Welfare Effects of Buyer and Seller Power

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Abstract

We provide a theoretical characterization of the welfare effects of buyer and seller power in vertical relations and introduce an empirical approach for quantifying the contributions of each to the welfare losses from market power. Our model accommodates both monopsony distortions from buyer power and double-marginalization distortions from seller power. Rather than imposing one of these vertical distortions by assumption, we let them be determined by a 'conduct selection' criterion that is based on model primitives. We show that the relative elasticity of upstream supply and downstream demand is the key determinant of whether buyer or seller power creates a market power distortion. Applying our framework to coal procurement by power plants in Texas, we attribute 74.9% of the distortion to monopoly power of coal mines, with the remainder attributed to the monopsony power of power plants.

Keywords: Monopoly, Monopsony, Market Power, Vertical Relations, Bargaining
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1 Introduction

There is a growing interest in the buyer power of firms, both in labor markets (Card et al., 2018; Berger et al., 2022; Lamadon et al., 2022) and in vertically-related industries (Grennan, 2013; Gowrisankaran et al., 2015; Rubens, 2023). This attention is mirrored in policy circles; for instance, the Department of Justice (DOJ) has challenged mergers on the grounds of monopsony concerns (DOJ, 2022), and tackling labor market power has come to the forefront of economic policy-making (The White House, 2023; DOJ and FTC, 2023).

However, the welfare implications of buyer power vary drastically across different vertical models. In one class of models, which we classify as "monopolistic vertical conduct," the downstream party controls output, either directly or indirectly by setting consumer prices, and bargains over input prices (Abowd and Lemieux, 1993; Crawford and Yurukoglu, 2012; Ho and Lee, 2019). In these models, *seller power* creates vertical distortions by generating upstream *markups*, and buyer power can countervail this distortion. In contrast, in another class of models, which we classify as "monopsonistic vertical conduct," the upstream party controls how much input to supply and bargains over input prices (Azkarate-Askasua and Zerecero, 2025; Angerhofer et al., 2025). In these models, *buyer power* creates vertical distortions by generating input price *markdowns*.

In this paper, we provide a theoretical characterization of the welfare effects of buyer and seller power in a unified framework and introduce an empirical approach to quantify how much each channel contributes to vertical distortions. Our framework nests both monopsonistic and monopolistic vertical conduct. The key novelty is that we do not assume a specific type of vertical conduct; rather, we let conduct be determined through a participation constraint that is based on model primitives. This feature allows us to characterize the conditions under which buyer power acts as countervailing or distortionary, as a function of the supply and demand elasticities.

In its basic form, our theoretical model is a perfect-information bilateral Nash bargaining game between a seller ("upstream") and a buyer ("downstream") that bargain over a linear input price, and either the seller chooses how much to supply ("monopsonistic bargaining") or the buyer chooses how much to produce ("monopolistic bargaining"). We model "buyer power" as the buyer's bargaining ability (β) compared to the seller's. We avoid functional-form assumptions on the demand and cost curves and allow for both simultaneous and sequential timing. Using this model, we analyze vertical distortions, defined as the output reduction relative to joint-profit maximization in the vertical chain.

The starting point of our paper is our result that under increasing upstream marginal costs and decreasing downstream demand, an equilibrium exists under both monopsonistic and monopolistic vertical conduct. This contrasts with most empirical IO models studying settings with constant marginal costs, where only monopolistic conduct is possible. Similarly, monopsony models in labor typically feature perfectly elastic downstream demand, where only monopsonistic conduct is possible.[1] However, in settings with both increasing marginal costs and decreasing demand, both types of vertical conduct could occur. To address this theoretical ambiguity, we develop two empirically testable conduct selection rules.

We argue that such settings are common and illustrate the application of our model in three empirical contexts: (i) a manufacturer with increasing marginal costs bargaining with a downstream firm, (ii) a union bargaining with an employer, and (iii) a sellers' collective bargaining with a buyer. In each of these applications, we show how to empirically determine whether the vertical distortions come from the buyer's monopsony power or the seller's monopoly power. Moreover, if both distortion types are present in an industry, we decompose the vertical distortion into buyer and seller power components. We illustrate this decomposition in our main empirical application of coal procurement by power plants.

We begin our theoretical analysis by examining monopolistic and monopsonistic bargaining separately. Our first result shows that buyer power has an opposite effect on output under each type of vertical conduct. Under monopolistic bargaining, greater buyer power raises output by reducing the double-marginalization problem of Spengler (1950). In contrast, under monopsonistic bargaining, greater buyer power lowers output due to a different form of double marginalization, in which the downstream firm marks down input prices in addition to marking up consumer prices (Robinson, 1933). Although these insights are recognized in the literature, we characterize the nonparametric conditions under which they arise in a bargaining setting.

To understand their properties, we compare monopsonistic and monopolistic bargaining with efficient bargaining, where upstream and downstream firms negotiate a two-part tariff that maximizes joint profits. We show that for a unique interior value of buyer power $\beta^* \in (0, 1)$, both the monopsonistic and monopolistic equilibria coincide with the efficient-bargaining outcome. Although it may not be immediately obvious, this result is intuitive: at β^*, which we call the "efficient level of buyer power," the buyer's monopsony power and the seller's monopoly power exactly offset each other, leading to the efficient-bargaining outcome with no vertical distortions.

We show that the efficient level of buyer power β^* is the key threshold determining the welfare effects of buyer and seller power. It is characterized by the relative elasticities

[1] Recently, monopsony models have been developed in which downstream residual demand is not perfectly elastic with respect to downstream prices, such as Kroft et al. (2023), Rubens (2023), and Lobel (2024).

of upstream cost and downstream demand, as these govern the extent of downstream monopsony power (cost curve) and upstream monopoly power (demand curve). A higher cost elasticity increases the potential for monopsony power, requiring more seller power (lower β^*) to countervail it. Similarly, less-elastic demand amplifies the scope for double marginalization, necessitating greater buyer power (higher β^*) to countervail seller power.

Having shown that two vertical conduct types are possible with distinct welfare effects, we next develop two criteria that select between monopsonistic and monopolistic conduct.

We impose a participation constraint as our first conduct-selection criterion: the seller requires a nonnegative markup, and the buyer requires a nonnegative markdown in order to trade. Under these constraints, vertical conduct is uniquely determined depending on how the actual buyer power (β) compares to the efficient buyer power (β^*). If buyer power is below β^*, the seller has "excess" power, resulting in monopolistic vertical conduct. Conversely, if buyer power exceeds β^*, the buyer has "excess" power, leading to monopsonistic vertical conduct. Thus, buyer power can be either countervailing (output-increasing) or distortionary (output-decreasing), depending on how β compares with β^*.

Although the nonnegative markup and markdown constraints seem intuitive, they warrant further discussion because firms can still earn positive profits due to inframarginal units. Thus, these constraints are more likely to hold when organizational frictions prevent internal transfers that enables firms to operate marginal units at a loss (Holmstrom and Tirole, 1991; Scharfstein and Stein, 2000). For example, if the seller is a labor union, a negative markup would require transfers among members to subsidize some workers to accept wages below their reservation levels—a scenario that is implausible. Similarly, if the seller is a multi-plant firm, it would require a manager to run a loss-making plant.

We develop a second conduct selection criterion that does not directly impose nonnegative markups and markdowns. We augment our model to allow firms to bargain over either a linear price contract or a two-part tariff. We introduce an incentive-compatibility constraint that firms choose a linear price contract only if they cannot unilaterally earn higher profits under a two-part tariff. Under this constraint, either the upstream party (under monopolistic conduct) or the downstream party (under monopsonistic conduct) has the incentive to choose a linear price contract over a two-part tariff in the β intervals defined under the first conduct selection rule. This, in turn, uniquely determines conduct as either monopsonistic or monopolistic.

The characterization of vertical conduct as a function of the actual level of buyer power, β, and the efficient level of buyer power, β^*, suggests potential empirical strategies for analyzing market power in vertical relations. First, β^* can be calculated from the elasticity of upstream cost and downstream demand, and can be compared to β estimated using a bargaining model. In our model, this comparison identifies the vertical conduct and whether seller or buyer power generates vertical distortions. Second, even if estimating the actual bargaining weight is not feasible, β^* alone could still be useful. Under a uniform prior for β, high levels of β^* suggest that the conduct is likely monopsonistic, while low levels of β^* indicate that the conduct is more likely monopolistic.

We then demonstrate how to implement these empirical strategies through three applications. In our main application, we analyze wholesale coal procurement by power plants in the Texas ERCOT market from 2005 to 2014. Using detailed cost data from coal mines and power plants alongside observed wholesale coal and electricity prices, we first estimate cost and demand curves for both sides of the market. With these structural primitives, we then estimate a Nash-in-Nash bargaining model of Horn and Wolinsky (1988) between mines and power plants to recover both the actual bargaining weights of power plants β and the efficient bargaining weights β^*.

The estimates suggest that power firms have relatively more bargaining power than mining firms, with an average bargaining parameter of 0.75. However, the actual bargaining parameters are still lower than the efficient bargaining parameters for most firm pairs, which arises mostly due to the more inelastic downstream demand curve relative to the supply curve of coal mines. Thus, according to our conduct selection criteria, vertical conduct is likely to be monopolistic in this market, with 74.9% of the vertical distortion coming from the monopoly power of coal mines, and the remaining 25.1% arising from the monopsony power of power plants.

The two other empirical examples use calibrated applications of our model to infer β^* rather than estimating a full bargaining model. First, using labor supply and demand estimates for U.S. construction workers from Kroft et al. (2023), we examine the effects of potential unionization in this industry. We find that if workers unionized, the output-maximizing bargaining power of employers would be 0.42, slightly favoring unions over employers. Second, we apply our model to the Chinese tobacco supply chain to examine the potential effects of a farmers' cooperative, using estimates from Rubens (2023). We find that the efficient level of buyer power of tobacco buyers would be 0.92, suggesting that farmer cooperatives would likely reduce output by creating double marginalization.

Our paper offers key insights for antitrust policy. In horizontal mergers in a vertical chain, we show that the effects of the resulting change in buyer power depend on whether the vertical conduct is monopsonistic or monopolistic, which itself is determined by supply and demand elasticities. Our model thus nests prior analyses of buyer power in merger control, with buyer power being pro-competitive in Nevo (2014); Craig et al. (2021); Sheu and Taragin (2021) but anti-competitive in Hemphill and Rose (2018); Berger et al. (2023).

Nevertheless, we emphasize that this paper focuses solely on the static effects of buyer and seller power while remaining agnostic about potential dynamic effects, such as those relating to innovation or investment incentives, which may be critical for welfare (Inderst and Shaffer, 2007; Inderst and Wey, 2007; Parra and Marshall, 2024). Moreover, we do not take a stand on how to weigh the surpluses of upstream and downstream parties; rather, we examine the effects of buyer and seller power on output and various welfare metrics.

Contribution to the Literature This paper contributes to the literature on bargaining models under bilateral monopoly/oligopoly, which have been applied in labor to analyze wage bargaining (Nickell and Andrews, 1983; Manning, 1987; Abowd and Lemieux, 1993; Hosken et al., 2024; Caldwell et al., 2025), in IO to study firm-to-firm bargaining (Crawford and Yurukoglu, 2012; Grennan, 2013; Gowrisankaran et al., 2015; Crawford et al., 2018; Ho and Lee, 2019; Cuesta et al., 2025), and in international trade to study importer-exporter bargaining (Atkin et al., 2024; Alviarez et al., 2025).[2] In these models, output is determined by the buyers, either directly or indirectly through setting prices, which implies that vertical distortions are due to seller power.[3]

Second, a distinct literature studies monopsony power in vertical relations while assuming that the *seller*, rather than the buyer, determines output. In these models, the downstream party sets wholesale prices (or wages, in labor applications) while facing an upward-sloping factor supply curve under various market structures: monopsonistic competition (Card et al., 2018; Lamadon et al., 2022; Bar-Isaac et al., 2025), oligopsonistic competition (Azar et al., 2022; Berger et al., 2022; Rubens, 2023), or monopsonistic bargaining (Angerhofer et al., 2025; Azkarate-Askasua and Zerecero, 2025; Rubens, 2025).[4]

We contribute to these two literatures by introducing a unified framework that selects the vertical conduct and decomposes the vertical distortions into seller and buyer power. By doing so, we also contribute to the literature testing vertical conduct (Berto Villas-Boas, 2007; Bonnet and Dubois, 2010; Atkin et al., 2024; Duarte et al., 2024). Differently from these papers, vertical conduct is an outcome in our model instead of a fixed primitive.

Third, we contribute to models of countervailing power (e.g., Galbraith, 1954; Horn and Wolinsky, 1988; Snyder, 1996; Dobson and Waterson, 1997; Iozzi and Valletti, 2014; Loertscher and Marx, 2022; Toxvaerd, 2024), for which empirical evidence was documented

[2] An important difference between our paper and Alviarez et al. (2025) is that the markdown in our paper represents a wedge between the marginal revenue product of an input and the price of that input paid by the buyer, whereas the markdown in Alviarez et al. (2025) means a negative markup of the seller.

[3] In the labor literature, this implies that the 'right to manage' is allocated to the employers, which is usually assumed in wage bargaining models except in models of efficient bargaining between unions and employers, such as McDonald and Solow (1981).

[4] These are the "neoclassical" monopsony models, as opposed to the "dynamic" monopsony models in the search-and-matching tradition (Manning, 2013).

in Gowrisankaran et al. (2015); Decarolis and Rovigatti (2021); Barrette et al. (2022); Angerhofer et al. (2025). We advance this literature by identifying the conditions under which buyer power is countervailing or distortionary.[5] In contemporaneous and complementary research, Avignon et al. (2025) derive similar results in a bargaining model where the upstream firm also has monopsony power, which introduces a novel "double markdownization" phenomenon. Other differences include our analysis of both simultaneous and sequential timing, a different selection criterion for vertical conduct, and bringing our model to the data.

Fourth, our paper relates to the literature that analyzes bilateral bargaining when suppliers face non-constant marginal costs. Previous work in this literature has examined the effects of buyer size (Chipty and Snyder, 1999), supplier incentives (Inderst and Wey, 2007), and supplier uncertainty (Smith and Thanassoulis, 2012) under different cost function assumptions. More recently, Mukherjee and Sinha (2024) analyzed the effects of vertical mergers on output when the upstream cost function is convex. We contribute to this literature by analyzing the different vertical distortions within a unified framework.

Finally, our paper contributes to the literature on coal markets and power generation (Hortaçsu and Puller, 2008; Cicala, 2015; Hortaçsu et al., 2019; Jha, 2022; Preonas, 2023; Gowrisankaran et al., 2024) by studying the sources of market power in this industry.

The rest of the paper is structured as follows. In Section 2, we set up our model. Section 3 analyzes the welfare effects of buyer power while taking vertical conduct as given. Section 4 develops two conduct selection criteria. In Section 5, we empirically implement our model in two calibrated applications while Section 6 presents a fully estimated application in the context of coal procurement of power plants. All proofs are given in the Appendix.

2 Model Setup

2.1 Primitives: Costs, Demand, and Payoffs

We consider a bilateral bargaining problem where an upstream firm U sells a quantity q of a good to a downstream firm D at a wholesale price w under linear pricing. The downstream firm D then resells this good directly to consumers without incurring any additional costs. D faces an inverse demand curve $p(q)$, with $p'(q) \leq 0$. U produces output at an average cost $c(q)$, with $c'(q) \geq 0$. We denote the downstream profit as $\pi^d(w,q) \equiv \big(p(q) - w\big)q$ and the upstream profit as $\pi^u(w,q) \equiv \big(w - c(q)\big)q$. To ensure gains from trade, we assume that $p(q) > c(q)$ on the interval $(0, \bar{q})$ with $p(\bar{q}) = c(\bar{q})$. We denote the upstream firm's marginal cost as $mc(q) \equiv \frac{\partial(c(q)q)}{\partial q}$ and the downstream firm's marginal

[5] See Toxvaerd (2024) for a review of results in this literature.

revenue as $mr(q) \equiv \frac{\partial(p(q)q)}{\partial q}$. In addition, we assume that both $p(q)$ and $c(q)$ are three times continuously differentiable functions. We include several extensions to this framework, including nonzero disagreement payoffs, multiple inputs to downstream production, and multiple buyers and sellers, which we present in Appendix E.

2.2 Relevance of Allowing for Increasing Marginal Costs

Our key departure from most of the prior bargaining literature is that we allow for increasing marginal costs for U. We argue that allowing for increasing marginal costs is important for understanding vertical relations across various industries. We highlight three vertical environments where increasing marginal costs matter and to which our model applies.

Example 1. ***Unions:*** *Labor unions representing workers with heterogeneous reservation wages.*

A long tradition of research has examined wage bargaining and labor unions (Ashenfelter and Johnson, 1969; Card, 1986; Abowd and Lemieux, 1993; Azkarate-Askasua and Zerecero, 2025; Angerhofer et al., 2025). In these applications, the upstream entity U is a labor union bargaining over wages w with a downstream employer D. The upstream marginal costs correspond to workers' reservation wages, i.e., their outside employment opportunities. Any heterogeneity in these reservation wages generates an upward-sloping labor supply curve for the employer. We illustrate this application in the context of U.S. construction workers in Section 5.

Example 2. ***Cooperatives:*** *Cooperatives of suppliers with heterogeneous marginal costs.*

When an upstream entity collectively bargains with a downstream buyer on behalf of multiple suppliers, the supply curve slopes upward due to heterogeneity in suppliers' costs. Agricultural cooperatives, which are prevalent in both the U.S. and developing countries, are an example of this structure (Cook, 1995; Banerjee et al., 2001; Ito et al., 2012). We illustrate this setting in Section 5 in the context of Chinese tobacco markets.

Example 3. ***Firm-Level Decreasing Returns to Scale:*** *Individual suppliers with increasing marginal costs at the firm level.*

In Examples 1 and 2, the aggregation of atomistic production units generates increasing marginal costs for the upstream entity. Individual firms can also face increasing marginal costs due to decreasing returns to scale when bargaining with downstream buyers. Production function estimates in manufacturing typically support decreasing returns to scale, especially in the short run (Collard-Wexler and De Loecker, 2015; Demirer, 2025).

Moreover, even firms with constant marginal costs at the plant level may still experience increasing marginal costs at the *firm level* if they operate multiple plants with heterogeneous costs.[6] Section 6 illustrates this category in the context of coal production.

2.3 Behavior: Monopolistic vs. Monopsonistic Bargaining

Our main analysis considers two alternative behavioral models of vertical conduct. In the first type, which we call "monopolistic bargaining," D makes an output decision q, and U and D bargain over the wholesale price w to maximize a Nash product:[7]

$$\begin{cases} \max_q \pi^d(w,q) & (1) \\ \max_w [(\pi^d(w,q))^\beta (\pi^u(w,q))^{1-\beta}] \quad \text{s.t.} \quad \pi^d \geq 0, \pi^u \geq 0 & (2) \end{cases}$$

We denote the solution to this problem as (q^{mp}, w^{mp}). A second type of vertical conduct, which we call "monopsonistic bargaining," involves U choosing how much output to supply while bargaining over the wholesale price with D:

$$\begin{cases} \max_q \pi^u(w,q) & (3) \\ \max_w [(\pi^d(w,q))^\beta (\pi^u(w,q))^{1-\beta}] \quad \text{s.t.} \quad \pi^d \geq 0, \pi^u \geq 0 \end{cases}$$

We denote the solution to this problem as (q^{ms}, w^{ms}). In the remainder of the paper, we refer to the bargaining weight of the buyer, β, as "buyer power" and $1-\beta$ as "seller power."

Note that under monopsonistic bargaining, the interpretation of "U chooses output" does not imply that the upstream firm directly sets the downstream output, as would be the case under resale price maintenance. Rather, the upstream firm chooses its input supply to D, which in turn constrains how much output D can sell.[8] The "U chooses output" model requires increasing marginal costs to be meaningful: with constant marginal costs, the upstream firm would supply unlimited input whenever the wholesale price exceeds marginal cost. Increasing marginal costs instead create a well-defined profit-maximization problem with an interior solution.

We consider two versions of our model that differ in terms of timing of the decisions: simultaneous bargaining and sequential bargaining.

Definition 1. *Under "Simultaneous Bargaining," the quantity choice by either U or D occurs*

[6] In addition, any monopsony power of the upstream firm over its sellers leads to increasing marginal costs.
[7] The model can be readily extended to settings where downstream firms choose a price (p) instead of a quantity (q), a more common assumption in empirical bargaining models for industries with product differentiation.
[8] This assumption can be extended by letting U choose a quantity that is an input to downstream production; we provide this extension in Section E.5. There, U influences, but does not directly control, downstream q.

simultaneously with bargaining over the wholesale price.

- Stage 0: U and D observe $c(\cdot), p(\cdot), \beta$, and vertical conduct.
- Stage 1: U and D bargain over w, and either U or D chooses q.

Definition 2. *Under "Sequential Bargaining," U and D bargain over a wholesale price, after which either U or D chooses an output quantity.*

- Stage 0: U and D observe $c(\cdot), p(\cdot), \beta$, and vertical conduct.
- Stage 1: U and D bargain over w.
- Stage 2: Either U or D chooses q.

Both types of timing assumptions are widely used in the literature.[9] The simultaneous model appears in Ho and Lee (2017) and Crawford et al. (2018), while the sequential model is used in Crawford and Yurukoglu (2012) and in several right-to-manage union bargaining models (Oswald, 1982; Nickell and Andrews, 1983; Abowd and Lemieux, 1993).

Under full buyer or seller power, our bargaining model simplifies to several classical models. With full buyer power ($\beta = 1$), sequential monopsonistic bargaining reduces to the classical monopsony model of Robinson (1933), in which sellers decide the quantity supplied at each input price (supply curve), and buyers set input prices conditional on the factor supply curve. With full seller power ($\beta = 0$), monopolistic conduct becomes the successive monopoly model of Spengler (1950) with double marginalization. In the remaining limit cases, the party with full power makes a take-it-or-leave-it (TIOLI) offer.[10]

Assuming that the second-order conditions hold, the solutions to bargaining problems in Equations (1), (3), and (2) are characterized by the following first-order conditions (FOC):

$$p'(q)q + p(q) = w \qquad \text{(D-FOC)} \qquad (4)$$

$$c'(q)q + c(q) = w \qquad \text{(U-FOC)} \qquad (5)$$

$$\beta \frac{\partial \pi^d(w,q)}{\partial w}\pi^u + (1-\beta)\frac{\partial \pi^u(w,q)}{\partial w}\pi^d = 0 \qquad \text{(B-FOC)} \qquad (6)$$

for $\beta \in (0,1)$.[11,12] The solution to monopolistic bargaining is given by (D-FOC) and (B-

[9] Another possible bargaining model we could consider is one where parties bargain over quantities in the second stage, rather than choosing them unilaterally. We consider this as an extension in Appendix E.2.

[10] See Table OA-2 for a summary of the limit cases of both models.

[11] Appendices A.1 and B.1 present the closed-form solutions of these FOCs for the simultaneous and sequential versions of the model. Note that the FOCs characterize the solution only for $\beta \in (0,1)$. At the limiting cases $\beta = 0$ and $\beta = 1$, these models must be solved as constrained optimization problems, as the nonnegative profit constraints become binding. Appendix D.1 analyzes these cases.

[12] The second-order conditions for (U-FOC) and (D-FOC) are given by $mc'(q) > 0$ and $mr'(q) < 0$. The second-order conditions (B-SOC) for (B-FOC) are presented in Appendix A.2 for simultaneous timing and in Appendix B.2 for sequential timing. While (B-SOC) is always satisfied under simultaneous timing, the sequential timing case yields a complex expression involving third derivatives of both cost and demand functions. In Appendix B.8, we develop some sufficient conditions under which (B-SOC) holds globally and under our conduct selection rule given in Section 4 with sequential timing.

FOC), while the solution to monopsonistic bargaining is given by (U-FOC) and (B-FOC). In the sequential timing, unlike in the simultaneous case, the Nash bargaining solution in (B-FOC) internalizes the impact of w on the quantity choice in the second stage.

2.4 Sources of Market Power in Vertical Relations

Since we do not take a stance between monopolistic and monopsonistic conduct, vertical distortions can arise from two sources of market power in our model: a seller markup and a buyer markdown. As usual, we define the markup as the wedge between the wholesale price w and the seller's marginal costs, and the markdown as the wedge between the buyer's marginal revenue and the wholesale price (Syverson, 2025):

$$\text{Seller Markup} : \mu^u(q) \equiv \frac{w - mc(q)}{mc(q)}, \qquad \text{Buyer Markdown} : \Delta^d(q) \equiv \frac{mr(q) - w}{mr(q)}.$$

These sources of market power can generate vertical distortions by creating a wedge between marginal cost $mc(q)$ and marginal revenue $mr(q)$. Under monopolistic bargaining, this wedge results from the upstream markup, while under monopsonistic bargaining, it is due to the downstream markdown. Note that a buyer markup in the downstream market also creates market power, but it exists independently of vertical conduct. Throughout the paper, we distinguish these vertical distortions by referring to seller markup as "upstream monopoly power" and buyer markdown as "downstream monopsony power."

2.5 Benchmark: Efficient Bargaining

We consider the "efficient-bargaining" problem as a benchmark against the monopsonistic and monopolistic bargaining models. Under efficient bargaining, upstream and downstream firms negotiate over both the wholesale price and quantity:

$$\max_{w,q} \left[(\pi^d(w,q))^{\beta} (\pi^u(w,q))^{1-\beta} \right] \tag{7}$$

This bargaining process gives the same solution as a two-part tariff, in which a lump-sum transfer is possible (Tirole, 1988). This solution also corresponds to a scenario where the parties maximize their joint surplus, as is the case under vertical integration. The efficient-bargaining quantity q^* from this problem is simply the quantity such that upstream marginal cost equals downstream marginal revenue: $mc(q^*) = mr(q^*)$.

One might question why firms use a linear price contract instead of engaging in efficient bargaining, which would yield greater joint profits. Although extensive literature documents the widespread use of linear contracts across industries and offers theoretical rationales, as reviewed in Cussen (2025), we largely remain agnostic about firms' motivations for using linear pricing. Instead, our analysis focuses on jointly analyzing monopsonistic and monopolistic vertical distortions that arise from linear contracts. Nevertheless, in one of our conduct selection methods in Section 4.2, we present conditions under which firms unilaterally find a linear price contract more profitable than a two-part tariff, providing a potential justification for firms' use of linear pricing.

3 Effects of Buyer Power: Monopolistic vs. Monopsonistic Conduct

We begin our analysis by examining the existence of the monopsonistic and monopolistic equilibrium. We then characterize the effects of buyer power on output, consumer surplus, and total surplus separately under monopolistic and monopsonistic bargaining. In the next section, we unify both forms of conduct and jointly analyze their welfare effects under a vertical conduct selection criterion. All results in this section hold under both simultaneous and sequential timing assumptions, so we do not explicitly state them.

3.1 Existence of Monopolistic and Monopsonistic Conduct

We establish the existence of equilibrium in monopolistic and monopsonistic bargaining by highlighting two special cases: constant marginal cost and constant marginal revenue.

Proposition 1. *(i) If the upstream marginal cost is constant, $mc'(q) = 0$, the monopsonistic bargaining problem does not have an interior solution for any β.*

(ii) If the downstream marginal revenue is constant, $mr'(q) = 0$, the monopolistic bargaining problem does not have an interior solution for any β.

(iii) In all other cases, both the monopolistic and monopsonistic bargaining problems have an interior solution for $\beta \in (0, 1)$.[13]

The intuition behind Proposition 1(i-ii) is straightforward. Under constant upstream marginal costs, the FOC for U's output choice in Equation (5) becomes undefined in the monopsonistic model when the input price exceeds the marginal cost; U would supply an infinite quantity in this case. Similarly, if marginal revenue is constant, D would choose to sell an infinite quantity under the monopolistic model whenever the wholesale price is below the downstream price.[14]

[13]We call a solution interior if the equilibrium wholesale price is different from the average upstream cost $c(q)$ and downstream price $p(q)$. In the simultaneous bargaining model, a solution may fail to exist for some values of β depending on the demand and cost curves. We characterize the β range for which a solution exists for the simultaneous models in Appendix D.2, but for simplicity, we use $\beta \in (0, 1)$ for the remainder of the paper. If necessary, these bounds can be replaced with those derived in Appendix D.2.

[14]In light of Proposition 1, we assume for the remainder of this section that $mc'(q) > 0$ when analyzing

Proposition 1 provides insight into why different literatures have tended to use specific types of vertical conduct. The IO literature, which often studies settings with constant marginal costs, uses monopolistic bargaining (Lee et al., 2021), while the classical monopsony literature, which historically assumed perfect competition in goods markets, adopts monopsonistic bargaining (Manning, 2021). Yet, as shown in Proposition 1(iii), an equilibrium under either conduct is possible when upstream costs increase and downstream demand decreases. As illustrated in Examples 1–3, studies of such settings have gained prominence in recent literature with the integration of monopsony power into IO models (Card, 2022; Azar and Marinescu, 2024), which motivates our unified approach.

3.2 Output and Buyer Power

We now characterize the relationship between equilibrium output q and buyer power β in monopsonistic and monopolistic bargaining. To do so, we introduce two additional assumptions on the cost and demand curves.

Assumption 1. *Increasing Differences Between Marginal and Average Costs:* $\frac{d(mc(q)-c(q))}{dq} > 0$

Assumption 2. *Decreasing Differences Between Marginal and Average Revenue:* $\frac{d(mr(q)-p(q))}{dq} < 0$

These assumptions govern the curvature of the cost and demand curves. They are weaker than the convexity of the average cost and the concavity of demand, but they imply that upstream marginal costs are increasing, $mc'(q) > 0$, and that downstream marginal revenue is decreasing, $mr'(q) < 0$.[15] We need Assumption 1 to hold only under monopsonistic bargaining, and Assumption 2 only under monopolistic bargaining.

Lemma 1. *In monopsonistic bargaining, the equilibrium quantity q^{ms} decreases and the downstream markdown Δ^d increases with buyer power β; that is, $dq^{ms}/d\beta < 0$ and $d\Delta^d/d\beta > 0$.*

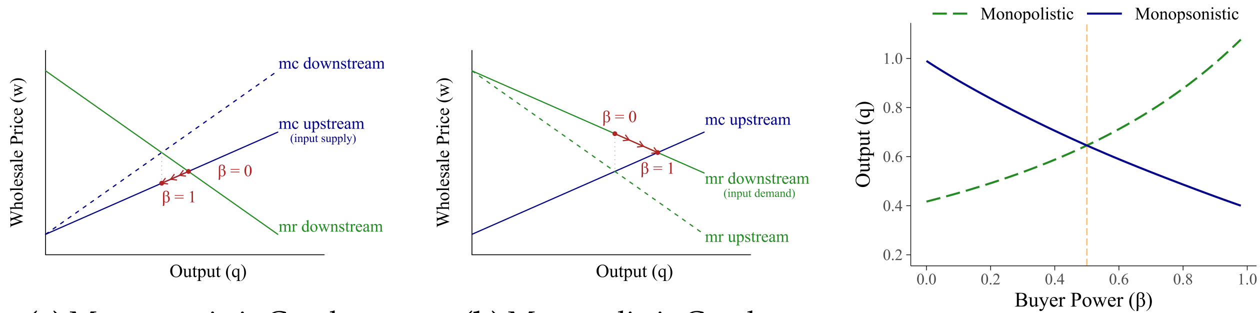
Lemma 1 establishes that an increase in buyer power reduces output under monopsonistic bargaining. Figure 1(a) illustrates the key intuition behind this result. In monopsonistic bargaining, the output is decided by U, which implies that $q^{ms}(w)$ is an input *supply* curve. An increase in buyer power β leads to movements along this input supply curve by lowering the wholesale price. This, in turn, reduces output and increases the markdown.

The "Increasing Differences Between Marginal and Average Costs" assumption is necessary for Lemma 1 because marginal cost drives the upstream firm's quantity choice, whereas average cost determines its profits and participation constraint. If marginal cost

monopsonistic bargaining and $mr'(q) < 0$ when analyzing monopolistic bargaining to ensure that the solutions are well-defined.

[15]See Lemma OA-15 in Appendix D.5 for this result.

Figure 1: Illustration of the Effects of Buyer Power on Output



(a) Monopsonistic Conduct **(b)** Monopolistic Conduct **(c)** Illustration

Notes: This figure illustrates how buyer power affects output under different vertical conduct types. Panels (a) and (b) show the theoretical intuition: in monopsonistic conduct, increased buyer power β moves output along the marginal cost curve, while in monopolistic conduct, it shifts output down the marginal revenue curve. Panel (c) presents numerical simulation results using cost curve $c(q) = q^{\psi}/(1+\psi)$ and demand curve $p(q) = q^{1/\eta}$ with parametrizations $\psi = 1/4$ and $\eta = -6$. Sequential timing is assumed; simultaneous timing results appear in Figure OA-6. For equilibrium derivations, see Appendix D.3.

rises more slowly than average cost, a more powerful buyer might prefer a higher input price—violating Lemma 1—since the revenue gains from higher quantity offset increased input costs while still maximizing the Nash product. Assumption 1 prevents this scenario.

Lemma 2. *In monopolistic bargaining, the equilibrium quantity q^{mp} increases and the upstream markup μ^u decreases with buyer power β; that is, $dq^{mp}/d\beta > 0$ and $d\mu^u/d\beta < 0$.*

Unlike the monopsonistic case, monopolistic bargaining implies that output is determined by D, implying that $q^{mp}(w)$ is an input *demand* curve, as illustrated in Figure 1(b). Consequently, an increase in β induces movements along the input demand curve, reducing the seller's markup and increasing output.

Together, Lemmas 1 and 2 reveal a key distinction between two types of vertical conduct: holding cost and demand curves constant, an increase in buyer power β *raises* output under monopolistic bargaining but *reduces* output in the monopsonistic bargaining model, as illustrated in Figure 1(c) using a numerical example. While similar theoretical insights have appeared in the literature under parametric assumptions or individual conduct (e.g., Chen (2003); Mukherjee and Sinha (2024); Toxvaerd (2024)), our results are, to the best of our knowledge, the first nonparametric treatment of this problem in a unified framework, introducing the necessary assumptions of increasing differences between marginal and average cost and increasing differences between marginal and average revenue.[16]

[16] As discussed earlier, some versions of these results were also derived independently by Avignon et al. (2025).

3.3 Distinguishing Between "Buyer Power" and "Monopsony Power"

In the literature, the terms *buyer power* and *monopsony power* are often used interchangeably. Our results clarify the distinctions between these concepts.

Corollary 1. *Under monopolistic bargaining, the downstream markdown Δ^d is zero for all values of β, so the buyer has no monopsony power. Under monopsonistic bargaining, the upstream markup μ^u is zero for all values of β, so the seller has no monopoly power.*

While there may be buyer power ($\beta > 0$) under monopolistic bargaining, the buyer markdown is always zero, because the downstream firm sets the marginal revenue equal to wholesale price in (D-FOC). Hence, there is no monopsony distortion in this model. Similarly, under monopsonistic bargaining, even with positive seller power ($(1-\beta) > 0$), the seller markup is always zero, because the upstream firm sets the marginal cost equal to the wholesale price in (U-FOC). Hence, there is no double-marginalization distortion. As a result, monopsony power arises only when increased *buyer* power reduces output, whereas upstream monopoly power arises only when increased *seller* power reduces output. In all other cases, buyer and seller power are countervailing.[17]

3.4 Characterization of the Efficient Level of Buyer Power

Having established how output depends on buyer power under each vertical conduct type, we turn to examine at what level of buyer power joint surplus, consumer surplus and total surplus are maximized under each vertical conduct. We start with joint surplus by comparing each conduct to the efficient-bargaining problem given in Equation (7).

Proposition 2. *There exists a unique bargaining parameter* $\beta^* = \dfrac{-p'(q^*)}{c'(q^*) - p'(q^*)} \in (0,1)$ *such that the equilibrium output from both the monopsonistic and monopolistic bargaining models corresponds to the efficient-bargaining model output.*

This proposition shows that at β^*, output under the monopolistic and monopsonistic conduct coincides and is equal to the level that would be reached under efficient bargaining.[18] This result arises because β^* represents the level of buyer power at which the buyer's monopsony power and the seller's monopoly power exactly offset one another, resulting in an outcome with neither monopsony nor upstream monopoly distortions.[19] We denote

[17]See Chen (2008) for a review of the various definitions of buyer power in the literature.

[18]In a distinct class of imperfect-information bargaining models, an interior value of β leads to bilateral efficiency as well (Loertscher and Marx, 2022).

[19]Proposition 2 has some similarity to the condition in Hosios (1990), which states that the worker's bargaining share must align with the relative ease of finding a job versus the difficulty firms face filling vacancies. Rather than balancing a congestion and market thickness externality in Hosios (1990), the efficient level of buyer power balances a markup and markdown distortion in our model.

β^* as the "efficient level of buyer power", indicating bilateral efficiency, as it will be the key parameter when we introduce the conduct criteria in the next section.

Proposition 2 also shows that β^* relates to the curvature of the cost and demand curves in an intuitive way, as shown in the following corollary.

Corollary 2. *The efficient level of buyer power β^* weakly decreases as the upstream marginal cost curve becomes steeper and weakly increases as the downstream inverse demand curve becomes steeper.*

The steeper the upstream cost curve, the higher the potential monopsony distortion becomes. To counterbalance this effect, the seller needs greater bargaining power, resulting in a lower value of β^*. Similarly, steeper downstream demand amplifies the potential for upstream monopoly power, requiring the buyer to have stronger bargaining power as a countervailing force. As a result, in extreme cases with constant marginal cost or constant inverse demand, the efficient level of buyer power is full buyer power ($\beta^* = 1$) or full seller power ($\beta^* = 0$), respectively.

An implication of our results is that equilibrium output can exceed the efficient-bargaining output. As observed in Figure 1(c), $q > q^*$ when $\beta < \beta^*$ in the monopsonistic model and when $\beta > \beta^*$ in the monopolistic model. This outcome arises because, in these regions, either the upstream markup or the downstream markdown becomes negative. These negative values partially offset the distortion generated by the downstream markup, driving output above the efficient-bargaining level.

Consumer and Total Surplus Since consumer surplus $CS(\beta) \equiv \int_0^{q(\beta)} \big(p(h) - p(q(\beta))\big) dh$ is monotonically increasing in output, it is maximized at the output-maximizing levels of buyer power, which are $\beta = 0$ under monopolistic bargaining and $\beta = 1$ under monopsonistic bargaining.[20] In contrast, the effects of buyer power on *total* surplus $TS = \int_0^{q(\beta)} [p(h) - mc(h)] dh$ are more subtle:

Proposition 3. *Under monopolistic bargaining, total surplus is maximized at some $\beta^\dagger$ in the range $\beta^* < \beta^\dagger \leq 1$, whereas under monopsonistic bargaining it is maximized at $\beta^\dagger = 0$.*

Proposition 3 shows that, unlike the constant-marginal-cost case, total welfare is not necessarily maximized at full buyer power under monopolistic bargaining. The reason is that with increasing marginal costs, full buyer power can lead to socially inefficient overproduction, as wholesale and downstream prices can fall below marginal cost while the upstream firm still earns positive profits. In contrast, under monopsonistic bargaining, total surplus reaches its maximum with full seller power. In that scenario, the seller makes

[20] Details and a proof are in Appendix D.6.

a TIOLI offer to the buyer, driving the buyer's profit to zero. The downstream price p then equals the wholesale price w, which equals upstream marginal costs from (U-FOC). As a result, the downstream price equals the marginal cost, maximizing total welfare.

3.5 Discussion and Extensions

Nonzero Disagreement Payoffs So far, we performed comparative statics with respect to the bargaining parameter β, while holding disagreement payoffs fixed at zero. However, merger-induced changes in buyer power typically manifest through firms' disagreement payoffs (e.g., Dafny et al., 2019). To capture this, we introduce disagreement payoffs into the model in Appendix E.1. We show that findings in Lemmas 1-2 continue to hold when buyer power operates through disagreement payoffs rather than bargaining weights. Thus, one can interpret buyer power as the size of the disagreement payoffs in our framework.

Bargaining over both Input Price and Quantity While our framework encompasses the widely used monopsonistic and monopolistic bargaining models, a more general formulation would allow the parties to negotiate over both w and q, with distinct bargaining weights β_w and β_q. This specification nests the monopsonistic bargaining model when $\beta_q = 0$ and the monopolistic bargaining model when $\beta_q = 1$. We analyze this general model in Appendix E.2 under some additional restrictions and show that the main intuition of our framework continues to hold in this more general setting.

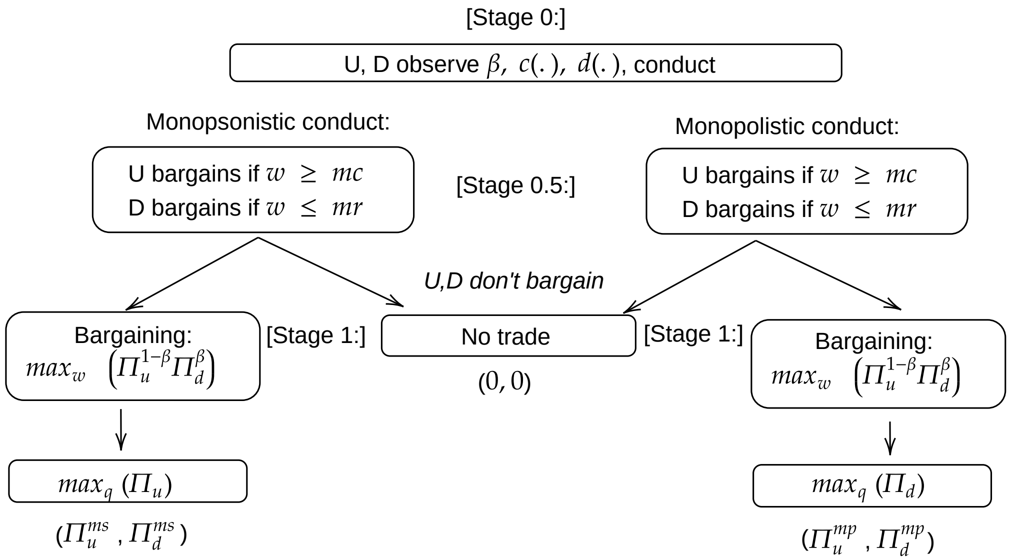
Other Extensions Appendix E presents other extensions. These include a multi-input downstream production where one input is obtained through bargaining while the other is sourced from a competitive market, multiple buyers competing oligopolistically in the downstream market, and multiple buyers and sellers bargain within a Nash-in-Nash framework. We implement these extensions empirically in our main application in Section 6.

Determination of Vertical Conduct In this section, we have shown that under general conditions, equilibrium exists under both monopsonistic and monopolistic bargaining, with opposite welfare effects of buyer power. In some cases, the type of vertical conduct might be clear from the institutional setting or observed directly from contracts. For example, in union bargaining, it is more common to observe that firms choose employment while bargaining over wages (Farber, 1986), while with cooperatives, it is more plausible that the cooperative sells all of its production to the buyer through an "output contract" (Weistart, 1973).[21] Another example is certain types of power purchase agreements in which the buyer purchases all the output of a power plant.[22] However, in other settings,

[21] For an example of this type of contract see Peace River Seed Co-operative and Proseeds Marketing Inc. where Proseeds agreed to buy Peace River's entire two-year grass-seed output at a fixed price.

[22] See, for example, GreenLife Solar and Shine Partners Agreement and County of Santa Clara PPA.

Figure 2: Decision Tree: Nonnegative Markup and Markdown



Notes: This decision tree illustrates the augmented bargaining game under the conduct selection rule defined in Section 4.1. The additional stage is Stage 0.5, where the upstream firm U decides to participate in bargaining if the anticipated markup is nonnegative, while the downstream firm D decides to participate in bargaining if the anticipated markdown is nonnegative. π^{ms} and π^{mp} correspond to profits under monopsonistic bargaining and monopolistic bargaining, respectively. The game is formally defined in Appendix C.5.

vertical conduct is unobservable to the researcher and requires determining whether the upstream or downstream firm rations output by exerting market power. To study vertical relations in these cases, we develop a method to select vertical conduct in the next section.

4 Effects of Buyer Power: Selecting Vertical Conduct

In this section, we develop two vertical conduct selection criteria by modifying the vertical bargaining model introduced in Section 2. First, we impose a participation constraint under which firms trade only if they achieve a positive markup or markdown. Second, we assume that firms adopt a linear price contract only if it yields a higher unilateral payoff than a two-part tariff. We show that under each of these selection criteria, the vertical conduct is either monopsonistic or monopolistic for any bargaining weight β.

4.1 Selecting Conduct: Nonnegative Markup and Markdown

We start by specifying a participation constraint that pins down vertical conduct, and that can be used in both the simultaneous and sequential bargaining models.

Participation Constraint 1. *D participates in bargaining if its resulting markdown is nonnegative, $\Delta^d \geq 0$. U participates in bargaining if its resulting markup is nonnegative, $\mu^u \geq 0$.*

We illustrate the bargaining game that incorporates these participation constraints in Figure 2 for simultaneous timing. U wants to bargain if it anticipates a nonnegative upstream markup, whereas D participates only if it anticipates a nonnegative markdown. If either party declines to bargain, both parties receive zero payoffs. Otherwise, they engage in bargaining, and either U or D determines output according to the conduct type.

Theorem 1. *Under Participation Constraint 1, for any bargaining parameter $\beta \neq \beta^*$, an equilibrium with trade exists under either monopsonistic or monopolistic bargaining but not both. Specifically, this equilibrium occurs under monopsonistic conduct if $\beta \geq \beta^*$, and under monopolistic conduct if $\beta \leq \beta^*$.*

To illustrate this result, we solve each subgame for every possible value of buyer power.[23] Under monopsonistic bargaining, if $\beta < \beta^*$, the downstream markdown is negative, so D does not want to bargain, and no subgame perfect equilibrium with trade exists. However, if $\beta \geq \beta^*$, we have that $\Delta^d \geq 0$ and $\mu^u = 0$, so both parties are willing to bargain, and monopsonistic conduct yields a subgame perfect equilibrium with trade. The monopolistic case is similar: when $\beta > \beta^*$, the negative markup makes U unwilling to bargain, while for $\beta \leq \beta^*$, markup and markdown are both nonnegative, and monopolistic conduct is a subgame perfect equilibrium. Thus, for every $\beta \neq \beta^*$, only one type of conduct produces a subgame perfect equilibrium with trade. At $\beta = \beta^*$, both types of conduct yield subgame perfect equilibria, but they are identical in that case.

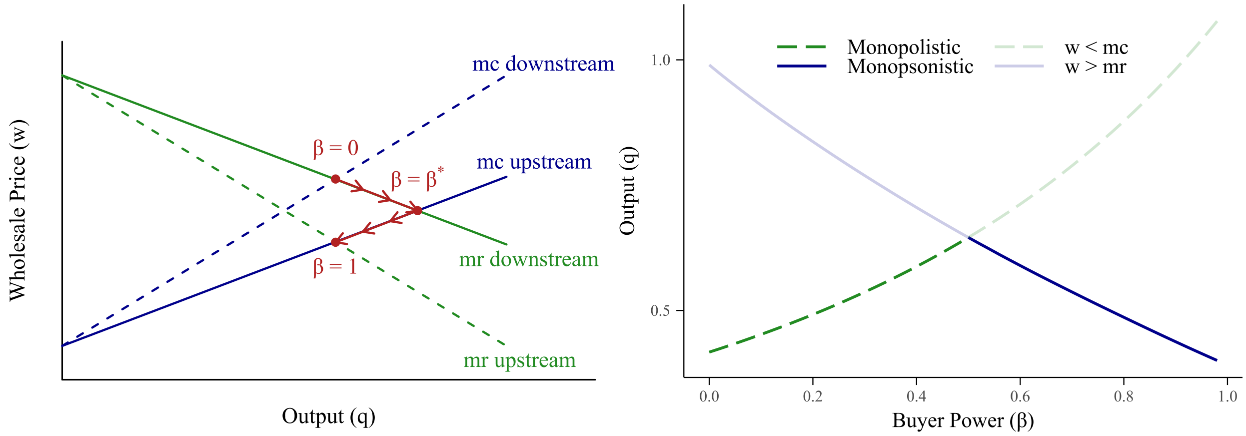
Theorem 1 leads to one of the central findings of the paper: an increase in buyer power creates a monopsony distortion (reducing output) when $\beta > \beta^*$, but counteracts upstream market power (increasing output) when $\beta < \beta^*$. Conversely, an increase in seller power causes a monopoly distortion when $\beta < \beta^*$, but offsets monopsony power when $\beta > \beta^*$.

Corollary 3. *An increase in buyer power β lowers output if $\beta > \beta^*$ but increases output if $\beta < \beta^*$ in both simultaneous and sequential models.*

In Figure 3(a), we combine Figures 1(a) and 1(b) to illustrate the Λ-shaped relationship between output and buyer power stated in Corollary 3. From $\beta = 0$ to β^*, the conduct is monopolistic bargaining, with the input price–output relationship tracing the input demand curve. In this range, increasing buyer power transitions the outcome from successive monopoly to efficient bargaining. Once $\beta > \beta^*$, the vertical conduct shifts to monopsonistic conduct, and the relationship between input price and output follows a factor supply curve. Further increases in buyer power result in movement along this supply curve, progressing from the efficient-bargaining outcome toward classical monopsony at $\beta = 1$.

[23] We formally define the game in the proof of Theorem 1 presented in Appendix C.5.

Figure 3: The Effects of Buyer Power on Output With Conduct Selection



(a) Intuition **(b)** Simulation

Notes: This figure illustrates the relationship between buyer power (β) and output (q) in bargaining models under our conduct selection approach in Participation Constraint 1. Panel (a) provides the intuition, showing how equilibrium wholesale price (w) and quantity (q) are determined by either the input supply curve or input demand curve. Panel (b) presents the numerical simulation under the design reported in Figure 1(c), where shaded lines indicate the buyer power β values under which equilibrium involves no trade under Participation Constraint 1.

We also illustrate this result in Figure 3(b) using a numerical example where we indicate the equilibrium points with no trade using shaded lines. In line with Corollary 3, this generates a Λ-shaped relationship between output and buyer power.

4.1.1 Discussion of the Nonnegative Markup and Markdown Constraint

Even when markups are negative, the upstream party can still earn positive overall profits from trade because of its inframarginal production units; a negative markup simply indicates that the marginal production unit is operating at a loss. Similarly, the downstream party can realize gains from trade under negative markdowns, again due to its inframarginal units. Thus, the reasonableness of these constraints depends on the feasibility of efficient internal transfers within the trading parties, which may be limited by fairness considerations, organizational constraints, or agency issues (Kahneman et al., 1986; Holmstrom and Tirole, 1991; Scharfstein and Stein, 2000). For example, in the labor union context (Example 1), it appears unrealistic that unions would subsidize certain workers to accept wages below their reservation levels. Likewise, in multi-establishment firms (Example 3), plant managers might resist overseeing loss-making production units. However, these constraints do not apply universally: if increasing marginal costs come from technological constraints in a single production unit or there are sunk investments, the firm might continue operating even if the marginal unit incurs losses.

4.1.2 Testing the Vertical Conduct Selection Rule

Although the applicability of nonnegative markups and markdowns may vary by specific setting, a key advantage is its empirical verifiability.

Proposition 4. *Under Participation Constraint 1, equilibrium output is always smaller than or equal to the efficient-bargaining output level q^*.*

Therefore, Participation Constraint 1 can be empirically tested by conducting a statistical test of whether observed quantities fall below the efficient-bargaining quantity level. We implement this test in our main empirical application in Section 6 and provide more details about how it can be conducted.[24]

4.2 Selecting Conduct: Incentive Compatibility of Linear Pricing

The sequential bargaining model provides another conduct selection criterion that does not directly impose nonnegative markups and markdowns. We augment our bargaining model by introducing the possibility that firms bargain efficiently over a two-part tariff instead of over a linear contract if it is incentive-compatible.

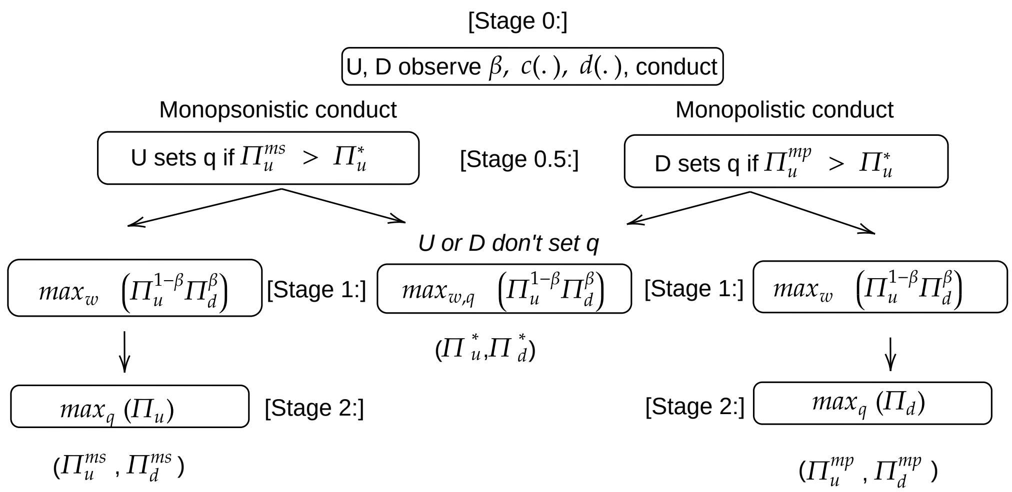
Participation Constraint 2. *Under monopsonistic conduct, the upstream firm has the right to choose q, and it does so if it cannot earn higher profits by bargaining over (q, w). Under monopolistic conduct, the downstream firm has the right to choose q, and it does so if it cannot earn higher profits by bargaining over (q, w). If neither party is willing to choose q, the parties bargain over a two-part tariff (q, w) instead of over a linear contract.*

Participation Constraint 2 states that U or D is willing to make an output choice in Stage 2 and bargain over a linear price only if the resulting profit surpasses the profit it would earn under efficient bargaining (i.e., the profit it would earn when *not* setting output unilaterally, but by jointly bargaining over output and wholesale prices). Figure 4 illustrates the resulting decision tree by adding a stage before bargaining where either the upstream or the downstream firm chooses whether to set q unilaterally.

Theorem 2. *Under Participation Constraint 2, for any $\beta \neq \beta^*$, either (q^{ms}, w^{ms}) or (q^{mp}, w^{mp}) is an equilibrium with a linear price contract, but not both. Specifically, this equilibrium occurs under monopsonistic conduct if $\beta \geq \beta^*$, and under monopolistic conduct if $\beta \leq \beta^*$.*

[24] Our results suggest additional approaches for testing vertical conduct. For instance, one can analyze how an exogenous change in wholesale price affects quantity since w moves in the opposite direction of q under different conduct types, as shown in Lemmas 1-2. Another possibility is to estimate markups and markdowns using a production approach and directly test Corollary 1. However, this approach typically requires behavioral assumptions, such as "downstream firms choose output to minimize costs," to estimate markups and markdowns using the production function (De Loecker and Warzynski, 2012; Rubens, 2025).

Figure 4: Decision Tree: Incentive Compatibility of Linear Pricing



Notes: This decision tree illustrates the augmented bargaining game under the conduct selection rule defined in Section 4.2. The addition is Stage 0.5, where the upstream or downstream firm decides to set q based on Participation Constraint 2. π^{ms}, π^{mp}, and π^* correspond to profit under monopsonistic bargaining, monopolistic bargaining, and efficient bargaining, respectively. The game is formally defined in Appendix C.8.

Theorem 2 implies, by revealed preference, that if we observe a linear price contract, the equilibrium is monopsonistic when $\beta > \beta^*$ or monopolistic when $\beta < \beta^*$. If $\beta = \beta^*$, neither party has the incentive to determine output, and firms simply maximize joint profits.

This theorem rests on the insight that parties may earn greater profits under monopsonistic or monopolistic vertical conduct than under efficient bargaining.[25] Under monopsony, the upstream firm's profit from linear pricing exceeds the two-part tariff profit if $\beta > \beta^*$, whereas under monopolistic bargaining, the downstream firm's profit from linear pricing exceeds the two-part tariff profit if $\beta < \beta^*$. Thus, this conduct selection rule ensures that the party choosing the output is never worse off than it would be under efficient bargaining.

The finding that firms do not always choose efficient bargaining has broader implications for full-information vertical bargaining models with linear contracts. A potential criticism of this class of models is that firms could achieve Pareto improvements by switching to nonlinear pricing (Lee et al., 2021). In our model, the possibility of inefficient bargaining arises from a holdup problem due to a lack of commitment. Under commitment, efficient bargaining would be reached because either party can convince the other not to set quantities in Stage 0.5 by committing to bargaining less aggressively in Stage 1. However, since the bargaining weights are predetermined and fixed, such a commitment would not be

[25]To see this, assume $\beta = 1$. Under monopsonistic bargaining, which corresponds to classical monopsony, the upstream profit is positive, whereas under a two-part tariff, the upstream profit is zero. The possibility of higher profit from linear prices than from a two-part tariff holds only under sequential timing, because the two-part tariff profit weakly dominates the linear price profit for any β under simultaneous timing.

credible. This holdup rationalization of linear price contracts has similarities to prior work on vertical contracts, such as Iyer and Villas-Boas (2003), where shocks between contract signing and delivery induce firms not to negotiate over two-part tariffs.

4.3 Welfare Effects of Buyer and Seller Power Under Conduct Selection

Now that we have developed an integrated framework that nests both monopolistic and monopsonistic bargaining models, we can address the key question of the paper: to what extent are welfare losses in vertical relations due to buyer power and seller power?

Under our conduct selection, vertical conduct is monopolistic when $\beta < \beta^*$ and monopsonistic when $\beta > \beta^*$. To quantify the magnitude and source of vertical distortions, we need two key parameters: the level of buyer power β, which can be estimated empirically, and the efficient level of buyer power β^*, which can be calculated from cost and demand estimates. Thus, the determinants of β^* analyzed in Section 3.4 are key primitives in understanding which conduct generates distortions. All else equal, a more inelastic downstream demand curve makes monopolistic conduct more likely, while a more inelastic upstream cost curve makes monopsonistic conduct more likely.

Proposition 5. *Under the bargaining models augmented with either Participation Constraint 1 or Participation Constraint 2, consumer surplus and total surplus are maximized at the efficient level of buyer power β^* in both monopsonistic and monopolistic bargaining.*

Thus, the relationship between buyer power and different surplus measures are unique under conduct selection. For consumer surplus, the result follows from its monotonic relationship with output, which reaches its maximum at the efficient level of buyer power β^* in Corollary 3. For total surplus, observe that β values that maximized total surplus under monopolistic and monopsonistic conduct in Proposition 3 are ruled out by conduct selection. As a result, under conduct selection, total surplus is also maximized at β^*.[26]

4.4 Implications for Antitrust Policy

With these welfare results at hand, we now turn to discussing the implications of our results for the competitive effects of horizontal and vertical mergers.

4.4.1 Horizontal Merger Policy

Assume that a horizontal merger between downstream firms increases their buyer power (higher β or lower disagreement payoff of the competitor). Under monopolistic bargain-

[26] Under Participation Constraint 1, β^* is the unique level of buyer power that maximizes consumer and total surplus. However, under Participation Constraint 2, β^* no longer uniquely maximizes welfare, as the values of β under which firms do not choose to set q induce efficient bargaining, yielding the same output as β^*.

ing, this increased buyer power reduces wholesale prices, potentially increasing output and consumer surplus depending on changes in downstream market power. Hence, all else equal, regulators are more likely to be lenient towards downstream mergers under monopolistic conduct, as discussed in Grennan (2013), Nevo (2014), and Sheu and Taragin (2021). However, under monopsonistic bargaining, horizontal mergers have the opposite effect: the associated increase in buyer power *reduces* both output and consumer surplus.

Our model provides insight into when increased buyer power through mergers is distortionary versus countervailing. Let β^0 represent premerger buyer power and β^1 represent postmerger buyer power.[27] When $\beta^0 < \beta^1 \leq \beta^*$, both pre- and postmerger conduct remain monopolistic, and the merger can increase output through countervailing forces. However, when $\beta^0 > \beta^*$, vertical conduct is monopsonistic, and a downstream horizontal merger reduces output by increasing monopsony power. In cases where $\beta^0 < \beta^*$ but $\beta^1 > \beta^*$, vertical conduct changes after the merger, and the net output effect can be positive or negative depending on the relative size of the monopsony and monopoly distortions.

This analysis ideally requires knowledge of both buyer power β and the efficient level of buyer power β^*. However, even in the absence of β, which is nontrivial to estimate, β^* can be estimated using only cost and demand primitives and still provide useful guidance. Under a uniform prior for β, a high β^* suggests that increased buyer power likely raises output, while a low β^* indicates the opposite.[28] Thus, β^* can serve as a screening tool in merger evaluations even without estimating a full bargaining model. In our empirical applications, we demonstrate the two alternative ways of using our model: in Section 5, we estimate only β^*, whereas in Section 6, we estimate both β^* and β.

4.4.2 Vertical Merger Policy

Our model can help quantify the potential competitive gains from the elimination of double marginalization in vertical mergers (Chipty, 2001; Crawford et al., 2018; Luco and Marshall, 2020; Cuesta et al., 2025). As shown in Section 3, under a fixed model of vertical conduct, consumer surplus is maximized at the corner cases of buyer power, $\beta = 0$ or $\beta = 1$. In this case, vertical integration leads to an output level given by $\beta^* \in (0, 1)$, so output could either rise or fall. However, under vertical conduct selection, this result changes: for any β, vertical integration increases output as a function of the distance between premerger and

[27] For expositional simplicity, we assume that β^* remains constant pre- and postmerger. However, as we explore in Appendix E.3, postmerger β^* will be different due to changes in the residual demand curve after the merger. In that case, these inequalities simply need to be adjusted for the pre- and postmerger β^* values.

[28] We compile buyer power estimates β from seven studies, listed in Table OA-4, that estimate firm-to-firm bargaining models. The distribution reported in Figure OA-5(a) broadly supports a uniform prior for β.

Table 1: Parameters for Empirical Illustrations

Industry	Sources	ψ	η	β^*
U.S. construction workers	Kroft et al. (2023)	0.29	-7.30	0.42
Chinese tobacco farmers	Rubens (2023) Ciliberto and Kuminoff (2010)	1.904	-1.14	0.92

Notes: This table reports parameters for the inverse price elasticity of supply, ψ, and the own-price elasticity of residual downstream demand, η, as estimated in the referenced studies, for each empirical application. The final column shows the implied efficient level of buyer power, β^*, computed from the parameters using the log-linear approximation derived in Appendix D.3.

efficient buyer power, $|\beta - \beta^*|$. Thus, as in horizontal mergers, knowledge of both β and β^* enables quantifying changes in output from vertical mergers.

5 Empirical Illustrations: Labor Unions and Farmer Cooperatives

We first consider a simplified analysis that estimates only the efficient level of buyer power β^* before conducting a full empirical analysis that estimates both β^* and the actual bargaining weight β. We argue that even when estimating β is not feasible (e.g., due to a lack of transaction price data), β^* can still be identified using cost and demand primitives to evaluate potential vertical distortions based on prior beliefs about β.[29] We demonstrate this approach through two calibrated case studies using estimates from the literature: labor unions in the U.S. construction industry and farmer cooperatives in the Chinese tobacco industry. Appendix F provides detailed documentation of these empirical applications.

5.1 Labor Unions

A natural application of our model is collective wage bargaining, as described in Example 1. With growing empirical evidence of monopsony power in labor markets (Card et al., 2018; Berger et al., 2022; Lamadon et al., 2022; Yeh et al., 2022), a key question is whether labor unions can effectively countervail this power (Angerhofer et al., 2025; Azkarate-Askasua and Zerecero, 2025). To answer this question, we calibrate a first-order approximation of our model using estimates from Kroft et al. (2023), who study buyer power in the U.S. construction industry. Their study assumes monopsonistic competition for workers, which in our notation implies that $\beta = 1$. This assumption is plausible in this setting because only 10% of U.S. construction workers are unionized (BLS, 2025).

[29]Estimating bargaining weights typically requires transaction prices. While wage data in employer-employee datasets often provide such information for labor applications, transaction-level wholesale prices have historically been less commonly observed in IO applications. However, the growing availability of administrative firm-to-firm transaction datasets has made wholesale prices increasingly observable.

However, suppose that construction workers form a union to bargain over wages with individual firms. To what extent would this countervail employer monopsony power, and at what level of union bargaining power would the total output be maximized? The answer depends critically on β^*, which we express as a function of supply and demand elasticities in Appendix D.3. Using the estimated values for these primitives from Kroft et al. (2023) given in Table 1, we calculate the efficient level of buyer power β^* to be 0.42.

This estimate suggests that collective wage bargaining requires careful consideration as a means to counteract monopsony power. If the resulting labor union possesses a bargaining weight above 0.58 ($1 - \beta^*$), it will replace the downstream monopsony distortion with an upstream monopoly distortion by creating double marginalization. Our compilation of bargaining weights from the labor union literature in Table OA-4 and Figure OA-5(b) suggests that this scenario is plausible—union bargaining power exceeds the estimated β^* threshold in approximately half of the reviewed studies.

5.2 Farmer Cooperatives

We next apply our model to seller cooperatives, as discussed in Example 2, in the context of Chinese tobacco farmers selling to cigarette manufacturers. We use supply elasticities from Rubens (2023), who estimates an oligopsony model assuming full buyer power ($\beta = 1$). This assumption is reasonable in this context, as tobacco leaf purchases are dominated by a concentrated group of cigarette manufacturers buying from numerous small farmers.

A natural question in this setting is how the introduction of a farmer cooperative, bargaining collectively with cigarette manufacturers, would affect market outcomes. To analyze this question, we calculate the efficient level of buyer power (β^*) by combining tobacco leaf supply elasticities from Rubens (2023) and cigarette demand elasticities from Ciliberto and Kuminoff (2010). Despite the highly inelastic supply from farmers, we estimate $\beta^* = 0.92$, indicating that near-complete monopsony power maximizes output in this industry, at least when abstracting from other inefficiencies of monopsony power, such as misallocation (Rubens, 2023). Therefore, unless the cooperative's bargaining power is extremely low—which prior estimates reported in Table OA-4 and Figure OA-5(c) do not support—double marginalization is the likely outcome of cooperative formation.

6 Empirical Application: Coal Procurement

We now turn to an application in which we estimate actual buyer power β in a bargaining model together with β^*. We analyze coal procurements by power plants from mining firms by incorporating three key features of this industry: (i) rich heterogeneity in cost and demand elasticities, (ii) the presence of multiple sellers and buyers, and (iii) oligopolistic competition in the downstream electricity market. In our analysis, we model mining costs by estimating individual mine marginal costs and then aggregating them to the firm level. For electricity markets, we closely follow the seminal works in the literature (Borenstein and Bushnell, 1999; Wolfram, 1999; Borenstein et al., 2002; Puller, 2007). The main objective of the model is to decompose the total vertical distortions into their monopolistic and monopsonistic components.

Our empirical setting is the ERCOT (Electric Reliability Council of Texas) market, which has been previously studied in the literature (Hortaçsu and Puller, 2008; Hortaçsu et al., 2019). The ERCOT market offers three advantages: (i) it operates independently without inter-regional trade, (ii) the majority of power plants are deregulated, and (iii) hourly price and generation data are readily available. We model coal transactions between all power plants operating in ERCOT and their coal suppliers, which may be located both within and outside the ERCOT region. We analyze the 10-year period between 2005 and 2014.

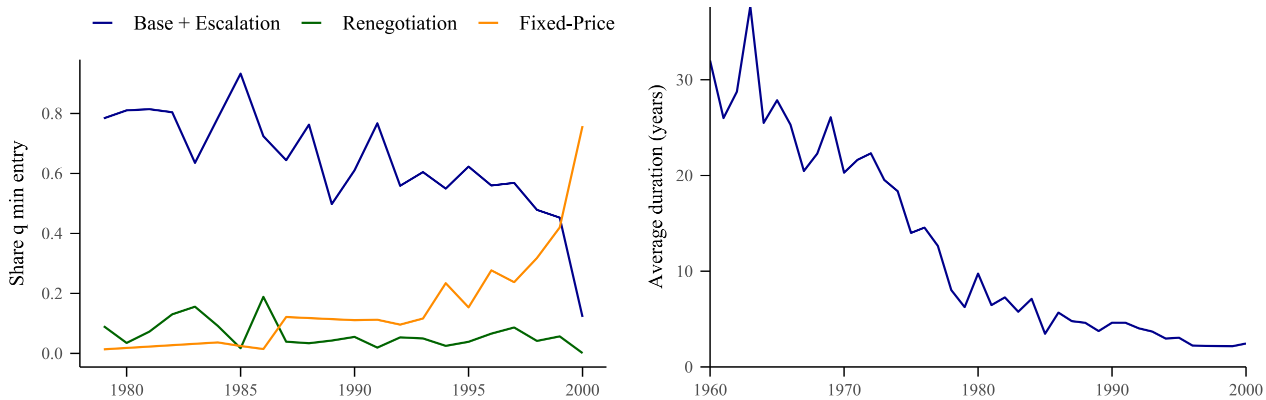
6.1 Institutional Details

Coal mining firms extract coal through underground and surface operations, with marginal costs varying significantly across geographic regions and mine types due to differences in geological conditions and local labor markets. Generally, surface mines have lower extraction costs compared to underground mines. Many mining companies operate multiple mines with different characteristics, leading to increasing marginal costs at the firm level. During our sample period, electricity generation was the primary use of coal in the U.S., accounting for 93.1% of total coal consumption in 2010 (Watson et al., 2010).

Coal-fired power plants generate electricity by burning coal to produce steam, which drives turbines. The generated electricity is injected into the transmission grid and distributed across the ERCOT region through an organized bidding market. Power plants source the majority of their coal from coal suppliers through contracts, supplementing additional requirements through purchases on the spot market. The bulk of coal is transported from mines to power plants by rail. Additionally, coal quality varies considerably, depending on attributes such as heat content (measured in Btu/lb), sulfur content, and ash levels. Higher heat content directly increases electricity output per ton of coal, whereas sulfur and ash content primarily affect compliance with environmental regulations.

In recent years, coal-fired power generation and coal-mining industries have undergone significant structural changes, with many facilities closing due to stricter emissions regulations and declining natural gas prices driven by the shale gas boom (Davis et al., 2022). To isolate our analysis from these confounding factors, we restrict our study to the period 2005–2014, during which coal's share of electricity generation in ERCOT remained

Figure 5: Coal Contract Characteristics by Signing Year



(a) Contract Type by Signing Year **(b)** Average Contract Duration by Signing Year

Notes: The data in this figure come from the EIA's Coal Transportation Rate Database for the years 1979–2000, as described in Appendix G.1. Panel (a) shows the share of coal quantity shipped by year and contract type, representing the three main types in the dataset. "Fixed-Price Contracts" are linear price contracts that remain constant throughout the contract's duration. Panel (b) presents the average duration of contracts (in years) by the year they were signed. Contracts signed prior to 1979 appear due to their overlap with the data period.

relatively stable at 35%–39% (see Figure OA-7). This timeframe also largely precedes the substantial wave of mine closures initiated in the early 2010s.[30]

Contract Types and Vertical Conduct The characteristics of the coal procurement market make it an ideal empirical setting to apply our framework. First, the industry structure aligns closely with our modeling assumptions: empirical evidence supports the widespread use of linear price contracts, the literature and antitrust enforcers have expressed concerns about both monopsony and monopoly power, and existing contracts do not necessarily specify which party determines quantities. Second, this market provides a uniquely data-rich environment: we observe detailed transaction-level data, including prices, quantities, and coal characteristics, along with comprehensive production and cost data for both power plants and coal mines.

While our data do not include contract types during the sample period that we study, historical data from 1980–2000 do provide such information. In this dataset, coal contracts take several forms, including base price plus escalation, market-indexed pricing, cost-plus contracts, and linear price contracts (Kozhevnikova and Lange, 2009). The data indicate that the share of linear price contracts increased from just 3% in 1979 to over 75% by 2000,

[30]We specifically conclude our sample in 2014, when the average capacity factor for coal power plants dropped notably from 78% to 65%. As noted by Gowrisankaran et al. (2024), this decline was largely due to the emergence of fracking, resulting in increased generator cycling and ramping costs and consequently accelerating coal plant retirements. Modeling ramping costs and exit decisions requires a dynamic framework (Borrero et al., 2024), which is beyond the scope of our static model. Thus, we select a period when ramping considerations were less critical and abstract away from these dynamics.

as shown in Figure 5(a). Assuming that this trend was not reversed after 2000, linear price contracts likely represent the majority of contracts in our sample period.

There is also no clear ex-ante indication as to which vertical conduct prevails in this industry, as concerns about market power have been expressed in the context of both monopsony power of power plants and monopoly power of coal mines. For example, the FTC highlighted increased market power of coal mines as a potential harm when challenging the proposed joint venture between Peabody Energy and Arch Coal (Federal Trade Commission, 2020; Wosińska et al., 2021), whereas several empirical studies have documented evidence of monopsony power exercised by utility firms (Atkinson and Kerkvliet, 1986, 1989; Wilson et al., 2020; Kellogg and Reguant, 2021).[31] Moreover, limited evidence from publicly available contracts suggests that both types of quantity-setting arrangements (by buyer or seller) are possible in this industry. Some contracts take the "requirements" structure, which allows downstream firms to determine quantities for a given linear price, whereas others use "take-or-pay" contracts, which set quantities at contract signing and require the downstream buyer to accept the specified volume (Baruya, 2015).[32]

Finally, it is also worth discussing the hold-up problem and coal specificity in this industry, which have been studied by the seminal works of Paul Joskow (Joskow, 1985, 1987, 1988). Since Joskow's papers from the 1980s, coal markets have undergone significant changes that have reduced asset specificity through technological advancements and regulatory reforms. For example, the widespread adoption of scrubbers has made coal more homogeneous from the perspective of power plants, thereby mitigating hold-up concerns (Kacker, 2014). Environmental regulations and reforms in railroad transportation have further diminished supplier specificity by incentivizing boiler upgrades and expanding access to diverse coal markets (Ellerman et al., 2000).[33] Collectively, these developments have markedly reduced the reliance on long-term contracts, as illustrated in Figure 5(b).

6.2 Data Sources and Summary Statistics

Our analysis combines data from four sources: Velocity Suite, CostMine, the BLS, and the Mine Safety and Health Administration (MSHA). We describe these data sources in detail in Appendix G.1 and provide a brief overview below.

[31] For other examples of concerns of monopsony power, see Pacific Power (2023) and Neuburger (2024).

[32] For an example of a requirement contract see Refined Coal Supply Agreement Mill Creek and for an example of take-or-pay contract see Armstrong Energy Inc. Contract #598018. In these take-or-pay contracts, the available information typically does not specify which party makes the quantity decision.

[33] The 1990 Clean Air Act Amendment led power plants to adopt technologies accommodating lower-sulfur coal, increasing their fuel flexibility (Ellerman et al., 2000). Supporting this observation, Kacker (2014) finds that during Phase I of the Amendment, plants required to switch technology were more likely to adopt shorter-term and fixed-price contracts compared to unaffected plants. Moreover, the 1980 Railroad Reform expanded the coal market for power plants by reducing transportation costs.

Our coal mine data are obtained from multiple sources. First, we utilize datasets from the Mine Safety and Health Administration (MSHA), which include quarterly data on production and employment (Form 8) as well as technical characteristics of mines, such as openings and vein thickness (Form 10). Mine ownership details are sourced from Velocity Suite. Additionally, mine-level cost data, including detailed operating and capital expenses, come from the 2019 Coal Cost Guide published by CostMine Intelligence, which has been previously used in the mining engineering literature (Shafiee and Topal, 2012) and other academic studies (World Bank, 2017). This guide classifies costs by mine characteristics, such as mining technology, daily capacity, and vein thickness. For wage information, we rely on data from the Quarterly Census of Employment and Wages provided by the U.S. Bureau of Labor Statistics (BLS), adjusted to annual averages at the state level and converted to hourly wages.

Power plant characteristics, costs, and generation data are compiled from Velocity Suite, which integrates information from various public sources such as EIA Forms 860, 906, and 923, EPA databases, NERC, and proprietary research. The datasets include detailed monthly generator characteristics, hourly generation and emissions data from the EPA's Continuous Emissions Monitoring System (CEMS), EIA-923, ERCOT hourly load data, and ERCOT's 60-Day SCED Disclosure Reports. Lastly, coal transaction data are sourced from Velocity Suite, which combines information on transaction details, prices, transportation modes, and contractual arrangements, primarily based on EIA-923 forms supplemented with internal research and railroad waybills.

Table 2 presents summary statistics for our empirical sample, which includes all mining firms supplying coal to ERCOT power plants and all electricity-generation firms (power firms) operating coal-fired plants in ERCOT. The sample consists of nine upstream mining firms operating 25 mines and two downstream power firms operating 19 coal-fired generators. Mining firms deal with 22.1 partners on average, including those outside of ERCOT, while power firms engage with an average of just 2.55 partners, suggesting that sourcing from multiple trade partners is common. The average share of the largest trading partner is roughly half in both upstream and downstream. We provide the list of upstream and downstream firms in Table OA-5.

Panel B of Table 2 provides summary statistics on transactions. The transactions typically take the form of medium-term contracts, with an average duration of 1.22 years and an average price of $0.84 per MMBtu. The majority of transactions occur through contracts, with spot market transactions accounting for 3% of total transactions.

Table 2: Summary Statistics

	Upstream	Downstream
	Panel A. Firm Characteristics	
Number of units (mine or generator)	25	19
Number of firms	9	2
Avg. number of units per firm	2.51	3.30
Avg. number of trade partners	22.15	2.55
Avg. share of largest partner	0.42	0.53
	Panel B. Transaction Characteristics	
Avg. FOB price (USD per MMBtu)	-	0.84
Avg. Contract duration (years)	-	1.22
Share of spot-market transactions	-	0.03

Notes: This table presents the summary statistics for the sample used in our empirical analysis. Panel A reports the characteristics of mining firms (upstream) and power firms (downstream), whereas Panel B provides information on transaction details. The sample includes all mining firms supplying coal to ERCOT power plants and all power firms operating coal-fired plants in ERCOT between 2005 and 2014.

6.3 Model Primitives

Our empirical framework involves a bargaining model between mining and power firms. We begin by estimating the model's primitives: the cost curve of mining firms, the cost curve of power firms, and the residual electricity demand faced by power firms. Using these primitives, we then estimate the bargaining model. Although we perform these estimations annually, we omit year subscripts for notational clarity. Appendix G provides the details of the estimation procedures, and Table OA-3 summarizes the model's notation.

6.3.1 Cost Curve of Mining Firms

Each upstream mining firm u operates a portfolio of n_u mines indexed by i. Each mine has capacity $\bar{q}^c_{iu}$ and constant marginal cost c_{iu}, determined by mine characteristics and labor costs.[34] To estimate marginal cost, we first specify the mine production function. Mine i produces q^c_{iu} short tons of coal using l_{iu} labor hours and m_{iu} units of intermediate inputs according to a Leontief production function:

$$q^c_{iu} = \min\{l_{iu}\gamma_{\theta(iu)}, m_{iu}\}\omega_{iu}$$

[34] The EIA collects data on coal mine capacity, which have been used in prior research (Johnsen et al., 2019). However, the EIA no longer makes these data available to researchers. Consequently, we infer mine capacity from production data. For each year, we define a mine's capacity as the maximum historical production observed at that mine up to that year. This approach makes mine capacity time-varying, as it reflects changes in production over time.

The Leontief specification reflects the limited input substitution possibilities in short-run coal production (Byrnes et al., 1988), assuming perfect complementarity between labor and intermediate inputs, and has been applied for other resource-extracting industries, such as oil drilling (Asker et al., 2019). Two key parameters capture technological heterogeneity in the production function: (i) $\gamma_{\theta(iu)}$, which determines the labor-materials ratio based on mine type θ (characterized by the combination of capacity bin, vein thickness, and mining technology), and (ii) ω_{iu}, which accounts for mine-specific productivity differences.[35]

Given hourly wages w^l_{iu} and material costs p^m_{iu}, the Leontief production function implies the following marginal cost function:

$$c_{iu} = w^l_{iu} \frac{l_{iu}}{q^c_{iu}} \left(1 + \gamma_{\theta(iu)} \frac{p^m_{iu}}{w^l_{iu}}\right) \quad \text{if} \quad q^c_{iu} \leq \bar{q}^c_{iu}. \tag{8}$$

While we can estimate unit labor costs by multiplying wages (w^l_{iu}) and mine-level output-per-labor (l_{iu}/q^c_{iu}), unit material costs are not directly estimable because our data do not include materials expenditures at the mine level. To address this, we utilize the Coal Cost Guide, published by the industry research firm CostMine, which provides engineering estimates of both labor and material unit costs for different mine types θ. From these data, we calculate the materials-to-labor cost ratio, equal to $\gamma_{\theta(iu)}(p^m_{iu}/w^l_{iu})$ for mines with type θ, enabling us to recover marginal costs in Equation (8).

Coal's value in electricity generation depends primarily on its heat content (measured in millions of British thermal units, or MMBtu) rather than its weight. To convert between these measures, we define a mine-specific conversion factor λ_{iu}, which equals heat content per short ton for mine i. This factor transforms weight-based quantities into heat-based quantities through $q_{iu} = \lambda_{iu} q^c_{iu}$. The conversion factor λ_{iu} varies by coal type and mining area, representing an important source of heterogeneity across mines. Following this conversion, we express all coal quantities and mine capacities in MMBtu and coal costs per MMBtu for the remainder of the paper.

Using mine marginal costs, we construct firm-level cost curves by ordering each firm's mines from lowest to highest marginal cost and calculating cumulative production cost. This aggregation yields the following firm-level cost function:

$$C_u(Q, c_u, \bar{q}_u) = \begin{cases} \sum_{i=1}^{n_u} c_{iu} \max\left\{0, \min\left[\bar{q}_{iu}, Q - \sum_{l=1}^{i-1} \bar{q}_{lu}\right]\right\}, & \text{if } 0 \leq Q \leq \sum_{i=1}^{n_u} \bar{q}_{iu}, \\ \infty, & \text{if } Q > \sum_{i=1}^{n_u} \bar{q}_{iu} \end{cases}$$

[35]The Coal Cost Guide provides 69 different mine types θ, of which 16 occur in our dataset.

where the vector $c_u := \{c_{iu}\}_{i=1}^{n_u}$ is such that $c_{1u} \leq c_{2u} \leq \cdots \leq c_{n_u u}$ and $\bar{q}_u$ is the vector of mine capacities.

6.3.2 Cost Curve of Power Firms

Each downstream power firm d operates a portfolio of n_d generation assets. Asset j is characterized by a constant marginal cost c_{jd} and a capacity k_{jdt}. The capacity can vary over time due to intermittency in renewable energy resources across seasons and hours of the day. We therefore define hourly capacity values for each time type t, representing specific combinations of month, hour, and weekend/weekday status.[36]

The marginal cost of a fossil-fuel generator depends on fuel prices and its efficiency, which is measured by the heat rate. We define marginal costs as follows:

$$c_{jd} = \begin{cases} (w_d + \kappa_{jd})h_{jd} + m_{jd} & \text{if coal} \\ w^{gas} h_{jd} + m_{jd} & \text{if gas} \\ 0 & \text{if nuclear and renewables} \end{cases}$$

where h_{jd} represents generator j's (inverse) heat rate, w^{gas} is the natural gas price common to all gas generators, w_d is firm d's weighted average FOB coal price, and m_{jd} represents the maintenance cost. For coal generators, we also add the per MMBtu average transportation cost κ_{jd} to generator j.[37] We assume constant heat rates within a year for each generator, calculated as total heat input divided by total electricity generation.[38]

To determine capacity k_{jdt}, we cannot rely solely on nameplate capacity, due to maintenance downtime in fossil-fuel units and intermittency in renewables. Instead, we calculate an "effective" capacity by multiplying the nameplate capacity by a capacity factor. For fossil-fuel units, we obtain annual, fuel-type-specific capacity factors from the Generating Availability Data System (GADS) maintained by the Federal Energy Regulatory Commission (FERC). For renewable units, we derive a time-varying capacity factor for each unit as the ratio of average hourly generation in each hour type t to the nameplate capacity.[39]

Using unit-level capacity and cost data, we construct firm d's cost function in hour type

[36] For example, 8 a.m. on a weekday in January represents one hour type t in our model. Even though capacity does not vary meaningfully across weekdays and weekends, we include it to capture variation in demand.

[37] We treat transportation costs κ_{jd} as exogenous and do not model railroad firms as separate agents in the value chain. Prior research shows that railroad companies could have significant market power in coal procurement markets (Preonas, 2023). In our model, upstream agents can be interpreted as jointly representing coal firms and railroad operators. For instance, if coal firms and railroad companies bargain efficiently, the upstream entity can be viewed as maximizing their joint profits. Thus, double marginalization attributed to coal firms can alternatively be interpreted as arising from railroad companies' market power.

[38] We calculate the marginal cost using coal prices from the transaction data, transportation costs, and the heat rate. This calculation assumes the coal is blended without a specific order if there are multiple coal suppliers.

[39] The capacity factors are, on average, 92%, 90%, 29%, and 21% for coal, gas, wind, and solar, respectively.

t by ordering all units in ascending order of marginal cost and calculating their cumulative production cost. The resulting cost curve takes the following form:

$$C_{dt}(Q, c_d, k_{dt}) = \begin{cases} \sum_{j=1}^{n_d} c_{jd} \max\left\{0, \min\left[k_{jdt}, Q - \sum_{l=1}^{j-1} k_{ldt}\right]\right\}, & \text{if } 0 \le Q \le \sum_{j=1}^{n_d} k_{jdt}, \\ \infty, & \text{if } Q > \sum_{j=1}^{n_d} k_{jdt} \end{cases}$$

where $c_d := \{c_{jd}\}_{j=1}^{n_d}$ is the vector of marginal costs ordered such that $c_{1d} \le c_{2d} \le \cdots \le c_{n_d d}$, and k_{dt} is the vector of generator capacities.

6.3.3 Downstream Electricity Demand and Profit

We model competition in the electricity market using a Cournot framework, following the prior literature (Borenstein and Bushnell, 1999; Borenstein et al., 2002; Puller, 2007). In this model, regulated firms and small firms (< 5% market share) act as price takers, while larger firms behave strategically. Although only two power firms operate coal-fired generators, our demand model includes all power firms with generation capacity in ERCOT.[40] Since both demand and capacity fluctuate hourly, we estimate a separate Cournot model for each hour type t. The expected demand curve faced by strategic firms is given by

$$Q_t(P) = \bar{Q}_t^D - Q_t^{\text{fr}}(P),$$

where $\bar{Q}_t^D$ denotes the expected inelastic demand during hour type t, and $Q_t^{\text{fr}}(P)$ denotes the quantity supplied by the competitive fringe firms at a price P. We assume that firms have rational expectations, so $\bar{Q}_t^D$ equals the mean inelastic demand in hour type t.[41] Let $P_t(Q)$ denote the expected inverse demand curve faced by strategic firms. The profit function of firm d in hour type t is given by

$$\pi_t^d(Q_{dt}, C_{dt}) = P_t(Q_{-dt} + Q_{dt})Q_{dt} - C_{dt}(Q_{dt}),$$

where Q_{-dt} denotes the total production of all strategic firms except firm d. The annual profit function is obtained by summing over hourly profits:

$$\pi^d(Q_d, C_d) = \sum_t f_t \pi_t^d(Q_{dt}, C_{dt}). \tag{9}$$

[40] Five strategic and 247 fringe firms are present in our data. In Appendix G.6, we present the details of how we implement the Cournot model.

[41] The realized demand is given by $Q_{\tau t} = \bar{Q}_t^D + \epsilon_{\tau t}$, where τ is an hour within an hour type t and $\epsilon_{\tau t}$ is the error term. We compute the expected demand by taking the average of realized demand within t as $\mathbb{E}_t[\bar{Q}_t^D + \epsilon_{\tau t}]$.

Here, f_t represents the number of occurrences of hour type t in a year, $Q_d = \{Q_{dt}\}_{t=1}^{n_t}$ is the vector of quantities, and $C_d = \{C_{dt}\}_{t=1}^{n_t}$ denotes the set of cost functions of firm d.

6.3.4 Upstream Profit

Each upstream firm u has a set of buyers D_u, where quantity q_{ud} is traded with each buyer d at price w_{ud}. The upstream firm's profit function is the total revenue from these transactions minus the total production cost:

$$\pi^u(w_u, q_u) = \sum_{d \in D_u} w_{ud} q_{ud} - C_u \left(\sum_{d \in D_u} q_{ud} \right). \tag{10}$$

Here, w_u and q_u represent the vector of all prices and quantities for firm u.

6.4 Bargaining Model Between Mining and Power Firms

We specify a sequential bargaining model in which mining and power firms negotiate annual linear pricing contracts. After bargaining, either the upstream firm determines how much coal to supply (monopsonistic bargaining) or the downstream firm determines its downstream quantity (monopolistic bargaining), taking wholesale prices as given.[42] We also maintain the passive-belief assumption, so u and d condition on all other bargaining outcomes when negotiating their wholesale price. In what follows, we first define each firm's individual optimization problem under monopolistic and monopsonistic conduct in the second stage. We then present the bargaining problem in the first stage.

6.4.1 Firms' Problem in Monopolistic Bargaining

Under monopolistic bargaining, the downstream firm d takes input prices as given, which affects its cost curve C_{dt}, and chooses the level of production every hour to maximize profit:

$$Q_{dt}^{mp}(C_{dt}) = \arg\max_{Q_{dt}} \left[P_t(Q_{-dt} + Q_{dt}) Q_{dt} - C_{dt}(Q_{dt}) \right]. \tag{11}$$

Let $q_{udt}^{mp}(C_{dt}, w_{ud})$ be the factor demand of firm d from mining firm u, which comes from the share of coal units in producing $Q_{dt}^{mp}(C_{dt})$ based on firm u's cost curve.[43] Using this,

[42] We use the sequential timing assumption because it nests the classical monopsony and successive monopoly models as special cases when $\beta \in \{0, 1\}$.

[43] We do not specify the problem that determines q^{mp}, because it simply follows the merit-order dispatch principle—generating electricity from lowest-cost generators first—which is embedded in d's cost function.

we can write the annual factor demand of firm d from firm u as:

$$q_{ud}^{mp}(w_{ud}) = \sum_t f_t q_{udt}^{mp}(C_{dt}, w_{ud}).$$

For mining firms, the passive-belief assumption implies that coal shipments to all partners except d are fixed and predetermined. Thus, under monopolistic bargaining, mining firm u meets power firm d's input demand by producing from its lowest-cost available mines.[44]

6.4.2 *Firms' Problem in Monopsonistic Bargaining*

Under monopsonistic bargaining, the upstream firm takes $\{w_{ul}\}_{l\neq d}$ and $\{q_{ul}\}_{l\neq d}$ as given and decides how much to supply to firm d with the following optimization problem:

$$q_{ud}^{ms}(C_u, w_{ud}) = \arg\max_{q_{ud}} \; w_{ud}\, q_{ud} - \left[C_u\left(Q_u^{-d} + q_{ud}\right) - C_u\left(Q_u^{-d}\right)\right]$$

where $Q_u^{-d} = \sum_{l\in\mathcal{D}\setminus\{d\}} q_{ul}$ denotes the total quantity that is sold to partners other than d. The solution to this problem is $q_{ud} = (C_u')^{-1}(w_{ud}) - Q_u^{-d}$, where firm u supplies firm d until its marginal cost equals the wholesale price w_{ud}.[45] For the downstream firm, u's supply decision does not directly determine downstream production, because electricity generation involves multiple input types at the firm level, as in Extension E.5. Thus, firm d solves the following problem:

$$Q_{dt}^{ms}(q_{ud}) = \underset{\tilde{Q}_{dt}}{\text{argmax}} \; P_t(Q_{-dt} + Q_{dt})Q_{dt} - \tilde{C}_{dt}^{-u}(Q_{dt}) \quad \text{s.t.} \quad Q_{dt} = \tilde{Q}_{dt} + Q_{udt}(q_{ud}^{ms}), \tag{12}$$

where $Q_{udt}(q_{ud}^{ms})$ represents the electricity generation from q_{ud}^{ms}—that is, the coal quantity supplied from u—and $\tilde{C}_{dt}^{-u}(Q_{dt})$ is the cost function after excluding the generation capacity used for generating $Q_{udt}(q_{ud}^{ms})$. In other words, firm d takes the electricity generation from firm u's coal supply as given and maximizes its profit conditional on q_{ud}^{ms}.

[44]This assumption would be violated if mining firms accounted for how their sales to d affect the production cost of coal sold to their other customers. However, we believe that passive belief is a reasonable assumption in coal mining since upstream firms typically supply many downstream buyers.

[45]If this quantity exceeds d's coal capacity, we assume that u supplies up to d's capacity limit.

6.4.3 Gains From Trade

Next, we calculate the gains from trade for the upstream and downstream firms. The annual profit of firm u, if we exclude partner d, is given by

$$\pi_u^{-d}(w_u, q_u) = \sum_{l \in \mathcal{D} \setminus \{d\}} w_{ul} q_{ul} - C_u\left(Q_u^{-d}\right)$$

Here, we assume that the upstream firm does not sell the quantity q_{ud} in the event of a disagreement. With this, the gain from trade for firm u with d is given by

$$\begin{aligned} \text{GFT}_{ud}^{u} &= \left[\sum_{l \in \mathcal{D}} w_{ul} q_{ul} - C_u(Q_u)\right] - \left[\sum_{l \in \mathcal{D} \setminus \{d\}} w_{ul} q_{ul} - C_u(Q_u^{-d})\right] \\ &= w_{ud} q_{ud} - \left[C_u(Q_u^{-d} + q_{ud}) - C_u(Q_u^{-d})\right], \end{aligned}$$

For power plants, it is unrealistic to assume zero production in the event of a bargaining disagreement due to their resource adequacy obligations and substantial capital investments. Consequently, we assume that if bargaining breaks down, firm d sources coal from the spot market rather than from firm u. Purchasing coal in the spot market exposes firms to both higher price levels and greater price volatility, negatively impacting profitability since firms generally dislike uncertainty. For instance, Jha (2022) shows that coal power plants are willing to incur an increase of \$1.62 in expected costs to reduce the standard deviation of their costs by \$1.[46] Motivated by this finding, we set the disagreement coal price equal to the mean spot market coal price plus 1.62 times its standard deviation. Detailed implementation steps for calculating disagreement payoffs are provided in Appendix G.7.

Under this assumption, a bargaining disagreement primarily impacts the power firm's cost function because of the change in the input prices. We define firm d's disagreement cost function as $C_{dt}^{-u}(Q)$, which is obtained by substituting the wholesale price w_{ud} with the spot market price. The resulting disagreement profit function is therefore:

$$\pi_{dt}^{-u}(Q_{dt}) = P_t(Q_{-dt} + Q_{dt})Q_{dt} - C_{dt}^{-u}(Q_{dt}).$$

Let Q_{dt}^{-u} denote the output level that maximizes this profit function. The gain from trade

[46] As noted by Jha (2022), "plant managers may pay a premium for contract coal because delivery is guaranteed. In contrast, plant managers have no assurance that they will find a spot supplier to purchase coal from every month."

is given by

$$\mathrm{GFT}^d_{ud} = \sum_t f_t\Big(\big[P_t(Q_{-dt}+Q_{dt})Q_{dt} - C_{dt}(Q_{dt})\big] - \big[P_t(Q_{-dt}+Q^{-u}_{dt})Q^{-u}_{dt} - C^{-u}_{dt}(Q^{-u}_{dt})\big]\Big) \quad (13)$$

With these definitions, we can represent the monopsonistic bargaining problem as follows:

$$\begin{cases} w^{ms}_{ud} = \underset{w_{ud}}{\operatorname{argmax}} \Big\{\Big[w_{ud}\, q^{ms}_{ud}(w_{ud}) - \Big(C_u\big(Q^{-d}_u + q^{ms}_{ud}(w_{ud})\big) - C_u\big(Q^{-d}_u\big)\Big)\Big]^{1-\beta_{ud}} \\ \qquad\qquad \times \Big[\sum_t f_t\Big(\big[P_t\big(Q_{-dt}+Q^{ms}_{dt}\big)\,Q^{ms}_{dt} - C_{dt}\big(Q^{ms}_{dt}\big)\big] - \big[P_t\big(Q_{-dt}+Q^{-u}_{dt}\big)\,Q^{-u}_{dt} - C^{-u}_{dt}\big(Q^{-u}_{dt}\big)\big]\Big)\Big]^{\beta_{ud}}\Big\} \\ q^{ms}_{ud}(C_u, w^{ms}_{ud}) = \underset{q_{ud}}{\operatorname{argmax}}\ w^{ms}_{ud}\, q_{ud} - \big[C_u\big(Q^{-d}_u + q_{ud}\big) - C_u\big(Q^{-d}_u\big)\big]. \\ Q^{ms}_{dt}(q_{ud}) = \underset{\tilde{Q}_{dt}}{\operatorname{argmax}}\ P_t(Q_{-dt}+Q_{dt})Q_{dt} - \tilde{C}^{-u}_{dt}(Q_{dt}) \qquad \text{s.t} \quad Q_{dt} = \tilde{Q}_{dt} + Q_{udt}(q^{\mathrm{ms}}_{ud}), \quad \text{for all t} \end{cases}$$

Similarly, we can write the monopolistic bargaining problem as follows:

$$\begin{cases} w^{mp}_{ud} = \underset{w_{ud}}{\operatorname{argmax}} \Big\{\Big[w_{ud}\, q^{mp}_{ud}(w_{ud}) - \Big(C_u\big(Q^{-d}_u + q^{mp}_{ud}(w_{ud})\big) - C_u\big(Q^{-d}_u\big)\Big)\Big]^{1-\beta_{ud}} \\ \qquad\qquad \times \Big[\sum_t f_t\Big(\big[P_t\big(Q_{-dt}+Q^{mp}_{dt}\big)\,Q^{mp}_{dt} - C_{dt}\big(Q^{mp}_{dt}\big)\big] - \big[P_t\big(Q_{-dt}+Q^{-u}_{dt}\big)\,Q^{-u}_{dt} - C^{-u}_{dt}\big(Q^{-u}_{dt}\big)\big]\Big)\Big]^{\beta_{ud}}\Big\} \\ Q^{mp}_{dt}(C_{dt}), q^{mp}_{udt}(w^{mp}_{ud}) = \underset{Q_{dt}, q_{udt}}{\operatorname{argmax}} \left[P_t(Q_{-dt}+Q_{dt})Q_{dt} - C_{dt}(Q_{dt})\right], \qquad q^{mp}_{ud}(w^{mp}_{ud}) = \sum_t f_t q^{mp}_{udt} \end{cases}$$

The solutions $(w^{ms}_{ud}, q^{ms}_{ud})$ and $(w^{mp}_{ud}, q^{mp}_{ud})$ to these problems characterize the equilibrium in monopsonistic and monopolistic bargaining, respectively.

6.5 Estimation

We solve the model separately for each contracting pair (mining and power firms) by year. First, we estimate the model primitives—the downstream firm's residual electricity demand and the upstream firm's cost—to construct the payoff functions. In estimating residual demand, we assume total electricity demand is fully inelastic in the short run and compute this demand by averaging observed demand within each hour type. This average serves as the expected demand during bargaining between upstream and downstream firms. To estimate fringe supply, we derive the marginal cost curve for each fringe firm and aggregate these curves to the industry level. We then assume fringe firms supply quantities in each hour such that the market price equals their marginal cost. Subtracting this fringe supply curve from the inelastic total demand yields the residual industry demand curve faced by strategic firms, which we use in the estimation of the Cournot model.

Using the estimated demand and supply functions, we calculate the profit functions defined in Equations (9) and (10). We then construct the Nash product as specified in Equation (13) and compute equilibrium quantities and wholesale prices $(q_{ud}(\beta), w_{ud}(\beta))$ under both monopsonistic and monopolistic bargaining by solving the Nash-bargaining problem given in Section 6.4 for each bargaining weight. We estimate the pair-specific bargaining weights β_{ud}^{ms} and β_{ud}^{mp} as the values that minimize the distance between the equilibrium wholesale price $w_{ud}(\beta)$ under each conduct and the observed wholesale price. Finally, we apply our conduct selection rule from Theorem 1 to determine the vertical conduct for each contracting pair.

The only source of uncertainty in our model is the inelastic demand curve in the market in a given hour type. To account for this uncertainty in the estimates, we implement a bootstrap procedure, resampling the demand in each hour within hour type with replacement. Appendix G provides details on the estimation procedure, while Appendix G.8 outlines the estimation algorithms separately for monopsonistic and monopolistic bargaining conduct.

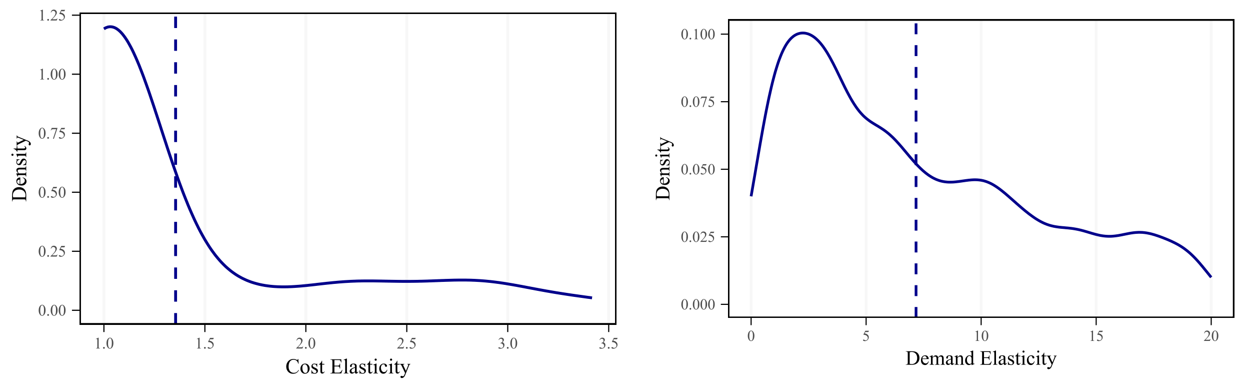
6.6 Results

6.6.1 Cost and Demand Elasticity Estimates

Figure 6(a) presents the distribution of estimated cost elasticities by mine-year. The estimates cluster around one, indicating that many mines operate under approximately constant marginal costs; however, several mines exhibit elasticities ranging from 1.5 to 3.5. This variation primarily arises from geographic differences. For instance, mines in the Powder River Basin (Wyoming and Montana) are characterized by large-capacity surface operations with relatively flat marginal cost curves, while mines in the Gulf region tend to be smaller underground facilities with more heterogeneous marginal cost structures. We find an average materials-to-labor cost ratio $\gamma_{\theta(iu)}(p_{iu}^{m}/w_{iu}^{l})$ of 2.32, which indicates that material costs are on average more than twice as high as labor costs. However, there is large heterogeneity across mines, with this ratio being merely 0.31 at the 10th percentile of mines, but 5.53 at the 90th percentile.

Figure 6(b) presents the distribution of estimated residual demand elasticities, with each observation corresponding to an hour-firm pair. The estimates exhibit considerable variation, though most are concentrated between 1 and 4. This variability primarily arises from changes in the shape of the fringe firms' supply curve across different times of day

Figure 6: Distribution of Cost and Demand Elasticities



(a) Upstream Cost Estimates

(b) Downstream Demand Estimates

Notes: Panel (a) presents a kernel density estimates of the distribution of the elasticity of the cost function of mining firms (which is equal to $1 + \frac{dmc(q)}{dq}\frac{q}{mc(q)}$). A cost elasticity of one implies constant marginal costs. Panel (b) presents a kernel density estimates of the distribution of the absolute value of the residual elasticity of demand of power firms (the elasticity of $p^{-1}(q)$ in our notation). Each observation corresponds to a mining firm-year in Panel (a) and an hour-type power firm in Panel (b). Since cost and demand functions are estimated nonparametrically, we report the elasticities at the observed quantity levels in Panel (a) and Panel (b). The dashed vertical line indicates the average in each panel.

and seasons. Additionally, we estimate the average market-level demand elasticity faced by strategic firms to be -0.84, which is broadly consistent with Puller (2007), who reports an average demand elasticity of -1.24 in the California electricity market.

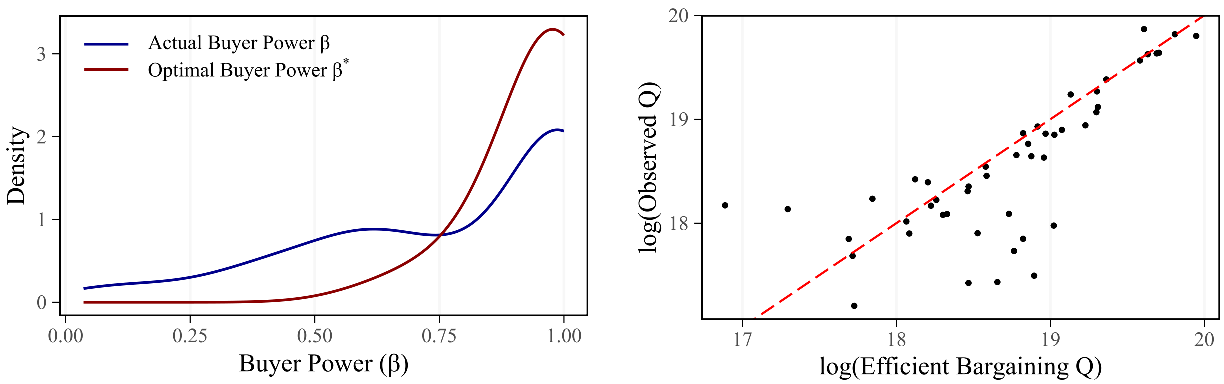
6.6.2 Bargaining Parameter Estimates

We report the distribution of the bargaining weight estimates β_{ud} in Figure 7(a) together with the optimal bargaining weights β^*_{ud}. The distribution of β_{ud} is skewed toward one, meaning that power firms have relatively more bargaining power than mining firms. While the distribution of β^*_{ud} shows a similar rightward skew, it is more pronounced than that of β_{ud}. The relatively small difference between the distributions of β_{ud} and β^*_{ud} suggests that the total vertical distortions are likely to be modest in magnitude.

Next, we apply our conduct selection criteria based on nonnegative markup and markdown. According to Theorem 1 in Section 4, vertical conduct is classified as monopsonistic when the bargaining weight exceeds β^* and monopolistic otherwise. Applying this criterion to the estimated bargaining weights shown in Figure 7(a), we find that five bargaining relationships exhibit monopsonistic conduct, whereas the remaining relationships are monopolistic. This result implies that most output distortion in this setting originates from seller market power rather than buyer power, leading primarily to double marginalization.

We also empirically test our conduct selection criteria using its implication from Propo-

Figure 7: Bargaining Model Estimates



(a) Buyer Power Estimates

(b) Comparison to Efficient Bargaining

Notes: Panel (a) shows a kernel density of the estimates of buyer power (β_{ud}) and efficient level of buyer power (β^*_{ud}) across each buyer-seller-year combination. Panel (b) compares the logarithm of observed coal-transaction quantities in log MMBtu ($\log(q)$) to the logarithm of the efficient bargaining quantity ($\log(q^*)$) across each buyer-seller-year combination. The red dashed line represents the 45-degree line.

sition 4, which states that observed output quantities should be lower than efficient-bargaining outputs. Figure 7(b) illustrates this comparison, showing observed quantities relative to efficient-bargaining quantities for each trading relationship. With only a few exceptions, which can be attributed to statistical noise, the observed output is consistently lower than the efficient-bargaining output, lending empirical support to our conduct selection criterion. To test this relationship formally, we rely on moment inequalities using its implication that $E[\log(q)] < E[\log(q^*)]$. By constructing these moments from the data, we find that the average log efficient quantity is statistically significantly larger than the average log observed quantity (difference coef. = 0.069, s.e. = 0.003).

Finally, we report two additional results as model validation exercises. First, since we estimate bargaining weights using only wholesale prices without targeting any moments of quantities, we can compare the model-predicted transaction quantities with the actual quantities as an external validity test. Figure OA-8 shows that observed quantities cluster around the fitted quantities, indicating that our model explains the data well. Second, our dataset includes transactions between a vertically integrated buyer and seller. We apply our bargaining model to this pair without imposing any efficiency assumptions. We find substantially lower deadweight loss for the vertically integrated pair compared to other transactions (3.51% vs. 14.7%), confirming more efficient bargaining due to integration.

6.6.3 *Decomposing Vertical Distortions: Monopolistic and Monopsonistic Conduct*

We use the estimated model to quantify the total vertical distortion and decompose it into components attributable to monopsony power and monopoly power. Since short-run elec-

Table 3: Decomposing Vertical Distortions

	Estimates
	Panel A. Total Quantity Distortion (%)
Percent Misallocated Quantity	8.03 (0.67)
	Panel B. Distortion Decomposition (%)
Due to Monopsony Power	25.10 (4.97)
Due to Monopoly Power	74.90 (4.97)

Notes: This table reports the share of total misallocated quantity (additional output produced by fringe firms compared to a wholesale coal market with no vertical distortion) and decomposes it into its monopsony and monopoly power components. Numbers in parentheses are bootstrapped standard errors reported for the percentages.

tricity demand is inelastic, market power distortions in electricity markets arise primarily from allocative inefficiency rather than lost output (Borenstein et al., 2002). Specifically, monopoly and monopsony distortions induce strategic firms to produce less than they would in the absence of market power, shifting production to higher-cost fringe firms. Accordingly, we measure the vertical distortion as the electricity generation allocated to higher-cost fringe firms from strategic firms due to double marginalization or monopsony power.

To decompose the total vertical distortion into monopsony and monopoly components, we first calculate the difference between the equilibrium output and efficient-bargaining output shown in Figure 7(b) for each trading pair, separately for trades under monopsonistic and monopolistic conduct. This gives us both the total underproduction of strategic firms compared to the benchmark with efficient bargaining and a decomposition of this amount into monopsonistic and monopolistic components.

The results are presented in Table 3. We estimate that the total misallocation in the ERCOT market corresponds to 8.03% of total output from coal transactions. In other words, the observed equilibrium quantities are 8.03% lower than what would be achieved if all firms engaged in efficient bargaining using non-linear contracts. This suggests that total efficiency losses are modest, which is not surprising since we find that the buyer power estimates β_{ud} are close to the estimates of efficient level of buyer power β^*_{ud}.

In terms of sources, 74.9% of the vertical distortion is attributed to double marginalization resulting from the monopoly power of coal mining firms, while the remaining portion is due to the monopsony power of power companies. Therefore, in this market, an increase in buyer power is likely to be countervailing, whereas an increase in seller power could be further distortionary. An important caveat to this statement is that any change in the market environment is also likely to change the efficient bargaining power parameter (β^*). Therefore, studying a specific policy requires estimating both the efficient level of buyer power and the corresponding changes in actual buyer power under that policy to draw definitive conclusions.

7 Concluding Remarks

Vertical relationships between buyers and sellers are studied across a variety of settings, ranging from labor unions to healthcare markets, to quantify market distortions under monopsony/oligopsony and double-marginalization settings. In this paper, we introduce a unified framework that nests both monopsonistic and monopolistic (double marginalization) vertical conduct. We first show that with increasing upstream marginal costs and decreasing downstream marginal revenues, an equilibrium exists under both conduct types with distinct welfare implications. We then provide a method to determine which type of vertical conduct emerges based on the relative bargaining positions of buyers and sellers and the underlying primitives of the cost and demand functions.

We illustrate our model using three empirical applications that include labor unions, farmer cooperatives, and sellers that face decreasing returns to scale. In our main empirical application, we use the model to quantify the sources of vertical distortions in coal procurement by power plants in Texas. We find that inefficiencies mainly come from double marginalization due to mining firms' monopoly power rather than from the monopsony power of power plants.

Our results provide several insights into antitrust policy. For horizontal mergers, we characterize the conditions under which changes in the bargaining power of upstream and downstream firms are distortionary or countervailing. Under monopolistic conduct, increased buyer power countervails double-marginalization distortions and increases welfare, whereas under monopsonistic conduct, increased buyer power increases monopsony distortions and reduces welfare. For vertical mergers, our framework provides an approach to evaluate potential efficiencies from eliminating double marginalization using the distance between the actual and efficient levels of buyer power.

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Welfare Effects of Buyer and Seller Power

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Online Appendix

Contents

A Proofs for Results Under the Simultaneous Model

This section provides first and second-order conditions of monopolistic and monopsonistic bargaining under simultaneous timing assumptions and provides the relevant proofs in Section 3.

A.1 First-Order Conditions

Under the simultaneous bargaining models, the maximization problems are given by:

$$\begin{cases} \max\limits_{q} \;\; p(q)q - wq & \text{(Downstream's problem)} \\ \max\limits_{q} \;\; wq - c(q)q & \text{(Upstream's problem)} \\ \max\limits_{w} \;\; [(p(q)q - wq)^{\beta}(wq - c(q)q)^{1-\beta}] & \text{(Bargaining problem)} \\ \max\limits_{w,q} \;\; [(p(q)q - wq)^{\beta}(wq - c(q)q)^{1-\beta}] & \text{(Efficient bargaining problem)} \end{cases}$$

These objective functions correspond to the following FOCs, for which we provide the proofs in Appendix A.3:

$$\begin{cases} w = p'(q)q + p(q) & \text{(D-FOC)} \\ w = c'(q)q + c(q) & \text{(U-FOC)} \\ w = (1-\beta)\, p(q) + \beta\, c(q) & \text{(B-FOC)} \\ q[p'(q) - c'(q)] + [p(q) - c(q)] = 0 & \text{(J-FOC)} \end{cases}$$

Based on these FOCs, the equilibrium quantities are given by:

$$\begin{cases} p'(q)q + \beta[p(q) - c(q)] = 0 & \text{(MP-Q-FOC)} \\ (1-\beta)[p(q) - c(q)] - c'(q)q = 0 & \text{(MS-Q-FOC)} \\ q\,[p'(q) - c'(q)] + [p(q) - c(q)] = 0 & \text{(J-Q-FOC)} \end{cases}$$

A.2 Second-Order Conditions

The second-order conditions are given by:

$$\begin{cases} p''(q)q + 2p'(q) < 0 & \text{(D-SOC)} \\ -c''(q)q - 2c'(q) < 0 & \text{(U-SOC)} \\ -\left[\beta/(p(q) - w)^2 + (1-\beta)/(w - c(q))^2\right] < 0 & \text{(B-SOC)} \end{cases}$$

A.3 Derivations of FOCs Under Simultaneous Bargaining

D-FOC and U-FOC are straightforward and therefore omitted.

A.3.1 B-FOC

Take the natural logarithm of the objective function:

$$\mathcal{L}(w) \equiv \beta \ln(p(q)q - wq) + (1-\beta)\ln(wq - c(q)q). \tag{OA.1}$$

Differentiating $\mathcal{L}(w)$ with respect to w and setting it to zero gives

$$\beta \cdot \frac{-q}{p(q)q - wq} + (1-\beta) \cdot \frac{q}{wq - c(q)q} = 0.$$

Solving for w gives $w = (1-\beta)p(q) + \beta c(q)$.

A.3.2 J-FOC

Take the derivative of $\mathcal{L}(w)$ from Equation (OA.1) with respect to q:

$$\beta \cdot \frac{p'(q)q + p(q) - w}{p(q)q - wq} + (1-\beta) \cdot \frac{w - c'(q)q - c(q)}{wq - c(q)q} = 0.$$

Substitute $w = (1-\beta)p(q) + \beta c(q)$ from (B-FOC) above:

$$\beta \cdot \frac{p'(q)q + p(q) - [(1-\beta)p(q) + \beta c(q)]}{p(q)q - [(1-\beta)p(q) + \beta c(q)]q} + (1-\beta) \cdot \frac{[(1-\beta)p(q) + \beta c(q)] - c'(q)q - c(q)}{[(1-\beta)p(q) + \beta c(q)]q - c(q)q} = 0.$$

The numerator and denominator for both terms above simplify to:

$$\frac{p'(q)q + \beta[p(q) - c(q)]}{q[p(q) - c(q)]} + \frac{(1-\beta)(p(q) - c(q)) - c'(q)q}{q(p(q) - c(q))} = 0.$$

This expression results in the joint profit maximization FOC (J-FOC):

$$q[p'(q) - c'(q)] + [p(q) - c(q)] = 0.$$

A.4 Proof of Proposition 1 for the Simultaneous Model

Proof. We will first show part (i) and part (ii). Note that the second-order conditions for either bargaining model do not hold under the assumptions of this proposition since the profit function of upstream is unbounded for $w > c = c(q)$ when marginal cost is constant, and the profit of downstream is unbounded for $p = p(q) < w$ when marginal revenue is constant. As a result, the first-order conditions cannot be relied on to find the equilibrium, and we must consider each of the maximization programs in cases. We will provide the proof separately for monopsonistic and monopolistic bargaining.

<u>**Monopsonistic Bargaining:**</u>

The equilibrium (w^e, q^e) maximizes the objective functions below in the monopsonistic bargaining model:

$$\begin{cases} \max_q \pi^u(w^e, q) & (U) \\ \max_w \pi^b(w, q^e, \beta) & (B) \end{cases} \quad \text{s.t} \quad \pi^u(w, q) \geq 0, \quad \pi^d(w, q) \geq 0,$$

where $\pi^b(w, q, \beta) \equiv (\pi^d(w, q))^\beta (\pi^u(w, q))^{1-\beta}$. For any β, (w^e, q^e) is an equilibrium if there is no other w such that $\pi^d(w, q^e) > \pi^d(w^e, q^e)$ and there is no other q such that $\pi^b(w^e, q, \beta) > \pi^b(w^e, q^e, \beta)$. Our result follows from analyzing the equilibrium under different β values.

Case I: $\beta \in (0, 1)$

We will show that under constant upstream marginal cost, the equilibrium for $\beta \in (0, 1)$ is $w^e = c$ and $q^e = p^{-1}(c)$. The profit functions are given by

$$\pi^d(w, q) = \big(p(q) - w\big)q \quad \text{and} \quad \pi^u(w, q) = \big(w - c\big)q.$$

Observe that at (w^e, q^e) we have $\pi^d(w^e, q^e) = 0$ and $\pi^b(w^e, q^e, \beta) = 0$.
First we will verify that $(c, p^{-1}(c))$ is indeed an equilibrium. Consider a deviation of $\tilde{q}$ from q^e. Observe that for any such deviation, the $\pi^u = 0$, so there is no profitable deviation.

Now, consider a deviation of $\tilde{w} > c$ from w^e. Observe that since $p(q^e) = w$, such a deviation does not satisfy the participation constraint because $\pi^d(\tilde{w}, q^e) = \big(p(q^e) - \tilde{w}\big)q < 0$.

Next, consider a deviation of $\tilde{w} < c$ from w^e. Observe that since $w^e = c$, such a deviation does not satisfy the participation constraint because $\pi^u(\tilde{w}, q^e) = (\tilde{w} - c)q^e < 0$. This proves that $w^e = c$ and $q^e = p^{-1}(c)$ is indeed an equilibrium. We now show that there is no other equilibrium by considering cases separately.
(i) Suppose $\bar{w} = c$ and $\bar{q} < q^e$ is an equilibrium. Consider a deviation from this equilibrium such that $\tilde{w} = c + \epsilon$, $\epsilon < p(\bar{q}) - p(q^e)$. Noting that $\tilde{w} = w^e + \epsilon$, the profit functions are given by

$$\pi^u(\tilde{w}, \bar{q}) = (c + \epsilon - c)\bar{q} > 0 \quad \text{and} \quad \pi^d(\tilde{w}, \bar{q}) = \big(p(\bar{q}) - (p(q^e) + \epsilon)\big)\bar{q} > 0.$$

Therefore, $\pi^b(\tilde{w}, \bar{q}) > \pi^b(\bar{w}, \bar{q})$, which means that there is a profitable deviation such that $(\bar{w} = c, \bar{q} < q^e)$ cannot be an equilibrium. We can also eliminate $(\bar{w} = c, \bar{q} > q^e)$ as a potential equilibrium since it does not satisfy the participation constraint of upstream.
(ii) Suppose $(\bar{w} > c, \bar{q})$ is an equilibrium, where $\bar{q} \in (0, p^{-1}(\bar{w}))$. In this case, $\tilde{q} = p^{-1}(\bar{w})$ is a profitable deviation for U

$$\pi^u(\bar{w}, \tilde{q}) = (\bar{w} - c)\tilde{q} > (\bar{w} - c)\bar{q} = \pi^u(\bar{w}, \bar{q}),$$

because $\bar{q} < \tilde{q}$ and $\pi^d(\bar{w}, \tilde{q}) = 0$ still satisfies the participation constraint of the downstream.

(iii) Now suppose that $(\bar{w} > c, p^{-1}(\bar{w}))$ is an equilibrium. Note that $\pi^d = \pi^b = 0$ in this case. Consider a deviation $\tilde{w} = \bar{w} - \epsilon$ where $\epsilon < \bar{w} - c$. We can write the profit functions as

$$\pi^u(\tilde{w}, \bar{q}) = (\tilde{w} - c)\bar{q} > 0 \quad \text{and} \quad \pi^d(\tilde{w}, \bar{q}) = (\bar{w} - (\bar{w} - \epsilon))\bar{q} > 0.$$

This deviation is profitable because $\pi^b > 0$. Therefore, $(\bar{w} > c, \bar{q} = p^{-1}(\bar{w}))$ cannot be an equilibrium.
(iv) We can directly eliminate any case $(\tilde{w} < c, \tilde{q})$ because it does not satisfy the participation constraint of upstream, and we can also eliminate any case $(\tilde{w} > c, \tilde{q} > p^{-1}(\tilde{w}))$ because it does not satisfy the participation constraint of downstream. This concludes the proof.

Case II: $\beta = 1$

We will show that if $\beta = 1$, there is a continuum of equilibria given by $w^e = c$ and $q^e \in [0, p^{-1}(c)]$. The equilibrium (w^e, q^e) should solve the following problems:

$$\begin{cases} \max\limits_{q} \pi^u(w^e, q) \quad (U) \\ \max\limits_{w} \pi^d(w, q^e) \quad (D) \end{cases} \quad \text{s.t} \quad \pi^u(w, q) \geq 0, \quad \pi^d(w, q) \geq 0.$$

First we verify that $w^e = c$ and $q^e \in [0, p^{-1}(c)]$ is indeed an equilibrium. Consider a deviation of $\tilde{w} > c$ from w^e. This will reduce the downstream profit for any q

$$\pi^d(\tilde{w}, q) = (p(q) - \tilde{w})q \ < \ (p(q) - w^e)q = \pi^d(w^e, q).$$

Thus, there is no profitable deviation from $w^e = c$ for any q. Similarly, when $w = c$, the profit function of U is always zero regardless of q, so there is no profitable deviation from q^e, and any q that satisfies the participation constraint is an equilibrium. Therefore, $w^e = c$ and $q^e \in [0, p^{-1}(c)]$ is an equilibrium.

Next, we will show that no other equilibria exist. Suppose $(\bar{w} > c, \bar{q})$ is an equilibrium for any $\bar{q}$. We cannot have $\bar{q} < p^{-1}(\bar{w})$, because then $\tilde{q} = p^{-1}(\bar{w})$ will be a profitable deviation for upstream. Similarly, we cannot have $\bar{q} > p^{-1}(\bar{w})$ because that would violate the participation constraint of downstream. Therefore, we only consider $(\bar{w} > c, \bar{q} = p^{-1}(\bar{w}))$ as a potential equilibrium.

Note that at $(\bar{w} > c, q = p^{-1}(\bar{w}))$, we have $\pi^d = 0$. Now, consider a deviation $\tilde{w} = \bar{w} - \epsilon$ such that $\epsilon < \bar{w} - c$. The downstream profit, in this case, is positive:

$$\pi^d(\tilde{w}, \bar{q}) = (p(\bar{q}) - \tilde{w})\bar{q} = (\bar{w} - \tilde{w})\bar{q} > 0.$$

Thus, there is a profitable deviation, and $(\bar{w} > c, q = p^{-1}(\bar{w}))$ cannot be an equilibrium. Finally, as an equilibrium candidate, $\tilde{w} < c$ violates the participation constraint of upstream, so it cannot be an equilibrium.

Case III: $\beta = 0$

We will show that if $\beta = 0$, there is a continuum of equilibria given by $(w^e > c, p^{-1}(w^e))$. The equilibrium (w^e, q^e) should solve the following problems:

$$\begin{cases} \max_{q} \pi^u(w^e, q) & (U) \\ \max_{w} \pi^d(w, q^e) & (D) \end{cases} \quad \text{s.t } \pi^u(w,q) \geq 0 \qquad \pi^d(w,q) \geq 0.$$

For any q, D is maximized at $w = p(q)$ subject to the participation constraint. Similarly for any w, (U) is maximized at q such that $w = p(q)$ to make participation constraint binding. Therefore, w is indeterminate in this case, so any $w \geq c$ with $q = p^{-1}(w)$ is an equilibrium.

Monopolistic Bargaining:

When marginal revenue is constant, $p(q) = p$, the equilibria for monopolistic bargaining for different β values is given by

$$\begin{cases} (w^e = p,\ q^e = c^{-1}(p)) & \text{if } \beta \in (0,1) \\ (w^e = p,\ q^e \in [0, c^{-1}(p)]) & \text{if } \beta = 0 \\ (w^e \leq p,\ c^{-1}(w^e)) & \text{if } \beta = 1. \end{cases}$$

We omit the proofs for these results as they follow in a very similar manner to the proof for the cases above for the monopsonistic bargaining model.

Note that under these results for all $\beta \in [0,1]$ values in both monopsonistic and monopolistic bargaining, either the downstream profit or upstream profits are zero. This proves that no interior equilibrium exists.

What's left to show is that if $mc'(q) > 0$, and $mr'(q) < 0$, equilibrium exists for an interior solution within the $\beta \in (0,1)$ in both monopsonistic and monopolistic bargaining.zThe existence of an equilibrium under monopsonistic and monopolistic bargaining follows from Lemmas OA-4 and OA-5, respectively. □

A.5 Proof of Lemma 1 for the Simultaneous Model

Proof. This result follows from an application of the Implicit Function Theorem. Note the first-order condition for U in the monopsonistic bargaining problem shown in Equation (A.3). Substituting w from (U-FOC) into (B-FOC), we have $c'(q)q = (1-\beta)[p(q) - c(q)]$.

Put $F(q,\beta) \equiv (1-\beta)[p(q) - c(q)] - c'(q)q$, and observe that $F(q,\beta) = 0$. As assumed in Section 2, we consider an interval $(0, \bar{q})$ such that $p(q) > c(q)$ for all $q \in (0, \bar{q})$. Hence,

$$\frac{\partial F(q,\beta)}{\partial \beta} = c(q) - p(q) < 0.$$

We verify that $\partial F/\partial q < 0$. Indeed, by Assumption 1, we have

$$\frac{\partial F(q,\beta)}{\partial q} = (1-\beta)\overbrace{[p'(q)-c'(q)]}^{\leq 0} - \overbrace{[c''(q)q + c'(q)]}^{>0} < 0.$$

By the Implicit Function Theorem, we have $\frac{dq}{d\beta} = -\frac{\partial F/\partial \beta}{\partial F/\partial q} < 0$ which concludes the proof that $\frac{dq^{ms}}{d\beta} < 0$. Next, consider the markdown $\Delta^d(q) = 1 - w/mr(q)$. Differentiating with respect to β yields:

$$\frac{d\Delta^d(q)}{d\beta} = -\frac{\frac{dw}{d\beta} mr(q) - w\frac{d\big(mr(q)\big)}{d\beta}}{(mr(q))^2} = -\frac{\frac{dq}{d\beta}\left(\frac{dq}{dw}\right)^{-1} mr(q) - w\frac{d\big(mr(q)\big)}{dq}\frac{dq}{d\beta}}{(mr(q))^2}.$$

Note that $mr'(q) < 0$ by assumption. We already showed that $dq/d\beta < 0$ and $dq/dw > 0$ holds from (U-FOC). Therefore, $d\Delta^d(q)/d\beta > 0$ and markdown is increasing with β. □

A.6 Proof of Lemma 2 for the Simultaneous Model

Proof. This result follows from an application of the Implicit Function Theorem. Substituting w from (D-FOC) into (B-FOC), we have $p'(q)q = \beta[c(q) - p(q)]$.

Put $F(q,\beta) \equiv p'(q)q - \beta[c(q) - p(q)]$, and observe that $F(q,\beta) = 0$. As assumed in Section 2.1, we consider an interval $(0,\bar{q})$ such that $p(q) > c(q)$ for all $q \in (0,\bar{q})$. Hence,

$$\frac{\partial F(q,\beta)}{\partial \beta} = p(q) - c(q) > 0.$$

We next verify that $\partial F/\partial q < 0$. Indeed, by Assumption 2, we have

$$\frac{\partial F(q,\beta)}{\partial q} = \overbrace{p''(q)q + p'(q)}^{<0} + \beta\overbrace{[p'(q)-c'(q)]}^{\leq 0} < 0.$$

By the Implicit Function Theorem, we have $\frac{dq}{d\beta} = -\frac{\partial F/\partial \beta}{\partial F/\partial q} > 0$ which concludes the proof that $dq^{mp}/d\beta > 0$. Next, consider upstream markup defined as $\mu^u(q) = w/mc(q) - 1$. Differentiating with respect to β yields:

$$\frac{d\mu^u(q)}{d\beta} = \frac{\frac{dw}{d\beta} mc(q) - w\frac{d\big(mc(q)\big)}{d\beta}}{(mc(q))^2} = -\frac{\frac{dq}{d\beta}\left(\frac{dq}{dw}\right)^{-1} mc(q) - w\frac{d\big(mc(q)\big)}{dq}\frac{dq}{d\beta}}{(mc(q))^2}$$

$mc'(q) > 0$ by assumption. We already showed that $dq/d\beta > 0$ and $dq/dw < 0$ by (D-FOC). Therefore, $d\mu^u(q)/d\beta < 0$, and markup decreases with β. □

A.7 Proof of Proposition 2 for the Simultaneous Model

Proof. First note that joint-profit maximizing quantity q^* satisfies (J-FOC)

$$p(q^*) - c(q^*) = -q^*[p'(q^*) - c'(q^*)], \tag{OA.2}$$

which is equivalent to $mr(q^*) = mc(q^*)$. Note that q^* is unique by Lemma OA-10. Any β^* that gives q^* should satisfy the FOC of monopsonistic bargaining given in (MS-Q-FOC).

$$p'(q^*)q^* = \beta^*[p(q^*) - c(q^*)]. \tag{OA.3}$$

Substituting Equation (OA.2) into Equation (OA.3), we obtain:

$$p'(q^*) = -\beta[p'(q^*) - c'(q^*)] \quad \Longrightarrow \quad \beta^* = -\frac{p'(q^*)}{p'(q^*) - c'(q^*)}, \tag{OA.4}$$

which shows the desired result. This also shows the uniqueness of β^* because q^* is unique by Lemma OA-10. For the monopolistic bargaining, the proof is equivalent, which proceeds by substituting Equation (OA.2) into the following FOC of the monopolistic bargaining in (MP-Q-FOC)

$$c'(q^*)q^* = (1-\beta)[p(q^*) - c(q^*)],$$

which gives the expression in Equation (OA.4). □

B Proofs for Results Under the Sequential Model

This section provides first and second-order conditions of monopolistic and monopsonistic bargaining under sequential timing assumptions and provides the relevant proofs in Section 3.

B.1 First-Order Conditions

Under the sequential bargaining models, the maximization problems are given by:

$$\begin{cases} \max_{q^d} \; p(q^d)\, q^d - w\, q^d & \text{(Downstream's problem)} \\ \max_{q^u} \; w\, q^u - c(q^u)\, q^u & \text{(Upstream's problem)} \\ \max_{w} \; \left[\left(p\left(q^d(w)\right) q^d(w) - w\, q^d(w)\right)^{\beta}\left(w\, q^d(w) - c\left(q^d(w)\right) q^d(w)\right)^{1-\beta}\right] & \text{(MP bargaining problem)} \\ \max_{w} \; \left[\left(p\left(q^u(w)\right) q^u(w) - w\, q^u(w)\right)^{\beta}\left(w\, q^u(w) - c\left(q^u(w)\right) q^u(w)\right)^{1-\beta}\right] & \text{(MS bargaining problem)} \end{cases}$$

The corresponding first-order conditions, shown in Section B.3, are[47]:

$$\begin{cases} w = p'(q)q + p(q) & \text{(D-FOC)} \\ w = c'(q)q + c(q) & \text{(U-FOC)} \\ \beta\left(\dfrac{-q + (p'(q)q + [p(q)-w])\,(dq^d/dw)}{[p(q)-w]\cdot q}\right) + (1-\beta)\left(\dfrac{q + ([w-c(q)] - c'(q)q)\,(dq^d/dw)}{[w-c(q)]\cdot q}\right) = 0 & \text{(D-B-FOC)} \\ \beta\left(\dfrac{-q + (p'(q)q + [p(q)-w])\,(dq^u/dw)}{[p(q)-w]\cdot q}\right) + (1-\beta)\left(\dfrac{q + ([w-c(q)] - c'(q)q)\,(dq^u/dw)}{[w-c(q)]\cdot q}\right) = 0 & \text{(U-B-FOC)} \end{cases}$$

Equilibrium quantities are given by:

$$\begin{cases} \beta\left(\dfrac{1}{p'(q)}\right) + (1-\beta)\left(\dfrac{q + (p(q) - c(q) + p'(q)q - c'(q)q)\cdot \dfrac{1}{2p'(q)+p''(q)q}}{[p(q)-c(q)+p'(q)q]}\right) = 0 & \text{(MP-Q-FOC)} \\ (1-\beta)\left(\dfrac{1}{c'(q)}\right) + \beta\left(\dfrac{-q + ([p(q)-c(q)] + [p'(q)q - c'(q)q])\,\dfrac{1}{2c'(q)+c''(q)q}}{[p(q)-c(q)] - c'(q)q}\right) = 0 & \text{(MS-Q-FOC)} \end{cases}$$

B.2 Second-Order Conditions

The second-order condition of monopsonistic bargaining under sequential timing is given by:

$$\beta\left\{\frac{1}{qD(q)}\left[\frac{N'(q)T(q) - N(q)T'(q)}{T(q)^3} - \frac{1}{T(q)}\right] - \left[\frac{N(q) - qT(q)}{qD(q)T(q)}\right]^2\right\} + (1-\beta)\left\{\frac{1}{T(q)q^2c'(q)} - \frac{1}{q^2c'(q)^2}\right\} < 0.$$

where

$$D(q) \equiv p(q) - c(q) - qc'(q), \quad N(q) \equiv p(q) - c(q) + q[p'(q) - c'(q)], \quad T(q) \equiv 2c'(q) + qc''(q).$$

The second-order condition of the monopolistic bargaining under sequential timing is given by:

$$(1-\beta)\left\{\frac{1}{q\tilde{D}(q)}\left[\frac{\tilde{N}'(q)\tilde{T}(q) - \tilde{N}(q)\tilde{T}'(q)}{\tilde{T}(q)^3} + \frac{1}{\tilde{T}(q)}\right] - \left[\frac{\tilde{N}(q) - q\tilde{T}(q)}{q\tilde{D}(q)\tilde{T}(q)}\right]^2\right\} + \beta\left\{\frac{1}{\tilde{T}(q)q^2p'(q)} - \frac{1}{q^2p'(q)^2}\right\} < 0.$$

where

$$\tilde{D}(q) \equiv p(q) + qp'(q) - c(q), \quad \tilde{N}(q) \equiv p(q) - c(q) + q[p'(q) - c'(q)], \quad \tilde{T}(q) \equiv 2p'(q) + qp''(q).$$

[47] We use q instead of q^u and q^d whenever there is no ambiguity to simplify the notation.

B.3 Derivation of FOCs Under Sequential Bargaining

B.3.1 U-B-FOC

Proof. We differentiate the logarithm of the objective with respect to w:

$$\beta\left(\frac{1}{[p(q)-w]\,q}\cdot\frac{d}{dw}\left([p(q)-w]\,q\right)\right)+(1-\beta)\left(\frac{1}{[w-c(q)]\,q}\cdot\frac{d}{dw}\left([w-c(q)]\,q\right)\right)=0.$$

Note the following intermediate derivatives:

<u>Derivative of $[p(q)-w]\,q$:</u>

$$\frac{d}{dw}\left([p(q)-w]\,q\right) \;=\; \left(\frac{d}{dw}[p(q)-w]\right)q+[p(q)-w]\frac{dq}{dw} \;=\; -q+\left(p'(q)q+[p(q)-w]\right)\frac{dq}{dw}$$

<u>Derivative of $[w-c(q)]\,q$:</u>

$$\frac{d}{dw}\left([w-c(q)]\,q\right) \;=\; \left(\frac{d}{dw}[w-c(q)]\right)q+[w-c(q)]\frac{dq}{dw} \;=\; q+\left([w-c(q)]-c'(q)q\right)\frac{dq}{dw}$$

Differentiating both sides of U-FOC, $w=c(q)+c'(q)\,q$ with respect to w, we find

$$\frac{dq}{dw}=\frac{1}{2\,c'(q)+c''(q)\,q}.$$

Substituting the expressions above into the FOC yields:

$$\beta\left(\frac{-q+\left(p'(q)q+[p(q)-w]\right)\dfrac{dq}{dw}}{[p(q)-w]\,q}\right)+(1-\beta)\left(\frac{q+\left([w-c(q)]-c'(q)q\right)\dfrac{dq}{dw}}{[w-c(q)]\,q}\right)=0,$$

and plugging in $\dfrac{dq}{dw}$:

$$\beta\left(\frac{-q+\left(p'(q)q+[p(q)-w]\right)\dfrac{1}{2c'(q)+c''(q)q}}{[p(q)-w]\,q}\right)+(1-\beta)\left(\frac{q+\left([w-c(q)]-c'(q)q\right)\dfrac{1}{2c'(q)+c''(q)q}}{[w-c(q)]\,q}\right)=0.$$

From U-FOC, substitute $w=c(q)+c'(q)q$ and simplify to obtain:

$$\beta\left(\frac{-q+\left([p(q)-c(q)]+[p'(q)q-c'(q)q]\right)\dfrac{1}{2c'(q)+c''(q)q}}{[p(q)-c(q)]-c'(q)q}\right)+(1-\beta)\left(\frac{1}{qc'(q)}\right)=0.$$

□

B.3.2 D-B-FOC

Proof. Calculate $\frac{dq}{dw}$ using $w = p(q) + p'(q)q$:

$$\frac{dq}{dw} = \frac{1}{2p'(q) + p''(q)q}.$$

Substitute $\frac{dq}{dw}$ and $w = p(q) + p'(q)q$ into the FOC:

$$\beta\left(\frac{-q + (p'(q)q + [p(q) - w]) \cdot \frac{1}{2p'(q)+p''(q)q}}{[p(q) - w] \cdot q}\right) + (1-\beta)\left(\frac{q + ([w - c(q)] - c'(q)q) \cdot \frac{1}{2p'(q)+p''(q)q}}{[w - c(q)] \cdot q}\right) = 0.$$

From (D-FOC), substitute $w = p(q) + p'(q)q$ and simplify to obtain:

$$\beta\left(\frac{1}{qp'(q)}\right) + (1-\beta)\left(\frac{q + (p(q) - c(q) + p'(q)q - c'(q)q) \cdot \dfrac{1}{2p'(q) + p''(q)q}}{[p(q) - c(q) + p'(q)q]}\right) = 0.$$

□

B.4 Proof of Proposition 1 for the Sequential Model

Proof. We will first show part (i) and part (ii). Since second-order conditions do not hold when $mr'(q) = 0$ and $mc'(q) = 0$, we cannot use first-order conditions to find an equilibrium. Therefore, we will directly work with the maximization programs under each bargaining model. We split each problem into multiple cases.

Monopsonistic Bargaining:

The equilibrium (w^e, q^e) maximizes the objective functions in the monopsonistic bargaining model:

$$\begin{cases} \max\limits_{q} \pi^u(w^e, q) & (U) \\ \max\limits_{w} \pi^b(w, q^e, \beta) & (B) \end{cases} \quad \text{s.t } \pi^u(w, q) \geq 0 \qquad \pi^d(w, q) \geq 0.$$

The subgame-perfect equilibrium $(w^*, q^*(w^*))$ is determined by backward induction. Specifically, for a given w, in the second stage, the upstream firm solves (U), yielding the best-response function $q^*(w)$. In the first stage, anticipating $q^*(w)$, the parties solve (B). Therefore, for any β, $(w^*, q^*(w^*))$ is a subgame-perfect equilibrium if there is no other w such that $\pi^b(w, q^*(w), \beta) > \pi^b(w^*, q^*(w^*), \beta)$, and $q^*(w)$ is indeed the maximizer of (U). We analyze equilibrium under different β values.

Case I: $\beta \in (0,1)$

If the marginal cost is constant, the equilibria for $\beta \in (0,1)$ in sequential monopsonistic bargaining are $w^e > c$ and $q^e(w)$:

$$q^*(w) = \begin{cases} 0 & w < c \\ p^{-1}(w) & c < w \\ [0, p^{-1}(w)] & c = w, \end{cases}$$

where $q^e(w)$ is the trivial reaction function of upstream when marginal cost is constant. Now, we must show that any w such that $w \geq c$ is an equilibrium. This follows because $\pi^b = 0$ for any value of w since we have that $\pi^u = 0$ and $\pi^d = 0$ when $w = c$ and $w > c$, respectively. Therefore, there is no profitable deviation.

Case II: $\beta = 1$

If marginal cost is constant, there are two equilibria for $\beta = 1$ in sequential monopsonistic bargaining:

$$q_1^*(w) = \begin{cases} 0, & w < c, \\ p^{-1}(w), & c < w, \\ (0, p^{-1}(w)), & c = w. \end{cases} \qquad w_1^e = c \qquad \text{and} \qquad q_2^*(w) = \begin{cases} 0, & w < c, \\ p^{-1}(w), & c < w, \\ p^{-1}(w), & c = w. \end{cases} \qquad w_2^e \geq c.$$

(i) Observe that in the first equilibrium $\pi^d(q_1^e, w_1^e) > 0$. This is an equilibrium because any deviation from $w_1^e = c$ to $\tilde{w} > c$ gives the downstream zero profit. Moreover, upstream profit is zero at $w = c$ for any value of q. Therefore, there is no profitable deviation for the upstream.
(ii) At $q_2^*(w)$ the downstream profit is always zero so any w is an equilibrium.

Case III: $\beta = 0$

If marginal cost is constant for $\beta = 0$, the equilibrium is given by:

$$q_1^*(w) = \begin{cases} 0, & w < c, \\ p^{-1}(w), & c < w, \\ (0, p^{-1}(w)), & c = w. \end{cases} \qquad w_1^e = \text{argmax}_w \ (w - c)p^{-1}(w).$$

When $w = c$, upstream profit is zero, which cannot be an equilibrium since $w > c$ leads to positive profit for the upstream. For $w > c$, the best response in the second stage is given by $p^{-1}(w)$, which leads to the profit function $(w - c)p^{-1}(w)$. The equilibrium w maximizes this profit function.

Monopolistic Bargaining:

Since this proof closely follows the proofs of monopsonistic bargaining, they are omitted. We just list the equilibria for different values of β as follows:

Case I: $\beta \in (0, 1)$

$$q^*(w) = \begin{cases} 0 & p < w \\ c^{-1}(w) & p > w \\ [0, c^{-1}(w)] & p = w \end{cases} \qquad w^e < p.$$

Case II: $\beta = 1$

$$q_1^*(w) = \begin{cases} 0 & p < w \\ c^{-1}(w) & p > w \\ (0, c^{-1}(w)) & p = w \end{cases} \qquad w_1^e = p, \qquad \text{and} \qquad q_2^*(w) = \begin{cases} 0 & p < w \\ c^{-1}(w) & p > w \\ c^{-1}(w) & p = w \end{cases} \qquad w_2^e \leq p.$$

Case III: $\beta = 0$

$$q_1^*(w) = \begin{cases} 0 & p < w \\ c^{-1}(w) & p > w \\ (0, c^{-1}(w)) & p = w \end{cases} \qquad w_1^e = \text{argmax}_w \ (p - w)c^{-1}(w).$$

Note that for all β values in both monopsonistic and monopolistic bargaining, either the downstream profit or upstream profits are zero. This proves that no interior equilibrium exists.

What's left to show is part (iii). That is, when $mc'(q) > 0$, and $mr'(q) < 0$, equilibrium exists for an interior solution within the β ranges specified in the proposition in both monopsonistic and monopolistic bargaining. This result follows from Lemma OA-8. □

B.5 Proof of Lemma 1 for the Sequential Model

Proof. By the Implicit Function Theorem, we have $dw/d\beta = -(\partial f/\partial\beta)/(\partial f/\partial w)$ where

$$f(\beta, w) = \beta\left(\frac{-q + (p'(q)q + [p(q) - w])\,(dq^u/dw)}{[p(q) - w] \cdot q}\right) + (1 - \beta)\left(\frac{q + ([w - c(q)] - c'(q)q)\,(dq^u/dw)}{[w - c(q)] \cdot q}\right) = 0$$

Let $f(\beta, w) = \beta A + (1-\beta)B$ so $(\partial f/\partial\beta) = A - B$. Substituting $c(q) - w = -c'(q)q$, B simplifies to $B = 1/(c'(q)q) > 0$. Since $\beta A + (1-\beta)B = 0$, $A < 0$, which implies that $(\partial f/\partial\beta) = A - B < 0$. $(\partial f/\partial w) < 0$ by the second-order conditions. Therefore, $dw/d\beta < 0$. Since $dq/d\beta = (dq/dw)(dw/d\beta)$ and $(dq/dw) > 0$ in the monopsonistic bargaining, this implies that $dq/d\beta < 0$.

The proof of $d\Delta^d/d\beta > 0$ is identical to the proof of Lemma 1 for the simultaneous model and is therefore omitted. □

B.6 Proof of Lemma 2 for the Sequential Model

Proof. By the Implicit Function Theorem, we have $dw/d\beta = -(\partial f/\partial\beta)/(\partial f/\partial w)$ where

$$f(\beta, w) = \beta\left(\frac{-q + (p'(q)q + [p(q) - w])\,(dq^d/dw)}{[p(q) - w]\cdot q}\right) + (1-\beta)\left(\frac{q + ([w - c(q)] - c'(q)q)\,(dq^d/dw)}{[w - c(q)]\cdot q}\right) = 0$$

Let $f(\beta, w) = \beta A + (1-\beta)B$ so $(\partial f/\partial\beta) = A - B$. Substituting $p(q) - w = -p'(q)q$, A simplifies to $A = 1/(p'(q)q) < 0$. Since $\beta A + (1-\beta)B = 0$, $B > 0$, which implies that $(\partial f/\partial\beta) = A - B < 0$. $(\partial f/\partial w) < 0$ by the second-order conditions. Therefore, $dw/d\beta < 0$. Since $dq/d\beta = (dq/dw)(dw/d\beta)$ and $(dq/dw) < 0$ in the monopolistic bargaining, this implies that $dq/d\beta > 0$.

The proof of $d\mu^u/d\beta > 0$ is identical to the proof of Lemma 2 for the simultaneous model and is therefore omitted. □

B.7 Proof of Proposition 2 for the Sequential Model

Proof. Any β^* that gives the q^* in the monopsonistic bargaining model satisfies

$$(1-\beta^*)\left(\frac{1}{c'(q^*)}\right) + \beta^*\left(\frac{-q^* + ([p(q^*) - c(q^*)] + [p'(q^*)q^* - c'(q^*)q^*])\,\frac{1}{2c'(q^*)+c''(q^*)q^*}}{[p(q^*) - c(q^*)] - c'(q^*)q^*}\right) = 0.$$

Substituting (J-FOC) $p(q^*) - c(q^*) = -q^*[p'(q^*) - c'(q^*)]$ in this expression, we obtain

$$\frac{\beta}{p'(q^*)} + \frac{1-\beta}{c'(q^*)} = 0.$$

which gives the desired result: $\beta^* = \dfrac{-p'(q^*)}{c'(q^*) - p'(q^*)}$.

For monopolistic conduct, the proof proceeds similarly. Substituting (J-FOC) into the following monopsony FOC,

$$\beta^*\left(\frac{1}{p'(q^*)}\right) + (1-\beta^*)\left(\frac{q^* + (p(q^*) - c(q^*) + p'(q^*)q^* - c'(q^*)q^*)\cdot\dfrac{1}{2p'(q^*) + p''(q^*)q^*}}{[p(q^*) - c(q^*) + p'(q^*)q^*]}\right) = 0,$$

yields $\beta^* = \dfrac{-p'(q^*)}{c'(q^*) - p'(q^*)}$. In both models, β^* is unique because q^* is unique by Lemma OA-10. □

B.8 Analysis of Second Order Condition under Sequential Timing

In this section, we will analyze the second-order conditions given in Section B.2. Since the second-order conditions are complex, there are no simple primitive conditions that guarantee that they hold. However, we develop two sufficient conditions under which the second order conditions hold separately under our conduct selection criteria given in Section 4 and also globally.

Lemma OA-1. *The second-order conditions for the sequential monopsonistic bargaining model hold if $mc''(q) \geq 0$ and $\Delta^d \geq 0$. The second-order conditions for the sequential monopolistic bargaining hold if $mr''(q) \leq 0$ and $\mu^u \geq 0$.*

The second-order conditions of the sequential monopsonistic bargaining model are given by:

$$\beta\left\{\underbrace{\frac{1}{qD(q)}}_{(+)}\left[\frac{\overbrace{N'(q)T(q)}^{(-)}-N(q)\overbrace{T'(q)}^{(+)}}{\underbrace{T(q)^3}_{(+)}}-\underbrace{\frac{1}{T(q)}}_{(+)}\right]-\underbrace{\left[\frac{N(q)-qT(q)}{qD(q)T(q)}\right]^2}_{(+)}\right\}+(1-\beta)\underbrace{\frac{1}{q^2c'(q)}}_{(+)}\underbrace{\left\{\frac{1}{T(q)}-\frac{1}{c'(q)}\right\}}_{(-)}$$

where

$$\begin{aligned} D(q) &= p(q)-c(q)-qc'(q) \geq 0, & D'(q) &= p'(q)-2c'(q)-qc''(q) < 0 \\ N(q) &= p(q)+qp'(q)-[c(q)+qc'(q)], & N'(q) &= [2p'(q)+qp''(q)]-[2c'(q)+qc''(q)] < 0 \\ T(q) &= 2c'(q)+qc''(q) > 0, & T'(q) &= 3c''(q)+qc'''(q) \end{aligned}$$

Therefore, we need to show that $N(q) \geq 0$. Note that $N(q) = mr(q) - mc(q)$. Since under monopsonistic bargaining $mc(q) = w$, $mr(q) \geq w$ implies that $N(q) \geq 0$.

The second-order conditions of the sequential monopolistic bargaining model are given by:

$$\beta\left\{\underbrace{\frac{1}{q\tilde{D}(q)}}_{(+)}\left[\frac{\overbrace{\tilde{N}'(q)\tilde{T}(q)}^{(+)}-\tilde{N}(q)\overbrace{\tilde{T}'(q)}^{(-)}}{\underbrace{\tilde{T}(q)^3}_{(-)}}+\underbrace{\frac{1}{\tilde{T}(q)}}_{(-)}\right]-\underbrace{\left[\frac{\tilde{N}(q)-q\tilde{T}(q)}{q\tilde{D}(q)\tilde{T}(q)}\right]^2}_{(+)}\right\}+(1-\beta)\underbrace{\frac{1}{q^2p'(q)}}_{(-)}\underbrace{\left\{\frac{1}{\tilde{T}(q)}-\frac{1}{p'(q)}\right\}}_{(+)}<0.$$

where

$$\begin{aligned} \tilde{D}(q) &\equiv p(q)+qp'(q)-c(q) \geq 0 & \tilde{D}'(q) &= -c'(q)+2p'(q)+qp''(q) < 0 \\ \tilde{N}(q) &\equiv p(q)+qp'(q)-[c(q)+qc'(q)] & \tilde{N}'(q) &= [2p'(q)+qp''(q)]-[2c'(q)+qc''(q)] < 0 \\ \tilde{T}(q) &\equiv 2p'(q)+qp''(q) < 0 & \tilde{T}'(q) &= 3p''(q)+qp'''(q) < 0 \end{aligned}$$

Therefore, we need to show that $\tilde{N}(q) \geq 0$. Note that $N(q) = mr(q) - mc(q)$. Since under monopolistic bargaining $mr(q) = w$, and positive markup implies that $mc(q) \leq w$, it follows that $N(q) \geq 0$.

Lemma OA-2. *The second-order conditions of the sequential monopsonistic bargaining model are satisfied for all β if $(1/mc(q))'' \geq 0$ and $mc''(q) \geq 0$.*[48]

[48]Even though this condition seems strong, we note that this is a sufficient condition. This condition is satisfied by some common functional form classes, such as exponential, polynomials, and linear functions.

Proof. As shown in the proof of Lemma OA-1, since all other terms are negative by assumption, we will focus on the following term:

$$\frac{1}{qD(q)}\left[\frac{N'(q)T(q)-N(q)T'(q)}{T(q)^3}-\frac{1}{T(q)}\right]=\frac{1}{qD(q)T(q)}\left[\frac{N'(q)T(q)-N(q)T'(q)}{T(q)^2}-1\right]$$

Note that $N(q) = mr(q) - mc(q)$ and $T(q) = mc'(q)$. Substituting these:

$$\begin{aligned}\left[\frac{N'(q)T(q)-N(q)T'(q)}{T(q)^2}-1\right]&=\left[\frac{(mr'(q)-mc'(q))mc'(q)-(mr(q)-mc(q))mc''(q)}{mc'(q)^2}-1\right]\\&=\left[\frac{mr'(q)}{mc'(q)}-mr(q)\frac{mc''(q)}{mc'(q)^2}+mc(q)\frac{mc''(q)}{mc'(q)^2}-2\right]\end{aligned}$$

We need to show that this expression is negative because $D(q) > 0$ and $T(q) > 0$. The first term is negative since $mr'(q) < 0$ and $mc(q) > 0$. The second term is also negative because $mr(q) > 0$ and $mc''(q) > 0$. Therefore, in order for this term to be negative, we need that $mc(q)mc''(q)/mc'(q)^2 \leq 2$. Note that this condition is equivalent to $(1/mc(q))'' \geq 0$, which concludes the proof. □

Lemma OA-3. *The second-order conditions of the sequential monopolistic bargaining model are satisfied for all β if $mr(q)mr''(q)/mr'(q)^2 \geq -2$ and $mr''(q) \leq 0$.*

Proof. As shown in the proof of Lemma OA-1, since all other terms are negative by assumption, we will focus on the following term in the second-order condition:

$$\frac{1}{q\tilde{D}(q)}\left[\frac{\tilde{N}'(q)\tilde{T}(q)-\tilde{N}(q)\tilde{T}'(q)}{\tilde{T}(q)^3}+\frac{1}{\tilde{T}(q)}\right]=\frac{1}{q\tilde{D}(q)\tilde{T}(q)}\left[\frac{\tilde{N}'(q)\tilde{T}(q)-\tilde{N}(q)\tilde{T}'(q)}{\tilde{T}(q)^2}+1\right]$$

Note that $\tilde{N}(q) = mr(q) - mc(q)$ and $\tilde{T}(q) = mr'(q)$. Substituting these:

$$\begin{aligned}\left[\frac{\tilde{N}'(q)\tilde{T}(q)-\tilde{N}(q)\tilde{T}'(q)}{\tilde{T}(q)^2}+1\right]&=\left[\frac{(mr'(q)-mc'(q))mr'(q)-(mr(q)-mc(q))mr''(q)}{mr'(q)^2}+1\right]\\&=\left[-\frac{mc'(q)}{mr'(q)}-mc(q)\frac{mr''(q)}{mr'(q)^2}+mr(q)\frac{mr''(q)}{mr'(q)^2}+2\right]\end{aligned}$$

We need to show that this expression is positive because $\tilde{D}(q) > 0$ and $\tilde{T}(q) < 0$. The first term is positive since $mr'(q) < 0$ and $mc'(q) > 0$. The second term is also positive because $mc(q) > 0$ and $mr''(q) < 0$. Therefore, in order for this term to be positive, we need that $mr(q)mr''(q)/mr'(q)^2 \geq -2$. □

C Proofs of Other Results

C.1 Proof of Corollary 1

Proof. $\mu^u(q) = 0$ follows immediately from (U-FOC) in the monopsonistic bargaining problem, which implies that $w(q) = mc(q)$. $\Delta^d(q) = 0$ follows immediately from (D-FOC) in the monopolistic bargaining problem, which implies that $w(q) = mr(q)$. □

C.2 Proof of Corollary 2

Proof. We examine changes in the absolute value of the derivative of $p'(q^*)$, $|p'(q^*)|$, and in the derivative $c'(q^*)$, both with respect to β^*, holding all else equal. In particular, changes in $|p'(q)|$ and $c'(q)$ also affect q^* that is present in the formula of β^*. Therefore, we condition on q^* and analyze the changes of $|p'(q)|$ and $c'(q)$ at q^*.

Given that $p'(q^*) \leq 0$, an increase in $c'(q^*)$ weakly increases the denominator of β^*, so β^* is weakly decreasing with $c'(q^*)$ ('steeper cost curve') . Observe that $1/\beta^* = 1 - c'(q^*)/p'(q^*)$. Since $c'(q^*)/p'(q^*) \leq 0$, $1/\beta^*$ is weakly decreasing with $|p'(q^*)|$, which implies that β^* is weakly increasing with $|p'(q^*)|$ ('steeper demand curve'). □

C.3 Proof of Proposition OA-1

Proof. First, consider monopolistic conduct. As is shown in Appendices D.1.7 and D.1.3, at $\beta = 1$ we have that $w^{mp} = c(q^{mp}) = mr(q^{mp})$. Achieving any $\tilde{q} > q^{mp}$ requires a wholesale price $\tilde{w} < c(\tilde{q})$. This leads to negative profits for the upstream firm and, hence, violates the participation constraint for upstream.

Second, consider monopsonistic conduct. As is proven in Appendices D.1.5 and D.1.1, at $\beta = 0$ we have that $p^{ms} = mc(q^{ms}) = w^{ms}$. Achieving any $\tilde{q} > q^{ms}$ requires a wholesale price $\tilde{p} < w^{ms}$. This leads to negative profits downstream and, hence, violates the participation constraint downstream. □

C.4 Proof of Proposition 3

Proof. Total welfare is maximized if prices are equal to marginal costs. Let $q^\dagger$ be the total-welfare maximizing output level:

$$p(q^\dagger) = mc(q^\dagger).$$

First, consider monopsonistic bargaining. As shown in Appendix D.1.2, $\beta = 0$ results in the condition $p(q) = mc(q)$. This is the first-best any planner could achieve, so total welfare is maximized at this point. Second, consider monopolistic bargaining. At $\beta = \beta^*$, $mr(q^*) = mc(q^*)$. Given that prices are set by downstream at a markup above marginal costs, this implies that $p(q) > mc(q)$ at the joint-profit-maximization level of buyer power β^*, which is lower than the first-best total welfare maximizing quantity.

As is proven in Appendix D.1.3, at $\beta = 1$ we have that $mr(q) = c(q)$. Hence, prices are above average costs:

$$p(q(\beta = 1)) = c(q(\beta = 1)) + \mu(q(\beta = 1)).$$

Let $b(q(\beta = 1)) = mc(q(\beta = 1)) - c(q(\beta = 1))$. It follows that there are three possibilities:

$$\begin{cases} b(q(\beta = 1)) = \mu(q(\beta = 1)) & \Rightarrow \beta^{\dagger} = 1 \\ b(q(\beta = 1)) < \mu(q(\beta = 1)) & \Rightarrow \beta^{\dagger} = 1 \\ b(q(\beta = 1)) > \mu(q(\beta = 1)) & \Rightarrow \beta^{\dagger} \in (\beta^*, 1) \end{cases}$$

First, if $b(q(\beta = 1)) = \mu(q(\beta = 1))$, $\beta = 1$ maximizes total welfare and leads to the first-best solution $p(q(\beta = 1)) = mc(q(\beta = 1))$. Second, if $b(q(\beta = 1)) < \mu(q(\beta = 1))$, prices are still too high at $\beta = 1$, as $p(q(\beta = 1)) > mc(q(\beta = 1))$. However, given that $\beta = 1$ is the highest possible value of β, welfare is maximized at this value. Third, if $b(q(\beta = 1)) > \mu(q(\beta = 1))$, the price at $\beta = 1$ is below marginal costs, meaning that there is overproduction. Given that $\frac{\partial q}{\partial \beta} > 0$ under monopolistic conduct and β^* leads to a total quantity lower than first-best, this implies that total welfare is maximized at $\beta^* < \beta < 1$. □

C.5 Proof of Theorem 1

Proof. We formally define the bargaining game as follows. Let $\kappa > 0$ be a constant.

- **Players:** i = {U, D}
- **Actions:** $a_i = \{B, DB\}$ (Bargain, Don't Bargain)
- **States:** $s = \{MS, MP\}$ (Monopsonistic Conduct, Monopolistic Conduct)
- **Payoffs:**

$$\begin{aligned}
&\pi_i(a_i = DB, a_{-i}) = 0 && \forall i \\
&\pi_u(a_u = B, a_d = B) = -\kappa && \text{if } \mu^u < 0 \\
&\pi_d(a_u = B, a_d = B) = -\kappa && \text{if } \Delta^d < 0 \\
&\pi_u(a_u = B, a_d = B, s = MS) = \pi_u^{ms} && \text{if } \mu^u \geq 0 \\
&\pi_u(a_u = B, a_d = B, s = MP) = \pi_u^{mp} && \text{if } \mu^u \geq 0 \\
&\pi_d(a_u = B, a_d = B, s = MS) = \pi_d^{ms} && \text{if } \Delta^d \geq 0 \\
&\pi_d(a_u = B, a_d = B, s = MP) = \pi_d^{mp} && \text{if } \Delta^d \geq 0
\end{aligned}$$

Players make the actions a in stage 0.5 of the game, bargaining takes place in stage 1, and payoffs are formed in stage 1 (under simultaneous bargaining) or stage 2 (under sequential bargaining). There are eight possible subgame perfect equilibria (s, a_u, a_d) that we need to examine, four for each conduct state: (i) (MS, B, B), (ii) (MS, DB, B), (iii) (MS, B, DB), (iv) (MS, DB, DB), (v) (MP, B, B), (vi) (MP, DB, B), (vii) (MP, B, DB), (viii) (MP, DB, DB).

First, consider the monopsonistic bargaining model in stage 0.5 of the game. Both players decide on whether to bargain or not by comparing their expected profits under bargaining and not bargaining, which are identical to realized profits due to the perfect information assumption. It follows from (U-FOC) that $w = mc(q)$, so the restriction $w \geq mc(q)$ is satisfied at any β. At $\beta = \beta^*$, the monopsonistic bargaining model equates joint profit maximization, so $mc(q(\beta^*)) = mr(q(\beta^*))$. Hence, $w(\beta^*) = mr(q(\beta^*))$, so the markdown is zero, $\Delta^d(\beta^*) = 0$.

Consider $\beta = \beta^* - \epsilon$, for $\epsilon > 0$. Given Lemma OA-13, it follows that the wholesale price markdown is negative, $\Delta^d(\beta^* - \epsilon) < 0$ in the monopsonistic bargaining model if $\beta < \beta^*$. This implies that when $\beta < \beta^*$, $\pi_d(a_d = B, s = MS) < \pi_d(a_d = DB, s = MS)$. Hence, subgames (i) and (ii) cannot be a subgame perfect equilibrium if $\beta < \beta^*$: the downstream player decides not to bargain in stage 0.5 because it expects a negative markdown. The only subgame perfect equilibria under monopsonistic bargaining are subgames (iii) and (iv), which are observationally identical equilibria in which no trade occurs.

Analogously, it follows that markdowns are positive for values of $\beta > \beta^*$ in the monopsonistic model, again from Lemma OA-13. Given that $\pi_d^{ms} > 0$, this means that for $\beta > \beta^*$, $\pi_d(a_d = B, s = MS) > \pi_d(a_d = DB, s = MS)$. Hence, subgames (ii) and (iv) are not subgame-perfect equilibria if $\beta > \beta^*$. Given that $\pi_u^{ms} > 0$, it follows that $\pi_u(a_u = B, a_d = B) > \pi_u(a_u = DB, a_d = B)$. Hence, only subgame (i) is a subgame perfect equilibrium if $\beta > \beta^*$.

Second, consider the monopolistic bargaining model, again at stage 0.5 when firms decide whether they want to bargain or not. The restriction $w \leq mr(q)$ is always satisfied under monopolistic conduct because (D-FOC) implies that $w = mr(q)$, so $\Delta^d = 0$. Turning to supplier markups, consider a $\beta = \beta^* + \epsilon$, for $\epsilon > 0$. Following the same logic as above, at $\beta = \beta^*$, we have $w(\beta^*) = mc(q(\beta^*))$. Given Lemma OA-14, it follows that $\mu^u(\beta^* + \epsilon) < 0$: seller markups are negative in the monopolistic bargaining model if $\beta > \beta^*$.

This implies that if $\beta > \beta^*$, $\pi_u(a_d = B, s = MP) < \pi_u(a_d = DB, s = MP)$: the upstream firm decides not to bargain in stage 0.5 as it anticipates a negative markup. Hence, subgames (v) and (vi) cannot be a subgame perfect equilibrium if $\beta > \beta^*$. Hence, the only subgame perfect equilibria under monopolistic bargaining are subgames (vii) and (viii), which are observationally identical equilibria in which no trade occurs.

Again, it is straightforward to repeat the same argument to show that markups are positive as soon as $\beta < \beta^*$ in the monopolistic bargaining model $\mu^u(\beta^* - \epsilon) > 0$. Hence, if $\beta < \beta^*$, $\pi_u(a_d = B, s = MP) > \pi_u(a_d = DB, s = MP)$, which means that subgames (vi) and (viii) are both not a subgame perfect equilibrium. Given that $\pi_d^{mp} > 0$, this means that if $\beta < \beta^*$, $\pi_d(a_d = B, s = MP) > \pi_d(a_d = DB, s = MP)$. Hence, subgames (vii) and (viii) cannot be a subgame perfect equilibrium if $\beta < \beta^*$. Hence, the only subgame perfect equilibrium under monopolistic bargaining if $\beta < \beta^*$ is subgame (iii), in which bargaining occurs.

To summarize, if $\beta > \beta^*$, only monopsonistic conduct yields a subgame perfect equilibrium with successful bargaining. Conversely, if $\beta < \beta^*$, only monopolistic conduct yields such an equilibrium. Furthermore, since all lemmas and results used in the proof hold under both simultaneous and sequential timing assumptions, the proof remains valid regardless of the bargaining timing structure.

□

C.6 Proof of Corollary 3

Proof. This follows immediately from Theorem 1 and Lemmas 1 and 2. □

C.7 Proof of Proposition 4

Proof. First, suppose $q > q^*$ and monopsonistic conduct applies. Given Lemma OA-13, this implies $\Delta^d < 0$; the downstream markdown is negative, which violates participation constraint 1. Second, suppose $q > q^*$ and monopolistic conduct applies. Given Lemma OA-14, this implies that $\mu^u < 0$; the upstream markup is negative, which also violates participation constraint 1. □

C.8 Proof of Theorem 2

Proof. We formally define the bargaining game as follows:

- **Players:** i = {U, D}
- **Actions:** $a_i = \{L, NL\}$ (Linear pricing (set q), Nonlinear pricing (bargain over q))
- **States:** $s = \{MS, MP\}$ (Monopsonistic Conduct, Monopolistic Conduct)
- **Payoffs:**

$$\begin{aligned}
&\pi_i(a_i = NL, s) = \Pi_i^* && \forall i \\
&\pi_u(a_u = L, s = MS) = \Pi_u^{ms} \\
&\pi_d(a_u = L, s = MS) = \Pi_d^{ms} \\
&\pi_u(a_d = L, s = MP) = \Pi_u^{mp} \\
&\pi_d(a_d = L, s = MP) = \Pi_d^{md}
\end{aligned}$$

We assume that the side that can pick q (upstream under monopsony, downstream under monopoly) sets the action a_i: it decides whether to set q_i unilaterally (in which case $a_i = L$) or to bargain over q_i (in which case $a_i = NL$). Hence, there are four possible subgame equilibria that we need to examine, two for each conduct state: (i) $s = MS, a_u = L$, (ii) $s = MS, a_u = NL$, (iii) $s = MP, a_d = L$, (iv) $s = MP, a_d = NL$.

First, consider monopsonistic conduct. Both players decide on whether to set quantities or bargain over quantities in stage 0.5 of the game by comparing their respective expected profits. Suppose $\beta < \beta^*$. From Lemma OA-16, it follows that $\pi_u^{ms} < \pi_u^*$. Hence, $a_u = L$ is not a subgame perfect equilibrium in this case, whereas $a_d = NL$ is: the game ends at stage 1 when downstream chooses nonlinear pricing, by bargaining over both w and q.

In contrast, if $\beta > \beta^*$, Lemma OA-16 implies that $\pi_u^{ms} > \pi_u^*$. Hence, $a_u = NL$ is not a subgame perfect equilibrium in this case, whereas $a_u = L$ is: the game proceeds to stage 1 in which U and D bargain over wholesale prices, which is followed by stage 2, in which U sets a quantity.

Second, consider monopolistic conduct. Suppose $\beta < \beta^*$. From Lemma OA-16, it follows that $\pi_d^{mp} > \pi_d^*$: downstream expects that if it sets quantities in stage 1, this will result in higher profits than under nonlinear pricing. Hence, $a_d = NL$ is not a subgame perfect equilibrium in this case, whereas $a_d = L$ is: firms bargain over wholesale prices in stage 1, which is followed by downstream setting quantities in stage 2.

In contrast, if $\beta > \beta^*$, Lemma OA-16 implies that $\pi_d^{mp} < \pi_d^*$. Hence, $a_d = L$ is not a subgame perfect equilibrium in this case, whereas $a_d = NL$ is: the game ends at stage 1 when downstream chooses to bargain over both output and wholesale prices.

In summary, if a linear price contrast is observed (either $a_d = L$ or $a_u = L$), this only happens under monopsonistic bargaining if $\beta > \beta^*$ and under monopolistic bargaining if $\beta < \beta^*$ □

C.9 Proof of Proposition 5

Proof. First, note that consumer surplus is monotonically increasing in output. Proposition 4 states that under our conduct selection criteria, output is maximized at $\beta = \beta^*$. Hence, consumer surplus is maximized at $\beta = \beta^*$.

Total surplus is defined as $TS = \int_0^q [p(q) - mc(q)]dq$. We take the derivative of total surplus with respect of output, which results in $\frac{\partial TS}{\partial q} = p(q) - mc(q)$.

Let $\bar{q}$ be defined as $p(\bar{q}) = mc(\bar{q})$. $\bar{q} > q^*$ because $mr(q^*) = mc(q^*)$, $mr(q) < p(q)$ for any q, and $mc(q)$ is an increasing function. Therefore, the total surplus is monotonically increasing for $q \in (0, q^*)$. This implies that it is also monotonically increasing in β in the range $\beta \in (0, \beta^*)$ under monopolistic bargaining because q is monotonically increasing in β by Lemma 1 and $q^{ms}(\beta = \beta^*) = q^*$. This also implies that total surplus is monotonically decreasing for $\beta \in (\beta^*, 1)$ under monopsonistic bargaining because q is monotonically decreasing in β in the range β by Lemma 2 and $q^{ml}(\beta = 1) = q^*$. Therefore, β^* is the unique value that maximizes total surplus. □

D Auxiliary Lemmas and Results

D.1 Equilibrium Under Limit Cases for β

We solve each version of the model (combination of monopolistic-monopsonistic and simultaneous-sequential) as a constrained profit-maximization model in the limiting cases of $\beta = 1$ and $\beta = 0$ and compare these corner solutions to the solutions obtained from the first-order conditions stated in the main text. These results are summarized in Table OA-2.

The most important takeaways from this appendix are that (i) the sequential monopsony has a solution at $\beta = 0$ using the constrained optimization problem but not using the FOCs, and (ii) the sequential monopolistic bargaining has a solution at $\beta = 1$ using the constrained optimization problem, but not using the FOCs. Hence, the participation constraints $\pi^d \geq 0$ and $\pi^u \geq 0$ are only binding in these two instances.

D.1.1 *Simultaneous Monopsony, $\beta = 1$*

$$\begin{cases} \max\limits_{q} \pi^u(w,q) \\ \max\limits_{w} \pi^d(w,q) \ \text{ s.t. } \ \pi^u(w,q) \geq 0. \end{cases}$$

The constrained profit-maximization problem yields no solution if $mc(q) \neq c(q)$:

$$\max_{q} \pi^u(w,q), \ \max_{w} \pi^d(w,q) \qquad \Rightarrow \qquad w = c(q), \ \text{mc}(q) = w.$$

The FOCs don't yield a solution because they imply average cost equals marginal cost:

$$c(q) = c'(q)q + c(q) \qquad \Rightarrow \qquad w = c(q), \ \text{mc}(q) = c(q).$$

In this case, as $\beta \longrightarrow 1$, the q will converge to 0.

D.1.2 *Simultaneous Monopsony, $\beta = 0$*

$$\begin{cases} \max\limits_{q} \pi^u(w,q) \\ \max\limits_{w} \pi^u(w,q) \ \text{ s.t. } \ \pi^d(w,q) \geq 0. \end{cases}$$

Solving the constrained profit-maximization problem implies a TIOLI offer being made by upstream, which results in the wholesale price being set equal to the downstream price:

$$\max_{q} \pi^u(w,q), \ \max_{w} \pi^u(w,q) \qquad \Rightarrow \qquad w = p(q), \ \text{mc}(q) = p(q).$$

The FOC results in the same condition:

$$p(q) = c'(q)q + c(q) \qquad \Rightarrow \qquad w = p(q), \ \text{mc}(q) = p(q).$$

D.1.3 *Simultaneous Monopoly, $\beta = 1$*

$$\begin{cases} \max\limits_{q} \pi^d(w,q) \\ \max\limits_{w} \pi^d(w,q) \ \text{ s.t. } \ \pi^u(w,q) \geq 0. \end{cases}$$

In this scenario, the downstream makes a TIOLI offer to the upstream, which results in the wholesale price being set equal to the upstream's average cost:

$$\max_{w,q} \pi^d(w,q) \qquad \Rightarrow \qquad \text{mr}(q) = c(q), \quad w = c(q).$$

This corner solution is identical to the solution obtained from the FOC:

$$c(q) = p'(q)q + p(q) \qquad \Rightarrow \qquad \mathrm{mr}(q) = c(q),\;\; w = c(q).$$

D.1.4 *Simultaneous Monopoly, $\beta = 0$*

$$\begin{cases} \max\limits_{q} \pi^d(w,q) \\ \max\limits_{w} \pi^u(w,q) \;\text{ s.t. }\; \pi^u(w,q) \geq 0. \end{cases}$$

This yields no solution if $mr(q) \neq p(q)$:

$$\max_{q} \pi^d(w,q),\; \max_{w} \pi^u(w,q) \qquad \Rightarrow \qquad w = p(q),\; \mathrm{mr}(q) = p(q).$$

Working out the first-order conditions does not yield a solution either:

$$p(q) = p'(q)q + p(q) \qquad \Rightarrow \qquad w = p(q),\; \mathrm{mr}(q) = p(q).$$

D.1.5 *Sequential Monopsony, $\beta = 1$*

$$\begin{cases} \max\limits_{q} \pi^u(w,q) \\ \max\limits_{w} \pi^d(w,q) \;\text{ s.t. }\; \pi^u(w,q) \geq 0. \end{cases}$$

The solution based on constrained profit maximization is the classical monopsony outcome:

$$\max_{q} \pi^u(w,q),\; \max_{w} \pi^d(w,q) \qquad \Rightarrow \quad w = mc(q), \quad mr(q) = mc'(q)q + mc(q)$$

The FOC results in the same condition:

$$p(q) - c(q) + p'(q)q - 3qc'(q) - q^2c''(q) = 0 \qquad \Rightarrow \quad w = mc(q), \quad mr(q) = mc'(q)q + mc(q).$$

D.1.6 *Sequential Monopsony, $\beta = 0$*

$$\begin{cases} \max\limits_{q} \pi^u(w,q) \\ \max\limits_{w} \pi^u(w,q) \;\text{ s.t. }\; \pi^d(w,q) \geq 0. \end{cases}$$

The solution based on constrained profit maximization is a TIOLI offer by upstream, which results in $mc(q) = p(q)$:

$$\max_{q} \pi^u(w,q),\; \max_{w} \pi^u(w,q) \qquad \Rightarrow \qquad w = p(q), \quad mc(q) = p(q).$$

The first-order condition does not yield a solution if $mc'(q) > 0$:

$$c(q) = p'(q)q + p(q) \qquad \Rightarrow \qquad \mathrm{mc}(q) = w, \quad 1/(mc'(q)q) = 0.$$

D.1.7 Sequential Monopoly, $\beta = 1$

$$\begin{cases} \max_q \pi^d(w,q) \\ \max_w \pi^d(w,q) \text{ s.t. } \pi^u(w,q) \geq 0. \end{cases}$$

The solution based on constrained profit-maximization is:

$$\max_{w,q} \pi^d(w,q) \qquad \Rightarrow \qquad \mathrm{mr}(q) = c(q),\ w = c(q).$$

Using the FOCs does not yield a solution if $p'(q) > 0$:

$$c(q) = p'(q)q + p(q) \qquad \Rightarrow \qquad \mathrm{mr}(q) = w,\ 1/(p'(q)q) = 0.$$

D.1.8 Sequential Monopoly, $\beta = 0$

$$\begin{cases} \max_q \pi^d(w,q) \\ \max_w \pi^u(w,q) \text{ s.t. } \pi^d(w,q) \geq 0. \end{cases}$$

The solution based on constrained profit-maximization is full double marginalization:

$$\max_q \pi^d(w,q),\ \max_w \pi^u(w,q) \qquad \Rightarrow \qquad \mathrm{mr}(q) = w, \quad mc(q) = mr'(q)q + mr(q).$$

The FOC results in the same condition:

$$c(q) - p(q) + c'(q)q - 3qp'(q) - q^2p''(q) = 0 \qquad \Rightarrow \qquad \mathrm{mr}(q) = w, \quad mc(q) = mr'(q)q + mr(q).$$

D.2 Auxiliary Lemmas on Equilibrium Existence

In this appendix, we discuss the existence and unicity of the monopolistic and monopsonistic equilibrium in both the simultaneous and sequential bargaining models.

D.2.1 Equilibrium Existence in the Simultaneous Model

In Lemmas OA-4 and OA-5, we find that in the simultaneous bargaining model, the monopsonistic and monopolistic equilibria both exist and are unique for a different range of buyer power values.

Lemma OA-4. *Assume that $mc'(q) > 0$. In simultaneous monopsonistic bargaining, equilibrium exists and is unique in the following β range:*

$$\beta \in [0, 1 - \lim_{q \to 0^+} s(q)),$$

where $s(q) = \frac{c'(q)\,q}{p(q)-c(q)}$ which is bounded below by 0.

Proof. In simultaneous monopsonistic bargaining, combining (U-FOC) and (B-FOC) gives

$$1 - \beta = \frac{c'(q)q}{p(q) - c(q)}. \tag{OA.5}$$

This means that β can take any value in support of $s(q)$. Note that $s(q) > 0$ because $p(q) - c(q) > 0$ and $c'(q) > 0$. Since $c'(q) > 0$ and $p(q) - c(q)$ is decreasing with q, the $\min_q s(q) = \lim_{q \to 0^+} s(q)$. Therefore, the minimum value β could take in monopsonistic bargaining is

$$1 - \lim_{q \to 0^+} s(q)$$

Similarly since $c'(q) > 0$, $q > 0$ and there exists $\bar{q}$ such that $p(\bar{q}) = c(\bar{q})$, $s(q)$ can be arbitrarily large $\max_q s(q) > 1$. Combining these two observations derives the bound for β

$$\beta \in [0, 1 - \lim_{q \to 0^+} s(q)).$$

Moreover, since $s(q)$ is a continuous function, by Intermediate Value Theorem, there exists q that satisfies Equation (OA.5) for all β in the range given above. This proves the existence of equilibrium for all $\beta \in [0, 1 - \lim_{q \to 0^+} s(q))$. □

Lemma OA-5. *Assume that $mr'(q) < 0$. In the simultaneous monopolistic bargaining model, equilibrium exists only in the following β range:*

$$\beta \in (\lim_{q \to 0^+} s(q), 1],$$

where $s(q) = -\frac{p'(q)\,q}{p(q) - c(q)}$.

Proof. In the simultaneous monopolistic bargaining, combining (D-FOC) and (B-FOC) gives

$$\beta = -\frac{p'(q)\,q}{p(q) - c(q)}. \tag{OA.6}$$

This means that β can take any value in support of $s(q)$. Note that $s(q) > 0$ because $p(q) - c(q) \geq 0$ and $p'(q) \leq 0$. Since $p'(q) \leq 0$ and $p(q) - c(q)$ is decreasing with q, the $\min_q s(q) = \lim_{q \to 0^+} s(q)$. Therefore, the maximum value β could take in monopolistic bargaining is

$$\lim_{q \to 0^+} s(q).$$

Similarly since $p'(q) \leq 0$ and $q > 0$ and there exists $\bar{q}$ such that $p(\bar{q}) = c(\bar{q})$, $s(q)$ can be arbitrarily large, which impies that $\max_q s(q) > 1$. Combining these two observations derives the bound for β

$$\beta \in (\lim_{q \to 0^+} s(q), 1].$$

Moreover, since $s(q)$ is a continuous function, by Intermediate Value Theorem, there exists q that satisfies Equation (OA.6) for all β in the range given above. This proves the existence of equilibrium for all β values. □

D.2.2 Equilibrium Existence in the Sequential Model

For the sequential monopolistic and monopolistic bargaining cases, we proceed as follows. In monopsonistic bargaining, we have already shown that when $\beta = 1$, the solution from the first-order conditions (FOC) corresponds to the constrained optimization problem. However, this result does not hold when $\beta = 0$. For this case, we will prove via lemma that as $\beta \to 0$, the FOC solution converges to the solution of the constrained optimization problem.

Conversely, in monopolistic bargaining, when $\beta = 0$, the FOC solution corresponds to the constrained optimization problem. This result breaks down when $\beta = 1$. In this case, we will prove via lemma that as $\beta \to 1$, the FOC solution converges to the solution of the constrained optimization problem.

Then, we will rely on the continuity of FOCs to show that equilibrium exists for all values of β.

Lemma OA-6. *The solution to the sequential monopolistic bargaining, characterized by its FOCs given in Appendix B.1 approaches as $\beta \to 1$ to the solution of the constraint-optimization problem at $\beta = 1$ provided in Appendix D.1.7.*

Proof. Define

$$A(q) \equiv \frac{1}{p'(q)} \quad \text{and} \quad B(q) \equiv \frac{N(q)}{D(q)} = \frac{q + [p(q) - c(q) + p'(q)q - c'(q)q]\frac{1}{2p'(q)+p''(q)q}}{p(q) - c(q) + p'(q)q}$$

The FOC that characterizes equilibrium q is $\beta\, A(q) \ + \ (1-\beta)\, B(q) \ = \ 0$. Rewrite β as $1-\varepsilon$. Then, the equation becomes

$$(1-\varepsilon)\, A(q) \ + \ \varepsilon\, B(q) \ = \ 0 \quad \Longrightarrow \quad \frac{1-\varepsilon}{\varepsilon}\, A(q) \ = \ -\, B(q).$$

As $\varepsilon \to 0$, the left side tends to $\pm\infty$ (unless $p'(q) = \infty$, which we rule out). Thus, $B(q)$ must also become unbounded in magnitude. If the numerator of $B(q)$ is finite, the denominator of $B(q)$ must vanish. Since

$$B(q) \ = \ \frac{N(q)}{D(q)} \quad \text{with} \quad D(q) \ = \ p(q) - c(q) \ + \ q\, p'(q),$$

the only way $B(q)$ goes to infinity is if $D(q)$ vanishes. Hence, as $\beta \to 1$, we have $p(q) - c(q) + qp'(q) = 0$, which corresponds to the solution given in the constraint-optimization problem given in Appendix D.1.7. □

Lemma OA-7. *The solution to sequential monopsonistic bargaining characterized by its FOC given in Appendix B.1 approaches as $\beta \to 0$ to the solution of the constraint-optimization problem at $\beta = 0$ given in Appendix D.1.6*

Proof. Define

$$A(q) = \frac{1}{c'(q)} \qquad \text{and} \quad B(q) \equiv \frac{N(q)}{D(q)} = \frac{-q + \left([p(q) - c(q)] + [p'(q)q - c'(q)q]\frac{1}{2c'(q)+c''(q)q}\right)}{p(q) - c(q) - c'(q)q}$$

The FOC that characterizes equilibrium q is $(1-\beta)\,A(q) \;+\; \beta\,B(q) \;=\; 0$. Rewrite β as ε. Then, the equation becomes

$$(1-\varepsilon)A(q) + \varepsilon B(q) = 0 \qquad \Longrightarrow \qquad \frac{\varepsilon}{1-\varepsilon} = \frac{A(q)}{B(q)}$$

As $\varepsilon \to 0$ (i.e., $\beta \to 0$), the multiplier $\frac{\varepsilon}{1-\varepsilon}$ tends to 0. If $A(q) \neq 0$ is finite, we must have $B(q)$ become unbounded (go to $\pm\infty$) in order to satisfy the above equality. This implies that as $\beta \to 0$, we have $p(q) - c(q) - q\,c'(q) = 0$, which corresponds to the solution given in the constraint-optimization problem in Appendix D.1.6. □

Lemma OA-8. *If $mc'(q) > 0$ and $mr'(q) < 0$ for both sequential monopolistic and monopsonistic bargaining problems, there exists a solution for $\beta \in [0,1]$. The solution is interior for $\beta \in (0,1)$.*

Proof. For monopsonistic bargaining, we show in Section D.1.5 that the solution to sequential monopsonistic bargaining exists for $\beta = 1$, and this solution coincides with the solution given by FOCs. Moreover, in Section D.1.6 we show that the solution to sequential monopsonistic bargaining exists for $\beta = 0$. Lemma OA-7 shows that the solution from FOC as $\beta \to 0$ corresponds to the solution obtained from constraint optimization Section D.1.6. Therefore, the solution to FOC converges to the corner cases of $\beta = 0$ and $\beta = 1$. The continuity of the FOCs implies that the solution exists for any $\beta \in (0,1)$. Since this solution is given by the FOC, it is in the interior.

For monopolistic bargaining, we show in Section D.1.8 that the solution to the sequential monopolistic bargaining exists for $\beta = 0$, and this solution coincides with the solution given by FOCs. Moreover, in Section D.1.7 we show that the solution to the sequential monopolistic bargaining exists for $\beta = 1$. Lemma OA-6 shows that the solution from FOC as $\beta \to 1$ corresponds to the solution obtained from constraint optimization in Section D.1.7. Therefore, the solution to FOC converges to the corner cases of $\beta = 0$ and $\beta = 1$. The continuity of FOCs implies that the solution exists for any $\beta \in (0,1)$. Since this solution is given by the FOC, it is in the interior. □

D.3 Loglinear Version of the Model

We solve the simultaneous bargaining model with log-linear costs and demand:

$$c(q) = \frac{1}{1+\psi} q^{\psi} \quad \text{and} \quad p(q) = q^{\frac{1}{\eta}}.$$

Solving the first-order condition for output in the monopsonistic conduct case (U-FOC) results in the factor supply curve $w = q^{\psi}$. Solving the first-order condition for output in the monopolistic conduct case (D-FOC) results in the factor demand curve $w = q^{\frac{1}{\eta}}(\frac{\eta+1}{\eta})$. The joint-profit-maximizing output level is found by equating marginal costs to marginal revenue, which results in $q^* = (\frac{1+\eta}{\eta})^{\frac{1}{\psi-\frac{1}{\eta}}}$.

Solving the bargaining problem (B-FOC) and setting it equal to the monopsonistic and monopolistic cases to find the intersection of the two output-buyer power curves results in the output-maximizing bargaining parameter

$$\beta^* = \left(\frac{1+\eta}{1+\psi} - \eta\right)^{-1}.$$

D.3.1 Corollary 2 in terms of elasticities

In the log-linear version of the model, we can write Corollary 2 as a function of supply and demand elasticities rather than the first derivatives of costs and demand.

Corollary OA-1. *The efficient level of buyer power β^* weakly decreases with the elasticity of downstream demand and weakly increases with the elasticity of upstream supply.*

Proof. The β^* expression in the log-linear model that was derived above:

$$\beta^* = \left(\frac{1+\eta}{1+\psi} - \eta\right)^{-1}.$$

The elasticity of downstream demand is η is negative, we conduct comparative statics in terms of $(-\eta)$ in order to have a higher value of this parameter indicate more elastic demand. Taking the first derivative of β^* to $(-\eta)$ results in:

$$\frac{\partial \beta^*}{\partial(-\eta)} = -\frac{\psi(1+\psi)}{(1-\eta\psi)^2} \leq 0$$

Hence, more elastic downstream demand implies a lower efficient level of buyer power β^*.
The elasticity of upstream supply is $\frac{1}{\psi}$. Taking the first derivative of β^* to ψ results in:

$$\frac{\partial \beta^*}{\partial \psi} = -\left(\frac{1+\eta}{1+\psi} - \eta\right)(-(1+\eta)) \leq 0$$

This expression is weakly positive because $\eta \leq -1$ is required for profit maximization, and because $\frac{1+\eta}{1+\psi} - \eta = \frac{1}{\beta^*} \geq 0$. It follows that the more inelastic the upstream supply is, the lower β^*. Hence, the more elastic the upstream supply, the higher β^*. □

Equilibrium existence under monopolistic bargaining

Solving the first-order conditions for the monopolistic bargaining problem, $q(\beta)$, is given by

$$q^{mpl} = \left(\frac{\psi+1}{\beta\eta} + 1 + \psi\right)^{\frac{1}{\psi-\frac{1}{\eta}}}.$$

Given that $\psi - \frac{1}{\eta} = \frac{5}{12} < 1$ in our numerical example, equilibrium existence requires

$$\left(\frac{\psi+1}{\beta\eta}\right) + 1 + \psi > 0.$$

Hence, it must hold that $\beta > -1/\eta$. In our numerical example, this condition is satisfied for $\beta > 1/6$, so the monopolistic equilibrium is defined only for this range of bargaining parameters.

Equilibrium existence under monopsonistic bargaining

Solving the FOCs of the monopsonistic bargaining model delivers the following $\beta(q)$ relationship:

$$\beta = \frac{q^{\psi} - q^{\frac{1}{\eta}}}{q^{\frac{1}{\eta}} + \frac{q^{\psi}}{1+\psi}}.$$

Given that $\psi > 0$ and $\eta < 0$, output is well-defined for any $\beta > 0$. Hence, the monopsonistic equilibrium always exists for the range of bargaining parameters we consider.

D.3.2 Limits in the Numerical Example

When we apply the bounds for existence from Proposition OA-5, the limit of monopolistic bargaining corresponds to

$$\lim_{q\to 0^+} -\frac{p'(q)\,q}{p(q)-c(q)} = \lim_{q\to 0} \frac{q^{1/\eta}}{q^{1/\eta} - (1+\psi)^{-1}q^{\psi}}.$$

Using l'Hôpital's rule, this limit can be found as

$$\lim_{q\to 0^+} -\frac{(1/\eta)q^{1/\eta}}{q^{1/\eta} - (1+\psi)^{-1}q^{\psi}} = -\frac{1}{\eta}$$

Since we set $\eta = -6$, the limit is $1/6$.

In monopsonistic bargaining, the upper bound is given by the limit:

$$\lim_{q\to 0^+} \frac{c'(q)\,q}{p(q)-c(q)} = \lim_{q\to 0^+} \frac{(\psi/(1+\psi))q^{\psi}}{q^{1/\eta} - (1+\psi)^{-1}q^{\psi}}$$

Using l'Hôpital's rule, this limit can be found as

$$\lim_{q \to 0^+} \frac{(\psi/(1+\psi))q^{\psi}}{q^{1/\eta} - (1+\psi)^{-1} q^{\psi}} = 0.$$

D.4 Lemmas on Markups and Markdowns

Lemma OA-9. *The results in equilibrium condition, quantity, markdown, markup, upstream profit, and downstream profits results in Table OA-1 hold.*

Proof. We will prove the results column by column.

(i) Equilibrium conditions: These are derived in Section D.1.

(ii) Quantities: We will only show this result for sequential monopsonistic bargaining because the results for other cases are identical and similar to derive. The equilibrium quantities are characterized by

$$\begin{aligned} \text{For } \beta = 1: &\quad mr(q_1) = mc'(q_1)q_1 + mc(q_1) \\ \text{For } \beta = \beta^*: &\quad mr(q^*) = mc(q^*) \\ \text{For } \beta = 0: &\quad mc(q_3) = p(q_3) \end{aligned}$$

where q_1 and q_3 are equilibrium quantities when $\beta = 1$ and $\beta = 0$. Note that since $mc'(q) > 0$, we have that $mc'(q)q + mc(q) > mc(q)$. Since $mr(q)$ is a decreasing function, it follows that $q^* > q_1$. For the comparison of q_3 and q^* note that $p(q) > mr(q)$ because $p'(q) < 0$, Since $mc(q)$ is an increasing function, it follows that $q_3 > q^*$.

(iii) Markups: Observe that in monopsonistic bargaining $w = mr(q)$, so the markup is given by $(mc(q) - mr(q))/mc(q)$ as defined in Section 2.4. It immediately follows from the relationship between $mc(q)$ and $mr(q)$ for different β values that $mc(q_1) - mr(q_1) < 0$, $mc(q) = mr(q)$ and $mc(q_3) - mr(q_3) > 0$.

(iv) Markdowns: Markdown results can be developed analogously to markup results and therefore are omitted.

(v) Upstream Profit: The equivalence of profit at β^* to joint-profit maximization profit follows from Proposition 2. The cases where $\pi_u = 0$ are also trivial because either the quantity approaches zero or the downstream firm makes a take-it-or-leave-it offer. Therefore, the only nontrivial cases are (i) Sim.MS with $\beta = 0$, (ii) Seq.MS with $\beta = 0$, (iii) Seq.MS with $\beta = 1$, and (iv) Seq.MP with $\beta = 0$. We will analyze these cases one by one.

Consider first simultaneous monopsony (Sim.MS) with $\beta = 0$ and Seq.MS with $\beta = 0$. When $\beta = 0$, under joint profit maximization, the upstream firm captures the entire profit so that $\pi_u(\beta = 0) = \pi_u^*$. Note that in both of these two cases, $mc(q) = p(q)$, meaning that the equilibrium quantity is less than the optimal quantity. This implies that the total profit, which is captured entirely by the upstream firm since $\beta = 0$, is below π_u^*.

Table OA-1: Equilibrium Outcomes under Limit Cases for β

Model	Equilibrium Condition	Explanation	q	Δ^d	μ^u	π_u	π_d
Sim. MS, $\beta = 1$	$q \to 0$	–	$q < q^*$	$\Delta^d > 0$	$\mu^u = 0$	$\pi_u = 0$	$\pi_d = 0$
Sim. MS, $\beta = \beta^*$	$mc(q) = mr(q)$	(JPM)	$q = q^*$	$\Delta^d = 0$	$\mu^u = 0$	$\pi_u = \pi_u^*$	$\pi_d = \pi_d^*$
Sim. MS, $\beta = 0$	$mc(q) = p(q)$	(U-TIOLI)	$q > q^*$	$\Delta^d < 0$	$\mu^u = 0$	$\pi_u < \pi_u^*$	$\pi_d = 0$
Sim. MP, $\beta = 1$	$mr(q) = c(q)$	(D-TIOLI)	$q < q^*$	$\Delta^d = 0$	$\mu^u < 0$	$\pi_u = 0$	$\pi_d = 0$
Sim. MP, $\beta = \beta^*$	$mr(q) = mc(q)$	(JPM)	$q = q^*$	$\Delta^d = 0$	$\mu^u = 0$	$\pi_u = \pi_u^*$	$\pi_d = \pi_d^*$
Sim. MP, $\beta = 0$	$q \to 0$	–	$q < q^*$	$\Delta^d = 0$	$\mu^u > 0$	$\pi_u = 0$	$\pi_d > \pi_d^*$
Seq. MS, $\beta = 1$	$mr(q) = mc'(q)q + mc(q)$	(C.M.)	$q < q^*$	$\Delta^d > 0$	$\mu^u = 0$	$\pi_u > \pi_u^*$	$\pi_d = 0$
Seq. MS, $\beta = \beta^*$	$mc(q) = mr(q)$	(JPM)	$q = q^*$	$\Delta^d = 0$	$\mu^u = 0$	$\pi_u = \pi_u^*$	$\pi_d = \pi_d^*$
Seq. MS, $\beta = 0$	$mc(q) = p(q)$	(U-TIOLI)	$q > q^*$	$\Delta^d < 0$	$\mu^u = 0$	$\pi_u < \pi_u^*$	$\pi_d = 0$
Seq. MP, $\beta = 1$	$mr(q) = c(q)$	(D-TIOLI)	$q < q^*$	$\Delta^d = 0$	$\mu^u < 0$	$\pi_u = 0$	$\pi_d < \pi_d^*$
Seq. MP, $\beta = \beta^*$	$mr(q) = mc(q)$	(JPM)	$q = q^*$	$\Delta^d = 0$	$\mu^u = 0$	$\pi_u = \pi_u^*$	$\pi_d = \pi_d^*$
Seq. MP, $\beta = 0$	$mc(q) = mr'(q)q + mr(q)$	(D.M.)	$q < q^*$	$\Delta^d = 0$	$\mu^u > 0$	$\pi_u < \pi_u^*$	$\pi_d > \pi_d^*$

Now consider the sequential monopsony case (Seq.MS) with $\beta = 1$, which corresponds to the classical monopsony model. Under joint profit maximization, $\pi_u = 0$ because the downstream firm captures the entire profit. However, in the case of sequential monopsony, $w = mc(q) > c(q)$ and the upstream profit is $\pi_u = (w - c(q))q > 0$. This implies that $\pi_u^{ms}(\beta = 1) > \pi_u^*(\beta = 1)$.

Finally, consider the case of the sequential monopoly (Seq.MP) with $\beta = 0$. The joint-profit maximization gives the entire joint profit, which also equals the highest profit the upstream firm can reach. However, when Seq.MP with $\beta = 0$, the downstream profit is positive because $\pi_d = (p(q) - w)q$ and $w = mr(q) < p(q)$. Since the total joint profit cannot be greater than $\pi_u^* + \pi_d^*$, it follows that $\pi_u^{mp}(\beta = 0) < \pi_u^* + \pi_d^*$.

(vi) Downstream Profit: The proof for downstream profit follows very similarly to that of upstream profit and is therefore omitted. □

Lemma OA-10. *Joint profit-maximizing quantity q^* that is characterized by the problem in Equation (7) is unique.*

Proof. q^* is characterized by (J-Q-FOC), which is given by $mr(q^*) - mc(q^*) = 0$. Since $mr'(q) < 0$ and $mc'(q) > 0$, there is a unique solution to this equation. □

Lemma OA-11. *In the monopsonistic bargaining model, $\Delta^d = 0$ if and only if q equals q^*.*

Proof. Since, in monopsonistic bargaining (U-FOC) implies that $\mu^u(q) = 0$, $\Delta^d(q) = 0$ if and only if $\mu^u(q) + \Delta^d(q) = 0$. Furthermore $\mu^u(q) + \Delta^d(q) = 0$ implies that $mc(q) = mr(q)$. Note that this equation only holds at q^* by Lemma OA-10, which concludes the proof. □

Lemma OA-12. *In monopolistic bargaining, $\mu^u = 0$ if and only if the equilibrium q equals q^*.*

Proof. Since, in monopolistic bargaining (D-FOC) implies that $\Delta^d(q) = 0$, $\mu^u = 0$ if and only if $\mu^u(q) + \Delta^d(q) = 0$. Furthermore $\mu^u(q) + \Delta^d(q) = 0$ implies that $mc(q) = mr(q)$. Note that this equation only holds at q^* by Lemma OA-10, which concludes the proof. □

Lemma OA-13. *In simultaneous/sequential monopsonistic bargaining $\Delta^d < 0$ when $\beta \in (0, \beta^*)$ and $\Delta^d > 0$ when $\beta \in (\beta^*, 1)$.*

Proof. By Lemma OA-9, we have $\Delta^d(\beta = 0) < 0$ and by Lemma OA-11 $\Delta^d(q^*) = 0$. Lemma OA-10 shows that β^* is the unique value of β that gives q^* as the equilibrium quantity. The continuity of Δ^d as a function of β, this proves that $\Delta^d < 0$ when $\beta \in (0, \beta^*)$. Similarly, we showed that at β^*, $\Delta^d = 0$ and at $\beta = 1$, $\Delta^d > 0$. Continuity of Δ^d as a function of β implies that $\Delta^d > 0$ when $\beta \in (\beta^*, 1)$ □

Lemma OA-14. *In simultaneous/sequential monopolistic bargaining $\mu^u > 0$ when $\beta \in (0, \beta^*)$ and $\mu^u < 0$ for $\beta \in (\beta^*, 1)$.*

Proof. This proof is identical to the proof of Lemma OA-13 and therefore omitted. □

D.5 Other Auxiliary Lemmas

Lemma OA-15. *The condition $c''(q)q + c'(q) > 0$ is equivalent to $\frac{\partial(mc(q)-c(q))}{\partial q} > 0$. The condition $p''(q)q + p'(q) < 0$ is equivalent to $\frac{\partial(mr(q)-p(q))}{\partial q} < 0$*

Proof. Since $mc(q) = d(c(q)q)/dq$, the difference between marginal and average cost is given by $mc(q) - c(q) = c'(q)q$ whose derivative is $c''(q)q + c'(q)$. Since $c'(q) > 0$, the condition given in Assumption 1, $c''(q)q + c'(q) > 0$ implies $mc'(q) > 0$. The proof with respect to marginal revenue is the same after replacing $c(q)$ functions with $p(q)$ functions. □

Lemma OA-16. *In the sequential bargaining model, the following inequalities about profits apply:*

$$\begin{cases} \pi_d^{ms} > \pi_d^* \\ \pi_u^{ms} < \pi_u^* \end{cases} (\beta < \beta^*) \quad \begin{cases} \pi_d^{mp} > \pi_d^* \\ \pi_u^{mp} < \pi_u^* \end{cases} (\beta < \beta^*) \quad \begin{cases} \pi_d^{ms} < \pi_d^* \\ \pi_u^{ms} > \pi_u^* \end{cases} (\beta > \beta^*) \quad \begin{cases} \pi_d^{mp} < \pi_d^* \\ \pi_u^{mp} > \pi_u^* \end{cases} (\beta > \beta^*)$$

Proof. First note that by Proposition 2, β^* is the only value that reaches the joint-profit maximization quantity q^*. In Lemma OA-9, we showed that the inequalities given in the Lemma hold in the corner cases of $\beta = 0$ and $\beta = 1$. We also know that $\pi_u^{ms} = \pi_u^{mp} = \pi_u^*$ and $\pi_d^{ms} = \pi_d^{mp} = \pi_d^*$ at β^*. Since no other value of β gives π^* other than β^* and the profit functions are continuous, the inequalities given in the Lemma are satisfied. □

D.6 Consumer Surplus Under Monopolistic and Monopsonistic Conduct

Having analyzed how buyer power affects output q, we now examine its impact on consumer surplus under both monopolistic and monopsonistic bargaining. We define consumer surplus as $CS(\beta) \equiv \int_0^{q(\beta)} \big(p(h) - p(q(\beta))\big) dh$.

Proposition OA-1. *Consumer surplus is maximized at $\beta = 1$ under monopolistic conduct and at $\beta = 0$ under monopsonistic conduct.*

Proposition OA-1 is intuitive: consumer surplus increases monotonically with output, so the level of buyer power that maximizes output necessarily maximizes consumer surplus. Under monopolistic bargaining, this occurs at the corner solution with full buyer power, whereas under monopsonistic bargaining, it occurs with full seller power.

E Extensions

In this Appendix, we extend our model by incorporating (i) nonzero disagreement payoffs, (ii) competition among buyers, (iii) multiple buyers and sellers, and (iv) multi-input downstream production. We show that our main results are robust to these extensions.

E.1 Nonzero Disagreement Payoffs

We incorporate nonzero disagreement payoffs into the simultaneous bargaining model. The Nash-bargaining problem becomes:

$$\max_{w} \left[(p(q)q - wq - o^d q)^{\beta}(wq - c(q)q - o^u q)^{1-\beta}\right]$$

Here, o^d and o^u represent the per-unit disagreement profits of downstream and upstream firms, respectively.[49] The following proposition characterizes how changes in these disagreement payoffs affect equilibrium output.

Proposition OA-2. *In monopolistic bargaining, output increases with the buyer's disagreement payoff and decreases with the seller's disagreement payoff, $dq^{mp}/do^d > 0$ and $dq^{mp}/do^u < 0$. In monopsonistic bargaining, the opposite occurs: output decreases with the buyer's disagreement payoff and increases with the seller's disagreement payoff, $dq^{ms}/do^d < 0$ and $dq^{ms}/do^u > 0$.*

Proof. With the disagreement payoffs, the firms' optimization problem for the simultaneous bargaining model becomes

$$\begin{cases} \max_{q} p(q)q - wq & \text{(Downstream's problem)} \\ \max_{q} wq - c(q)q & \text{(Upstream's problem)} \\ \max_{w}[(p(q)q - wq - o^d q)^{\beta}(wq - c(q)q - o^u q)^{1-\beta}] & \text{(Bargaining problem)} \end{cases} \tag{OA.7}$$

[49] In labor applications, o^u would be given by outside employment opportunities available to the workers.

which leads to the following FOCs

$$\begin{cases} w = p'(q)\, q + p(q) & \text{(D-FOC)} \\ w = c'(q)\, q + c(q) & \text{(U-FOC)} \\ w = (1-\beta)\left[p(q) - o^d\right] + \beta\left[c(q) + o^u\right] & \text{(B-O-FOC)} \end{cases} \tag{OA.8}$$

(B-O-FOC) and (U-FOC) imply that

$$(1-\beta)[p(q) - c(q)] = c'(q)q + (1-\beta)o^d - \beta o^u.$$

(B-O-FOC) and (D-FOC) imply that

$$\beta[c(q) - p(q)] = p'(q)q + (1-\beta)o^d - \beta o^u.$$

First, consider the monopsony case. Using the Implicit Function Theorem, dq/do^u and dq/do^d can be obtained as

$$\frac{dq}{do^u} = -\frac{dF/do^u}{dF/dq} = -\frac{\beta}{s'(q)} \quad \text{and} \quad \frac{dq}{do^d} = -\frac{dF/do^d}{dF/dq} = \frac{(1-\beta)}{s'(q)},$$

where

$$F(q, o^u, o^d) = \underbrace{(1-\beta)[p(q) - c(q)] - c'(q)q}_{s(q)} - (1-\beta)o^d + \beta o^u.$$

$s'(q)$ is given by

$$s'(q) = (1-\beta)(p'(q) - c'(q)) - [c''(q)q + c'(q)].$$

We have $c''(q)q + c'(q) > 0$ by assumption. $p'(q) \leq 0$ and $c'(q) \geq 0$, therefore $s'(q) < 0$. Hence, this proves that in monopsonistic bargaining, $dq/do^d < 0$ and $dq/do^u > 0$.

Second, consider monopolistic bargaining. The Implicit Function Theorem gives

$$\frac{dq}{do^u} = -\frac{dF/do^u}{dF/dq} = -\frac{\beta}{s'(q)} \quad \text{and} \quad \frac{dq}{do^d} = -\frac{dF/do^d}{dF/dq} = \frac{(1-\beta)}{s'(q)},$$

where

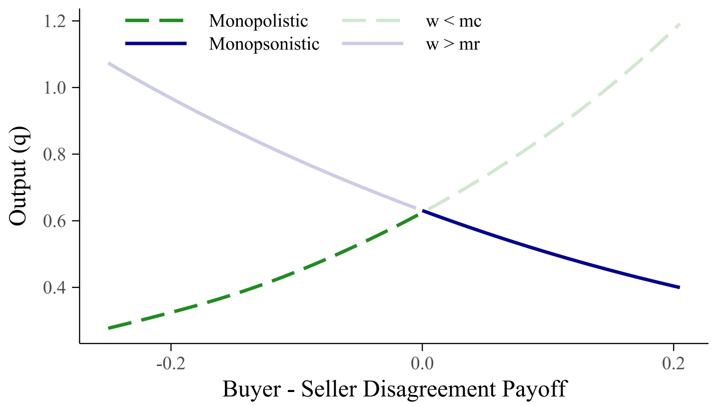
$$F(q, o^u, o^d) = \underbrace{\beta[c(q) - p(q)] - p'(q)q}_{s(q)} - (1-\beta)o^d + \beta o^u.$$

$s'(q)$ is given by

$$s'(q) = \beta[c'(q) - p'(q)] - [p''(q)q + p'(q)].$$

We have $c'(q) \geq 0$, $p'(q) \leq 0$ and $(p''(q)q + p'(q)) < 0$, so $s'(q) > 0$. This proves that under

Figure OA-1: Output and Relative Disagreement Payoffs



Notes: This figure illustrates the relationship between output (q) and relative disagreement payoffs, defined as the difference between the buyer's disagreement payoff and the seller's disagreement payoff when bargaining weight β is normalized to 0.5. The green line represents the simultaneous monopolistic bargaining case, while the blue line represents the simultaneous monopsonistic bargaining case. Parameter values under which equilibrium is no trade according to Participation Constraint 1 are indicated with shaded color.

monopolistic conduct, $dq/do^d > 0$ and $dq/do^u < 0$. □

E.1.1 Nonzero Disagreement Payoffs: Loglinear Case

For the simple functional forms $c(q) = \frac{1}{1+\psi}q^{\psi}$ and $p(q) = q^{\frac{1}{\eta}}$, we obtain Equation (OA.9) for the monopolistic model, and Equation (OA.10) for the monopsonistic model:

$$q^{\frac{1}{\eta}}\left(1 - \beta - \left(\frac{1+\eta}{\eta}\right)\right) + \frac{\beta}{1+\psi}q^{\psi} - ((1-\beta)o^d - \beta o^u) = 0 \tag{OA.9}$$

$$q^{\frac{1}{\eta}}(1-\beta) + \left(\frac{\beta}{1+\psi} - 1\right)q^{\psi} - ((1-\beta)o^d - \beta o^u) = 0. \tag{OA.10}$$

Neither of these equations has a closed-form solution. Hence, we numerically solve these equations for q at given values of η, ψ, and β. We calibrate $\eta = -10$ and $\psi = 0.25$, as before. We express q as a function of the difference between the outside option of the buyer compared to the outside option of the seller, $o^d - o^u$. We let this difference in disagreement payoffs be uniformly distributed on the interval $[-1/4, 1/4]$. We set the bargaining parameter to $\beta = 0.5$.

Figure OA-1 illustrates that higher buyer disagreement payoff increases output in the monopolistic model but decreases it in the monopsonistic model. Applying our conduct selection approach of nonnegative markups and markdowns reveals a similar Λ-shaped relationship between disagreement payoffs and output. In this case, there exists an output-maximizing disagreement payoff gap $(o^d - o^u)$, and the vertical conduct depends on whether the actual disagreement payoff gap falls above or below this optimal level.

E.2 Bargaining over Wholesale Prices and Quantities

In this section, we discuss an alternative bargaining procedure in which upstream and downstream bargain over both prices and quantities, but with differing bargaining abilities over prices (β_w) and quantities (β_q):

$$\begin{cases} \max_{w} \ [(p(q)q - wq)^{\beta_w}(wq - c(q)q)^{1-\beta_w}] \quad \text{(B-w)} \\ \max_{q} \ [(p(q)q - wq)^{\beta_q}(wq - c(q)q)^{1-\beta_q}] \quad \text{(B-q)} \end{cases}$$

Monopolistic and monopsonistic bargaining models analyzed in the main text are special cases of this model. When $\beta_q = 1$ the model collapses to the monopolistic bargaining where the downstream firm chooses the quantity whereas when $\beta_q = 0$ the model collapses to the monopsonistic model where the upstream firm chooses the quantity. Thus, $\beta_q \in (0, 1)$ determines the firms' relative ability to influence the quantity traded.

From our results, we know that when $\beta_q = 1$, output increases with β_w, while when $\beta_q = 0$, output decreases with β_w. This suggests that for values of $\beta_q \in (0, 1)$, the effect of buyer power β_w on output could be non-monotonic. Intuitively, when $\beta_q = 0$, the relationship between w and q is governed by the input supply curve, whereas when $\beta_q = 1$, it is governed by the input demand curve. For intermediate values of β_q, the relationship reflects a combination of both supply and demand curves, resulting in a potentially ambiguous relationship between w and q.

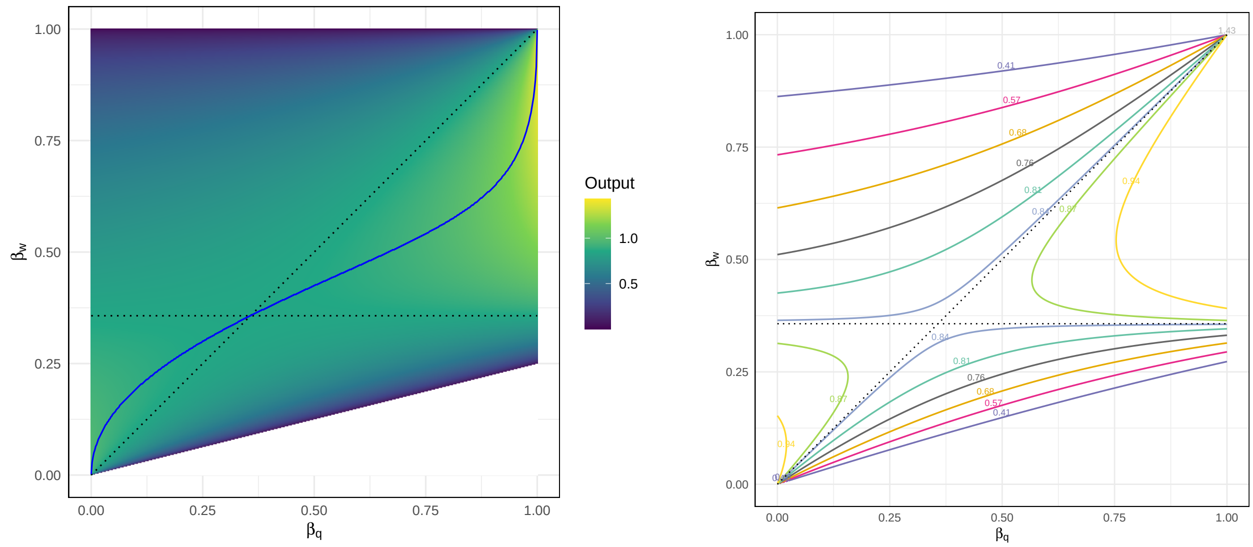
We analyze this general model under both simultaneous and sequential timing. While its analytical intractability prevents us from deriving results fully analogous to our main findings, we establish some theoretical results and illustrate the model's key insights under parametric assumptions, showing that the main intuitions under this model is consistent with our main analysis when $\beta_q \in \{0, 1\}$. Since the derivations in this section closely parallel those in the monopolistic and monopsonistic cases, we omit them for brevity. We begin by examining the conditions under which the equilibrium output coincides with the efficient bargaining outcome.

Proposition OA-3. *If $\beta_w = \frac{-p'(q^*)}{c'(q^*)-p'(q^*)}$, where q^* is the efficient bargaining quantity defined in Section 2.5, the equilibrium output equals the joint profit-maximizing output q^* for any $\beta_q \in [0, 1]$ under both simultaneous and sequential timing.*

This proposition demonstrates that Proposition 2 that we showed under monopsonistic and monopolistic bargaining continues to hold under this general model. In particular, $\beta_w = \beta^*$ yields the efficient bargaining output regardless of the extent to how firms influence the output decision. However, $\beta_w = \beta^*$ is not the only parameter value that can generate the efficient bargaining outcome, as we show next.

Proposition OA-4. *If $\beta_w = \beta_q = \beta$ where $\beta \in (0, 1)$, the equilibrium output equals the joint profit-maximizing output under both simultaneous and sequential timing.*

Figure OA-2: Output and indifference curve results.



(a) Output heatmap (simultaneous) **(b)** Indifference curves (simultaneous)

Notes: This figure shows heatmaps of output and indifference curves for the simultaneous (β^q, β^w) model. These are numerical simulation results using cost curve $c(q) = q^{\psi}/(1+\psi)$ and demand curve $p(q) = q^{1/\eta}$ with parametrizations $\psi = 3/2$ and $\eta = -4$.

This result is intuitive: when bargaining weights are equivalent, both stages of the game maximize the same objective function, which naturally yields a two-part tariff solution. Together, these two propositions provide insight into the equilibrium structure of the model. Specifically, the β-space is divided into four regions by the lines $\beta_q = \beta^*$ and $\beta_q = \beta_w$. Within each region, the relationship between equilibrium output and the bargaining weights can be analyzed to understand the effects of the change in β_w and β_q in equilibrium output.

To illustrate these, we present numerical simulations using the cost function $c(q) = \frac{q^{\psi}}{1+\psi}$ and the demand function $p(q) = q^{1/\eta}$, with parameters $\psi = 1/4$ and $\eta = -6$. Under these assumptions, Figure OA-2 illustrates how output varies with the two bargaining parameters under the simultaneous timing where we show a heatmap of output as a function of (β_w, β_q) along with the corresponding indifference curves.[50] As discussed above, the plane is divided into four regions by the 45-degree line and the $\beta_w = \beta^*$ line.

Three observations are worth highlighting. First, as anticipated, output is not monotonic in β_w: it first increases and then decreases with β_w for any value of β_q. This implies that the parameter space can be partitioned into two subregions where the relationship between output and β_w is monotonic. We indicate this boundary with the curved blue line, above which q is increasing in β_w and below which q is decreasing in β_w. Propositions OA-3 and OA-4 imply that this line lies within the triangular regions and is increasing in β_q. Therefore, as the buyer gains more

[50] We verified that the sequential bargaining model produces the same patterns discussed in this section. However, due to computational complexity, we could not simulate it on a fine grid for illustration.

influence over quantity (increase in β_q), the region in which β_w raises output also expands. This provides intermediate cases between the two corner outcomes represented by monopsonistic and monopolistic bargaining that exhibit full monotonicity.

The second observation is that, for a given β_w, output is a monotonic function of β_q: it increases in the region above $\beta_w = \beta^*$ and decreases in the region below $\beta_w = \beta^*$.[51] Although not reported in the plots, we showed that markups are positive when $\beta_w > \beta^*$ and negative otherwise under the assumed parametrization and the opposite holds for markdowns. This provides the intuition for how q varies with β_q: when the markdown is positive, granting the downstream firm greater power over quantity increases total output, since the firm earns positive profit on the marginal unit and benefits from expanding output. By contrast, when the markdown is negative, the firm loses money on the marginal unit and therefore finds it optimal to restrict output when it holds more quantity-setting power.

The final observation is that, output is below the efficient bargaining quantity (q^*) in the upper and lower quadrants formed by the 45-degree and $\beta_w = \beta^*$ lines. These are the cases where one party has greater bargaining power in quantity setting, while the other party has greater bargaining power in input pricing. This outcome is consistent with the main intuition of our model: the party with pricing power reduce the other party's margin, but since the other side primarily determines quantity, it under-supplies (seller) or under-demands (buyer), generating distortions. By contrast, when bargaining powers are similar in both price and quantity (around 45 degree line), or when one party dominates in both dimensions (the triangular regions), output tends to be higher.

E.3 Multiple Buyers That Compete Downstream

While our baseline model focused on a single supplier and buyer, it can be naturally extended to multiple competing buyers by incorporating their residual downstream demand. In this Appendix, we illustrate this extension using a Cournot model where multiple downstream firms compete oligopolistically in the product market. Unlike the single-buyer case, where the downstream firm's decisions depend on market-level demand elasticity, firms in an oligopoly make decisions based on their *residual* demand elasticity. The presence of more competing firms increases this residual demand elasticity, which in turn reduces the efficient level of buyer power β^*.[52] As a result, increased downstream competition expands the range of β values that yields a monopsonistic equilibrium, making it more likely to occur.

Let there be firms $j = 1, ..., J$, with $\sum_{j=1}^{J} q_j = Q$. Assume $p(Q)$ is the industry inverse demand

[51] This result can be proven analytically under simultaneous timing, whereas in the sequential model the analysis is too intractable to yield a formal proof.

[52] For an illustration of these effects, see Figure OA-4.

function. The firms' optimization problem becomes

$$\begin{cases} \max_{q_j} p(Q)q_j - w_j q_j & \text{(Downstream's problem)} \\ \max_{q_j} w_j q_j - c(q_j)q_j & \text{(Upstream's problem)} \\ \max_{w_j} [(p(Q)q_j - w_j q_j)^{\beta}(w_j q_j - c(q_j)q_j)^{1-\beta}] & \text{(Bargaining problem)} \end{cases} \tag{OA.11}$$

Compared to the single-buyer version of the model, in which $-\eta$ was the firm-level price elasticity of demand, $-\eta$ is now the market-level price elasticity of demand. In the Cournot case, the residual price elasticity of demand at the firm level becomes $\frac{\eta}{s_j}$, with $s_j = \frac{q_j}{Q}$. Hence, the more competing firms there are in the downstream market, the more elastic residual demand becomes, and the lower the efficient level of buyer power β^*. This implies that the more competitive the downstream market becomes, the more likely it is that the wholesale market is monopsonistic; the range of bargaining parameters for which equilibrium conduct is monopsonistic increases.

Numerical Example

We simulate the same parametric version of our model used earlier but with multiple buyers that compete downstream, à la Cournot. We keep $\psi = 0.25$ but now set the market-level elasticity $\eta = -3$, which implies that firm-level demand elasticities are between -3 (if there is a single downstream firm) to -12 (if there are four equally sized downstream firms). Figure OA-4 shows the resulting output-buyer power graphs when there are one to three firms per downstream market. As competition increases, residual demand faced by the buyers becomes more elastic. Hence, the efficient level of buyer power decreases, and monopsonistic competition is the equilibrium form of vertical conduct for an increasing range of relative bargaining abilities.

E.4 Multiple Buyers and Sellers

In most industries, firms in both upstream and downstream markets interact with multiple partners. Our framework extends to these settings through the passive-belief assumption, commonly used in the "Nash-in-Nash" approach of Horn and Wolinsky (1988). Under this assumption, each firm expects all other equilibrium outcomes to remain the same, regardless of the outcome of its current negotiation.[53] Within this framework, we can calculate gains from trade and estimate demand and cost curves by conditioning on the equilibrium outcomes of other negotiations to operationalize our model. We demonstrate this approach in our empirical application in Section 6.

E.5 Multi-Input Downstream Production

Our baseline model assumes a single-input production function where the downstream firm simply resells the input in the downstream market. In this Appendix, we extend this model to incorporate multi-input downstream production. We show that while the bargaining problem remains

[53]For extensions of this assumption, see Ho and Lee (2019).

largely unchanged, it requires some modifications. Specifically, under monopsonistic bargaining, the upstream firm's output choice influences downstream output through a monotone function rather than by determining it directly, as the downstream firm can substitute to other inputs in its production process. Similarly, under monopolistic bargaining, the downstream firm's output choice no longer directly dictates the upstream quantity; rather, it influences it via a monotone input demand function.

The multi-input production introduces a key parameter affecting the model's comparative statics: the elasticity of substitution between inputs. When this elasticity approaches zero, the production function converges to a Leontief form, creating a one-to-one mapping between upstream and downstream output, mirroring our baseline model. Conversely, as the elasticity of substitution grows, the relationship between upstream and downstream outputs weakens, reducing the scope of buyer and seller power in the vertical chain.

E.5.1 Monopolistic Bargaining

Assume that the downstream firm produces according to the following CES production function with two inputs :

$$q = (\alpha_1 x_1^{\rho} + \alpha_2 x_2^{\rho})^{1/\rho}.$$

For simplicity, we assume that there is no productivity term. For input x_2, the downstream firm negotiates through monopolistic bargaining while taking the price of input x_1 as given in the market. Under monopolistic bargaining, the downstream firm takes the input price w_1 as given and negotiates over w_2. Given the negotiation outcome of w_2 and market price w_1, it then determines its profit-maximizing quantity. From this, we can express the firm's demand for x_2 as a function of its target output quantity q:

$$x_2(q) = \left(\frac{\alpha_2}{w_2}\right)^{\frac{1}{1-\rho}} q \left((\alpha_1/w_1)^{1/(1-\rho)} + (\alpha_2/w_2)^{1/(1-\rho)}\right)^{-1/(1-\rho)}.$$

The CES function leads to the following cost function:

$$C_d(q) = q \left((\alpha_1/w_1)^{1/(1-\rho)} + (\alpha_2/w_2)^{1/(1-\rho)}\right)^{1-1/\rho}.$$

Taking the derivative to find the marginal cost,

$$mc_d(w_2) = \left((\alpha_1/w_1)^{1/(1-\rho)} + (\alpha_2/w_2)^{1/(1-\rho)}\right)^{1-1/\rho},$$

which is the same as the average cost $c_d(w_2)$ due to constant returns to scale. With these objects, we can write the firm's maximization problems as

$$\pi^d(w_2, q) = \big(p(q) - mc_d(w_2)\big)q$$
$$\pi^u(w_2, q) = \big(w_2 - c_u(x_2(q))\big)x_2(q).$$

These problems resemble the problem in the paper with the following exceptions: w_2 in the upstream firm's maximization problem shows up in $c_d(w_1, w_2)$ instead of as a simple linear function in w_2. Similarly, q in the downstream firm's problem shows up as $x_2(q)$ instead of as a simple linear function. Since $c_d(w_1, w_2)$ is increasing in w_2 and $x_2(q)$ is increasing in q, having a multi-input downstream firm does not change the main economics of the problem.

We evaluate this model for two extreme cases of the elasticity of substitution ρ. First, consider the limiting case of $\rho \to -\infty$. In this case, the production function takes the Leontief form:

$$q = \min\{\alpha_1 x_1, \alpha_1 x_2\}$$

In this case, we are back to the model in the main text, but with an additional marginal cost term w_1, which is non-negotiated.

Second, consider the limiting case of $\rho = 1$, which corresponds to perfect substitutes:

$$q = \alpha_1 x_1 + \alpha_2 x_2$$

Under this production function, the firm will only use x_2 if $\frac{a_2}{w_2} \geq \frac{a_1}{w_1}$. Hence, the bargaining problem over w_2 is only relevant to the extent that this condition holds.

Finally, for any $-\infty < \rho < 1$, firms bargain over w_2 while internalizing that x_1 and x_2 are either gross complements (if $\rho < 0$) or gross substitutes (if $\rho > 0$). We refer to Rubens (2025) for an empirical implementation of the monopsonistic bargaining model with a CES production function under gross complements.

E.5.2 Monopsonistic Bargaining

Now we will consider monopsonistic bargaining. In monopsonistic bargaining, the production function remains the same, but since the upstream firm determines the input x_2, the downstream firm will take x_2 as given. Therefore, the firm will solve the constrained cost minimization problem conditional on x_2

$$\min_{x_1} \; w_1 x_1 \quad \text{s.t} \quad q \leq (\alpha_1 x_1^{\rho} + \alpha_2 x_2^{\rho})^{1/\rho}.$$

This leads to a conditional factor demand conditional on x_2:

$$x_1(q,x_2) = \left(\frac{\alpha_1}{w_1}\right)^{\frac{1}{1-\rho}} \left(\frac{q^\rho - \alpha_2 x_2^\rho}{(\alpha_1/w_1^\rho)^{1/(1-\rho)}}\right)^{1/\rho}.$$

Similarly, we obtain a conditional cost function:

$$C_d(q,x_2) = (q - \alpha_2 x_2^\rho)^{1/\rho} \left((\alpha_1/w_1^\rho)^{1/(1-\rho)}\right)^{(\rho-1)/\rho} + w_2 x_2.$$

Denote the average cost as $c_d(q,w_2) = C_d(q,w_2)/q$. Taking the derivative to find the marginal cost,

$$mc_d(q,x_2) = \frac{1}{\rho}\left(\frac{w_1^\rho}{\alpha_1}\right)^{1/\rho} (q - \alpha_2 x_2^\rho)^{\frac{1}{\rho}-1}$$

Given x_2, the firm will set marginal cost to marginal revenue: $mc_d(q,x_2) = p'(q)q + p(q)$. Let the solution to this problem be $q_d(x_2)$. Now, we can write the firms' maximization problems as

$$\begin{aligned}
\pi^d(w_2,x_2) &= \big(p(q) - c_d(q_d(x_2),w_2)\big)q_d(x_2)\\
\pi^u(w_2,x_2) &= \big(w_2 - c_u(x_2)\big)x_2.
\end{aligned}$$

where $c_u(x_2)$ is the average cost function of the upstream firm. These problems resemble the problem in the paper with the following exceptions: w_2 in the downstream firm's maximization problem shows up as $c_d(q,w_2)$ instead of as a simple linear function w_2. Similarly, q in the downstream problem appears as $q_d(x_2)$ instead of as itself. In this case, we do not see any change in the upstream firm's cost function. Since both $c_d(w_2)$ and $q_d(x_2)$ are monotone functions, they do not change the basic mechanisms of the model.

F Empirical Application Appendix: Unions and Cooperatives

F.1 Labor Unions Application

In our labor unions application, we rely on the estimates for labor supply and demand for U.S. construction workers from Kroft et al. (2023). Given that their labor supply model is log-linear, it has the same functional form as our numerical example from Appendix D.3. Using their notation of firms being indexed as j, wages W_j and number of workers L_j, their inverse labor supply curve at the firm level is

$$W_{jt} = L_{jt}^\theta U_{jt}.$$

Denoting output as Q_{jt}, the goods price as P_{jt}, and an aggregate price index as $\bar{P}_t$, their downstream residual demand curve is

$$Q_{jt} = \left(\frac{P_{jt}}{\bar{P}_t}\right)^{\frac{-1}{\epsilon}}.$$

Hence, their inverse elasticity of labor supply is θ and their inverse elasticity of goods demand is ϵ.

The production function is Leontief in materials and a composite term of labor and capital. Given that we study wage bargaining on the short term, we treat capital as fixed, which results in output being proportional to the labor input. Translating their notation into the notation of Appendix D.3, we have that $\eta = -\frac{1}{\epsilon}$ and $\psi = \theta$.

We use the β^* formula applied to the loglinear example, as worked out in Appendix D.3. Using the notation from Kroft et al. (2023), this gives

$$\beta^* = \left(\frac{1 - \frac{1}{\epsilon}}{1 + \theta} + \frac{1}{\epsilon}\right)^{-1}.$$

We use the estimated inverse demand elasticity $\epsilon = 0.137$ from Table 2, Panel B, and the RDD estimate for the inverse labor supply elasticity $\theta = 0.286$ from Table 2, Panel A. Plugging these into the β^* formula above results in $\beta^* = 0.417$.

F.2 Farmer Cooperatives Application

In our farmer cooperatives application, we focus on the setting of tobacco farmers in China, as analyzed in Rubens (2023). Although Rubens (2023) presents a discrete-choice oligopsony model in Appendix A1, we take a first-order approximation of this model by modeling loglinear leaf supply and assuming monopsonistic competition instead. Denoting total leaf production at manufacturer f as M_f, the leaf price at firm f as P^m_f, an aggregate leaf price as $\bar{P}^m$, and a demand residual as A_f, leaf supply is given by

$$M_f = \left(\frac{P^m_f}{\bar{P}^m}\right)^{\frac{1}{\psi}} A_f.$$

In equilibrium, the ratio of the marginal revenue product of tobacco leaf $MRPM$ over the leaf price is equal to one plus the inverse leaf-supply elasticity:

$$\frac{MRPM}{P^M} = 1 + \psi.$$

Using the preferred GMM specification in the third column of Table 1, Panel B, the MRPM/Leaf price ratio is estimated at 2.904, which implies an inverse leaf-supply elasticity of $\psi = 1.904$.

Given that the production function is Leontief in tobacco leaf, cigarette production is proportional to tobacco-leaf usage. We approximate cigarette demand by the same loglinear demand function used above, denoting cigarette production at firm f as Q_f, the cigarette price as P_f, a price aggregator as $\bar{P}_t$, and the inverse demand elasticity as ϵ:

$$Q_f = \left(\frac{P_f}{\bar{P}_t}\right)^{\frac{-1}{\epsilon}}.$$

As an estimate of the cigarette demand elasticity $\frac{-1}{\epsilon}$, we rely on the estimates of Ciliberto and

Kuminoff (2010). Given that only median own-price elasticities (rather than average elasticities) are reported, we rely on these median elasticities. We use the estimate of $\frac{1}{\epsilon} = 1.14$ from Table 4, column 6, given that this is one of the two preferred specifications that relies on GMM. Using the formula above results in $\beta^* = 0.916$. The key driver of the large efficient-level of buyer power is the inelastic demand for cigarettes due to the addictive nature of the product.[54] Alternatively, using the other GMM specification (in column 7) of $\frac{1}{\epsilon} = 1.11$ results in a very similar efficient level of buyer power of $\beta^* = 0.933$.

G Empirical Application Appendix: Coal Procurement

G.1 Data Sources

Coal-Mine Characteristics and Production Data. For coal mines, we use two datasets: one from the Mine Safety and Health Administration (MSHA) (Mine Safety and Health Administration, 2024) and one from Velocity Suite. The MSHA data provides information on production, employment, and technical mine characteristics. Quarterly production and employment (in hours worked and total employment) come from MSHA Form 8. Mine characteristics, such as the number and type of openings and the vein thickness, are obtained from MSHA Form 10. We merge these MSHA datasets with each other by matching on the MSHA mine identifier. We use the Velocity data to obtain ownership information. While ownership details are also available in the MSHA data, we found it unreliable due to the lack of unique owner IDs, inconsistent spellings, and unaccounted ownership changes.

Coal-Mine Cost Data. We purchased cost information for coal mines from the 2019 Coal Cost Guide published by Costmine Intelligence. This data source provides detailed data on operating costs, capital costs, labor requirements, and equipment expenses for different mining technologies used in the United States and Canada. The Coal Cost Guide provides data on five types of operating expenses (in USD per short tons) and nine types of capital expenses (in USD). The data is provided at the level of mine characteristics, which consist of a combination of: (i) the mine type (Surface, Continuous Underground with Ramp Access, Continuous Underground with Shaft Access, Longwall Underground with Ramp Access, Longwall Underground with Shaft Access, Room & Pillar Underground with Ramp Access, Room & Pillar Underground with Shaft Access), (ii) the mine's daily capacity (in short kilotons: 1, 2, 4, 8, 24, 72, 216 short kilotons), (iii) the average vein thickness (in meters: 1.5, 2.5, 3.5 meters for underground mines, 1, 3, 12, 18, 24, and 27 meters for surface mines). We obtain this data from pages 5-74 in Chapter 3 of the 2019 Coal Cost Guide (InfoMine USA, 2019).

Power-Plant Characteristics, Cost and Generation Data. For data on power plants, we rely on data from Velocity Suite, which compiled data from EIA 860, EIA 906, EIA 923, NERC 411

[54] This explains why elasticity estimates are so low; other studies even estimate cigarette demand report elasticities below one (Liu et al., 2015; Lopez and Pareschi, 2024); which is inconsistent with our model of static profit maximization.

forms, EPA, as well as from their own proprietary research. We use five different datasets from Velocity. The first dataset is at the month-generator level and includes the universe of all generators in the U.S., capturing characteristics such as age, fuel type, boiler type, capacity, location, ISO region, installation date, operating status, ownership and regulation status of the owner. Velocity collects this data from various public sources and their proprietary research. The second dataset provides hourly generation data for fossil fuel generation units, sourced from the EPA's CEMS database, which includes details on generation, fuel usage, heat rate, and emissions. The third dataset contains monthly plant-level data, offering information on plant characteristics and monthly generation by fuel type, compiled from the EIA-923 form. The fourth dataset is hourly load data for ERCOT, sourced directly from ERCOT's website. Finally, the fifth dataset consists of hourly generation data for generation units in ERCOT, obtained from ERCOT's 60-Day SCED Disclosure Report.

BLS Wage Data. We obtain weekly earnings of coal miners from the Quarterly Census of Employment of Wages of the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2024). We download the data at the 4-digit industry level for industry '2121 Coal Mining'.[55] We keep weekly earnings at the state-quarter level and average across quarters to obtain annual averages of weekly earnings per state. For some states in some years, earnings are not reported. In these cases, we impute wages by averaging over broader regions that correspond to the coal basins: Northwest, Southwest, Midwest, Appalachia, and Southeast. We recompute weekly earnings into hourly wages by assuming a 45-hour work week, following average data reported by the CDC.[56]

Coal Transaction Data [2005-2014]. Velocity Suite provides two datasets related to coal transactions between power plants and coal mines. The first dataset is transaction-level, where each record includes coal mine and plant IDs, quantity shipped, FOB price, transportation price, contract information (ID and duration), and coal characteristics (ash, sulfur, and type). Most of the information in this dataset comes from the EIA-923 form, and Velocity augments this data with FOB prices obtained from railroad waybills and their own internal model. The second dataset focuses on coal routes and includes leg-level transportation information, such as the mode of transport (railroad, truck, vessel), carrier details for railroads, costs, and routing points. This data is sourced from waybills and Velocity's proprietary research.

Coal Transaction Data [1979-2000]. This dataset provides historical information on coal transactions and contracts from 1979 to 2000, sourced from the EIA's Coal Transportation Rate Database. It includes details on transportation rates, contract terms, and other relevant information about coal shipments during this period. We use this dataset to obtain historical information on contract types and duration.

[55] The data is available at more disaggregated industry levels (e.g., surface vs. underground mining) and geographical levels (e.g., county), but both of these more detailed data sources have the disadvantage of being much sparser, both along the time and geographical dimension.

[56] https://www.cdc.gov/niosh/mining/content/economics/safetypayscostesttechguide.html

G.2 Hourly Electricity Generation Construction for Power Plants

Since we estimate Cournot competition for every hour, we must observe hourly generation data of all generators operating in ERCOT. This data is sourced from three main datasets: (i) the CEMS database of hourly generation from the EPA, (ii) the ERCOT 60-day hourly generation report, and (iii) EIA monthly generation data at the plant-fuel level. The CEMS data cover all fossil-fuel generation units subject to environmental regulations but exclude renewables and other plants not regulated under these standards. For renewables, we rely on unit-level data from the ERCOT 60-day generation report. For a small subset of units without hourly generation data from either source, we use EIA Form 923 to obtain monthly generation information and assume that monthly generation is uniformly distributed across hours within the given month.

G.3 Capacity Estimation of Coal Mines and Power Plants

Power Plants

We calculate capacities separately for fossil-fuel power plants and other generation sources. For fossil fuel power plants, we obtain capacity factor information by fuel type from the GADS database, calculated based on the maintenance frequency of power plants using different fuel types. In our analysis, these capacity factors are applied uniformly across all hours; we do not account for strategic maintenance timing, as this involves a complex, dynamic problem that is beyond the scope of this study. The effective capacity of each unit is thus determined by multiplying its capacity factor by its nameplate capacity.

For solar, wind, hydroelectric, geothermal, other renewables, and nuclear power plants, we calculate capacity factors based on their generation, as these are zero-marginal-cost generators, and their actual generation should reflect their availability to produce electricity. For these generators, we compute a unit-level capacity factor by averaging their generation within a given month-hour-weekend/weekday bin and dividing it by their nameplate capacity. Multiplying this capacity factor with the nameplate capacity provides the effective capacity of the generator by hour type.

Coal Mines

The EIA collects data on coal mine capacity, which have been used in prior research (Johnsen et al., 2019). However, the EIA no longer makes this data available to researchers. Consequently, we infer mine capacity from production data. For each year, we define a mine's capacity as the maximum historical production observed at that mine up to that year. This approach makes mine capacity time-varying, as it reflects changes in production over time.

G.4 Heat Rate Calculations and Coal Weight to Heat Content Conversion

To determine the cost of fossil-fuel generators, we calculate their heat rate annually by dividing their total MMBtu fuel consumption by their total electricity generation. This heat rate is assumed to remain constant throughout the year. To estimate the cost per MMBtu, we multiply the inverse of the heat rate by the per-MMBtu cost of coal.

To convert coal quantities from short tons to MMBtu, we calculate an annual conversion factor by dividing the total coal production (in short tons) by the total heat content of coal produced during the same year. This conversion factor is then assumed to remain constant throughout the year.

G.5 Marginal Cost Estimation Details for Coal Mines

Matching the Coal Cost Guide with the MSHA data

We match the Coal Cost Guide dataset to the MSHA data as follows. First, we rely on the 'technology' variable in the MSHA data to match the mine types. We group 'surface', 'strip/open pit', and 'mountain top' mines in the MSHA data into the 'surface mine' category of the Coal Cost Guide, and the 'continuous', 'longwall', and 'room-pillar' technologies from the MSHA into the corresponding technologies in the Coal Cost Guide. If the technology variable is unobserved in the MSHA dataset, we categorize the mine type as 'other'. We keep only mines of the types 'Auger', 'Bank', 'Surface', 'Underground', and 'Surface at Underground' from the MSHA data, in order to exclude non-production units such as administrative offices.

We categorize mines for which there are one or more shafts reported in the MSHA dataset as 'shaft access' in the Coal Cost Guide, and the remaining mines as 'ramp access'. We use the 'maximum vein thickness' variable in the MSHA data to classify the mines into the corresponding vein thickness category in the Coal Cost Guide. If the vein thickness is unobserved in the MSHA data, we assign the smallest vein thickness type (which corresponds to the highest marginal cost). We assign each mine to the Coal Cost Guide capacity categories based on its capacity as calculated in Section G.3.

Computation of Labor-to-Material-Cost Ratios

We use the 'hourly labor cost' subdivision of the operating costs variable in the Coal Cost Guide as our definition of variable labor costs, and the remaining operating costs reported as intermediate input costs. We also add the 'equipment costs' reported under capital expenditure into intermediate input costs because extracting more coal requires more equipment. Given that equipment costs are unlikely to fully depreciate within a year, unlike the other operating costs listed, we let it depreciate linearly over a period of 5 years. We consider the remaining capital expenses that are listed in the Coal Cost Guide, 'Preproduction Development', 'Surface Facilities', 'Working Capital', 'Engineering & Construction Management', and 'Contingency' to be fixed costs, so we do not include these in our marginal costs measures.

Taking the ratio of these two operating costs, variable labor and intermediate input expenditure, results in the variable $\bar{\gamma}_{\theta(iu)}\frac{p^m}{w^l}$. We assume that the ratio of intermediate input prices over wages is the same across mines in a given year, which allows us to recover $\bar{\gamma}_{\theta(iu)}$ up to a constant. Combining this information with the mine-specific hourly wage that we described below allows us to recover $\gamma_{\theta(iu)}$.

Computation of Mining Marginal Costs

The unit labor and intermediate input costs in the Coal Cost Guide are based on the average input requirements within a mine type. However, the mines in our dataset can diverge from the average daily labor requirements in the Coal Cost Guide because mines are heterogeneous in terms of their productivity. This prevents us from directly using the cost information in the Coal Cost Guide. To address this, we compute observed labor productivity for mine i as hours worked per ton of coal extracted l_{iu}/q^c_{iu} from the MSHA data. This labor productivity corresponds to total factor productivity under the Leontieff production function assumption as shown in Equation (8).

One complication is that the MSHA data reports the total hours worked per year for all labor, including production and non-production workers. Since non-production workers should be considered as fixed costs, we isolate the production worker hours using the 'hourly labor' information in the Coal Cost Guide. In particular, we convert the total hours reported in the MSHA data to the total hours worked by hourly workers by taking the ratio of the hourly worker requirement to the total worker requirement reported in the Coal Cost Guide. We compute this ratio as an average at the level of the mine type θ, as surface and underground mines and mines with different capacities differ in their labor-to-material ratios. We multiply this ratio by the total hours reported in the MSHA data to obtain the total hours worked by hourly workers in mine i in a given year.

We compute hourly wages w^l_{iu} from the BLS data as explained above. We multiply hourly wages with labor productivity to compute the labor cost per ton in each mine, and combine this with the ratio of intermediate to labor costs to compute marginal costs for each mine, as shown in Equation (8).

We then aggregate these marginal costs to firm-level as described in Section 6.3.1. For firms with a small number of mines, this leads to a discrete cost function, which makes it difficult to obtain the solution of Nash bargaining. Therefore, we smooth the cost function at the firm level using a polynomial approximation.

G.6 Cournot Demand Estimation Details

As described in the main text, we assume a Cournot competition model with strategic and fringe firms. We estimate a separate and independent Cournot competition model in each hour type, which is a month-hour-weekday/weekend combination. We assume that all regulated firms and firms whose total capacity is below 5% are fringe firms in a given year. With these assumptions, modeling downstream competition requires the consumer demand and supply of fringe firms every hour type.

We assume that total demand is fully inelastic in the short run and calculate the inelastic demand by averaging the actual observed demand in each hour type. We assume that this average is the expected demand during the bargaining between upstream and downstream firms. For fringe supply, we first calculate the cost curve of each fringe firm and aggregate them to the industry level. We assume that fringe firms supply a quantity in a given hour such that the price equals the marginal cost.

Subtracting this fringe supply curve from the inelastic demand yields the industry demand curve faced by strategic firms. The analysis then follows standard Cournot competition modeling, where each strategic firm faces a residual demand curve determined by the industry demand minus observed generation from other strategic firms.

G.7 Disagreement Payoff Estimation

Coal Mines

We assume that the disagreement payoff of mining firms equals the profit from sales to all other firms, implying that if a negotiation fails, the coal mine will not produce the quantity that is negotiated. We think this assumption is reasonable because for mining firms, each transaction is small relative to total capacity as mining firms transact with many partners.

Power Plants

For power firms, the assumption of no production in the event of a disagreement is unrealistic, as coal power plants contribute significantly to the total capacity of power firms and require substantial upfront capital investments. Moreover, power plants are subject to reliability requirements. Thus, it is more reasonable to assume that coal power generators would continue operating even if negotiations fail. In such cases, we assume that the power firm would procure coal from the spot market. However, the spot market is volatile, and delivery is not guaranteed. If power firms are risk-averse, as supported by Jha (2022) in the context of regulated power plants, it is necessary to account for disutility from uncertainty. To address this, we calculate the yearly mean spot price of coal sold from the same basin and coal type, along with its standard deviation. Using the estimates from Jha (2022), who finds that "plants are willing to trade a \$1.62 increase in their expected costs for a \$1 decrease in their standard deviation of costs", we assume that the power plants perceive the cost of coal in the spot market as the mean spot price plus 1.62 times its standard deviation.

G.8 Bargaining Model Estimation Algorithm

Consider a grid of potential wholesale coal prices, denoted by $[0, \bar{w}]$. The following steps outline the procedure to compare the resulting equilibria across these different prices:

Monopsonistic Bargaining

1. First, calculate how much quantity will be supplied by the upstream firm at any price w. Denote this as $q^{ms}(w)$.

2. Calculate upstream profits as a function of w and $q^{ms}(w)$.

3. Calculate downstream profit as a function of w and $q^{ms}(w)$. To find the downstream profit, we need to construct the cost curve of the downstream firm for a given $q^{ms}(w)$. Since in monopsonistic bargaining, the upstream firm chooses the quantity, we assume that the downstream firm will use that quantity in production. The way we operationalize this is as follows:

   - We construct the supply curve of all other power plants in the power company's portfolio. We take that as given, and it is not affected by the negotiation between coal mines and the power company.
   - We also take as given other prices such as price of natural gas and coal from other mining companies. This, together with the assumption above, constructs the supply curve from all inputs other than the one negotiated with the mining company.
   - We assume that the quantity supplied by U, $q^{ms}(w)$, is allocated to each coal generator in the portfolio of the power company proportionally to their capacity. For example, if the downstream quantity is 100 tons, and we have two coal power plants, A and B, whose capacity is 50 tons and 200 tons, respectively, we assume that 20 tons (100 tons x (50/250)) will go to plant A and 80 tons will go to plant B. This will matter to the extent that plant A's heat rate is different than plant B's. If their heat rates are the same, this is without loss of generality.
   - We further assume that the coal quantity is distributed uniformly throughout each hour of the day. For example, there are 8,760 hours in a given year, so plant A will have 20/8,760 tons of coal to use in a given hour. This assumption ignores the optimal intertemporal allocation of limited coal quantity over the course of the year. For example, if coal is limited, Plant A might want to use all of it when the price is high. However, we think the potential role of this dynamic channel is limited as coal generators operated the majority of the time during our sample period.
   - With these steps, we now have the tons of coal allocated to each plant in a given hour. The downstream firm takes as given that the allocated coal is used for electricity generation under any market conditions. Then, it optimizes the production of the rest of its portfolio following static profit maximization under Cournot competition.

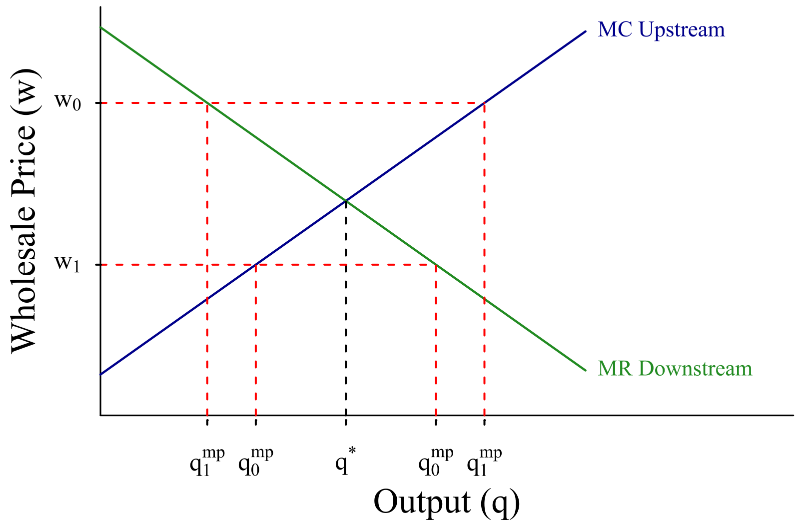
4. Now we have the profits as a function of wholesale prices for both parties. Construct the Nash product.

5. For each β, find w that maximizes the Nash product. This gives us $q^{ms}(\beta)$ and $w^{ms}(\beta)$.

Monopolistic Bargaining

1. In the monopoly setting, we calculate how much quantity will be demanded by the downstream firm. To find this quantity, take w as given and construct the downstream firm's

Figure OA-3: Conduct Identification: Intuition



Notes: This figure illustrates how we identify vertical conduct for two different observed values of the wholesale price: w_0 and w_1.

supply curve as a function of w. When doing this, we condition on all prices except w_{ud} so the part of the supply curve that comes from non-coal generators or parts of the coal generators that come from other coal mines $(-u)$ remains fixed. In other words, if d receives coal from multiple suppliers, then w_{ud} affects only the remaining capacity of coal generators in the firm's cost curve. After obtaining the cost curve as a function of w_{ud}, we solve the Cournot model to calculate the quantity produced by firm d. The firm produces this quantity from their lowest cost generators. Using this, we calculate the corresponding coal input demand of d from u, $q^{mp}(w_{ud})$.

2. Given $q^{mp}(w_{ud})$ and w_{ud}, find the upstream profit for each w_{ud}.

3. We fix a β and construct the Nash product.

4. For each β, find w that maximizes the Nash product, which gives us $q^{mp}(\beta)$ and $w^{mp}(\beta)$ for $\beta \in (0, 1)$.

Vertical Conduct Identification

To identify the vertical conduct, we use $w^{ms}(\beta)$ and $w^{mp}(\beta)$ calculated in the estimation. Then we find β^{ms} and β^{mp} such that $w^{ms}(\beta^{ms}) = w^{obs}$ and $w^{mp}(\beta^{mp}) = w^{obs}$. With these β values, we apply Theorem 1 to select the conduct, which implies that the monopsonistic equilibrium exists if $\beta \geq \beta^*$, while the monopolistic equilibrium exists if $\beta \leq \beta^*$. Lemmas 1-2 guarantee that either $\beta^{ms} < \beta^*$ and $\beta^{mp} < \beta^*$ or $\beta^{ms} > \beta^*$ and $\beta^{mp} > \beta^*$. To see this, note that $dq^{ms}/d\beta < 0$ by Lemma 1 and $dq^{mp}/d\beta > 0$ by Lemma 2. By the FOCs, we also have that $dq/dw^{ms} > 0$ and $dq/dw^{mp} < 0$. The chain rule implies that $dw^{ms}/d\beta < 0$ and $dw^{mp}/d\beta < 0$. Therefore, w is decreasing with β under both types of conduct. Since $w^{ms}(\beta^*) = w^{mp}(\beta^*)$, it follows that either $\beta^{mp} < \beta^*$ or $\beta^{mp} > \beta^*$, implying a unique conduct.

Figure OA-3 provides a graphical intuition for our procedure to identify vertical conduct. Assume a certain wholesale price w_0 is observed. The corresponding monopsonistic and monopolistic quantities q_0^{ms} and q_0^{mp} are computed using the two estimation algorithms that were explained above. We determine vertical conduct by comparing these quantity values to the joint-profit-maximizing output value q^*, following Proposition 4. In this particular example, $q_0^{ms} < q^*$ and $q_0^{mp} > q^*$, so vertical conduct is monopsonistic. For a different wholesale price w_1, we obtain the opposite result, so vertical conduct is monopolistic for wholesale price w_1. The bargaining parameter β is estimated as the value that rationalizes the observed wholesale price under the vertical conduct model that was found to apply.

Standard Error Calculations

The only source of uncertainty in our model is the inelastic demand curve in the market for a given hour type. We calculate the inelastic demand in a given hour type t as the average demand value across a finite sample of hours of that type in our estimation. To account for this uncertainty in the estimates, we implement a bootstrap procedure with 100 iterations, where we calculate the average demand of hour type t after resampling hours within that hour type with replacement. We then repeat the entire estimation procedure to obtain a bootstrap distribution of our estimates.

H Additional Tables

Table OA-2: Summary of limit cases for β

Case	Equilibrium Condition		Explanation	
	FOC	Cons. Max	FOC	Cons. Max
Sim. MP, $\beta = 1$	$mr(q) = c(q)$	$mr(q) = c(q)$	(D-TIOLI)	(D-TIOLI)
Sim. MP, $\beta = 0$	–	–	–	–
Sim. MS, $\beta = 1$	–	–	–	–
Sim. MS, $\beta = 0$	$mc(q) = p(q)$	$mc(q) = p(q)$	(U-TIOLI)	(U-TIOLI)
Seq. MP, $\beta = 1$	–	$mr(q) = c(q)$	–	(D-TIOLI)
Seq. MP, $\beta = 0$	$mr(q) = w$	$mr(q) = w$	(D.M.)	(D.M.)
Seq. MS, $\beta = 1$	$mc(q) = w$	$mc(q) = w$	(C.M.)	(C.M.)
Seq. MS, $\beta = 0$	–	$mc(q) = p(q)$	–	(U-TIOLI)

Notes: This table summarizes the equilibrium of monopsonistic and monopolistic bargaining in the limit cases separately using FOCs and from the constraint maximization problems. We use the following abbreviations: "D-TIOLI" (downstream take-it-or-leave-it) and "U-TIOLI" (upstream take-it-or-leave-it), "D.M." (double marginalization), "C.M." (classical monopsony). "–" denotes that equilibrium does not exist.

Table OA-3: Key Notation Used in the Model

Mining (Upstream)		Power (Downstream)	
q^c_{iu}	Coal output of mine i (short tons)	Q^D_t	Electricity demand in hour t
l_{iu}	Labor hours used at mine i	Q^{fr}_t	Fringe supply in hour t
m_{iu}	Intermediate inputs at mine i	Q^{st}_t	Strategic supply in hour t
$\theta(iu)$	Mine type for mine i	P_t	Electricity price in hour t
$\gamma_{\theta(iu)}$	Labor–material ratio by mine type	c_{jd}	Marginal cost of generator j in firm d
ω_{iu}	Productivity shifter at mine i	k_{jdt}	Capacity of generator j in hour t
w^l_{iu}	Hourly wage at mine i	$C_{dt}(Q_{dt})$	Downstream cost function in hour t
p^m_{iu}	Material unit cost at mine i	Q_{-dt}	Output of other downstream firms in hour t
λ_{iu}	Conversion factor (short ton to MMBtu)		
c_{iu}	Marginal cost at mine i		**Bargaining**
c_u	Vector of mine marginal costs for firm u	D_u	Set of downstream partners for firm u
$\bar{q}_u$	Vector of mine capacities for firm u	q_{ud}	Quantity traded between u and d
$C_u(Q_u)$	Upstream cost curve for firm u	w_{ud}	Wholesale coal price between u and d
Q_u	Total coal output of firm u	π_u	Profit function of firm u
n_u	Number of mines owned by u	π_{dt}	Period-t profit of downstream firm d
$\bar{q}_{iu}$	Capacity of mine i	Q^{ms}_{dt}	Monopsonistic downstream quantity in hour t
		Q^{mp}_{dt}	Monopolistic downstream quantity in hour t
		β_{ud}	Bargaining power of buyer in pair (u, d)
		Q_{-d}	Total coal output supplied to downstream partners other than d
		Q^{-u}_{dt}	Disagreement output (without upstream u) for firm d in hour t

Notes: Subscripts i, j, u, d, and t denote mine index, generator index, upstream firm, downstream firm, and hour type, respectively.

Table OA-4: Buyer Power from the Empirical Bargaining Literature

Sources	Industry	Range	Mean	Median	Std. Dev.
		Panel A. Firm-to-Firm			
Crawford and Yurukoglu (2012)	Television	[0.170, 0.770]	0.559	0.595	0.159
Gowrisankaran et al. (2015)	Healthcare	{0.500}	0.500	0.500	0
Crawford et al. (2018)	Television	[0.280, 0.370]	0.325	0.325	0.064
Ho and Lee (2017, 2019)	Healthcare	[0.310, 0.470]	0.387	0.38	0.080
Hosken et al. (2024)	Healthcare	[0.370, 0.990]	-	0.93	-
Alviarez et al. (2025)	Intl. Trade	-	0.812	-	0.101
Cuesta et al. (2025)	Healthcare	[0.167, 0.680]	0.476	0.518	0.187
		Panel B. Union-to-Firm			
Svejnar (1986)	Multiple	[0.140, 0.890]	0.513	0.555	0.281
Doiron (1992)	Woodworking	[0.499, 0.791]	0.648	0.678	0.116
Abowd and Lemieux (1993)	Multiple	[0.608, 0.850]	0.727	0.738	0.078
Mumford and Dowrick (1994)	Coal	{0.141}	-	-	-
Cahuc et al. (2006)	Multiple	[0.020, 1.000]	0.804	0.855	0.247
Coles and Hildreth (2000)	Manufacturing	-	0.144	-	0.088
Breda (2014)	Multiple	[0.636, 0.805]	0.713	0.709	0.061
Fuess (2001)	Multiple	[0.176, 0.592]	0.357	0.250	0.099
		Panel C. Cooperative-to-Firm			
Prasertsri and Kilmer (2008)	Dairy	[0.217, 0.334]	0.267	0.267	0.034
Ahn and Sumner (2012)	Dairy	[0.861, 0.912]	0.889	0.896	0.020
Ge et al. (2015)	Dairy	[0.880, 0.881]	0.8804	0.8803	0.000
Hayashida (2018)	Dairy	[0.209, 1.179]	0.8739	0.9765	0.2470
Shokoohi et al. (2019)	Dairy	{0.690}	-	-	-
Sano et al. (2022)	Vegetables	[0.481, 0.844]	0.707	0.707	0.089

Notes: This table summarizes bargaining parameters from empirical papers implementing models with a *Nash-in-Nash* bargaining protocol. All weights denote buyer power. We summarize the estimates from the authors' preferred specifications when available. Some papers (e.g., Crawford and Yurukoglu (2012)) provide weights from bargaining pairs (some only report the distribution, e.g., Coles and Hildreth (2000)), and others (e.g., Abowd and Lemieux (1993)) provide weights under different model specifications. Cahuc et al. (2006) do not specifically study union-based wage negotiation, but we include them in this panel for their focus on wage bargaining.

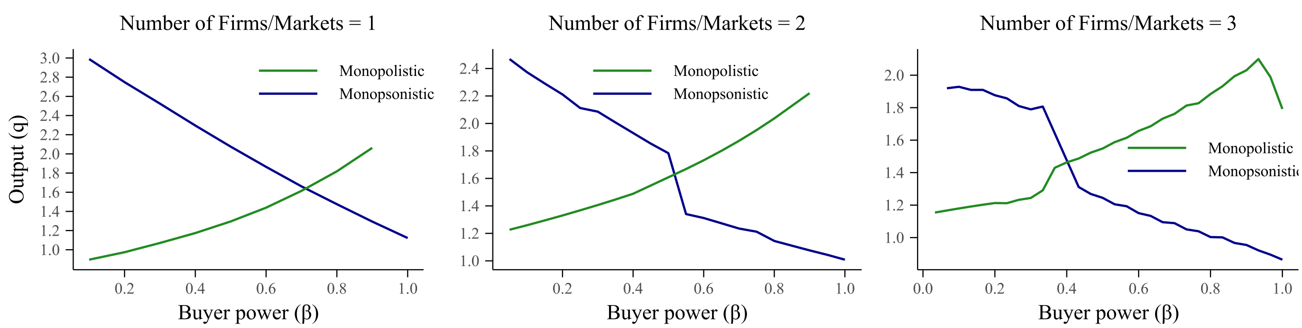
Table OA-5: List of Firms

Upstream Firms	**Downstream Firms**	
	A. With Coal Plants	*B. Without Coal Plants*
Peabody Energy Corp	NRG Energy Inc	Energy Capital Partners
Rio Tinto Energy America	Vistra Energy	Energy Future Holdings Corp
Westmoreland Coal Co		NextEra Energy Inc
Cloud Peak Energy		
Arch Resources Inc		
Foundation Coal Corp		
Peter Kiewit Sons Inc		
Alpha Natural Resources LLC		
Vistra Energy		

Notes: This table lists the upstream and downstream firms in Section 6. The list of upstream firms and downstream firms with coal power plants is included in the bargaining model. Downstream firms without coal power plants are strategic firms in the demand model with more than 5% market share.

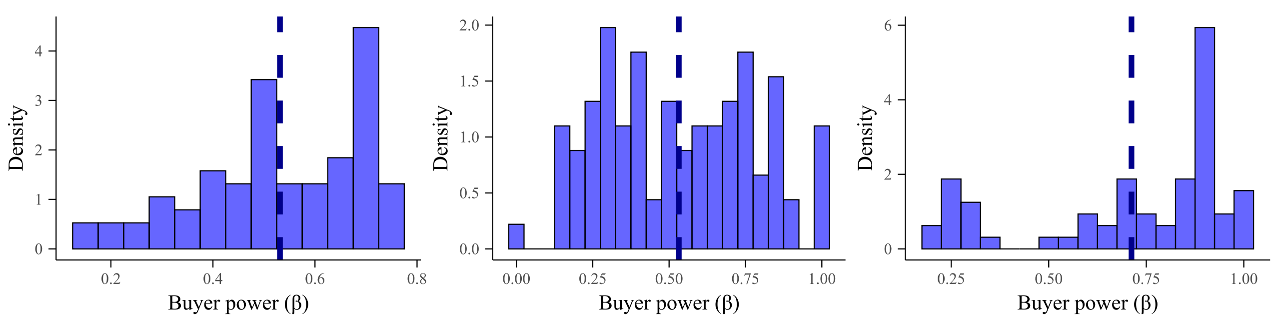
I Additional Figures

Figure OA-4: Change in β^* with the Number of Downstream Firms



Notes: This figure presents numerical simulation results showing the relationship between output (q) and buyer power (β) when there are one to three firms in each downstream market.

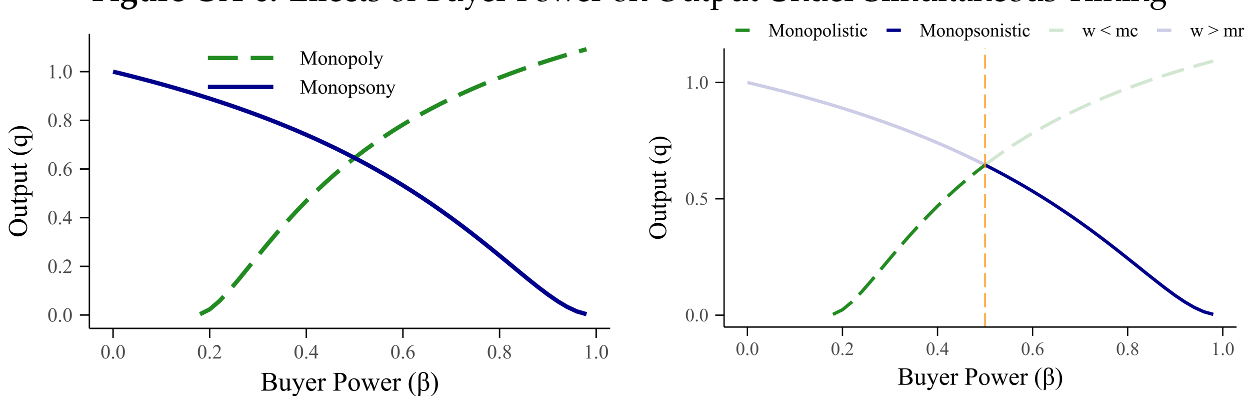
Figure OA-5: Buyer Power from the Empirical Bargaining Literature



(a) Firm-to-Firm **(b)** Union-to-Firm **(c)** Cooperative-to-Firm

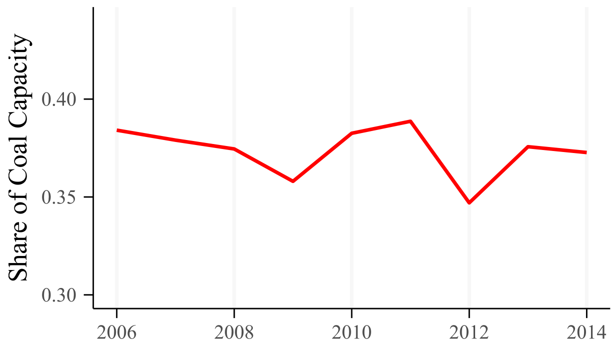
Notes: This figure presents the distribution of bargaining weights from Table OA-4.

Figure OA-6: Effects of Buyer Power on Output Under Simultaneous Timing



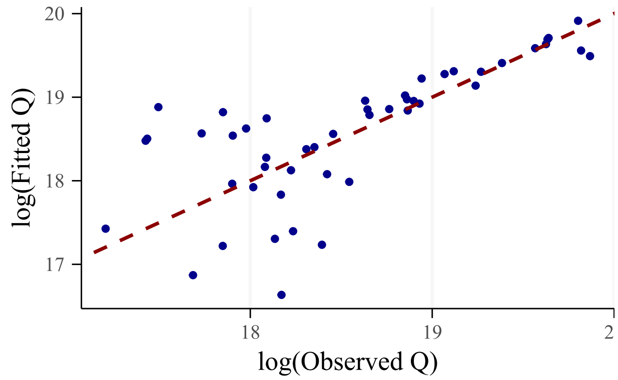
Notes: Panel (a) simultaneous case of Figure 1(c). Panel (b) is the simultaneous case of Figure 3(b). The simultaneous monopolistic bargaining model does not have a solution for $\beta < 1/6$ as we show in Appendix D.3.2.

Figure OA-7: ERCOT Share of Coal Generation



Notes: This figure reports the share of electricity generation by coal-fired generators in the ERCOT market during the sample period between 2006 and 2014.

Figure OA-8: Observed vs Model-predicted Quantities



Notes: This figure shows the scatter plot of observed vs. model-predicted coal transactions in MMBtu. An observation is a combination of firm pair and year.

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