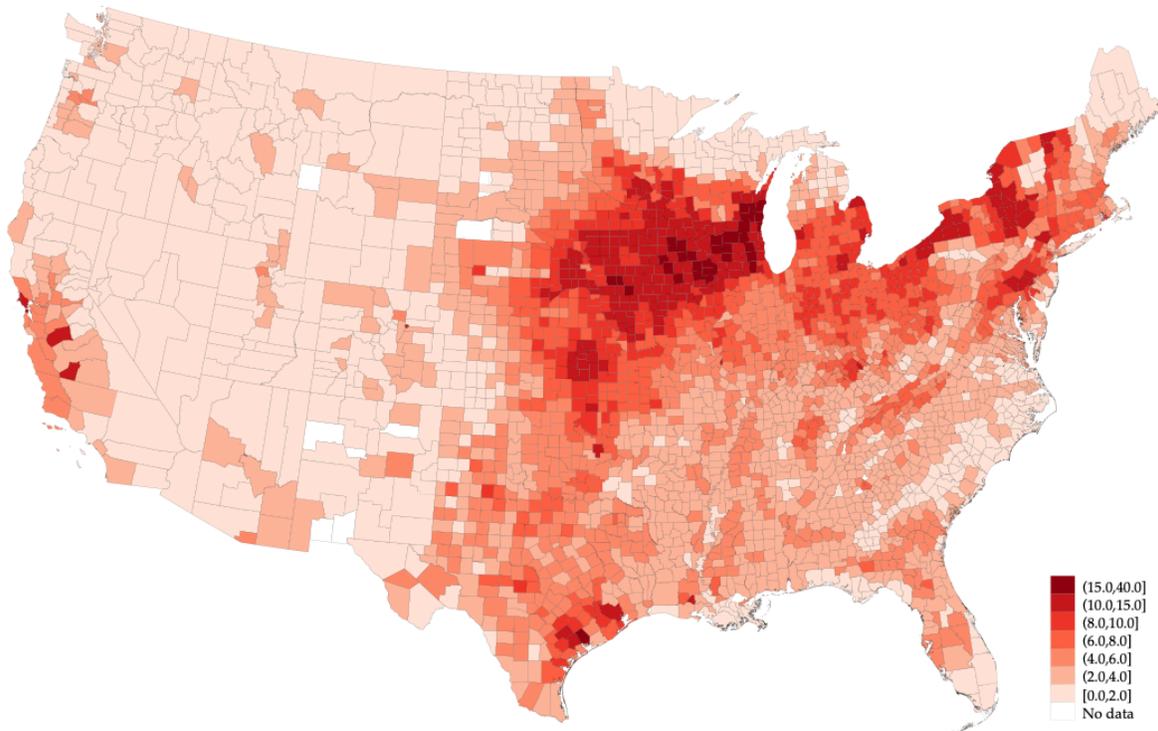
Appendix Table 4: Coefficient Estimates for Higher-Level AIDS System

Food Segments	Constant	Cross-Price Coefficient				Expenditure
		Meat	Dairy	Starch	Vegetable	
	(1)	(2)	(3)	(4)	(5)	(6)
Meat	-1.340 (1.198)	-0.266* (0.152)	0.254 (0.212)	0.098** (0.044)	-0.085 (0.055)	0.138 (0.096)
Dairy	3.075* (1.723)	0.254 (0.212)	-0.523 (0.319)	0.046 (0.073)	0.223*** (0.084)	-0.212 (0.136)
Starch	-0.140 (0.474)	0.098** (0.044)	0.046 (0.073)	-0.062 (0.047)	-0.082*** (0.023)	0.028 (0.038)
Vegetable	-0.596 (0.459)	-0.085 (0.055)	0.223*** (0.084)	-0.082*** (0.023)	-0.057** (0.026)	0.045 (0.037)

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

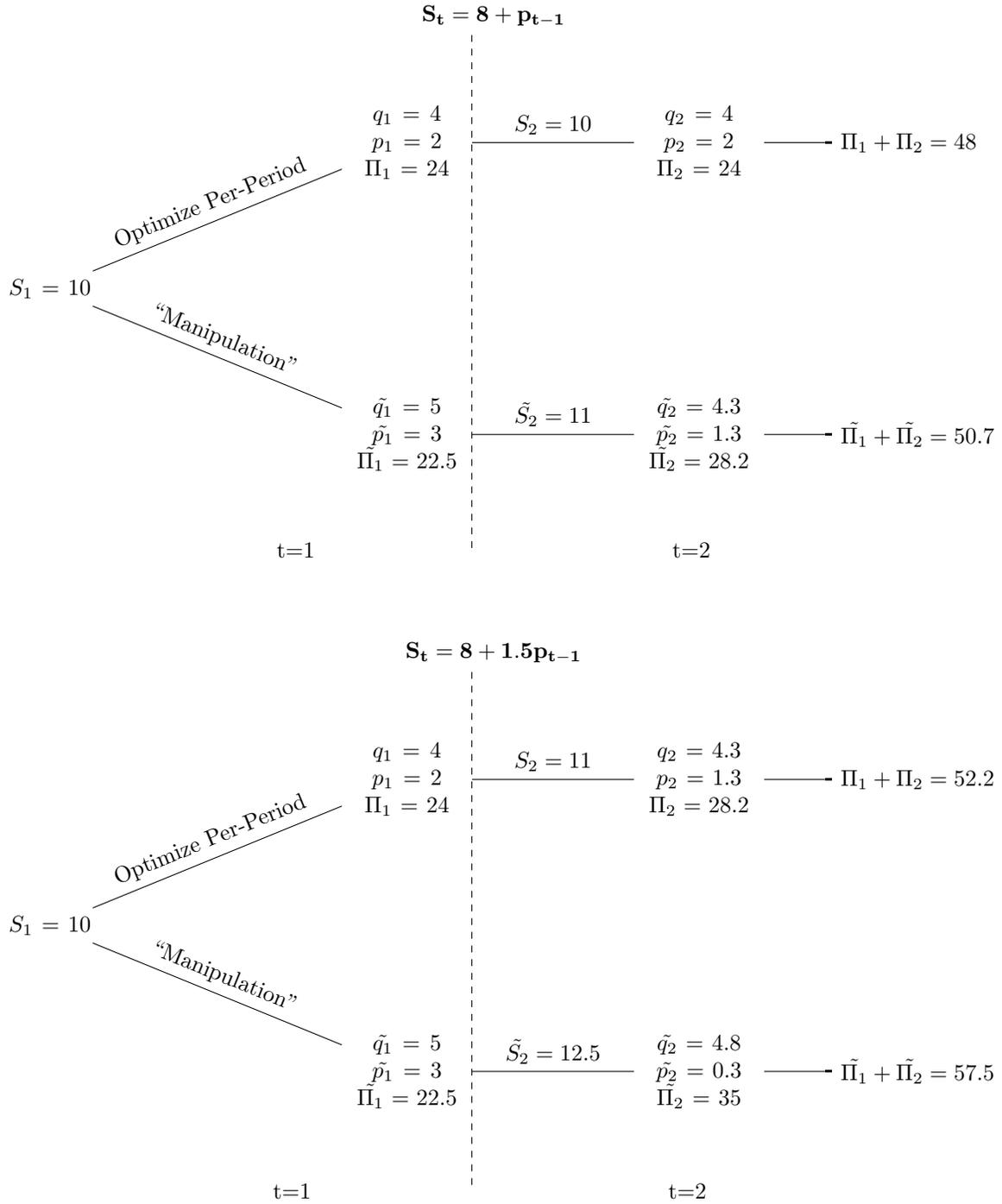
F Appendix Figure

Appendix Figure 1: Cattle Density (per hundred acre), 1910



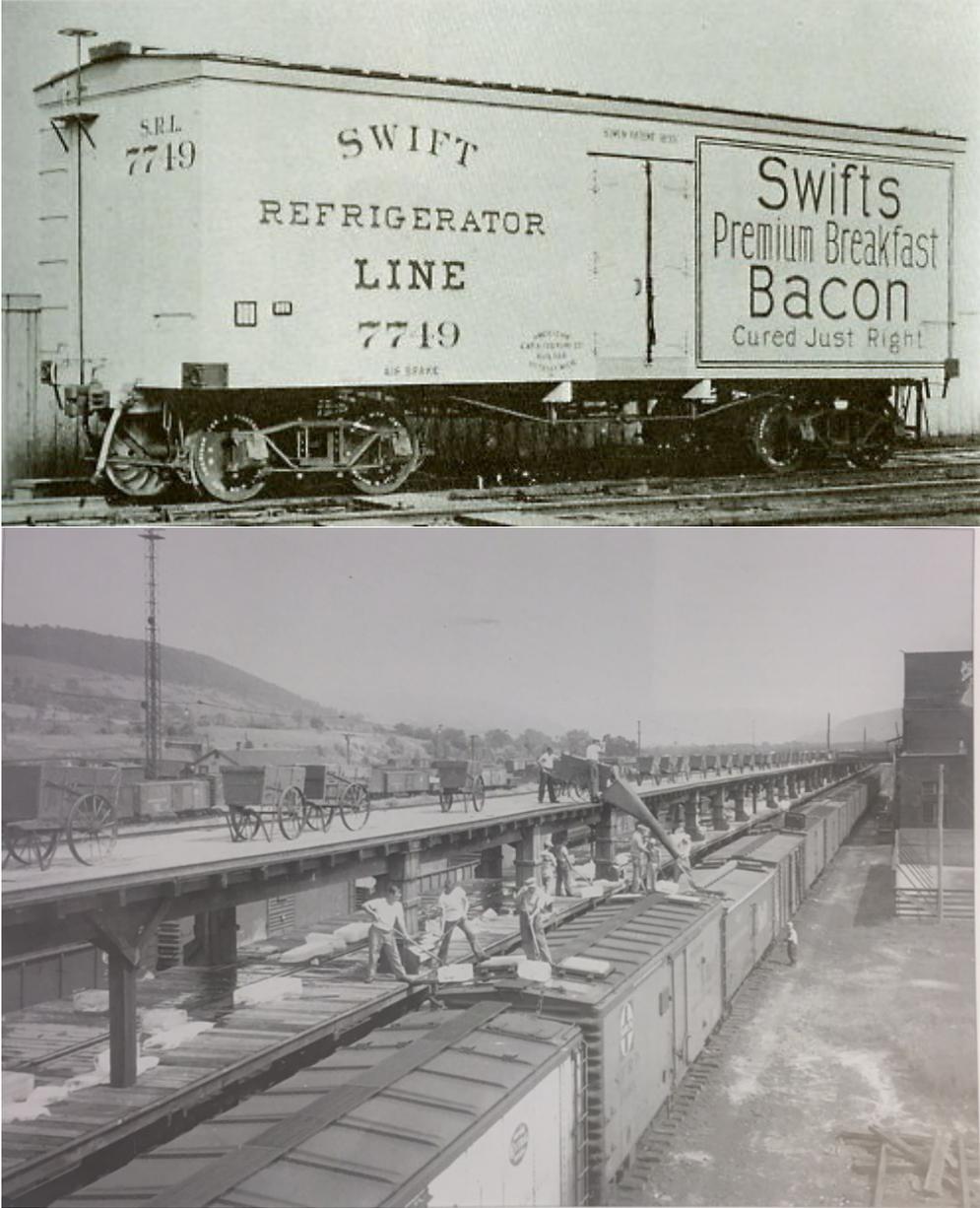
Note: Data from the 1910 Census of Agriculture ([Haines et al., 2018](#)). Values exclude milk cows and working oxen. The data is plotted with 1910 county boundaries.

Appendix Figure 2: Numeric Two-Period Market Example

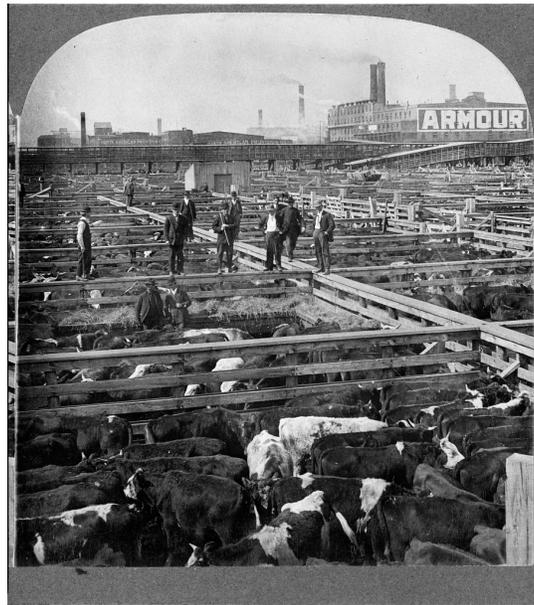


Note: The strategy to “optimize per-period” is the solution to the cartel’s static profits maximization problem in each period, given the downstream demand $D_t = 10 - 0.5q_t$ and the spot-market supply $p_t = 8 + q_t - S_t$. The “manipulation” strategy illustrated here is not the optimal quantity path. The above calculation is one example where manipulation can outperform the static strategy.

Appendix Figure 3: Swift Ice-Refrigerated Rail Car and Ice-Manufacturing Plant



Appendix Figure 4: Buyers at Chicago's Union Stock Yards, 1909



Note: *In the heart of the Great Union Stock Yards, Chicago, U.S.A.* Chicago Illinois, ca. 1909. Photograph. <https://www.loc.gov/item/89711602/>.

Appendix Figure 5: Cattle Slaughter Relied Primarily on Manual Labor



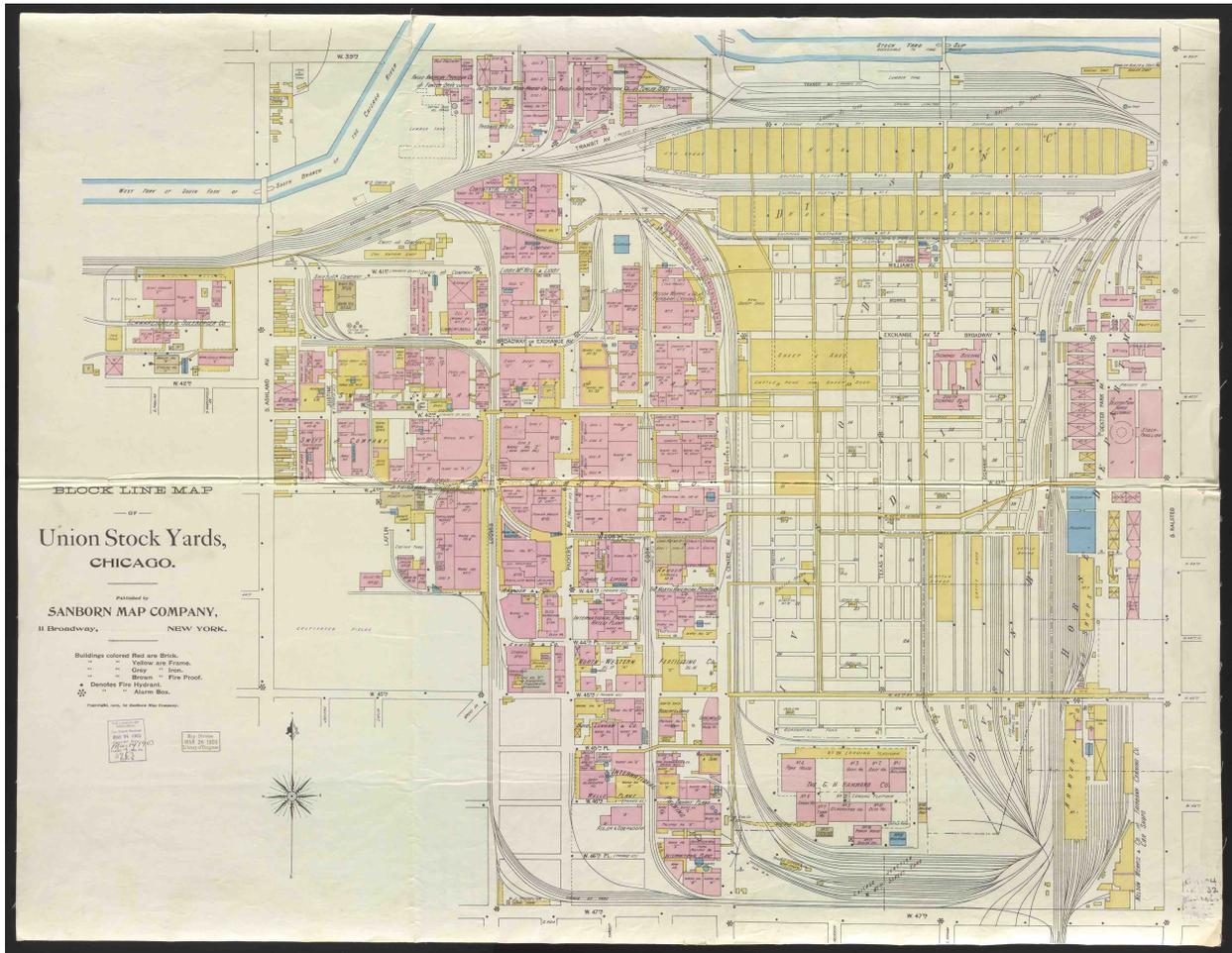
Note: H.C. White Co. Chicago - Meat Packing Industry: dressing beef—removing hides and splitting backbones, Swift's Packing House, Chicago, U.S.A. Chicago Illinois, 1906. North Bennington, Vt.: H.C. White Co., Publishers. Photograph. <https://www.loc.gov/item/2006679958/>.

Appendix Figure 6: Example of *The National Provisioner* Market Information

WEEKLY AVERAGE PRICE OF LIVESTOCK.					CHICAGO LIVE STOCK					
	Cattle.	Hogs.	Sheep.	Lambs.	RECEIPTS.					
This week	\$7.00	\$6.33	\$4.55	\$6.80						
Previous week	6.95	6.17	4.10	6.35						
Cor. week, 1911	6.20	7.93	4.10	6.25						
Cor. week, 1910	6.25	8.57	5.50	8.30						
Cor. week, 1909	5.95	6.03	4.80	7.50						
CATTLE.					RECEIPTS.					
Good to prime steers	\$7.50@8.50				Cattle.	Calves.	Hogs.	Sheep.		
Fair to good heaves	6.15@7.50				Monday, Jan. 8.	15,973	904	22,028	28,289	
Common to fair heaves	4.00@6.15				Tuesday, Jan. 9.	12,026	2,011	50,362	27,370	
Inferior killers	4.00@5.00				Wednesday, Jan. 10.	17,618	1,358	53,439	34,382	
Fair to fancy yearlings	6.50@8.25				Thursday, Jan. 11.	9,928	1,548	39,130	33,348	
Good to choice cows	4.40@5.50				Friday, Jan. 12.	5,210	690	26,526	20,887	
Canner bulls	2.75@3.25				Saturday, Jan. 13.	1,314	168	20,469	3,542	
Common to good calves	6.50@7.00				Total last week	62,069	6,679	211,954	142,818	
Good to choice vealers	7.00@9.00				Previous week	60,400	8,367	137,920	128,294	
Heavy calves	4.50@5.25				Cor. week, 1911	59,770	7,292	157,406	100,470	
Feeding steers	4.45@6.00				Cor. week, 1910	63,908	5,024	152,294	81,187	
Stockers	3.25@5.25				SHIPMENTS.					
Medium to good beef cows	3.50@4.50				Monday, Jan. 8.	4,622	276	7,097	1,246	
					Tuesday, Jan. 9.	3,659	238	5,519	2,371	
					Wednesday, Jan. 10.	5,805	314	10,853	4,013	
					Thursday, Jan. 11.	4,762	294	5,162	2,664	
					Friday, Jan. 12.	3,990	205	1,865	4,116	
					Saturday, Jan. 13.	511	71	2,440	1,200	
					Total last week	23,349	1,398	32,936	15,610	
					Previous week	24,339	1,133	35,847	18,185	
					Cor. week, 1911	27,875	509	34,345	6,182	
					Cor. week, 1910	28,315	644	39,081	10,315	

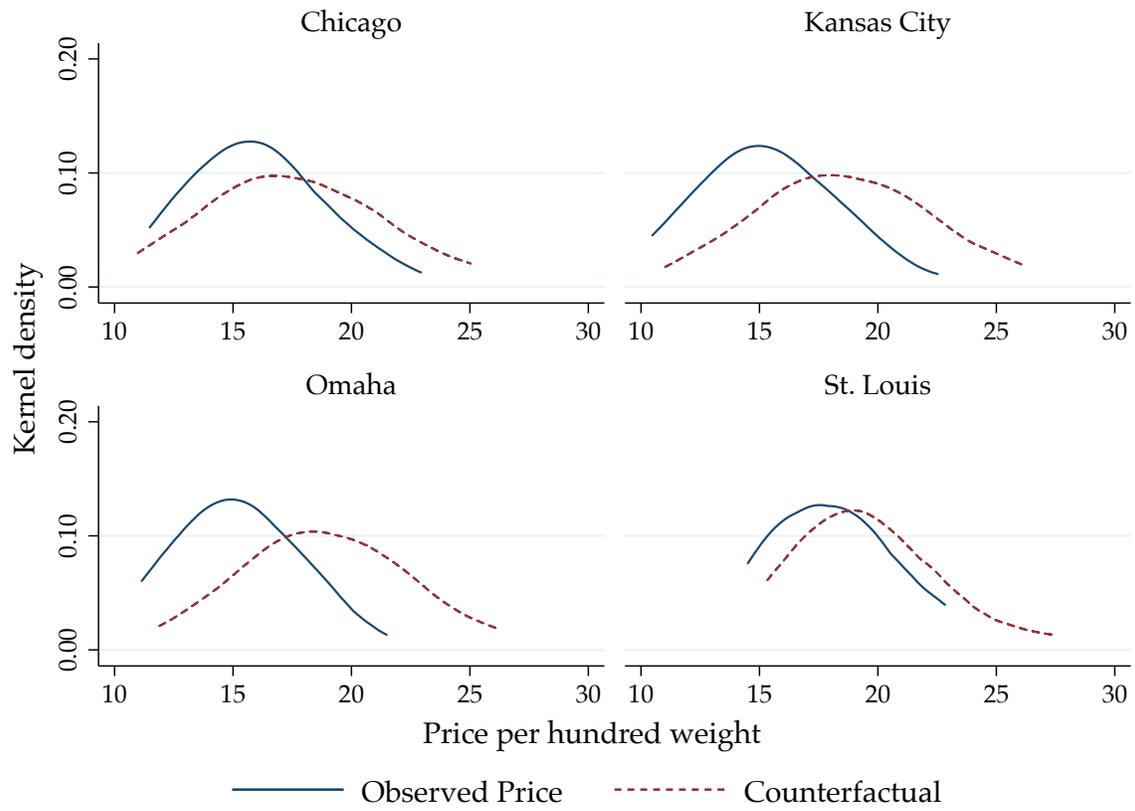
PACKERS' PURCHASES			
Purchases of livestock by packers at principal centers for the week ending Saturday, January 3, 1914, are reported as follows:			
Chicago.			
	Cattle.*	Hogs.	Sheep.*
S. & S. Co.	5,124	12,300	9,177
Armour & Co.	5,075	15,700	18,632
Swift & Co.	4,098	12,100	18,621
Morris & Co.	3,812	6,300	7,024
G. H. Hammond Co.	1,614	5,700	...
Libby, McNeill & Libby	693
Anglo-American Packing Co., 8,500 hogs; Boyd, Lunham & Co., 6,200 hogs; Western Packing & Provision Co., 9,700 hogs; Roberts & Oake, 4,200 hogs; Miller & Hart, 3,300 hogs; Independent Packing Co., 8,200 hogs; Brennan Packing Co., 4,000 hogs; others, 10,000 hogs.			
*Incomplete.			
Kansas City.			
	Cattle.	Hogs.	Sheep.
Armour & Co.	2,842	9,143	6,071
Fowler Packing Co.	997	...	2,597
S. & S. Co.	2,735	7,444	4,875
Swift & Co.	3,712	6,985	7,781
Cudahy Packing Co.	3,256	6,057	7,587
Morris & Co.	2,646	5,543	3,831
Butchers	104	921	13
Omaha.			
	Cattle.	Hogs.	Sheep.
Morris & Co.	1,414	5,731	8,709
Swift & Co.	2,149	7,705	9,897
Cudahy Packing Co.	3,101	11,194	6,973
Armour & Co.	2,056	11,391	7,720
Swartz & Co.	...	779	...
J. W. Murphy	...	4,161	...
Lincoln Packing Co., 119 cattle; John Morrell & Co., 32 cattle; South Omaha Packing Co., 11 cattle.			
St. Louis.			
	Cattle.	Hogs.	Sheep.
Morris & Co.	1,949	5,779	3,983
Swift & Co.	2,997	7,256	5,789
Armour & Co.	2,151	6,270	5,630
St. Louis D. B. Co.	523	145	...
Independent Packing Co.	791	2,172	150
East Side Packing Co.	115	3,139	...
Bela Packing Co.	...	1,005	...
Hell Packing Co.	5	517	...
Carondelet Packing Co.	...	134	...
Krey Packing Co.	...	2,546	...

Appendix Figure 7: 1903 Map of Chicago's Union Stock Yards



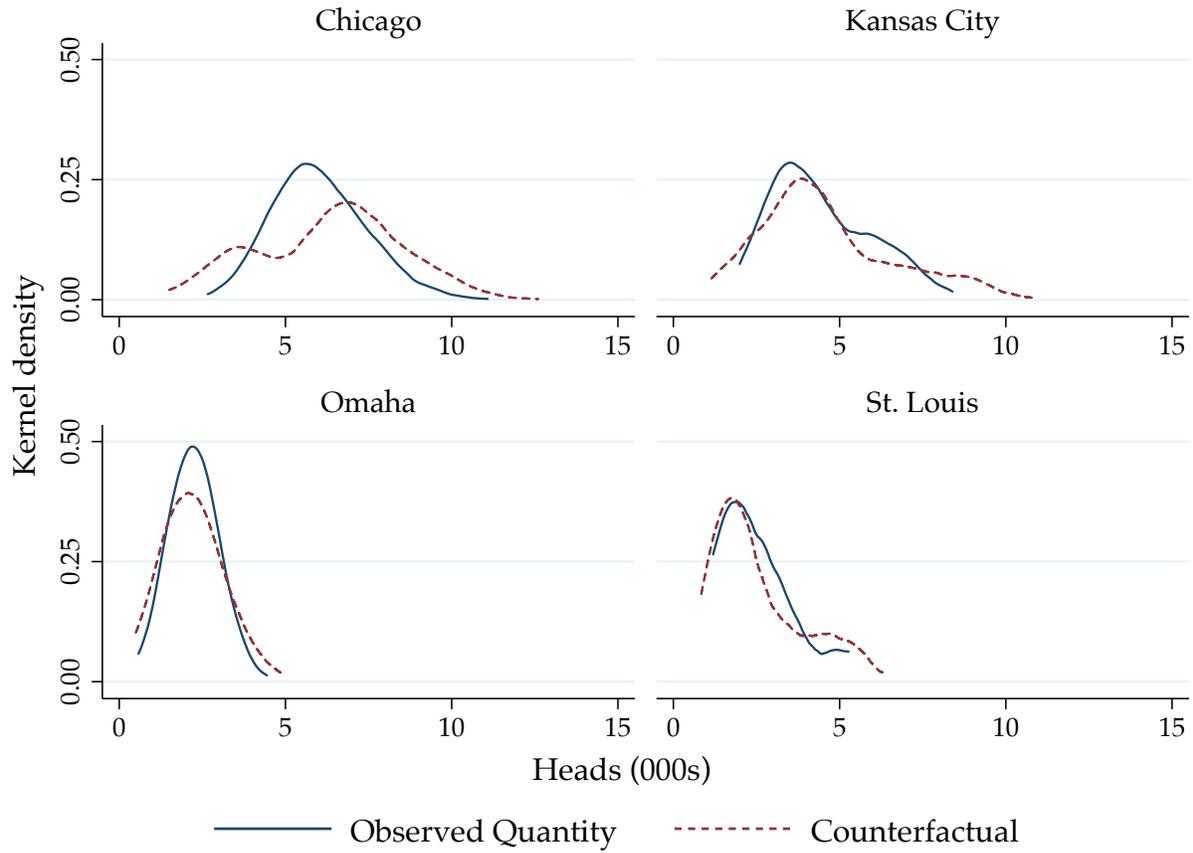
Note: Digital map accessed through the University of Illinois at Urbana-Champaign Map Library. The pink areas were meatpacking plants and other by-product manufacturing facilities.

Appendix Figure 8: Distribution of Counterfactual and Observed Cartel Price by Stockyards



Note: The value of the counterfactual prices is calculated by solving (8), with estimated elasticities during the dynamic manipulation period.

Appendix Figure 9: Distribution of Counterfactual and Observed Cartel Quantities by Stockyards



Note: The value of the counterfactual quantity is calculated by solving (8), with estimated elasticities during the dynamic manipulation period.