# Dynamic Bargaining between Hospitals and Insurers

Jacob Dorn*

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**Abstract**

Many markets, including American healthcare markets, feature bilateral bargaining to determine contracts that remain in place for multiple years. Researchers studying these markets generally assume contracts are short-lived. In the United States, hospitals and commercial insurers calculate prices as long-lived multiples of quantities used as benchmarks, such as hospital-set list prices and government-set Medicare payments. This study uses a unique panel dataset on hospital–insurer contracts to study how persistent increases to Medicare reimbursement would impact negotiated payments on behalf of the commercially insured. I extend standard vertical market models to accommodate forward-looking bargaining over multiperiod contracts, and I prove the extension uniquely controls the growth of relevant bargaining states. I apply the model to consider a one-percentage-point annual increase in Medicare payments. The model allows forward-looking negotiators to offset future Medicare-driven price increases by reducing starting prices. After nine years, I estimate that spending on behalf of the commercially insured would increase by 1.319%. Extrapolated nationally, the change would increase 2015 spending by $4.98 billion. In contrast, a myopic model lacking forward-looking offsets would overestimate the effect of the Medicare reimbursement reform by $2.35 billion.

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# 1 Introduction

Many vertical markets feature multiyear contracts reached through bilateral bargaining. For example, telecommunications providers agree to pay cable networks based on intricate contracts that can last up to a decade (Marcelo, 2021). Manufacturers employ sophisticated price indexing schemes to maintain supplier contracts over multiple years (Joskow, 1987). In the context I consider, commercial health insurers in the United States typically use external benchmarks, such as hospital-set list prices and government-set Medicare payments, to set prices with hospitals under contracts that last for multiple years (Abbey, 2012, Cooper et al., 2019). The resulting payments under these contracts exceed $400 billion annually.

This paper develops and estimates a model of vertical market bargaining over multiyear contracts. The model is applied to commercially insured hospital care in the United States, investigating how changes in the growth rate of benchmark prices would affect spending on behalf of commercially insured patients. The work focuses on the effect of the proposed changes on private insurer payments negotiated as fixed multiples of benchmark prices. The proposed model enables negotiators to look forward and offset future benchmark price increases by reducing their associated multiple and starting prices. The empirical analysis utilizes a novel panel dataset summarizing West Virginia's hospital–insurer contracts from 2006 to 2015, which I describe in Dorn (2024).

The primary counterfactual considers a change in government-set Medicare reimbursement to track reported hospital cost growth. The counterfactual is implemented as a one-percentage-point increase in annual payments for the benchmark prices used for 47% of West Virginia private insurer spending. I find that persistent Medicare payment increases would have real effects on the payments negotiated by commercial insurers, even after accounting for forward-looking offsets. After nine years, the change increases inpatient spending on behalf of the commercially insured would extrapolate nationally to a $4.98-billion increase in hospital spending.

This work contributes to important policy questions around Medicare reimbursement. Medicare is a large national program that reimburses hospitals for inpatient care based on diagnosis with local wage adjustments. Hospitals argue it is "broadly acknowledged" that Medicare spending has failed to keep up with their costs (AHA, 2022). In the era I study, I find that growth in Medicare payments to West Virginia hospitals trailed the growth in hospital reported costs by approximately one percentage point annually.

The vertical market bargaining literature generally adopts a single-period-contract approach, which is unsuitable for understanding multiyear contract responses. In vertical markets, downstream retailers like insurers trade with upstream suppliers like hospitals. In a vertical market, the gains from trade of a downstream retailer with one supplier depend on how negotiation failure will affect the retailers payments to other suppliers under the prevailing contracts. Researchers typically rely on secondary sources on contract outcomes like payments, but these sources rarely reveal the timing of contract revision. Consequently, the prevailing approach uses data from a short time frame and assumes a static model in which all contracts are negotiated at the start of the bargaining game's single period.

In such a single-period model, Medicare reimbursement levels and other benchmark prices have no real effect because negotiators can immediately offset changes in Medicare payment levels by revising their multiple in the opposite direction. Conversely, a myopic bargaining model would overestimate Medicare reimbursement reform effects if negotiators care about multiple periods. Forward-looking negotiators that target a time-weighted average of payments respond to anticipated future price increases by reducing starting prices.

Certain methodological challenges, such as state space growth, emerge when forward-looking bargainers negotiate multiperiod contracts in vertical markets. To illustrate the state space growth, consider a hospital and insurer that negotiate a two-year contract today. When bargaining, the negotiators assess the value of agreement relative to the value of disagreement at the current moment. Suppose that at any time the two parties fail to reach an agreement, they will quickly return to the bargaining table to minimize their loss. In a vertical market, the outcome of the two-year contract will affect how each party bargains with other firms in the future while the contract remains in place. As the parties repeatedly disagree, other negotiations draw nearer and then are resolved, introducing a new bargaining state for each return to the bargaining table. The single-period-contract approach manages this challenge by ensuring that future contracts are simultaneously formed in every future period, regardless of the outcome of any current negotiation. However, the single-period-contract approach would mechanically rule out the mechanism of interest, the role of benchmark price dynamics on commercial insurer prices negotiated as multiyear fixed multiples of those benchmark prices.

Methodologically, this work proposes a dynamic vertical market bargaining model, enabling negotiation of multiperiod contracts with uncertainty over future profits and benchmark prices. The proposed model builds on the Ho and Lee (2017) static hospital–insurer Nash-in-Nash bargaining model, extending it to multiyear agreements. In static Nash-in-Nash bargaining, contracts are chosen to split gains from trade relative to not contracting for the game's single period. In the proposed dynamic model, contracts are chosen to split gains from trade relative to not contracting for an instant and then returning to the bargaining table. Such a model involves an infinite number of bargaining states. I show that this model produces the same predictions as if the players negotiate relative to an *impasse* point (Binmore et al., 1989). Under impasse, the firms persistently attempt to bargain and at every instance all players expect the pair to succeed, but each period ultimately ends in disagreement.

This dynamic extension corresponds to the Kalai (1977) proportional bargaining solution, which aligns with laboratory behavior and uniquely controls the number of relevant bargaining states. In principle, forward-looking negotiators time must consider how the changing path of internalized spillovers would affect their negotiations after every period of impasse. As periods become short, the number of bargaining states is unbounded. Under Kalai proportional bargaining, gains from trade can be defined relative to a specific impasse point that involves only a small number of bargaining states — namely, the periods in which others respond to the pair's anticipated success. The bargaining model yields a moment for estimation with uncertainty, a property that does not hold in general under Nash bargaining. Kalai proportional and Nash bargaining differ when an important component of the effect of the negotiated price on subsequent profit is the price's spillovers on future negotiations. This study's estimates suggest that internalized spillovers in West Virginia were usually minimal. Consequently, Kalai proportional bargaining would be a valuable approximation in my empirical setting even if negotiators truly followed a more complex dynamic Nash bargaining model. The existence, if any, of an empirically tractable representation of Nash bargaining with important time-varying spillovers is an open direction for future work.

The key inputs to the project's bargaining model are hospital and insurer demand functions. I take a similar approach to hospital and insurer demand estimation as work like Ho and Lee (2017) and Ghili (2022). Hospital demand depends on ex ante insurance demand and ex post patient choices within an insurer's network. For hospital demand, I leverage data from Blue Cross patients, who have comprehensive network access, to predict ex post hospital choices and the ex ante utility of a network of hospitals to a consumer before becoming sick. I model patients as choosing a hospital based on diagnosis, home location, and insurer networks. Insurer demand depends on consumer willingness to pay for access to an insurer's hypothetical network before they become sick, which is generally correlated with premiums. I estimate the contribution of ex ante network quality to ex ante insurer choice using inpatient data from 2016 and leveraging Affordable Care Act (ACA) premium restrictions. The regulations prevented insurers from differentiating premiums within geographic rating areas beyond a limited set of homogeneously incorporated factors. The contribution of network quality to insurer sales conditional on premiums is identified by the correlation of network quality with sales within rating area. Combined, these models predict how adding or removing a hospital from an insurer's network would affect the insurer's sales and the distribution of patients across hospitals and insurers.

The estimated model of forward-looking bargaining over multiperiod contracts leverages the estimated hospital and insurer demand functions and West Virginia's unique contract panel data. Unlike the standard single-period approach, I estimate bargaining parameters using only new contracts and consider gains from trade over the multiple years a contract can remain in place. The key parameter is the patience (or discount) rate $\beta$: the degree to which bargainers value inflation-adjusted profits next year relative to profits this year. A larger patience parameter $\beta$ corresponds to bargainers being more patient and doing more to offset future Medicare-driven price increases by reducing their negotiated multiple and associated starting price. I obtain a convenient test of myopia as the null hypothesis that $\beta = 0$. I identify $\beta$ from variation in anticipated price increases and contract length.

Empirically, I find that bargainers are forward-looking and respond to future Medicare-driven price increases. I estimate that bargainers value one dollar next year equivalently to 90 cents this year. I consider a one-percentage-point annual increase in Medicare payments that would lead Medicare payments to roughly track hospital costs. The change is implemented as a surprise announcement at the end of 2006 that is fully known in every subsequent period. I estimate that this change to Medicare reimbursement would increase spending on behalf of the commercially insured by 1.319%. Extrapolated nationally in 2015 and converted to 2019 dollars, the effect corresponds to a $4.98-billion increase in spending. There are important spending dynamics beyond the general increase, including years in which payments would decrease. The two alternative models available are a myopic model and a single-period contracting model. Under a myopic model, the estimated effect in 2015 would be too large by $2.35 billion. Under single-period contracting, Medicare reimbursement dynamics would have no effect.

This study also examines the impact of regulations aimed at curbing the growth of hospital-set list prices. Hospital list prices — the standard benchmark for small and medium-sized insurers — grew roughly three percentage points faster than costs in West Virginia. I consider a lax regulation that would cut aggregate list price inflation to roughly two percentage points faster than costs. The associated regulation would reduce payments by 0.11%–1.3% depending on the year. However, the contracts benchmarked to hospital list prices are rarely revised. Consequently, most of the effect of the list price regulation are mechanical effects on renewing contracts, and the forward-looking addition of the dynamic model has only a small effect on the predicted change in spending.

This work illustrates that a multiperiod perspective is needed for dynamic questions in vertical markets, and offers a framework for tractably adopting such a perspective in empirical work. When negotiators are forward-looking about multiperiod contracts, estimates of the effect of Medicare reimbursement reform and stricter list price caps based on single-period-contract models have predictable biases. However, forward-looking negotiation in vertical markets can easily grow empirically intractable. This work proposes an internally consistent model for such dynamic bargaining that is uniquely tractable. The finding that forward-looking offsets are an important response to hypothetical Medicare reimbursement reform underscores the broader importance of adopting a dynamic perspective to understand the consequences of dynamic changes in vertical markets.

The remainder of this work is as follows. The remainder of Section 1 discusses key related work. Section 2 uses a toy model to illustrate that forward-looking bargainers negotiating a fixed multiple of an externally-set benchmark price respond to future benchmark price increases by reducing starting prices. Section 3 proposes this work's empirical model. Section 4 briefly summarizes the data I use from West Virginia, outlines how I estimate the empirical model with the data at hand, and presents the estimated parameters. Section 5 presents the estimated counterfactual effects of changes in benchmark price dynamics on payments to hospitals made on behalf of the commercially insured for inpatient care. Section 6 concludes and discusses some implications of the work.

## Related Literature

My work on dynamic vertical market bargaining between hospitals and insurers touches on literature from many fields. I briefly summarize the paper's key contributions here and discuss other related work in Appendix B.

This work extends the existing vertical market bargaining literature to enable bilateral bargaining to determine contracts that can begin at different times for different pairs. Lee et al. (2021) and Yürükoğlu (2022) offer recent summaries on vertical market contracting. The literature generally models bargaining over static contracts that remain in place for the game's single period. A smaller body of literature models dynamic period-by-period contracting, in which current networks can affect future contract formation but contracts remain in place for only a single period (Lee and Fong, 2013, Liu, 2021, Tiew, 2022, Deng et al., 2022, 2023). I extend that literature by proposing a tractable vertical market bargaining model that enables multiyear contracts that are formed at different times.

The workhorse approach to empirical vertical market bargaining is the Nash-in-Nash bargaining model (Collard-Wexler et al., 2019, Bagwell et al., 2020). In the Nash-in-Nash model, contracts result from Nash bargaining over gains from trade that are calculated holding simultaneous decisions fixed (Nash equilibrium). Recent work argues the Nash equilibrium assumption can do a poor job of replicating true responses to disagreement (Ho and Lee, 2019, Yu and Waehrer, 2019, Froeb et al., 2021, Liebman, 2022, Ghili, 2022). Empirical

Nash-in-Nash bargaining models have a zero-sum structure in many (Lee and Fong, 2013, Ho and Lee, 2017, Crawford et al., 2018, Collard-Wexler et al., 2019) but not all (Crawford and Yurukoglu, 2012, Grennan, 2013, Gowrisankaran et al., 2015) applications. Under zero-sum bargaining, every dollar in added profit for one firm corresponds to one dollar in lost profit for their partner. Such zero-sum games are called *Transferable Utility* (TU) games in the coalitional bargaining literature. I use the Kalai proportional bargaining solution, which is the same as Nash bargaining in the standard TU case and which I show adapts uniquely well to dynamic bargaining settings. Another popular bargaining solution, the Kalai and Smorodinsky (1975) bargaining solution, does not offer the same advantages. Methodologically, this work builds on Ho and Lee (2017)'s static Nash-in-Nash bargaining model, enabling contracts to overlap and remain in place for multiple periods. Similar ideas extend to other models of bargaining in vertical markets.

Much of the dynamic bargaining literature is theoretical (Malcomson and MacLeod, 1989, MacLeod and Malcomson, 1993, Levin, 2003, Miller and Watson, 2013, Watson et al., 2020, Dutta, 2021). An important part of the theoretical dynamic bargaining literature with empirical applications is the literature proposing dynamic underpinnings of static bargaining solutions (Binmore et al., 1986, Stole and Zwiebel, 1996, Coles and Muthoo, 2003, Brügemann et al., 2018, Collard-Wexler et al., 2019, Maskin et al., 2021, Dutta, 2022). A small body of theoretical literature considers stylized dynamic bargaining with overlapping contracts in triangular vertical markets (De Fraja, 1993, Bárcena-Ruiz and Casado-Izaga, 2008, Do and Miklós-Thal, 2022).

Empirical dynamic bargaining models often focus on negotiations between two parties in isolation (Roth et al., 1988, Rica and Espinosa, 1997, Keniston, 2011, Backus et al., 2020). Vertical market contracts have been considered explicit or implicit trade secrets (Reinhardt, 2006, Gudiksen et al., 2019), precluding researchers from observing contract dynamics. This may change in coming years due to regulations requiring price transparency in healthcare. An important setting that models dynamic bargaining with interactions between contracts formed through staggered bargaining is the search-on-the-job literature, which models overlapping contracts with spillovers through market prices (Diamond and Maskin, 1979, Shimer, 2006). In the empirical search-on-the-job literature, bargaining is typically TU (Cahuc et al., 2006, Gottfries, 2022, Bilal et al., 2022), so that the Nash and Kalai proportional bargaining solutions would have the same predictions. There is also a literature on staggered non-TU bargaining in which overlapping contracts interact through market states and can affect future bargains in a stylized process (Gertler et al., 2008, Gertler and Trigari, 2009). My setting differs from the prior empirical dynamic bargaining literature because West Virginia contract spillovers depend on consumer substitution between individual firms.

This paper contributes to the empirical literature on vertical market contracting beyond West Virginia hospitals. This project sheds light on the practice of long-term contracting, which has implications for the literature on bargaining in hospital markets — as examined in work like Gowrisankaran et al. (2015), Ho and Lee (2017), Ghili (2022), and Prager and Tilipman (2022) — and may hold in other vertical markets, such as retail supply chains (Draganska et al., 2010, Baudendistel, 2023), medical device supply (Grennan, 2013, New York State Procurement, 2014, Grennan and Swanson, 2022), and content distribution (Crawford et al., 2018, Marcelo, 2021). This work exploits public record contract data and complements Cooper et al. (2019)'s analysis of five years of claims data from three major national insurers. Their research measures service-level prices and forms a crucial foundation to my work. Weber et al. (2019) complement Cooper et al. by describing prices using claims data that encompasses both large and small insurers in Colorado.

## 2 Illustration That Forward-Looking Bargainers Offset Benchmark Price Increases

In this section, I present a toy model to illustrate why contract prices negotiated as fixed multiples of changing benchmark prices require a dynamic perspective. Bargainers that consider only one contract period at a time respond to their benchmark's current price level but do not respond to anticipated future prices. Similar results have been found in in inflation settings settings in which prices are chosen unilaterally rather than through bilateral bargaining (Taylor, 1980, Calvo, 1983, Abbott, 1995). The effects of benchmark price increases can be subtle in vertical markets with bargaining.

A monopolist insurer (MCO, for managed care organization) would like a monopolist hospital (HOSP) to be in its network. For every year in which HOSP and MCO have a contract in place, MCO will sell an additional \$20 million of insurance. HOSP must agree to a contract and associated payment to be in MCO's network. There are no costs. I consider the years 2013 and 2014.

The firms bargain to split gains from trade equally. The simplest way to split gains from trade equally would be for MCO to pay HOSP \$10 million per year in both 2013 and 2014. Under such a contract, HOSP gains a \$10-million payment each year, and MCO gains \$10 million in added profit after its payment to HOSP.

A payment is negotiated as a fixed multiple $\alpha$ to be applied to an exogenous benchmark price. In practice, a hospital like HOSP would provide thousands of services and rely on a benchmark to price every instance of care.[1] In this toy model, HOSP will provide 1,000 units of care for MCO patients if HOSP is in-network. If the benchmark price is \$5,000, then a multiple of $\alpha = 2.0$ will lead to a payment of $2.0 \times \$5,000$ per unit of care for each of the 1,000 units of care and lead to an overall payment of \$10 million. I will consider negotiations under three scenarios: a single-period-contract model in which contracts are negotiated at the start of each year and remain in place for one year, a myopic model in which contracts last two years but bargainers only care about the first year of profits, and a forward-looking model in which contracts last two years and bargainers care about both years of profits.

In the single-period-contract scenario, the benchmark price is irrelevant. Suppose HOSP and MCO negotiate every year and the first year's benchmark price is \$5,000. Then the two can agree to a multiple of $\alpha_{2013} = 2.0$ and reach a payment of \$10 million in 2013. If the second year's benchmark price is also \$5,000, they can choose the same multiple of $\alpha_{2014} = 2.0$ to reach a payment of \$10 million. If instead the second year's benchmark price is \$20,000 per unit of care, firms bargaining over single-period contracts can negotiate a new multiple of $\alpha_{2014} = 0.5$ and reach the same \$10-million payment. Things become more complicated if the contract will remain in place for multiple years.

In the myopic scenario, bargainers tautologically do not respond to future benchmark price increases. Under myopic bargaining, contracts can last for arbitrarily many periods, but bargainers care only about the first period of the contract. Suppose MCO and HOSP must agree in 2013 on a multiple $\alpha$ to apply in both 2013 and 2014. The empirical model will incorporate uncertainty in benchmark prices, but for simplicity in the myopic and forward-looking scenarios, the benchmark price will be the known values of \$5,000 in 2013 and \$20,000 in 2014. Myopic bargainers care only about 2013 profits and generate a 2013 payment of \$10 million with a multiple of $\alpha = 2.0$. The 2014 payment is \$40 million. MCO could become predictably insolvent in 2014 if the bargainers are myopic in 2013.

In the forward-looking scenario, bargainers offset future benchmark price increases by reducing starting prices. Suppose the bargainers have a discount factor of $\beta = 1/2$ and value 2014 half as much as 2013. The net present value (NPV) gains from trade are \$20 million + $0.5 \times$ \$20 million = \$30 million. The firms can split the net present value gains equally with a multiple of $\alpha = 1.0$. The forward-looking contract pays only \$5 million in the first year and \$20 million in the second year, offsetting future benchmark price increases by reducing starting prices.

Similar results that forward-looking agents target a time-weighted average of payments have been found in the context of price setting with inflation expectations (Taylor, 1980,

[1] I use the term *benchmark* to refer to an externally observable quantity used for calculating payments under a contract. Benchmarks have other uses in bargaining (Grennan and Swanson, 2020).

Calvo, 1983) and pharmaceutical price caps (Abbott, 1995, Ridley and Zhang, 2017). Here, prices are bargained rather than set and have spillovers that depend on consumer substitution patterns. As a result, the response to anticipated benchmark prices requires new tools to study in my setting. I illustrate the subtleties introduced by vertical market bargaining in Appendix D.1. In that toy model, benchmark price dynamics can increase insurer spending or have no net present value effect in equilibrium depending on when contracts are bargained.

In the next section, I present my empirical model. The model will allow bilateral bargaining over multi-year contracts with multiple asymmetric hospitals, multiple asymmetric insurers, and potential uncertainty in future conditions.

# 3 A Model of Dynamic Bargaining between Hospitals and Insurers

I propose a novel empirical model of repeated dynamic bargaining between many hospitals and many insurers. The model yields a moment for negotiated payments that only relies on decisions made at times that contracts are reached in equilibrium, even if bargaining under impasse would be attempted arbitrarily quickly. The associated moment nests the static Nash-in-Nash model's bargaining moment as the special case of myopia. The model enables vertical market firms to bilaterally bargain over multiperiod contracts that have foreseeable spillovers on future negotiations between other entities conducted while the contract remains in place.

All hospitals and insurers are risk neutral, share rational expectations towards the future, play Markov strategies, and share an intertemporal patience rate $\beta \in [0, 1)$. I abuse notation: in this section, I use $\beta$ to refer to a generic single-period discounting rate, but in my empirical results, I use $\beta$ to refer to an annual discounting rate. Bargaining over new contracts is always conducted through asymmetric Kalai proportional bargaining, wherein each hospital–insurer pair $ij$ has fixed insurer bargaining weight $\tau_{ij} \in (0, 1)$. (I discuss the Kalai proportional bargaining solution at a high level in Section 3.2 and in further detail in Appendix D.2.) There is a negotiation cost to incentivize forming multiperiod contracts.

The model accommodates uncertainty. Future demand functions are uncertain, so that hospitals and insurers cannot efficiently contract over multiple periods at a time. The sides instead adapt to future conditions by reaching prices as a fixed multiple $\alpha$ applied to a benchmark price while the contract remains in place. The benchmark prices can be uncertain and correlated with future realizations of demand. Shared rational expectations will be a key driver of the model's empirical tractability. Bargaining models with asymmetric information or biased expectations are outside the scope of this work.

The game's timing in each period $t$ is as follows:

1. *Information is revealed.* Hospital and insurer demand functions $D^H$ and $D^M$ are realized and information about future states is revealed to all hospitals and insurers. If $t$ corresponds to the first period of a calendar year, then benchmark prices are set for the year.

2. *Auto-renew decisions are made.* If $t$ corresponds to the first period of a calendar year, then firms play a renewal strategy with regard to which of their auto-renew contracts they will give notice they will not allow to renew.

3. *Contracts are bargained and premiums are set.* New contracts (expiration, choice of benchmark, and benchmark multiple) are simultaneously formed through Kalai proportional bargaining. If $t$ corresponds to the first period of a calendar year, then at the same time, premiums are set through Nash-Bertrand competition.

4. *Flow profits are formed.* Flow profits are formed through the following process.

   (a) Consumers purchase insurance based on network quality and premiums.

   (b) Consumers independently can become sick with age-dependent probability.

   (c) Flow profits result, as specified in Equation (1) below.

I next discuss the model in further detail.

## 3.1 Information Is Revealed and Auto-Renew Decisions Are Made

In Stage 1, demand functions are revealed and benchmark prices are set. The insurer — also known as MCO — demand function $D^M_{nt}(\mathcal{G}, \phi)$ corresponds to the units of insurance sold by MCO $n$ in year $t$ with realized networks $\mathcal{G}$ and premiums $\phi$. The hospital demand function $D^H_{hnt}(\mathcal{G}, \phi)$ corresponds to the units of care provided by hospital $h$ for patients with insurer $n$ in year $t$ with those networks and premiums. I write benchmark $B$'s price level in period $t$ as $p^B_{ht} > 0$. I adapt the notation for the two stylized benchmarks from Cooper et al. (2019). $B = P$ corresponds to the Medicare-based prospective benchmark and $B = C$ corresponds to the list-price-based chargemaster benchmark.

I treat benchmark prices increases, including endogenous hospital list-price setting, as determined exogenously. That assumption is fairly innocuous for estimation. Medicare prices are set nationally and plausibly exogenous. While hospital list prices are set endogenously, the list prices are set in response to a complex set of incentives, including West Virginia's list price capping system and many small list-price-benchmarked contracts, that is unlikely to be affected substantially by any single contract. My two counterfactuals, changes to Medicare reimbursement and stronger restrictions to hospital-set list prices, should have a predictable effect on the endogenous choice of list price. The model could accommodate an endogenous list price response to an individual contract negotiation, at the cost of modeling the effect of the contract on subsequent list prices and auto-renew decisions. Such a model would add substantial complexity, depart from the literature, and fail to speak more persuasively to my counterfactuals of interest.

In Stage 2, auto-renew decisions are made. Most list-price-benchmarked contracts are also auto-renew contracts (Dorn, 2024): contracts that carry a formal commitment for only one year but that automatically renew until a side gives at least 30 days' notice it will not allow the contract to renew. I allow the auto-renew process to be endogenous but assume the renewal decisions would be the same in counterfactuals. I model the auto-renew decisions as being made at the start of the year. Staggered auto-renew decisions would fit in the model at the cost of adding notation for decision time.

I abstract from many details by viewing prices as per abstract unit of care. That modeling choice is standard in the literature. I discuss some key limitations in Section 3.4 and discuss details of those and other limitations in Appendix C.4.

## 3.2 New Contracts Are Bargained

In Stage 3, hospitals and insurers bargain with regards to a contract's expiration, benchmark, and the multiple to apply to the benchmark while the contract remains in place. Future benchmark prices can be unknown and only partially predictable. Disagreement corresponds to reaching the null contract.

Without loss of generality, I view the firms as negotiating an initial price rather than a contract multiple. Initial benchmark prices are known before negotiation. It is equivalent to negotiate the initial multiple $\alpha_{ht_0}$ to apply to a benchmark price that starts at the known price $p^B_{ht_0}$ or to negotiate the initial price $p_{ht_0} = \alpha_{ht_0} p^B_{ht_0}$ directly.

The contract formed from one bargain is described as a benchmark $b$, maximum remaining length including the current period $\ell$ (where $\ell = \infty$ for auto-renew), and negotiated first period price per unit of care $p$. Disagreement corresponds to reaching the null contract ($b = N$, $\ell = 0$, $p = 0$). I assume that subgame contracts are not randomized for convenience.

The bargaining states for hospital $i$ and insurer $j$ considering a contract in period $t_0$ are the current demand functions $\{D^M_{jt_0}\}$ and $\{D^H_{hnt_0}\}$; the current benchmark prices $\{p^B_{ht_0}\}$; the equilibrium contract states in the bargaining subgame $\mathbb{C}_{t_0} = ((b_{hnt_0}, \ell_{hnt_0}, p_{hnt_0}))_{hn}$; and symmetric information $\mathcal{I}_{t_0}$ about the distribution of future states as a function of $\mathbb{C}_{t_0}$. The remaining history of the game does not enter bargaining under the maintained assumption of Markov strategies. The bargaining states generate recursive value functions of realized contracts $\mathbb{C}_t$ of the form

$$V(\mathbb{C}_t, S_t) = \pi(\mathbb{C}_t, S_t) + \beta E[V(\mathbb{C}_{t+1}, S_{t+1}) \mid S_t],$$

wherein $S_t$ is the realization of bargaining states at the time of negotiation in period $t$ and the flow profits $\pi$ are defined in Equation (1) below. The gains from trade for realized contracts $\mathbb{C}_t$ are defined (with future negotiation responses left implicit) as $GFT_{ijt}(\mathbb{C}_t, S_t) = V(\mathbb{C}_t, S_t) - V(\mathbb{C}_t/ij, S_t)$, where $\mathbb{C}_t/ij$ replaces the $ij$ contract of $\mathbb{C}_t$ with the null contract.

I model dynamic bargaining through Kalai proportional bargaining rather than the ostensibly more-usual Nash bargaining. Nash bargaining has become the dominant tool in fields like labor economics (Haake et al., 2023) and industrial organization (Lee et al., 2021). When bargaining includes prices with a differentiable effect on profits, Nash bargaining splits gains from trade as $\frac{GFT^M_{ijt}(\mathbb{C}_t)}{GFT^H_{ijt}(\mathbb{C}_t)} = \frac{\tau_{ij}}{1-\tau_{ij}} \frac{\frac{-\partial GFT^M(\mathbb{C}_t)}{\partial p_{ijt}}}{\frac{\partial GFT^H(\mathbb{C}_t)}{\partial p_{ijt}}}$, where $\tau_{ij}$ is insurer $j$'s bargaining weight when negotiating with hospital $i$. Kalai proportional bargaining splits gains from trade as $\frac{GFT^M_{ijt}(\mathbb{C}_t)}{GFT^H_{ijt}(\mathbb{C}_t)} = \frac{\tau_{ij}}{1-\tau_{ij}}$. The two differ based on whether the split of gains from trade incorporates the ratio of marginal values of prices $\frac{\frac{-\partial GFT^M(\mathbb{C}_t)}{\partial p_{ijt}}}{\frac{\partial GFT^H(\mathbb{C}_t)}{\partial p_{ijt}}}$. (Insurer bargaining weights of $\tau_{ij} = 0$ or $\tau_{ij} = 1$, corresponding to take-it-or-leave-it offers, have the same interpretation under both solutions provided one side strictly prefers higher prices and the other side strictly prefers lower prices.)

Dynamic Nash bargaining would introduce bargaining state space growth. Realized disagreement is rare and painful. As a result, I assume in Assumption 2 below that if $i$ and $j$ disagree in $t_0$, they return to the bargaining table in good faith in period $t_0 + 1$ with a new relevant bargaining state. The $t_0 + 1$ bargain is recursively negotiated relative to a $t_0 + 2$ bargain with yet another bargaining state. If the period $t_0 + 1$ contract will expire later than the equilibrium contract, then each disagreement will permanently change how other pairs negotiate in the future. The state space growth is unbounded if bargaining is microfounded as a limit of instantaneous alternating offers. The alternating offers limit is a differential equation unless the $ij$ Pareto frontier is homothetic in time (Coles and Muthoo, 2003). Pareto frontiers are not homothetic in this vertical market with overlapping contracts: a three-year $ij$ contract negotiated today will have internalized spillovers on how $i$ and $j$ bargain with other firms while the contract remains in place, and the relevant spillovers will change if $i$ and $j$ disagree today and reach a contract in the future. As a result, a dynamic

Nash bargaining model would only retain the tractable single-period-contract form under heroic assumptions. I find that the resulting violations of homotheticity from internalized spillovers are likely small in my setting, and as a result, dynamic Nash bargaining would introduce a new methodological challenge with limited empirical relevance in my context.

There are three primary reasons I use the Kalai proportional bargaining solution for empirical work on dynamic bargaining. First, the Kalai proportional solution is the only bargaining solution that avoids requiring heroic simplifying assumptions on bargaining under impasse to control the bargaining state space as the period length tends to zero. Second, as I show in Theorem 1, the Kalai proportional solution produces payments that extend the standard static Nash bargaining solution of bargaining relative to one-period disagreement to dynamic bargaining, with uncertainty entering through expectations. Third, the Kalai proportional solution has favorable axiomatic, intuitive, and laboratory evidence (Nydegger and Owen, 1974, Kalai, 1977, Duffy et al., 2021, Ghili, 2022).[2]

I hold benchmark choice and contract length fixed rather than endogenizing those choices. For estimation, this may fail to exploit all information in the data. For counterfactuals, this is innocuous: my counterfactuals would be unlikely to affect benchmark choice or the decision to form auto-renew contracts substantially, as both are well-predicted by insurer and changing between benchmarks is associated with substantial hassle costs (Brown, 2014, p. 22). The most substantive assumption with respect to length is that the counterfactual Medicare reimbursement increases would not affect which Blue Cross contracts would last for three years or five years. The most substantive assumption with respect to benchmarks is that the counterfactual would not lead the sides to introduce negotiation over time-varying multiples. Such multiples are not, to my knowledge, used in practice despite the substantially disparate behavior of the two most common benchmarks. I discuss this choice in the context of counterfactuals further in Section 5.1.

This stage also includes a simultaneous premium-setting stage which is highly stylized. Insurers generate profit through direct insurance sales to consumers; employer-sponsored insurance; and a *self-funded* (also known as *self-insured*) market, wherein employers purchase network access and administrative services and pay for residual care. Insurance choice typically reflects an employer's portfolio choice and a family insurance choice within an employer's portfolio. My limited sales data precludes separately modeling these choices and the different markets. The model must capture insurer incentives in bargaining by summarizing the joint employment choice, plan portfolio choice, and family insurance choice as a function

[2] Kalai proportional bargaining has been criticized because it is not scale invariant, which makes it difficult to microfound (Dagan and Serrano, 1998). I provide a microfoundation based on Dutta (2012, 2022)'s demands games with revocation costs in Appendix D.3. I compare the approaches further in Appendix D.2.

of counterfactual networks. The reduced-form individual choice model attempts to summarize the effect of network on plan choice across many disparate insurance offerings. Further, I measure premiums at the annual level. Premium revision throughout the year could be incorporated with appropriate data. I estimate back-of-the-envelope downstream impacts of prices on premiums based on calibrated premium elasticity and make the conservative choice not to model compounding effects of new premiums on prices.

## 3.3 Flow Profits Are Realized

Flow profits are based on Ho and Lee (2017). Hospital $i$ and insurer $j$'s flow profits in period $t$ are as follows:

$$\begin{aligned} \pi_{it}^{H} &= \sum_{n \in \mathcal{G}_{it}^{H}} D_{int}^{H}\left(\mathcal{G}_t, \phi_t\right)\left(p_{int} - c_i\right) - r_i^H R_{int} \\ \pi_{jt}^{M} &= D_{nt}^{M}\left(\mathcal{G}_t, \phi_t\right)\left(\phi_{jt} - \eta_j\right) - \sum_{h \in \mathcal{G}_{jt}^{M}} D_{hjt}^{H}\left(\mathcal{G}_t, \phi_t\right) p_{hjt} - r_j^M R_{hjt}. \end{aligned} \tag{1}$$

In Equation (1), the quantity of care provided by hospital $i$ for patients with insurer $n$ in year $t$ is the hospital demand function $D_{int}^{H}$ evaluated at the realized networks $\mathcal{G}$ and premiums $\phi$; hospital $i$'s cost of inpatient care is $c_i$; insurer $j$'s number of plans sold is the insurer demand function $D_{jt}^{M}$ evaluated at the realized networks and premiums; and insurer $j$'s cost of noninpatient care is $\eta_j$. I extend Ho and Lee profits by including negotiation costs $r$ for each new contract formed, where $R_{hnt}$ is an indicator for hospital $h$ and insurer $n$ reaching a new contract in period $t$.

Hospital and insurer demand reflects a process with multiple stages. Each consumer chooses an insurance plan (or the outside option of a small insurer) based on the available networks and premiums and their age and location. After choosing a plan, each consumer independently either draws one diagnoses category or does not get sick. The diagnosis probabilities depend on age but not county or insurance. Sick consumers become patients and choose exactly one hospital within their insurer's network. The number of units of care provided depends on the hospital and diagnosis.

Gains from trade are largely driven by the effect of a hospital being added to the insurer's network before accounting for their negotiated payment. The flow gains from trade from hospital $i$ agreeing to be included in insurer $j$'s network in period $t$ at an $ijt$ price of zero and before accounting for negotiation costs are:

$$
\begin{aligned}
\left[\Delta_{ij}\pi_{it}^{H}\right] &= -\overbrace{D_{ijt}^{H}c_i}^{\substack{\text{Hospital}\\ \text{cost effect}}} + \overbrace{\sum_{n\in\mathcal{G}_{it}^{H}/j}[\Delta_{ij}D_{int}^{H}](p_{int}-c_i)}^{\text{Recapture effect}} \\
\left[\Delta_{ij}\pi_{jt}^{M}\right] &= \underbrace{[\Delta_{ij}D_{jt}^{M}](\phi_{jt}-\eta_j)}_{\text{Premium and enrollment effect}} - \underbrace{\sum_{h\in\mathcal{G}_{jt}^{M}/i}[\Delta_{ij}D_{hjt}^{H}]p_{hjt}}_{\text{Price reinforcement effect}}.
\end{aligned} \tag{2}
$$

These are the flow Nash-in-Nash gains from trade. The description of terms in Equation (2) is adapted from Ho and Lee (2017)'s Nash-in-Nash model. The hospital must pay the cost of providing care for some of insurer $j$'s patients and loses profits recaptured from patients with other insurance. The insurer gains premium revenue from added enrollees after covering noninpatient costs. The insurer also experiences a money-saving price reinforcement effect: the added contract typically reduces the insurer's payments to other hospitals by diverting enrollees.

Prices in this model have spillovers. Higher negotiated prices under other contracts $p_{hnt}$ generally make the hospital recapture effect more negative and the insurer price reinforcement effect more positive. Both mechanisms have the same direction of effect: higher anticipated prices lead to higher new prices. The precise effect depends on the consumer substitution patterns from hospital and insurer demand.

I add a negotiation cost borne after bargaining succeeds. Real negotiations require costs both at the stage of preparing for negotiations (Gooch, 2019, ECG, 2020, Fletcher, 2020, Beier, 2020) and at the stage of carefully checking the terms of a potential agreement (STD TAC and Moss, 2014, PMMC, 2019, Fletcher, 2020). I model the bargaining friction as only the cost to validate a potential agreement. Some work includes a sunk negotiation cost (Prager and Tilipman, 2022). In a static model, sunk negotiation costs do not enter into payments. In a dynamic model, changes in anticipated future sunk negotiation costs enter payments in a complex way. In addition, sunk costs can prevent firms from forming Pareto-efficient contracts.

## 3.4 Caveats

I will highlight some key caveats. In hospital demand, I do not model cross-border movement or historical hospital investment. This approach may miss an important component of the market when border hospitals negotiate with insurers that have asymmetric relationships across state lines. In insurer demand, I summarize the process of employers choosing insurance portfolios and families choosing plans within that portfolio with a marginal individual insurance choice, which should capture the key consumer substitution patterns but not family choice, and back out demand before 2016 based on only state-level sales, which may miss historical regional variation. I use a stylized model of benchmarks that captures first-order effects. I do not endogenize the contract length choice or network formation process in order to focus on the price formation process. There are other potential biases introduced by the finite horizon approach I take to estimation and by my plug-in approach to counterfactual expected charges. I measure contracting by day (as reported in the contract scans) but demand, benchmark prices, and premiums on an annual basis, and so estimate an annual patience parameter based on a weighted average of calendar year gains from trade beginning from the day a contract is introduced.

The limited premium data in West Virginia leads me to simplify the premium-setting process substantially. I use only state-level premiums that do not identify age multiples, so that insurer gains from trade will be misspecified when consumers differentially select between insurers based on age. This would cause issues for identification of $\beta$ if it leads the model to miss important dynamics in the relative value of different patients. My estimation routine models price negotiation at the equilibrium premiums, which misses any response of future premium setting to current negotiated prices. The direct effect on the insurer's future profits through future optimized premium responses is zero by the envelope theorem, but nondirect effects through other firm responses can be nonzero. I leave a more precise approach to premium setting for future work with appropriate data. I discuss these and other caveats further in Appendix C.4.

## 3.5 Bargained Payments

I make a few restrictions on behavior: regularity conditions and good-faith disagreement. Those assumptions yield a closed-form bargaining moment for estimation that only relies on modeling bargaining at discrete times.

I maintain some regularity conditions.

**Assumption 1. (Regularity conditions)**
In any subgame's contract formation Stage 3, bargainers calculate expected gains from trade taking other pairs' simultaneous bargaining strategies as given. The gains from trade Pareto frontier is a convex curve and expected gains from trade are split proportionally to the $\tau_{ij}$ bargaining weights in the sense $\tau_{ij} GFT^H_{ijt}(\mathbb{C}_t, \mathcal{I}_t) - (1-\tau_{ij}) GFT^M_{ijt}(\mathbb{C}_t, \mathcal{I}_t) = 0$. There are also transversality conditions: (i) value functions are equal to the net present value of expected profits and (ii) for $t$ fixed and as $T \to \infty$, the supremum of period-$t$ net present value

expected profits starting at any period-$T$ subgame tends to zero uniformly.

The simultaneous bargaining assumption is the Nash-in-Nash model's Nash equilibrium assumption applied to my setting. The assumption allows for a firm to make a correlated decision of what negotiations to enter, but does not allow a firm to consider changing multiple contract outcomes at the same time during negotiations. In practice, few contracts are actually formed at the same exact time, so the content of taking simultaneous bargaining strategies as given is likely to be minimal. Nonconvex bargaining problems introduce subtle considerations (Shimer, 2006). Convexity is immediate if the bargainers are allowed to randomize between contracts (with the bargaining moment taking expectations over contracts that could be formed) and often holds exactly or approximately without randomization. The proportionality assumption rules out bargaining problems in which all proportional allocations are strictly Pareto dominated. The transversality conditions rule out perverse contracts.

I take a stance on disagreement based on the empirical rarity of disagreement in my setting. Only three modeled hospital–insurer pairs ever dissolve for any time. (Two of the three seem to reflect regulatory holdup or clerical errors.) On roughly 12 reported occasions, a contract would remain in place on a short-term basis while bargaining remained ongoing. Firms in my model that fail to form an agreement keep bargaining in good faith, expecting to avoid further painful exclusion.

**Assumption 2. (Good-faith disagreement)**
Let $G^{t(s),t+1:\infty}$ be the function that maps histories at a subgame in the flow profit Stage 4 of period $t$ to the equilibrium distribution of networks beginning in period $t+1$. Consider a subgame in the negotiation Stage 3 of a period $t_0$. Let $h^{t_0(4)}$ be in the support of the equilibrium of Stage 3. Let $\hat{h}^{t_0(4)}$ correspond to that Stage 3 outcome except that $ij$ reach the null contract. Then $G^{t_0(4),t+1:\infty}(h^{t_0(4)})$ and $G^{t_0(4),t+1:\infty}(\hat{h}^{t_0(4)})$ are equal.

Assumption 2 essentially says that bargainers attempt to exit impasse as soon as possible: if $ij$ bargaining fails in period $t_0$, then $i$ returns to $j$'s network as soon as they would have been in-network in equilibrium. Future networks are assumed to be unaffected by $ij$ disagreement because everyone continues to expect $ij$ to reach a contract.[3] Good-faith disagreement is in line with the empirical rarity of disagreement, which suggests disagreement

[3] The assumption only refers to one disagreement, but Assumption 2 rules out continued impasse affecting subsequent networks by inductively applying the following argument to construct $t_0+2$ networks under impasse. First draw $t_0+1$ networks from $G^{t_0(4),t+1:\infty}(\hat{h}^{t_0(4)})$, which by Assumption 2 is the same as drawing from $G^{t_0(4),t+1:\infty}(h^{t_0(4)})$; then draw $h^{t_0+1(4)}$ from the distribution of $t_0+1$ histories conditional on $\hat{h}^{t_0(4)}$ and $t_0+1$ networks; and then substitute the null contract for $ijt_0+1$. This process generates the distribution of $(\mathcal{G}_{t_0+1}, \mathcal{G}_{t_0+2})$ under impasse. By Assumption 2 applied to both draws, this process generates the same distribution as drawing $(\mathcal{G}_{t_0+1}, \mathcal{G}_{t_0+2})$ from $G^{t_0(4),t+1:\infty}(h^{t_0(4)})$.

is painful and consistently avoided. The good-faith assumption is also in line with the Nash-in-Nash bargaining model's Nash equilibrium assumption: under single-period Nash-in-Nash bargaining, contracts are formed assuming other bargains will succeed. I implicitly rule out any effect of current networks on subsequent future demand. If Assumption 2 did not hold and disagreement affected subsequent networks, as in Lee and Fong (2013)'s model, then the form of payments would be modified to incorporate the effect of impasse on subsequent network formation.

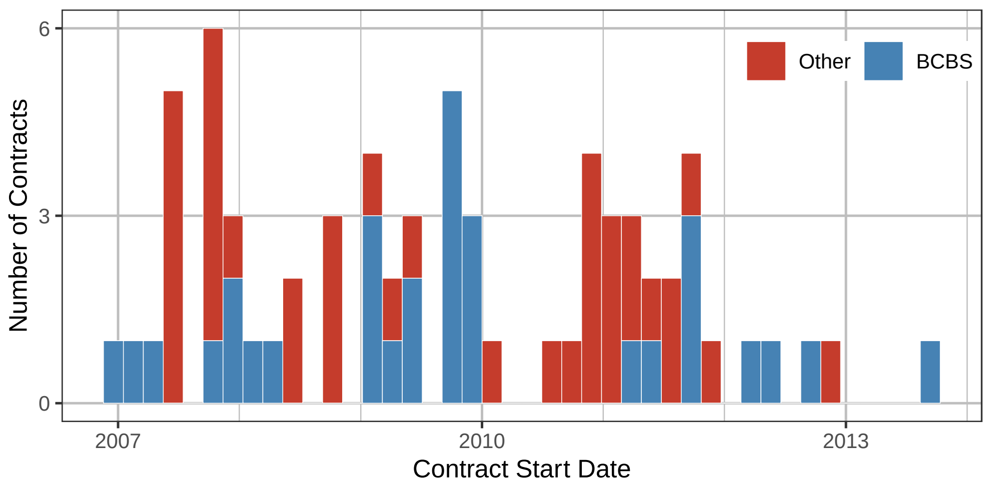


Figure 1: Histogram of contract start dates for contracts used in the estimation and introduced between 2007 and 2014 for Highmark BCBS (blue) and other modeled insurers (pink). Vertical lines indicate January 1 of a given year.

The bargaining moment under the model will surmount two challenges created by overlapping contracts. First, reality exists in continuous time. As Figure 1 shows, contracts are introduced throughout the year. If a hospital and insurer enter painful impasse, they may attempt to return to agreement arbitrarily quickly. This short disagreement behavior also holds if negotiation is microfounded as a limit of alternating offers as the time between offers tends to zero (Binmore et al., 1986, Coles and Muthoo, 2003, Collard-Wexler et al., 2019). Negotiators that consider an agreement now relative to bargaining in an instant, with every disagreement point bargain recursively defined relative to a subsequent disagreement bargain, must consider an unbounded number of bargaining states.

The second empirical challenge the Kalai proportional model will surmount is uncertainty. Nash bargaining does not always incorporate uncertainty in an empirically convenient manner. Even unobservables that are uncorrelated with instruments may prevent researchers from forming moments on Nash bargains, provided the uncertainty is realized after negotiation and causes suitable features of the realized gains from trade to be correlated. Appendix D.4

offers an example wherein under Nash bargaining, nominally ignorable uncertainty introduces estimation bias.

My proposed bargaining model produces a moment that generalizes the static Nash-in-Nash bargaining model's moment as follows.

**Theorem 1.** *Suppose hospital $i$ and insurer $j$ form a contract in a subgame period $t_0$ through the (potentially random) terminal date $t^*$ that yields (potentially random) realized prices $p^*_{ijt}$. Then the expected net present value of realized payments at the moment of contract formation is equal to the sum of the expected net present value of flow period Nash-in-Nash payments, a negotiation cost payment, and an impasse repricing payment term:*

$$\mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t^*}\beta^{t-t_0}D^H_{ijt}(\mathcal{G}_t,\phi_t)p^*_{ijt}\right]=\text{Pay}_{NiN}+\text{Pay}_{NC}+\text{Pay}_{IRT},\tag{3}$$

*where the expected net present value of static Nash-in-Nash payments is:*

$$\text{Pay}_{NiN}=\mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t^*}\beta^{t-t_0}\left(-\tau_{ij}\left[\Delta_{ij}\pi^H_{it}\right]+(1-\tau_{ij})\left[\Delta_{ij}\pi^M_{jt}\right]\right)\right],\tag{4}$$

*the negotiation cost payment* $\text{Pay}_{NC}$ *is equal to* $-\tau_{ij}r^H_i+(1-\tau_{ij})r^M_j$*, and the impasse repricing payment* $\text{Pay}_{IRT}$ *is defined in footnote 4.*[4]

Theorem 1 is my main theoretical result. I now provide a proof.

*Proof.* Suppose hospital $i$ and MCO $j$ reach a bargain in a period $t_0$ subgame. For simplicity, I proceed assuming bargaining in the period $t_0$ subgame is a pure strategy equilibrium and in every future subgame (including after current disagreement), $ij$ will reach an infinite number

[4] The full term requires some notation. Let $A$ superscripts denote the (potentially random) path of premiums and prices if the firms agree in $t_0$ and then enter impasse at the next opportunity. Let $D$ superscripts denote the (potentially random) path if the firms disagree in $t_0$ and then enter impasse. Then the impasse repricing term (IRT) is as follows:

$$\begin{aligned}\text{Pay}_{IRT}=&-\mathbb{E}_{t_0}\left[\sum_{t=t_0+1}^{\infty}\beta^{t-t_0}(\tau_{ij})\sum_{n\in\mathcal{G}^H_{it}/j}\begin{pmatrix} & D^H_{int}\left(\mathcal{G}_t/ij,\phi^A_{jt|t_0}\right)\left(p^A_{int|t_0}-c_i\right)\\ - & D^H_{int}\left(\mathcal{G}_t/ij,\phi^D_{jt|t_0}\right)\left(p^D_{int|t_0}-c_i\right)\end{pmatrix}\right]\\ &+\mathbb{E}_{t_0}\left[\sum_{t=t_0+1}^{\infty}\beta^{t-t_0}(1-\tau_{ij})\left(D^M_{nt}(\mathcal{G}_t/ij,\phi^A_{t|t_0})(\phi^A_{jt|t_0}-\eta_j)-D^M_{nt}(\mathcal{G}_t/ij,\phi^D_{t|t_0})(\phi^D_{jt|t_0}-\eta_j)\right)\right]\\ &+\mathbb{E}_{t_0}\left[\sum_{t=t_0+1}^{\infty}\beta^{t-t_0}(1-\tau_{ij})\left(\sum_{h\in\mathcal{G}^M_{jt}/i}D^H_{hjt}(\mathcal{G}_t/ij,\phi^A_{t|t_0})p^A_{hjt|t_0}-D^H_{hjt}(\mathcal{G}_t/ij,\phi^D_{t|t_0})p^D_{hjt|t_0}\right)\right].\end{aligned}\tag{5}$$

of future bargains.[5]

Let $t_{d+1}$ be the (potentially random) next period in which $i$ and $j$ reach a bargain if they deviate from equilibrium and disagree $d \geq 0$ times after period $t_0$ before returning to equilibrium. Let $V_{ijt}^{H,(d)}$ and $V_{ijt}^{M,(d)}$ be the (potentially random) expected net present value profits beginning in period $t$ under that state. Similarly, let $\phi_t^{(d)}$ and $p_{hnt}^{(d)}$ be the (potentially random) premiums and prices on such a path. To align with Equation (5), I write (potentially random) premiums and prices with an agreement followed by impasse as $\phi^A$ and $p^A$, respectively. I write the premiums and prices with disagreement followed by impasse as $\phi_t^D$ and $p_{hnt}^D$, respectively.

I now evaluate value functions. I ignore the net present value negotiation costs outside the $ij$ pair which, under Assumption 2, are unaffected by the $ij$ bargaining outcome. The expected value of the agreement to hospital $i$ is:

$$V_{ijt_0}^{H,(0)} = \mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t_1-1} \beta^{t-t_0}\left(D_{int}^H(\mathcal{G}_t, \phi_t^{(0)})(p_{int}^{(0)} - c_i)\right) - r_i^H + \beta^{t_1-t_0} V_{ijt_1}^{H,(0)}\right].$$

Let the (potentially random) joint gains from trade from returning to equilibrium after $d$ disagreements and then bargaining in period $t_d$, measured relative to $d+1$ disagreements followed by agreement, be $GFT_{ijt}^{(d)}$.

I now rewrite and simplify the value function using the Kalai proportional bargaining solution concept. Under any definition of Kalai proportional bargaining with convex feasible payoffs (Assumption 1), the hospital's gains from trade from disagreeing only $d$ times rather than $d+1$ times are $V_{ijt_{d+1}}^{H,(d)} - V_{ijt_{d+1}}^{H,(d+1)} = (1-\tau_{ij}) GFT_{ijt_{d+1}}^{(d)}$. Let the expected gains from trade available from the opportunities to exit impasse after the first agreement be $GFT_{ijt_0}^A \equiv \mathbb{E}_{t_0}\left[\sum_{d=1}^{\infty} \beta^{t_d - d_0} GFT_{ijt_d}^{(d-1)}\right]$. This is finite by the transversality condition (Assumption 1). Note that for all $t_d \leq t < t_{d+1}$, $\phi_t^{(d)} = \phi_t^A$ and $p_t^{(d)} = p_t^A$ (disagreeing more than $d+1$ times has an effect on prices only after $d+2$ potential disagreements). Note that Assumption 2 implies that expected networks are unchanged by impasse: an additional $ij$ disagreement does not change the distribution of future networks conditional on current non-$ij$ networks. By recursive arguments I omit for brevity, the value of the agreement to hospital $i$ is:

$$V_{ijt_0}^{H,(0)} = \mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t^*} \beta^{t-t_0}\left(D_{int}^H(\mathcal{G}_t, \phi_t^A)(p_{int}^A - c_i)\right) + \sum_{t=t^*+1}^{\infty} \beta^{t-t_0}\left(D_{int}^H(\mathcal{G}_t/ij, \phi_t^A)(p_{int}^A - c_i)\right)\right]$$
$$- r_i^H + (1-\tau_{ij}) GFT_{ijt_0}^A.$$

[5] In estimation, it is infeasible to include an infinite number of bargains without imposing unreasonable assumptions like West Virginia being in steady state. I therefore impose a finite horizon model for estimation.

By an analogous argument, the value of disagreeing in the current period can be written in terms of the impasse premiums and prices $\phi^D$ and $p^D$, respectively, as:

$$V_{ijt_0}^{H,D} = \mathbb{E}_{t_0}\left[\sum_{t=t_0}^{\infty} \beta^{t-t_0}\left(D_{int}^{H}(\mathcal{G}_t/ij, \phi_t^D)(p_{int}^D - c_i)\right) + (1-\tau_{ij})GFT_{ijt_0}^D\right],$$

for some (potentially random) joint postdisagreement expected net present value gains $GFT_{ijt_0}^D$. Analogous results hold for the MCO but with $\tau_{ij}$ $GFT$ terms.

The price is chosen to satisfy:

$$V_{ijt_0}^{H,(0)} - V_{ijt_0}^{H,D} = (1-\tau_{ij})\left(V_{ijt_0}^{H,(0)} + V_{ijt_0}^{M,(0)} - V_{ijt_0}^{H,D} - V_{ijt_0}^{M,D}\right).$$

The remainder of the proof follows by subtracting $(1-\tau_{ij})\mathbb{E}_{t_0}\left[GFT_{ijt_0}^A - GFT_{ijt_0}^D\right]$ on both sides and demonstrating, by tedious algebra which I omit for brevity, that only a payment of the form in the theorem satisfies the remaining equality. □

*Intuition.* Repeated bargaining with short disagreement introduces state space growth in part because a failed $ij$ agreement in $t_0$ will change the bargaining states beginning in $t_0+1$. Under Kalai proportional bargaining, the $ij$ negotiators know that any $ij$ gains from trade negotiated in future periods will be split proportionally to the $\tau_{ij}$ bargaining weights. Kalai proportional bargainers can act as-if every future $ij$ negotiation attempt will deviate from equilibrium and fail; the remaining expected gains will not require compensation to split proportionally. This simplification is a unique property of Kalai proportional bargaining (Kalai, 1977, Roth, 1979). The Kalai proportional bargaining payment can be chosen to proportionally split the expected gains created from agreement followed by impasse (with prices superscripted $A$) relative to immediate impasse (with prices superscripted $D$), even if the true bargaining process involves only disagreeing for one period. In my case, I add and subtract the value of the Ho and Lee (2017) Nash-in-Nash disagreement profit (with prices on the $A$ path) to yield Equation (3).

As the next corollary shows, Theorem 1 implies that a discrete-timed representation of negotiation will suffice even if real contracting is attempted arbitrarily quickly. Among the terms in Equation (3), only $\text{Pay}_{IRT}$ reflects off-equilibrium prices. Those additional prices are the prices formed if $ij$ remain in impasse. Those prices are only formed at discrete times: the times in which other pairs negotiate or in which insurers set premiums. If bargaining is conducted in continuous time, the number of instances in which $ij$ might bargain under impasse without any other player reacting to their anticipated contract is unbounded. For the purposes of computing the equilibrium contract, those instances can be ignored. This is the principal empirical advantage of the Kalai proportional bargaining solution for vertical markets: even if negotiation is truly attempted arbitrarily quickly, there is an equivalent bargaining model in discrete time that produces the same predicted payments. In addition, Theorem 1 shows that under the Kalai proportional bargaining model, uncertainty enters through expected net present values, so that empirical researchers can form moments for estimation.

**Corollary 1.** *Consider games of the form of this section, wherein $ij$ use a fixed bargaining solution $f(a, S)$ that is weakly Pareto-optimal, homogeneous ($f(\alpha a, \alpha S) = \alpha f(a, S)$ for all $\alpha > 0$), invariant to adding a scalar to either side's value ($f(a + b, S + b) = f(a, S) + b$), satisfies Thomson (1994)'s Hausdorff continuity condition, and predicts a unique predicted successful contract in some subgame. Write $g_\tau^{Kalai}$ for the Kalai proportional bargaining solution with insurer weight $\tau \in [0, 1]$. Consider a new game in which period lengths are split in half, but subsequent conditions are otherwise unchanged going forward from the original subgame (formalized in Appendix Assumption 7). Then:*

***Kalai implies state space simplification.*** *If $f = g_{\tau_{ij}}^{Kalai}$ for some $\tau_{ij}$, then in the split-in-half subgame with halved period lengths, the negotiated length is twice as long and other contract terms are unchanged.*

***State space simplification essentially implies Kalai.*** *Suppose for all such subgames, in the split-in-half subgame with halved period lengths, the negotiated length is twice as long and other contract terms are unchanged. Then there is a $\tau_{ij} \in [0, 1]$ such that for all $S$ with linear Pareto frontiers and all $a$, $f(a, S) = g_{\tau_{ij}}(a, S)$.*

The homogeneity restriction is that the bargaining solution provides the same predictions when measuring profits in dollars or in cents; other bargaining solutions are not plausible for empirical work for bargaining over profits. The scalar addition requirement is that the sides are applying a bargaining solution to expected profit, so that changing the calculation of expected value to include expected value in independent markets would not change the predicted contract in this market. The Hausdorff continuity assumption is satisfied by most bargaining solutions, but not the utilitarian solution; utilitarian bargaining with equal weights technically satisfies the property of Corollary 1 because of the game's strong restrictions. If the game were generalized to include arbitrary pairs of agreement and split-in-half disagreement Pareto frontiers, the homogeneity, continuity, and linearity requirements could be replaced by a strong individual rationality condition (Roth, 1979).

*Proof.* See Appendix Appendix D.6. □

While the form of Equation (3) is context-specific, the logic of Theorem 1 is modular. The gains from trade that Kalai proportional bargainers may achieve in the future after disagreeing in the present do not have an impact on the contract they will choose in the present. If the ingredients of flow profits like hospital and insurer demand were changed, a similar result would hold. If demand were dynamic or disagreement were long-lived, then under appropriate regularity conditions like Miller and Watson (2013)'s no-fault disagreement, the expected value of impasse would change but the fundamental logic would continue. The negotiators would still choose a contract to split the expected gains of agreement then impasse relative to the value of immediate impasse. A full generalization to such models is outside the scope of this paper.

In the particular context of this empirical model, the impasse repricing term $\text{Pay}_{IRT}$ reflects that a future period's disagreement state is not the future period's Nash-in-Nash disagreement state. Under good-faith bargaining, the disagreement state in period $t$ reflects an impasse point in which the firms continually attempt to bargain starting in $t_0$ but defect from the resulting subgame equilibrium and fail to agree on a contract. The impasse threat point produces the same equilibrium payments but allows the negotiators and the researcher to ignore the many bargaining states they might enter under impasse at instances during which no one responds to the pair's anticipated agreement. The term is zero in steady state. Outside steady state, the term reflects an increasing number of bargaining states as the bargaining horizon is allowed to grow.[6]

## 3.6 Comparison to the Literature

It may help to describe the bargaining moment from Equation (3) relative to the corresponding moment from the static Nash-in-Nash bargaining model's predictions and convenient generalizations of the literature's static approach.

A static Nash-in-Nash bargaining model produces a bargaining moment that is the special case of Equation (3) with one-period contracts. Under Nash bargaining, bargainers choose a contract to maximize the asymmetric product of gains from trade relative to disagreement. Write the *realized* gains from trade to hospital $i$ and insurer $j$ agreeing to a contract in period $t_0$ with starting price $p$ (holding other characteristics fixed) as $G\hat{F}T^{H}_{ijt_0}(p)$ and $G\hat{F}T^{M}_{ijt_0}(p)$, respectively. I implicitly assume that the disagreement value is unaffected by the hypothetical price the two would like to reach. Then the Nash bargaining solution is:

$$p^*_{\text{Nash}} = \underset{p}{\operatorname{argmax}} \left(\mathbb{E}_{t_0}\left[G\hat{F}T^{M}_{ijt_0}(p)\right]\right)^{\tau_{ij}} \left(\mathbb{E}_{t_0}\left[G\hat{F}T^{H}_{ijt_0}(p)\right]\right)^{1-\tau_{ij}}.$$

[6] I currently constrain the $\text{Pay}_{IRT}$ term to be equal to zero. I expect the term to be small due to the limited scope of internalized spillovers in West Virginia and because the term is equal to zero in steady state.

Under static Nash bargaining, the negotiated price satisfies

$$D^H_{ijt_0} p^*_{\text{Nash}} = -\tau_{ij}[\Delta_{ij}\pi^H_{it_0}] + (1-\tau_{ij})[\Delta_{ij}\pi^M_{jt_0}] + \text{Pay}_{NC},$$

where the Nash-in-Nash flow gains from trade are defined in Equation (2). This bargaining moment corresponds to the special case of Equation (3) in which contracts only remain in place for one period. Bargaining in Lee and Fong (2013)'s period-by-period model would follow the same structure except the $[\Delta_{ij}\pi]$ terms would incorporate any effect of a successful contract on future profits.

It should be no surprise that the Kalai proportional bargaining model extends static Nash bargaining. Period-by-period Nash bargaining in this setting is zero-sum at the margin, so Nash bargaining and Kalai proportional bargaining coincide. In some vertical market models, Nash bargaining is not zero-sum (Crawford and Yurukoglu, 2012, Grennan, 2013, Gowrisankaran et al., 2015). A similar generalization argument would hold for such NTU models if the ratio of marginal values is exactly constant in time and hold as an approximation argument if the ratio of marginal values is roughly constant in time. This work leaves as an open question if there is an empirically tractable representation of Nash bargaining with important variation in marginal value ratios over time.

A bargaining model with multiperiod contracts and static-Nash-type moment corresponds to myopic bargaining. If bargainers are myopic and only consider the first period of a contract ($\beta = 0$), then the resulting moment is a special case of Equation (3). Myopic Nash-in-Nash bargaining is essentially static Nash-in-Nash bargaining. The only philosophical difference of myopic Nash-in-Nash is that some contracts are fixed because they were formed in the past. Under myopic bargaining, predicted new-contract payments are the static bargaining predicted payments but only applied to new contracts. The impasse repricing term is zero under myopia because Nash disagreement and impasse prices are equal in the only period that the bargainers care about ($t_0$).

Equation (3) nests a limited bargaining foresight Nash bargaining model. The state space challenge of extending Nash bargaining to multiperiod contracting in vertical markets comes from internalizing time-varying spillovers of $ij$ bargaining on other pairs' contracts in the split of gains from trade. One could consider a limited bargaining foresight model (Dranove et al., 2015) that has firms Nash bargain with a hold-fixed stance on both current and future prices. There would be no internalized price spillovers, and the generated moment would be equivalent to this model with $\text{Pay}_{IRT}$ set to zero.

# 4 Estimation of Empirical Model

I study how changes to benchmark price increases would have affected real spending in West Virginia. My empirical model requires estimates of hospital and insurer demand as inputs to gains from trade. My estimated demand systems are empirically plausible. I overwhelmingly reject a null hypothesis of myopia in bargaining.

## 4.1 Setting, Data, and Key Descriptives

I characterize contract terms in West Virginia by using three main datasets: unique public record hospital–insurer panel contract data, more-usual hospital billing data, and state-level insurer sales data. The contract data shows two characteristics that are likely to hold in many markets: contracts remained in place for multiple years and were formed at different times.

I am able to estimate the proposed dynamic bargaining model using novel data on hospital–insurer contracting from West Virginia. The state had a corridor system: a ceiling on hospital list prices and an average cost floor on payments. The state made hospital–insurer contracts public records as part of certifying that payments exceeded the non-binding floor. Both the corridor system and practice of making contracts public records make West Virginia is unrepresentative for extrapolating effects to the rest of the United States, but the direction of bias is often unclear. I find that list price-benchmarked contracts were more common in West Virginia than Weber et al. (2019) find in Colorado. As a result, changes to Medicare-based benchmark prices would be likely to have smaller effects in West Virginia than other states. For more on the state's rate review system, see Murray and Berenson (2015). I discuss the setting and novel contract data further in Dorn (2024).

I use 2016 uniform billing (UB) data to directly estimate hospital demand and indirectly estimate insurer sales by location. The UB data covers every inpatient stay in West Virginia. The data includes each patient's home county; age range (0–17, 18–44, 45–64, 65–74, or 75+); MS-DRG diagnosis code; reported primary payor — if the primary payor is one of Aetna, Highmark Blue Cross Blue Shield (BCBS), or the Health Plan of the Upper Ohio Valley (HPUOV); and some variables I do not incorporate, such as sex and consumer zip code. The data is not claims data, because it does not include negotiated or realized payments. I group diagnoses into one of six main categories based on Ho (2006)'s International Classification of Diseases (ICD) categories. The main categories are labor, cardiac, digestive, neurological, and cancer care, as well as other care that is not classified as one of those categories. The diagnosis category frequencies are in Appendix Table 5.

I take annual sales and premiums in the West Virginia fully insured market from state-level accident and health reports like Offices of the Insurance Commissioner (2016). The reports cover every plan sold in which an insurer is paid a premium to provide comprehensive medical insurance. I convert premiums and other monetary data to 2019 dollars based on consumer price index (CPI) inflation. Federal regulations precluded the state from collecting data on sales in the self-funded market. I infer self-funded sales in 2016 to match estimated combined sales in the UB data and use the fully insured market to infer premiums and insurer values before 2016. (See Appendix C.1 for details.)

I focus my main analysis on six insurers: the largest insurer, Highmark BCBS; a regional insurer, HPUOV; and the four largest for-profit firms, Aetna, Carelink, Cigna, and UnitedHealth. Carelink was a regional subsidiary of Coventry between 1999 and Aetna's acquisition of Coventry at the end of 2014. I refer to these insurers as "modeled" because they are included in model estimation. I group the other, smaller, insurers into a category of "other" insurers.

| MCO | Prospective | Share of Charges |
|---|---|---|
| All | 46.74 | 53.26 |
| Modeled MCOs | 60.20 | 39.80 |
| Highmark BCBS | 72.27 | 27.73 |
| HPUOV | 56.24 | 43.76 |
| Other Modeled | 13.14 | 86.86 |
| Nonmodeled | 3.03 | 96.97 |

Table 1: The estimated share of inpatient payments by benchmark type for fiscal years 2011–16. Prospective contracts were common, especially for Highmark BCBS.

I find that benchmark choice was highly associated with insurer. The distribution of inferred contract benchmarks is shown in Table 1. An estimated 47% of inpatient payments were negotiated based on Medicare DRG codes.[7] Prospective payments were driven by Highmark BCBS, for which 72% of payments were prospective. (More than three-quarters of the remaining payments were at one large and unusual hospital, Charleston Area Medical Center.) The regional HPUOV was small at the state level (3.8% to 11.7% of estimated sales), relatively large in the regions in which it actively competed (more than 27% of estimated

[7] I observe that in some hospital 2023 price reports, Highmark BCBS payments are benchmarked to DRG-based weights that are not equal to Medicare's DRG weights. The differences are small ($R^2$ of 0.92 between the weights). I assume that the benchmark prices generally move proportionally to Medicare, based in part on the common association of prospective payments with Medicare weights (Cooper et al., 2019, see Appendix C.3 for further discussion). Even if the two Medicare-based benchmark prices are updated in different ways, my counterfactual results still hold for the impact of changes to the dynamics of the Medicare-based benchmarks used by Highmark BCBS.

2016 sales in the northern panhandle), and paid prospectively for an estimated 56.2% of payments (more than three-quarters from two hospitals in Wheeling in the northern panhandle). The other medium-sized insurers I model used list prices as benchmarks for an estimated 87% of payments, and the remaining small insurers I do not model used list prices for an estimated 97% of payments. Further detail on contract structure is available in Dorn (2024).

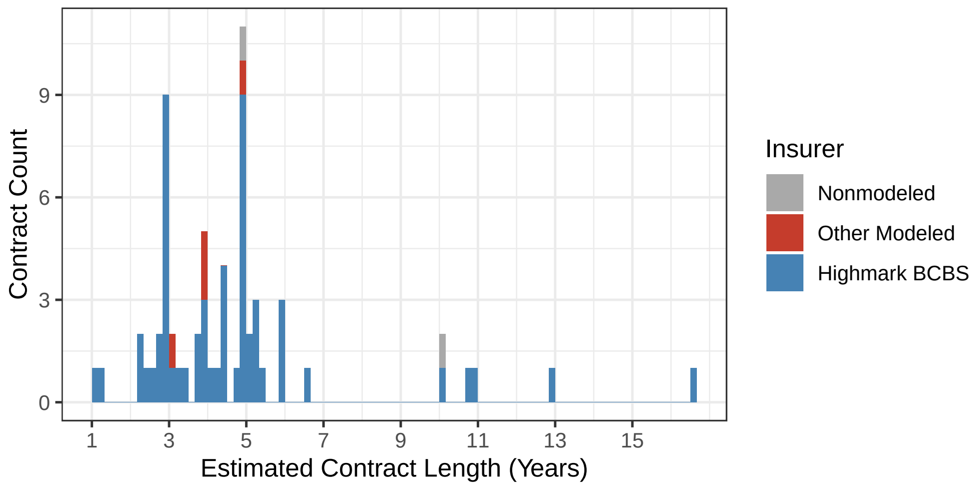


Figure 2: Distribution of reported contract term lengths (hospital-insurer-start-end tuples) for contracts with fixed expiration dates for Highmark BCBS (blue), other modeled (red), and nonmodeled insurer (grey) contracts. The two nonmodeled insurer contracts were special Wheeling-Pittsburgh Steel contracts with hospitals in the state's northern panhandle.

Contracts would remain in place for multiple years. I present retrospective contract length data for fixed-length contracts with reported lengths in Figure 2. A given observation is a hospital-insurer-start-end tuple. As discussed in Figure 2, small contracts would not have a reported start date but would usually be auto-renew. A point's x-position represents the time elapsed between the reported end date and the reported start date in years. Contracts colors differentiate between Highmark BCBS (blue), other modeled (red), and nonmodeled (grey) insurers. Large spikes are visible at three years and five years, indicating that these were standard Highmark BCBS contract lengths. There is a right tail of extreme lengths, which reflect either expired contracts that were extended or data reporting issues. There were only four fixed-length contracts from other modeled insurers that were large enough to reach this graph, all of which had reported lengths of at least three years. As I demonstrate in Dorn (2024), the omitted auto-renew contracts generally had realized durations of a decade or longer.

Contracts were formed at different times, even within a give year. Figure 3 plots the contract start dates for contracts used in the estimation sample below. These are contracts between modeled insurers and West Virginia hospitals that had reliable start and end dates

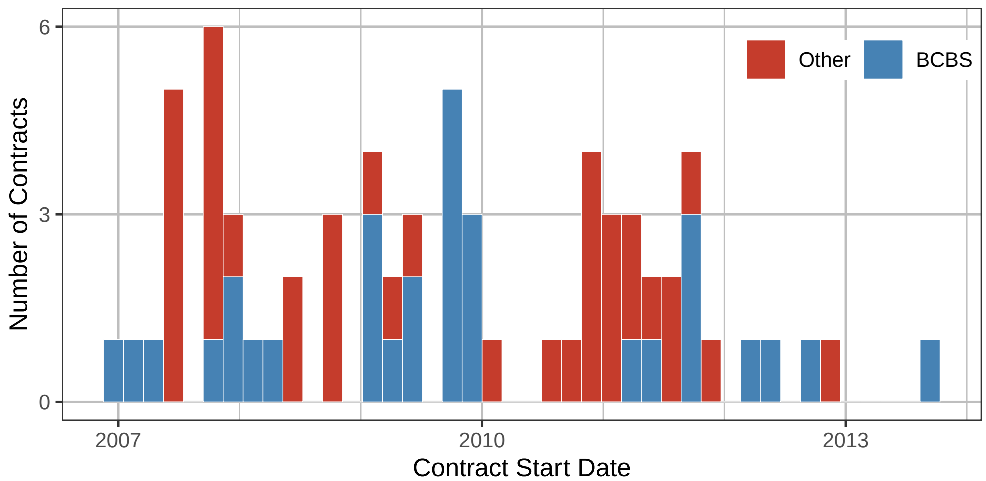


Figure 3: Histogram of contract start dates for contracts used in the estimation sample and introduced 2007–2014 for Highmark BCBS (blue) and other modeled insurers (pink). Vertical lines indicate January 1 of a given year. Contracts were not systematically introduced on the same dates.

in my sample. Contracts were introduced in many months within a given year. This pattern of staggered formation held even between contracts formed by Highmark BCBS. Further, the market did not play a follow-the-leader strategy. For example, in 2007, the medium-sized insurers I model introduced contracts at different times than Highmark BCBS.

I present more descriptive statistics in Appendix C.2 and Dorn (2024). The descriptive statistics in Appendix C.2 include contract scale based on the estimated hospital demand system for West Virginia residents at West Virginia hospitals that I discuss in Section 4.3 below.

## 4.2 Empirical Simplifications

I make some empirical simplifications on dynamics to address the finite number of years of data available.

I estimate a finite horizon model: I consider only the first $T$ years of a contract in calculating gains from trade, where $T = 5$ for my current analysis. I cannot estimate a compelling infinite horizon model because West Virginia is nonstationary. I take $T = 5$ as an approximation: as the length of available data goes to infinity, $T$ would go to infinity slowly to enable the number of bargains in estimation to go to infinity as well. The finite horizon makes a constant patience parameter $\beta$ at best an approximation because the fifth year in should principle best approximate later years. The finite horizon model also calls for care in modeling how impasse affects other bargainers near the end of the horizon. I calculate gains from trade through 2016. Contracts in 2016 are calculated by linearly extrapolating list price levels from calendar year 2015 contract reports and extrapolating contract list price shares from 2015.

I do not incorporate the impasse repricing term: I enforce $\text{Pay}_{IRT} = 0$ in my current estimation. Impasse repricing would be equal to zero in steady state. I anticipate it will be small in the West Virginia setting. This restricts the bargaining space when $\beta > 0$ but does not change the space of myopic predictions. As a result, I expect the bargaining model to continue to reject myopia after incorporating impasse repricing.

I parameterize the bargaining weights as an insurer fixed effect with hospital size effects on a logit scale:

$$\log\left(\tau_{ij}/(1-\tau_{ij})\right) = log(\tau_j/(1-\tau_j)) + \tau^{Size} log(HospSize_{i,2006}/MeanHospSize_{2006}), \quad (6)$$

where hospital size is measured as the size of the bargaining system in my first year of 2006 and $\tau_j$ is insurer bargaining power measured at the average-sized hospital system. I do not require $\tau_{ij}$ to be between zero and one. Instead, if $\tau_j \notin (0, 1)$, I take $\tau_{ij} = \tau_j$. Larger hospitals have more bargaining weight if $\tau^{Size}$ is negative. I assume that the insurer bargaining weight parameter $\tau_j$ is shared for the for-profit insurers I model (Aetna, Cigna, Carelink, and UnitedHealth). I set the hospital negotiation costs $r_i^H$ to zero because it is not clear the parameter is separately-identified from the insurer costs $r_j^M$. I assume the $r_j^M$ parameters are constant for non-Highmark-BCBS insurers to increase statistical power.

## 4.3 Estimation

I estimate hospital demand through logistic maximum likelihood. I estimate insurer demand and bargaining parameters through the generalized method of moments (GMM).

The bargaining moment is:

$$p^*_{ijt_0}\mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t^*}\beta^{t-t_0}D^H_{ijt}(\mathcal{G}_t,\phi_t)\frac{p_{it}^{B_{ijt}}}{p_{it_0}^{B_{ijt}}}\right] = \mathbb{E}_{t_0}\left[\sum_{t=t_0}^{t^*}\beta^{t-t_0}\left(-\tau_{ij}\left[\Delta_{ij}\pi^H_{it}\right] + (1-\tau_{ij})\left[\Delta_{ij}\pi^M_{jt}\right]\right)\right] + (1-\tau_{ij})r_j^M.$$

The left-hand side is observed up to the patience parameter $\beta$. The right-hand side includes bargaining frictions $r$, bargaining weights $\tau$, and the Nash-in-Nash flow gains from trade. The Nash-in-Nash flow gains from trade (Equation (2) on Page 16) depend on hospital demand $D^H$, insurer demand $D^M$, hospital costs $c_i$, insurer noninpatient costs $\eta_j$, and prices per unit of care $p$. I estimate hospital demand as an input to both the insurer demand model and bargaining model. I then estimate insurer demand as an input to the bargaining model. The bargaining model is estimated based on observed and predicted payments for observed bargains. I bootstrap standard errors by resampling inpatient cases and state-level sales.

Similar strategies have been used with various datasets in static models, though there are important differences. Some notable papers with similar identification strategies are Grennan (2013), Gowrisankaran et al. (2015), Ho and Lee (2017, 2019), Ghili (2022), Liebman (2022) and Prager and Tilipman (2022). Gowrisankaran et al. (2015) and Prager and Tilipman (2022) assume insurers maximize a criterion other than profits. Grennan (2013) and Ghili (2022) have a non-zero-sum downstream response to negotiated prices, which could be partially captured in levels by my flexible hospital–insurer bargaining weight specification (Equation (6)). However, such time-varying NTU bargaining cannot fit into my Kalai proportional bargaining model for reasons discussed in Appendix D.2. Ho and Lee (2019) and Ghili (2022) consider network formation in response to disagreement, which is at odds with my good-faith disagreement and simultaneous bargaining Assumptions 1 and 2. Many of these works estimate premium responsiveness (Gowrisankaran et al., 2015, Ho and Lee, 2017, 2019, Liebman, 2022, Ghili, 2022). I instead use market premium regulations to estimate demand given observed premiums and focus on price counterfactual effects that can be conservatively bounded without an estimate of premium responsiveness.

I estimate hospital demand with maximum likelihood. I adapt the notation of Ho (2006), but similar models are widely used (Capps et al., 2003, Gowrisankaran et al., 2015, Ho and Lee, 2017, Prager and Tilipman, 2022). I assume that to a patient, the utility of a potential hospital is a function of the patient's diagnosis, the hospital's quality, and the patient's location. In particular, I assume the utility of consumer $i$ visiting in-network hospital $h$ with diagnosis $\ell$ (cancer, cardiac, digestive, labor, neurological, or other) is:

$$u^H_{i,h,\ell} = \delta^H_{h,\ell} + \nu_{i,h,\ell}\rho + \varepsilon_{i,h,\ell},$$

where $\delta^H_{h,\ell}$ is a hospital-diagnosis fixed effect, $\nu_{i,h,\ell}$ are patient-hospital characteristics (distance in miles, distance squared, and distance interacted with emergency), and $\varepsilon$ is a type 1 extreme value shock. I estimate the model with Blue Cross patients in 2016, as all hospitals are in-network for Blue Cross.

Hospital demand is identified by selection on observables. If consumers are highly likely to choose Charleston Area Medical Center (CAMC) relative to Saint Francis Hospital one mile away, my estimates will infer that CAMC offers more utility to consumers after adjusting for location. The degree to which patients with similar diagnoses choose closer hospitals identifies the $\rho$ distance coefficients. There are three key assumptions for the hospital demand model to be accurate for bargaining estimation. First, Blue Cross hospital choice should be representative of the generic consumer hospital choice decision conditional on location and diagnosis (i.e., no endogeneity of insurance choice with respect to hospital value). Second, observed choices should identify counterfactual choice probabilities with different hospital choice sets (i.e., unconfoundedness and correct functional form). Third, observed hospital choice should capture the value of hypothetical hospital networks when choosing an insurer.

I estimate insurer demand mainly using cross-sectional data from 2016, the year in which I have estimates of local sales. The equation I estimate in 2016 is:

$$u^M_{i,j,c,m} = \tilde{\delta}^M_{j,m} + \gamma_k WTP_{j,k,c} + \xi_{j,k,c} + \varepsilon_{i,j,c,m},$$

where $u_{i,j,c,m}$ is the utility of individual $i$ choosing insurer $i$ in county $c$ within market $m$, $\tilde{\delta}^M_{j,k,m}$ is an insurer–rating-area fixed effect that includes premium levels, $WTP_{j,k,c}$ (Capps et al., 2003) is the ex ante expected utility of insurer $j$'s network to an individual of age-group $k$ in county $c$, $\gamma_k$ are age-group-dependent coefficients on WTP, $\xi_{j,k,c}$ is an age–county unobservable, and $\varepsilon$ is a type 1 extreme value shock. Similar models have been used by Ho and Lee (2017) and Ghili (2022). The equation is estimated using the moment $E[WTP_{j,k,c}\xi_{j,k,c}] = 0$, matching observed county-age shares for insurers identified in the inpatient data, and matching state-level sales for all modeled insurers. I assume that the insurer-rating area fixed effects $\tilde{\delta}^M_{j,m}$ are constant across markets for the two insurers that are not identified in the inpatient data, Cigna and UnitedHealth.

The utility equation does not include premiums. Since 2014, the Affordable Care Act (ACA) restricts insurer premium setting substantially (CMS, 2023). Insurers set premiums (outside the large-group market) by geographic rating area defined by the state of West Virginia.[8] Premium variation in 2016 is essentially subsumed into the $\tilde{\delta}^M_{j,m}$ insurer-rating-area fixed effects.

My counterfactual analysis must account for changes in insurer attractiveness and premiums over time. For years before 2016, I include an insurer-time fixed effect $\tilde{\delta}^M_{j,t}$. The fixed effect $\tilde{\delta}^M_{j,t}$ captures systematic changes in insurer value and premiums in previous years. I solve for the values to match state-level sales by year after adjusting for changes in networks and local population. I discuss other estimation details in Appendix C.1.

Insurer demand is identified based on variation in network quality conditional on premiums. Insurer regional coverage was heterogeneous within West Virginia's 11 market rating areas (see Appendix Figure 23). The $\gamma_k$ coefficients are identified by the degree to which con-

[8]Insurers also have a limited ability to adjust premiums based on tobacco use, family size, and age. In practice, insurers applied at most a small adjustment for tobacco use, a similar adjustment for large families, and the same age multipliers. I hold these multiples fixed in my analysis.

sumers are more likely to choose an insurer with better coverage within a rating area that standardizes premiums. The key identification assumption is exogeneity: the market-level unobservables should be uncorrelated with network quality itself. I do not model any potential variation of large-group employer premiums within ACA rating areas. My main analysis holds premiums fixed and calculates back-of-the-envelope downstream effects of counterfactual prices on Nash-Bertrand optimal premiums based matching the average premium elasticity from Ho (2006). As a result, my analysis does not require estimating premium responsiveness. I discuss these and some other caveats in demand estimation in Appendix C.4.

I estimate my dynamic bargaining model with GMM. I define $\omega_{ijt}(\bar{\theta})$ to be the normalized net present value residual payment from $ij$ negotiating in period $t$ at parameters $\bar{\theta}$:

$$\omega^p_{ijt}(\bar{\theta}) = \frac{\sum_{t=t_0}^{t^*} \bar{\beta}^{t-t_0} \left( D^H_{ijt} p^H_{ijt} - \left\{ -\bar{\tau}_{ij}[\Delta_{ij}\bar{\pi}^H_{it}] + (1-\bar{\tau}_{ij})[\Delta_{ij}\bar{\pi}^M_{jt}] \right\} \right) - (1-\bar{\tau}_{ij})\bar{r}^M_j}{\sum_{t=t_0}^{\lfloor mean(t-t_0) \rfloor} \bar{\beta}^{t-t_0} + (mean(t-t_0) - \lfloor mean(t-t_0) \rfloor)\, \bar{\beta}^{\lceil mean(t-t_0) \rceil}}, \tag{7}$$

where a $\bar{\text{b}}$ar denotes a parameter that is estimating in my bargaining model and $mean(t-t_0)$ is the average bargain's number of years elapsed. The denominator is added to express $\omega_{ijt}$ in terms of the $ij$ net present value payment and an aggregate normalization to avoid attenuating the estimated patience parameter $\beta$. (As seen in Appendix Table 8, I would estimate a similar $\hat{\beta}$ if I instead normalized by the average value of $\sum \beta^t$ across bargains used in model estimation.) My main specification calibrates hospital costs from reported hospital average costs, which should roughly track the outside option of Medicare payments if hospitals are near capacity, and adjust hospital costs in robustness tests. The parameters to estimate are the $\tau_j$ insurer bargaining weights, $\tau^{Size}$ contribution of size to hospital bargaining weight, $\beta$ patience parameter, $\eta_j$ insurer noninpatient costs, and payment-equivalent negotiation costs $r^M_j$.

Bargaining moments are constructed as follows. I take the net present value payment residual $\omega^p_{ijt}(\bar{\theta})$ from Equation (7). I define $\omega^M_{jt}(\bar{\theta}) = \sum_{t=2011}^{2016} \frac{\bar{\eta}_j D^M_{jt} + \sum_h D^H_{hjt} p_{hjt}}{\phi_{jt} D^M_{jt}} - MLR_{j,t}$ as the difference between model-implied medical loss ratio and the medical loss ratios $MLR_{j,t}$ reported to CMS for years 2011 and later. My moments are $E[Z^p \omega^p] = 0$ and $E[Z^M \omega^M] = 0$. The hospital–insurer payment instruments $Z^p$ are insurer dummies and indicators for hospital size in six groups. The insurer medical loss ratio instruments $Z^M$ are insurer dummies.

Identification of bargaining parameters comes from various sources. The $\eta_j$ insurer noninpatient costs are identified primarily from the CMS medical loss ratio reports but are shifted by the GMM procedure based on observed payments. The flow gains from trade $[\Delta_{ij}\pi]$ are identified from estimated demand, $\eta_j$ noninpatient costs, and calibrated hospital costs $c$. The $\tau_{ij}$ bargaining weights are identified by the ratio of realized gains from trade at the negotiated price and varying the hospital or insurer. The $\beta$ bargaining weights are identified by future gains from trade and payments helping explain the realized price conditional on current gains. The $r^M$ negotiation costs are identified from any remaining differences in the levels of payments and the levels of predicted payments. I discuss potential biases in Appendix Appendix C.4.

## 4.4 Parameter Estimates

My estimated demand systems are generally plausible. I overwhelmingly reject the null hypothesis of myopia and estimate an annual patience parameter of $\beta = 0.899$.

| | *Dependent variable:* | | | | | |
|---|---|---|---|---|---|---|
| | choice | | | | | |
| | Cancer | Cardiac | Digestive | Labor | Neurological | Other |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Distance | $-0.115^{***}$ | $-0.113^{***}$ | $-0.117^{***}$ | $-0.121^{***}$ | $-0.077^{***}$ | $-0.108^{***}$ |
| | (0.014) | (0.004) | (0.005) | (0.004) | (0.003) | (0.002) |
| Distance Squared | $0.0004^{***}$ | $0.0004^{***}$ | $0.0004^{***}$ | $0.0003^{***}$ | $0.0002^{***}$ | $0.0003^{***}$ |
| | (0.0001) | (0.00002) | (0.00002) | (0.0001) | (0.00002) | (0.00001) |
| Distance x Emergency | $-0.010$ | $-0.012^{***}$ | $-0.024^{***}$ | $0.020^{***}$ | $-0.013^{***}$ | $-0.015^{***}$ |
| | (0.015) | (0.003) | (0.004) | (0.005) | (0.004) | (0.001) |
| Observations | 284 | 2,469 | 2,048 | 4,143 | 1,094 | 10,053 |
| $R^2$ | 0.555 | 0.577 | 0.615 | 0.646 | 0.497 | 0.555 |
| Log Likelihood | −286.987 | −2,722.077 | −2,324.572 | −3,923.918 | −1,297.677 | −12,578.030 |
| *Note:* | | | | | | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

Table 2: Estimated consumer valuation of distance in hospital choice (in utility units) by diagnosis category. Consumers generally are admitted to closer hospitals, have a diminishing loss from travel, and — with the exception of labor cases — are especially unlikely to travel distances for emergency care.

I present estimated hospital demand distance parameters in Table 2. Regardless of diagnosis, consumers prefer closer hospitals and have a diminishing loss from distance. Consumers with neurological conditions are relatively insensitive to distance. Patients travel less far for emergency care outside labor cases. In the 201 hospital-diagnosis fixed effects I estimate but omit for space, consumers place the highest value on Ruby Memorial, the West Virginia University (WVU) Health system's flagship hospital. Hospitals near the state's border like Cabell Huntington and Mon Health Medical Center are generally higher value than their state-level share would suggest, consistent with border hospitals also competing for patients from neighboring states. Hospital fixed effects are comparable for most diagnoses but are smaller for labor discharges.

| | *MCO:* | | | | |
|---|---|---|---|---|---|
| | Aetna | Highmark BCBS | HPUOV | Cigna | UnitedHealth |
| | -1.39*** | 1.33*** | -0.8*** | -3.54*** | -2.43*** |
| | (0.13) | (0.13) | (0.13) | (0.11) | (0.11) |
| *Note:* | | | | | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

Table 3: Estimated average 2016 insurer value including premiums ($\tilde{\delta}^{M}_{j,m}$) after accounting for variation in inpatient network quality.

My insurer demand estimates are in Table 3 and Appendix Table 6. Table 3 includes insurer mean $\tilde{\delta}^{M}_{j,m}$ fixed effects inclusive of premiums. Consumers are more likely to choose Highmark BCBS than can be explained by the insurer's inpatient network alone, which may reflect a better outpatient network, better perceived quality, inertia, or Highmark BCBS's nonprofit status. The regional HPUOV is also nonprofit and has a larger fixed effect than the three national for-profit insurers, which in part reflects lower premiums. Appendix Table 6 presents the estimated WTP coefficients. Consumers are more likely to purchase insurance with a better network. The network value coefficients differ substantially by age in absolute terms. The scale of network valuation reflects age differences: younger consumers are less likely to get sick and so have a smaller variation in WTP across networks.

My main bargaining estimates are presented in Table 4. I present estimates under three bargaining strategies, all of which use the same hospital and insurer demand estimates:

a. *Only-2015.* This approach estimates bargaining parameters as-if only data from 2015 is available. In particular, the only-2015 model includes all hospital–insurer pairs with 2015 contracts as if they simultaneously negotiated new contracts at the start of the year, even if the contract was truly formed many years earlier. This approach also only includes 2015 MLRs in the GMM procedure.

b. *Myopic.* This approach estimates bargaining parameters for contracts with confirmed start and end dates, but constrains the discount rate $\beta$ to zero to recover a static-type estimation strategy.

c. *Forward-Looking.* This approach is analogous to myopic, but allows the annual discount rate $\beta$ to take on any value between zero (which corresponds to myopia) and one (which corresponds to no discounting after inflation).

| | Parameter | | | | |
|---|---|---|---|---|---|
| | $\beta$ | $\tau_{BCBS}$ | $\tau_{HPUOV}$ | $\tau_{FP}$ | $-\tau^{Size}$ |
| Only-2015 | $\cdot$ | 0.487** | -7.54 | 0.694*** | 3.354 |
| (Nash/Kalai) | $(\cdot)$ | (0.191) | (17.204) | (0.175) | (22.875) |
| Myopic | $\cdot$ | 0.876*** | 0.825*** | 0.861*** | 1.037*** |
| (Nash/Kalai) | $(\cdot)$ | (0.012) | (0.232) | (0.034) | (0.199) |
| Forward-Looking | 0.899*** | 0.854*** | 0.877*** | 0.889*** | 0.989*** |
| ($\text{Pay}_{IRT} = 0$) | (0.03) | (0.006) | (0.026) | (0.005) | (0.028) |

*Note:* $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01

Table 4: Estimated bargaining and patience weights for the only-2015-data (first row) myopic (second row) and more general forward-looking (third row) bargaining models. The MCO $\tau_j$ bargaining weights are estimated for Highmark BCBS (BCBS), HPUOV, and the modeled for-profit insurers (FP) and are evaluated at the average bargain's hospital bargaining system log 2006 size. Estimates under alternative bargaining models are presented in Table 8.

I present estimates of noninpatient costs ($\eta$) and net negotiation costs ($r_j^M$) in Table 7.

I find that bargainers are forward-looking. I find excellent model fit (Appendix Figure 11). My estimated model overwhelmingly rejects a null hypothesis of myopia, which corresponds to the case $\beta = 0$. My estimated patience parameter of $\beta = 0.899$ is also below one. These indicate that firms care about future period profits ($\beta > 0$) but value a dollar today less than a dollar tomorrow ($\beta < 1$). Even though the forward-looking model targets years beyond the initial year of the contract, the forward-looking bargaining model even does a slightly better job of predicting initial share of list prices than the myopic model (Appendix Figure 7), with correlations between predicted and real starting share of list prices of 0.521 and 0.452, respectively.

The estimated bargaining weights under the forward-looking model are generally empirically plausible. I find little heterogeneity in bargaining power across insurers: I estimate that insurers keep 85%–89% of the joint surplus when bargaining with a medium-sized hospital system (Table 4). The estimated weights are somewhat larger than other estimates in the literature based on claims data (Ho and Lee, 2017, Ghili, 2022). There is no restriction in my estimation procedure that both sides must gain from trade under the negotiated contracts, so it is reassuring that the myopic and forward-looking models estimate bargaining weights $\tau$ between zero and one.

Including old contracts in estimation would change the impression of bargaining power. The Only-2015 approach, which includes both old and new contracts in estimation, would underestimate BCBS and for-profit bargaining power relative to the bargaining models that include only new contracts. The estimated for-profit bargaining weight is larger than the estimated BCBS bargaining weight, but the difference is statistically imprecise. The Only-2015 approach would estimate a large but statistically imprecise coefficient on hospital size and a highly negative but highly imprecise HPUOV bargaining power.

The results are qualitatively similar under most other specifications (Table 8). Other plausible specifications can reduce the estimated discounting rate $\beta$ to 0.7, but continue to reject a null hypothesis of myopia. The estimated discount parameter $\beta$ is also dependent on the exact split of hospital groups in constructing instruments: bootstrapped $\beta$ standard errors with reestimated hospital groups increase from 0.03 to 0.109, driven by the 18% of bootstraps in which United Hospital Center's assignment changes. Restricting $\tau^{Size}$ to zero stabilizes the Only-2015 model and changes the BCBS, HPUOV, and for-profit bargaining weight estimates to 0.365, 0.278, and 0.16, respectively, underscoring Dorn (2024)'s descriptive evidence that current payments can underrate smaller insurers' bargaining power.

I find the Kalai proportional bargaining model's predictions would likely approximate a complex dynamic Nash bargaining model's predictions. Under a Kalai proportional bargaining model, gains from trade are split proportionally to the $\tau_{ij}$ bargaining weights. Under a Nash bargaining model, the split of gains from trade also reflects the ratio of marginal values of the negotiated price. I calculate predicted marginal value ratios including the direct effect of each bargain's price on the firms' profits through other contracts. I find that the estimated marginal value ratios are generally close to one (Appendix Figure 9). The rare exceptions have the opposite correlation with payment residuals as the Nash model would predict (Appendix Figure 10). The result is neither dispositive evidence that a Nash bargaining model would estimate similar marginal values nor that a complex dynamic Nash bargaining model would be more accurate. However, the evidence is consistent with the Kalai proportional bargaining model offering substantial tractability gains with potentially small consequences for empirical conclusions, as well as limited ability to use observed payments to reject either model.

# 5 Counterfactuals under Dynamic and Static Models

I empirically investigate benchmark price counterfactuals. I consider a change to Medicare cost reimbursement to roughly track hospital reported costs. I find that faster Medicare payment increases would be passed on to commercial insurer spending through Medicare's role as a benchmark. A myopic model overestimates the effect by 45% or more by ruling out forward-looking offsets.

## 5.1 Changing Benchmark Price Increases

Medicare reimbursement is an active topic of regulatory debate. Medicare inpatient expenditures amounted to $319 billion in 2019 (CMS, 2022), comparable to the gross domestic product of Egypt (World Bank, 2023) and enough to account for 27% of American hospital expenditures, 40% of Medicare expenditures, and 7% of federal government spending (CBO, 2020, CMS, 2022). The American Hospital Association argues that Medicare payment increases have failed to keep up with costs (Thompson, 2023) as policymakers reduce Medicare payments to make up for budgetary shortfalls (Finder, 2022).

Spending at hospitals on behalf of patients with commercial insurance is an important policy target. In 2019, hospital expenditures paid for under private insurance reached $434 billion — 42% of private health insurance expenditures and 36% more than Medicare expenditures (CMS, 2022). The high prices paid on behalf of commercially insured patients are often considered major drivers of American health spending (McGough et al., 2023). Commercially insured payments to hospitals averaged 235% of what Medicare would have paid for the same care in 2019 (Whaley et al., 2022), making spending on behalf of commercially insured patients at hospitals an important policy target. Those costs are passed on to consumers in the form of increased premiums (Handel, 2013, Trish and Herring, 2015, CBO, 2022) and wage and employment reductions (Baicker and Chandra, 2006, Arnold and Whaley, 2020).

I study the consequences of proposed changes to Medicare benchmark price increases on commercially insured payments, focusing on Medicare's role as a benchmark in negotiated prices. If Medicare reformed reimbursement to increase payments more quickly in response to hospital pressure, then it would affect the dynamics of the many Highmark BCBS and occasional HPUOV contracts that were benchmarked to prices based on Medicare. I focus on benchmark dynamics and hold any effect on Medicare-based outside options constant (Clemens and Gottlieb, 2017). My specific counterfactual is an additional one-percentage-point annual increase in hospital prospective prices announced at the end of 2006 to begin in 2007. The one-percentage-point increase would roughly offset the divergence between West Virginia Medicare payments and hospital costs in this era (Appendix Figure 8). The change would correspond to a $26.5-billion increase in 2015 Medicare hospital expenditures (CMS, 2022, expressed in 2019 dollars).

Counterfactual payments are calculated as follows. I hold benchmark choice, contract length, and premiums constant in calculating counterfactual prices. The choice of benchmark is highly associated with bargaining power and likely to be at most moderately affected by the change in benchmark dynamics. Most fixed-length contracts were formed by

Highmark BCBS, so holding lengths constant mostly corresponds to assuming that Highmark BCBS would not change which contract terms were formed on a three-year or five-year basis and that the other insurers would not change their share of charges renewal strategies. Premiums would increase in response to higher bargained prices. I estimate back-of-the-envelope downstream premium effects based on Ho (2006)'s estimated own-price elasticity and a Nash-Bertrand premium model. I am conservative by not estimating any reinforcing effect of higher premiums on prices. I use plug-in estimates of counterfactual benchmark prices. I interpret the $\omega^p$ net present value payment residuals as counterfactual-invariant unobserved components of gains from trade, and choose starting payments to leave $\omega^p$ unchanged. This approach may introduce slight bias if benchmark price uncertainty is first-order relative to the change to benchmark price dynamics. One potential avenue for future work is to apply tools from the time series literature to develop a more precise approach to counterfactuals.

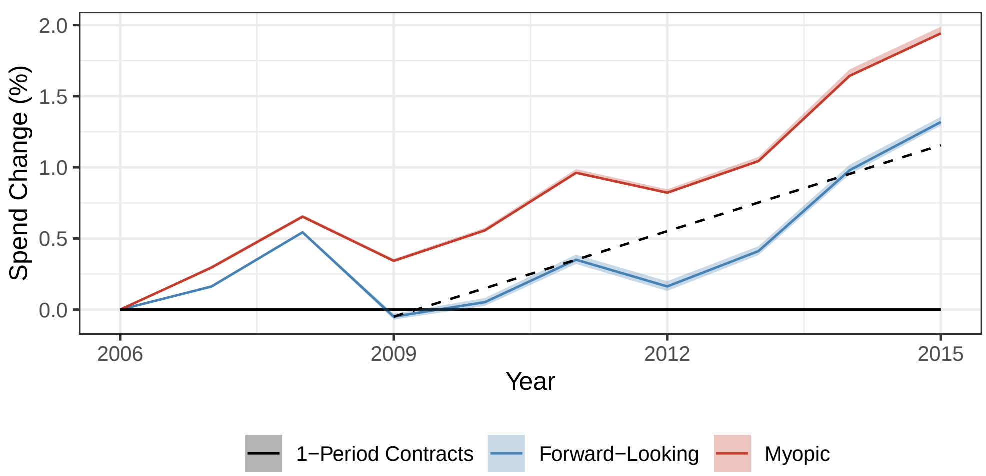


Figure 4: Estimated counterfactual spending effects from a one-percentage-point increase in Medicare payments from a myopic (blue) and dynamic (red) bargaining model. The dashed line indicates 0.20 percentage point additional annual spending increases starting in 2009.

I summarize the estimated effects by year under the estimated myopic and forward-looking bargaining models in Figure 4. The effects are presented as a percentage of modeled insurer spending. (In Dorn (2024), I estimate that nonmodeled insurers accounted for roughly one-quarter of spending.) The estimated effect under the forward-looking model is negative and near-zero in 2009 and 2010, when Highmark BCBS and HPUOV negotiated many new prospective contracts and correspondingly reduce starting prices. There is an analogous dip in 2012 when Highmark BCBS revised many of the contracts formed in 2009. In later years, contracts remain in place and effects compound. After nine years, the estimated increase in spending is 1.3%. The estimated increase in West Virginia spending in the commercially insured inpatient market would be \$7.1 million. The percent change in spending after nine years, if extrapolated to the 2015 national hospital market and inflation-adjusted to 2019 dollars, corresponds to a \$4.98-billion effect.

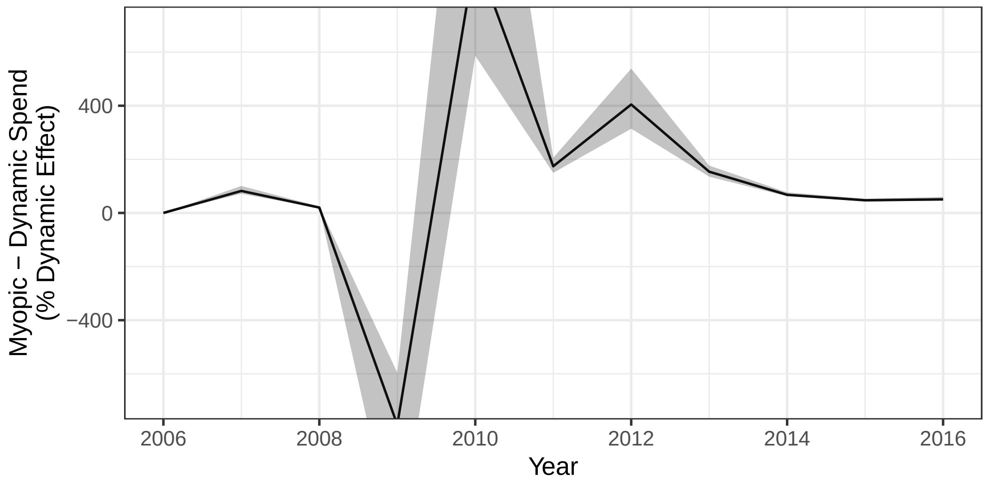


Figure 5: The degree to which myopic counterfactual predicted spending exceeds dynamic predicted spending as a percent of the estimated effect under the dynamic model. The myopic model often overestimates the effect by 45% or more.

A myopic model would substantially overestimate the effects. Figure 5 reports the annual overestimate of the myopic model as a percentage of the dynamic estimated effect. The myopic model consistently overestimates the effect by 45% or more. In the middle of the panel, when the forward-looking model estimates are small due to many renegotiations, the myopic model overestimates the effect by many multiples. The reason the myopic bargaining model overestimates the effects of benchmark price increases is because forward-looking bargainers respond to anticipated future increases under the contracts they negotiate by reducing starting prices and offsetting the effect.

The estimated annual spending increase of 1.319% is below the benchmark price increase of 9.37% for three main reasons: many payments were benchmarked to unaffected list prices, the Medicare-benchmarked contracts were renegotiated often, and the forward-looking bargainers revise starting prices downward based on the anticipated future benchmark price increases. I measure the importance of the first mechanisms by considering a same-multiple model, wherein the firms kept their original negotiated benchmark multiples $\alpha$ in place. Appendix Figure 12 presents the different estimated effects. Viewed as a change to annual spending increases, such a same-multiple model produces an annual spending increase of 0.564 percentage point after nine years. The myopic model, which accounts for the first two responses, reduces the annualized increase by 0.35 percentage point. The forward-looking model, which incorporates all three responses, further reduces the annualized increase by 0.068 percentage point and introduces important dynamics along the way.

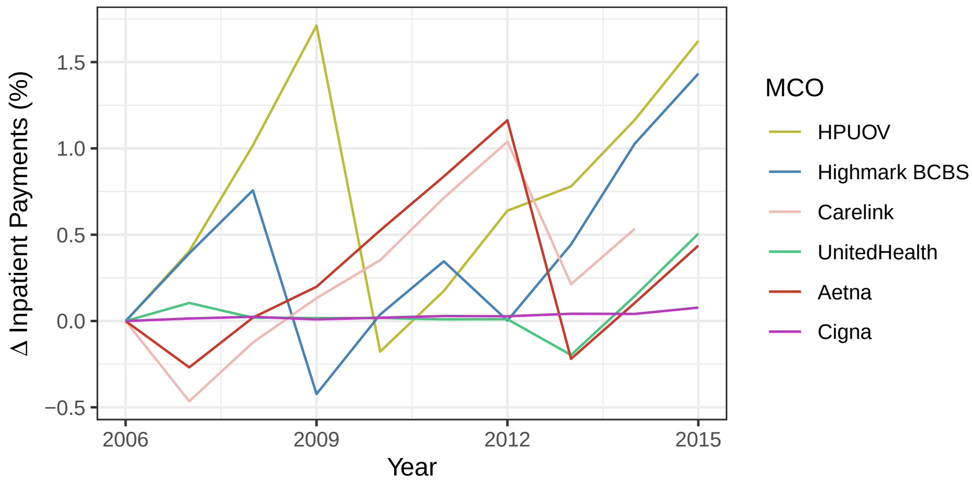


Figure 6: Estimated effects on payments by insurer from a one percentage point annual increase in Medicare payments.

The effects on insurer payments and hospital payments are in Figure 6 and Appendix Figure 13, respectively. The effects are largest for the insurers that use prospective contracts most frequently (Highmark BCBS, HPUOV, and Carelink before being acquired in 2014). In 2009, Highmark BCBS payments would change by -0.42% due to the forward-looking response for Highmark BCBS's many new prospective contracts. Other insurers often see reduced payments in years where they negotiated new prospective contracts with the WVU Health System. Turning to hospital payments, in 2015, most hospitals would have spending increases of 1% to 3%. A fair number of medium-sized hospitals would be almost entirely unaffected.

I add a premium-responsiveness coefficient to estimate downstream effects of the new prices on premiums. I calculate the premium coefficient needed to match Ho (2006)'s average own-price elasticity of -1.14, which corresponds to a coefficient on 2019 annual premiums of -0.00032. I then estimate downstream effects on premiums from Nash-Bertrand competition, with insurer-year marginal costs inverted from the Nash-Bertrand premium-setting first order condition. I do not estimate any reinforcing effect of new premiums on negotiated prices, which would exacerbate the effects further.

Appendix Figure 14 presents the full path of estimated downstream premium effects. I estimate that in 2015, Highmark BCBS premiums would increase by 0.2%, and HPUOV premiums would increase by 0.51%. The other modeled insurers are less likely to use Medicare-based benchmarks and would see premiums increase by 0.1%. Altogether, premiums would increase by 0.21%, which extrapolates nationally based on inflation-adjusted earned premiums (NAIC, 2022) to $1.33 billion. The extrapolated premium effects are smaller than the extrapolated payment effects because this premium extrapolation holds outpatient payments constant.

I use my estimated system to study other counterfactuals. In Appendix Figure 15, I plot the estimated spending effect of instead reducing Medicare benchmark prices by one percentage point annually; after nine years, the estimated effect would be a 1.29% reduction in spending. Measuring the effect as an annualized change to spending after nine years, spending is increased by 0.146 percentage point annually in the main counterfactual and reduced by 0.14 percentage point here.

In Appendix Figure 16, I plot the estimated spending effect of a lax restriction on list price increases. The counterfactual is implemented as a cap at the previous year's Medicare spending increase plus two percentage points, with significant safeguards to the hospitals' benefit. (More details on the construction are available in Appendix C.5.) To be conservative, I hold prices constant for CAMC, a large hospital with mostly low-discount share of charges contracts, when calculating counterfactual payments. I estimate that this regulation would reduce aggregate list price increases from roughly three percentage points faster than costs annually to roughly two percentage points faster than costs and would reduce payments by 0.11%–1.3% depending on the year. The list price restriction counterfactual is directly relevant to policy. However, the associated share of charges contracts are rarely renegotiated, so the estimated effects are only slightly too large under a myopic bargaining model.

# 6 Discussion

I find that dynamic benchmarks play an important role in hospital–insurer payments based on a unique panel dataset of contracts in West Virginia. I study the implications of changing Medicare payment dynamics through Medicare's role as a benchmark used to construct payments under multiyear contracts. I propose a tractable dynamic vertical market bargaining model. The model enables negotiators to be forward-looking and respond to future benchmark price increases by reducing starting prices. I reject the null hypothesis of myopia and find that forward-looking firms offset changes to benchmark price increases substantially but incompletely.

The recognition that many real hospital–insurer contracts are dynamic opens up exciting directions for future research in health economics. I study only lax counterfactuals that would have minimal effects on contract length and benchmark choice due to data restrictions. Other panel datasets from other states or after the end of West Virginia's corridor system in

2016 could speak to dynamic regulations with stronger impacts. As Dorn (2024) documents, list-price-benchmarked contracts lead to predictably quick payment increases under auto-renew contracts that often remain in place for a decade or more. The existence of long-lived list-price-benchmarked contracts is intuitively surprising, but may reflect efficiency gains through foregone negotiations. There are also interesting questions around the drivers and consequences of variation in contract terms across hospitals and insurers.

Bargaining has dynamic implications in other settings. For example, carriage contracts between television distributors and networks often last for multiple years (Nallen et al., 2019, Marcelo, 2021), and disputes are often ended by the threat of not carrying specific time-bound programming (Hayes, 2023). In the consumer packaged goods industry, multiyear contracts can create lagged inflation effects (Baudendistel, 2023). Many markets beyond healthcare have auto-renew contracts that in practice renew for many years (Dutta, 2021). In a labor economics context, firms can bargain with multiple unions (Machin et al., 1993) and those unions can have contracts with multiple firms (Davidson, 1988) that may be negotiated at different times. Many important questions can be answered by focusing on one period in isolation, but this work may help answer questions about the dynamics of multiyear contracts that interact.

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# A Appendix Tables and Figures

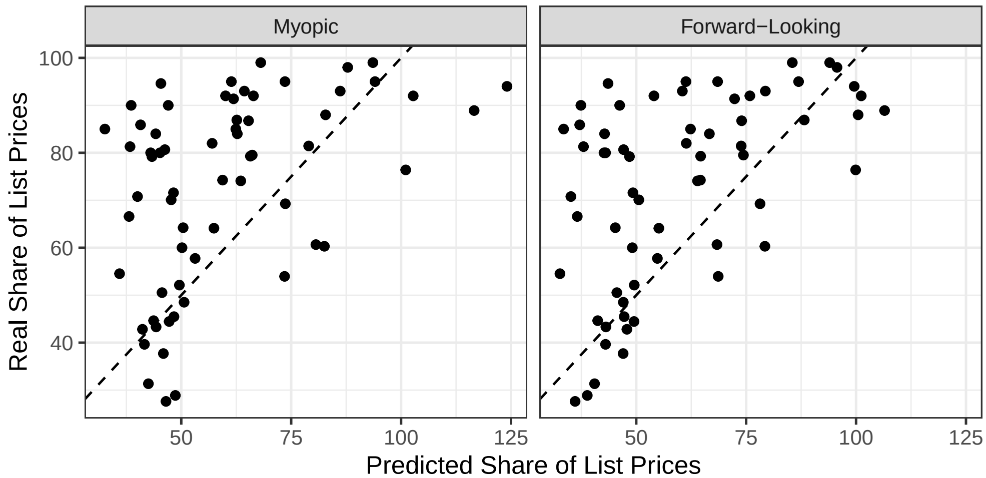


Figure 7: Predicted (x axis) and realized (y axis) bargain starting share of list prices under myopic (left, $R^2 = -0.116$) and forward-looking (right, $R^2 = 0.027$) bargaining models. $R^2$ can be negative because model predictions are chosen to minimize net present value payment residuals, while this $R^2$ reflects list price share residuals.

Table 5: The percent of discharges by diagnosis category for all inpatient discharges (top row), the commercial nonnewborn discharges I use for estimation (middle row), and the Highmark BCBS subset of commercial discharges I use for hospital demand estimation (bottom row). Labor and cardiac discharges are the largest share of actively defined categories. Medicare patients are more likely to have cardiac discharges and less likely to have labor discharges than the commercially insured sample I use in estimation.

| Discharges | Labor | Cardiac | Digestive | Neurological | Cancer | Other |
|---|---|---|---|---|---|---|
| All | 16.86 | 15.42 | 8.29 | 7.47 | 1.04 | 50.16 |
| Commercial WV | 19.85 | 12.41 | 9.97 | 5.60 | 1.33 | 50.11 |
| Highmark BCBS | 20.22 | 12.49 | 9.84 | 5.52 | 1.49 | 49.72 |

Table 6: Insurer demand coefficient on network willingness to pay by age group. Consumers are generally more likely to purchase insurance from insurers with better networks. The coefficients are largest for young groups with smaller standard deviations in network quality.

| | WTP Coefficient | | | | |
|---|---|---|---|---|---|
| | $\gamma_{0-17}$ | $\gamma_{18-44}$ | $\gamma_{45-64}$ | $\gamma_{65-74}$ | $\gamma_{75+}$ |
| | 26.6*** | 4.94*** | 2.76*** | 2.79*** | 2.05*** |
| | (2.65) | (0.67) | (0.33) | (0.27) | (0.15) |

*Note:* $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01

Table 7: Additional estimated bargaining parameters with estimated $\tau^{Size}$ hospital size coefficient (top) and with $\tau^{Size}$ set to zero (bottom) in calculating hospital–insurer bargaining weights. BCBS parameters correspond to Highmark BCBS. "Data" corresponds to average difference between MLR-implied costs per life and estimated average inpatient payments per life insured, and would exactly set the MLR moment to zero for the myopic and forward-looking models. The estimated $\beta$ would be similar if $\eta$ were constrained to exactly fit MLR reports (Appendix Table 8). The $r^M$ net negotiation costs are close to their starting point of \$10,000 and may weakly identified or unidentified.

| | Parameter ($\tau^{Size}$ Estimated) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $\eta_{BCBS}$ | $\eta_{HPUOV}$ | $\eta_{Aetna}$ | $\eta_{UnitedHealth}$ | $\eta_{Cigna}$ | $\eta_{Carelink}$ | $r^M_{yBCBS}$ | $r^M_{nBCBS}$ |
| Only-2015 | 3657*** | 3404*** | 3658*** | 2008*** | 4627*** | 3139*** | 10000*** | 9999*** |
| (Nash/Kalai) | (45) | (85) | (116) | (29) | (32) | (39) | (2614) | (1441) |
| Myopic | 4640*** | 4036*** | 3659*** | 3197*** | 4624*** | 3139*** | 10000*** | 10000*** |
| (Nash/Kalai) | (14) | (650) | (37) | (374) | (26) | (463) | (1444) | (1) |
| Forward-Looking | 4638*** | 3631*** | 3660*** | 3284*** | 4626*** | 3140*** | 9999*** | 9999*** |
| ($Pay_{IRT} = 0$) | (130) | (302) | (37) | (69) | (30) | (45) | (29) | (65) |
| Data | 3600 | 3356 | 3554 | 1999 | 4635 | 3114 | | |
| *Note:* | | | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

| | Parameter ($\tau^{Size} = 0$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $\eta_{BCBS}$ | $\eta_{HPUOV}$ | $\eta_{Aetna}$ | $\eta_{UnitedHealth}$ | $\eta_{Cigna}$ | $\eta_{Carelink}$ | $r^M_{yBCBS}$ | $r^M_{nBCBS}$ |
| Only-2015 | 3639*** | 3412*** | 3660*** | 2010*** | 4622*** | 3139*** | 10001*** | 23581*** |
| (Nash/Kalai) | (14) | (28) | (37) | (27) | (26) | (36) | (1143) | (1415) |
| Myopic | 4639*** | 3412*** | 3659*** | 2008*** | 4624*** | 6176*** | 17779*** | 10000*** |
| (Nash/Kalai) | (14) | (349) | (37) | (28) | (26) | (493) | (904) | (0) |
| Forward-Looking | 4638*** | 3413*** | 3659*** | 2008*** | 4624*** | 5972*** | 10000*** | 18098*** |
| ($Pay_{IRT} = 0$) | (1546) | (295) | (487) | (447) | (390) | (521) | (761) | (699) |
| Data | 3600 | 3356 | 3554 | 1999 | 4635 | 3114 | | |
| *Note:* | | | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

Table 8: Comparison of estimated bargaining parameters with other potential modeling choices. I describe the rows in Appendix C.6.

| | Parameter | | | | |
|---|---|---|---|---|---|
| | $\beta$ | $\tau_{BCBS}$ | $\tau_{HPUOV}$ | $\tau_{FP}$ | $-\tau^{Size}$ |
| Forward-Looking (Baseline) | 0.899*** (0.03) | 0.854*** (0.006) | 0.877*** (0.026) | 0.889*** (0.005) | 0.989*** (0.028) |
| Forward-Looking (No Hosp. Size) | 0.714*** (0.032) | 0.852*** (0.012) | 0.86*** (0.008) | 0.685*** (0.028) | $\cdot$ $(\cdot)$ |
| Forward-Looking (Mean $\sum \beta^t$ normalization) | 0.925 $(\cdot)$ | 0.854 $(\cdot)$ | 0.876 $(\cdot)$ | 0.89 $(\cdot)$ | 0.991 $(\cdot)$ |
| Forward-Looking (Estimate Hospital Costs) | 0.497 $(\cdot)$ | 0.939 $(\cdot)$ | 0.938 $(\cdot)$ | 0.942 $(\cdot)$ | 1.009 $(\cdot)$ |
| Forward-Looking (Hospital Costs * 2) | 1 $(\cdot)$ | 1 $(\cdot)$ | 1 $(\cdot)$ | 1 $(\cdot)$ | -0.276 $(\cdot)$ |
| Forward-Looking (Hospital Costs * 0.9) | 0.931 $(\cdot)$ | 0.838 $(\cdot)$ | 0.858 $(\cdot)$ | 0.875 $(\cdot)$ | 0.969 $(\cdot)$ |
| Forward-Looking (Hospital Costs * 1/2) | 1 $(\cdot)$ | 0.778 $(\cdot)$ | 0.781 $(\cdot)$ | 0.821 $(\cdot)$ | 0.903 $(\cdot)$ |
| Forward-Looking (Medicare Costs) | 0.895 $(\cdot)$ | 0.834 $(\cdot)$ | 0.847 $(\cdot)$ | 0.871 $(\cdot)$ | 0.913 $(\cdot)$ |
| Forward-Looking ($\eta$ from MLR) | 0.826 $(\cdot)$ | 0.864 $(\cdot)$ | 0.874 $(\cdot)$ | 0.891 $(\cdot)$ | 0.892 $(\cdot)$ |
| Forward-Looking (Inpat. Share GFT Weight) | 0.722 $(\cdot)$ | 0.881 $(\cdot)$ | 0.905 $(\cdot)$ | 0.897 $(\cdot)$ | 0.847 $(\cdot)$ |
| Forward-Looking ($\beta = 0.99$) | 0.99 $(\cdot)$ | 0.854 $(\cdot)$ | 0.875 $(\cdot)$ | 0.881 $(\cdot)$ | 1 $(\cdot)$ |
| Forward-Looking (Hospital TIOLI) | 0.696 $(\cdot)$ | 0.001 $(\cdot)$ | 0.001 $(\cdot)$ | 0.001 $(\cdot)$ | $\cdot$ $(\cdot)$ |
| Forward-Looking ($\tau = 0.5$) | 0.817 $(\cdot)$ | 0.5 $(\cdot)$ | 0.5 $(\cdot)$ | 0.5 $(\cdot)$ | $\cdot$ $(\cdot)$ |
| Forward-Looking (MCO TIOLI) | 0.52 $(\cdot)$ | 0.999 $(\cdot)$ | 0.999 $(\cdot)$ | 0.999 $(\cdot)$ | $\cdot$ $(\cdot)$ |
| Only-2015 (Baseline) | $\cdot$ $(\cdot)$ | 0.487** (0.191) | -7.54 (17.204) | 0.694*** (0.175) | 3.354 (22.875) |
| Myopic (Baseline) | $\cdot$ $(\cdot)$ | 0.876*** (0.012) | 0.825*** (0.232) | 0.861*** (0.034) | 1.037*** (0.199) |
| Only-2015 (No Hosp. Size) | $\cdot$ $(\cdot)$ | 0.365*** (0.011) | 0.278* (0.143) | 0.16*** (0.048) | $\cdot$ $(\cdot)$ |
| Myopic (No Hosp. Size) | $\cdot$ $(\cdot)$ | 0.863*** (0.006) | 0.845*** (0.016) | 0.631*** (0.027) | $\cdot$ $(\cdot)$ |
| *Note:* | | | *p<0.1; **p<0.05; ***p<0.01 | | |

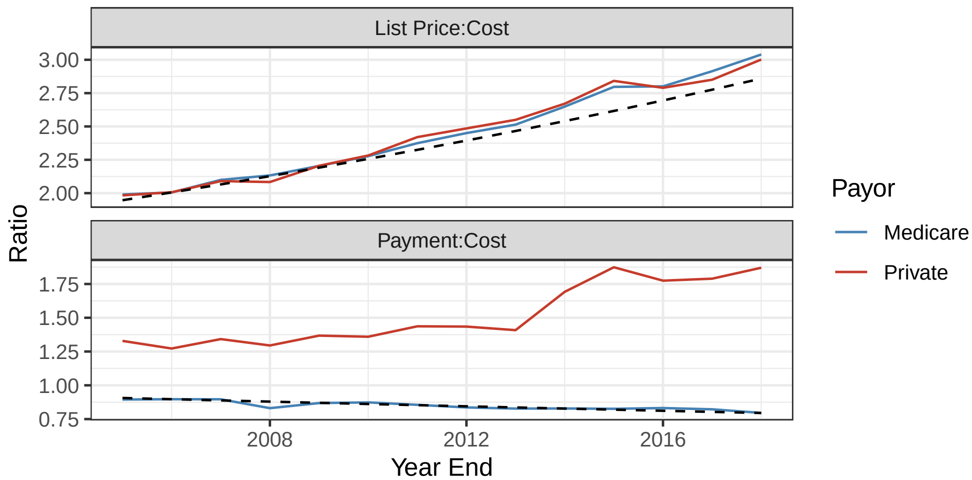


Figure 8: The ratio of list price charges (top) and real payments (bottom) to reported costs by Medicare (red) and private payors (blue) for West Virginia hospitals by year from hospital reports. Dashed lines represent Medicare 2006 values extrapolated based on 103% and 99% annual increase rates, respectively.

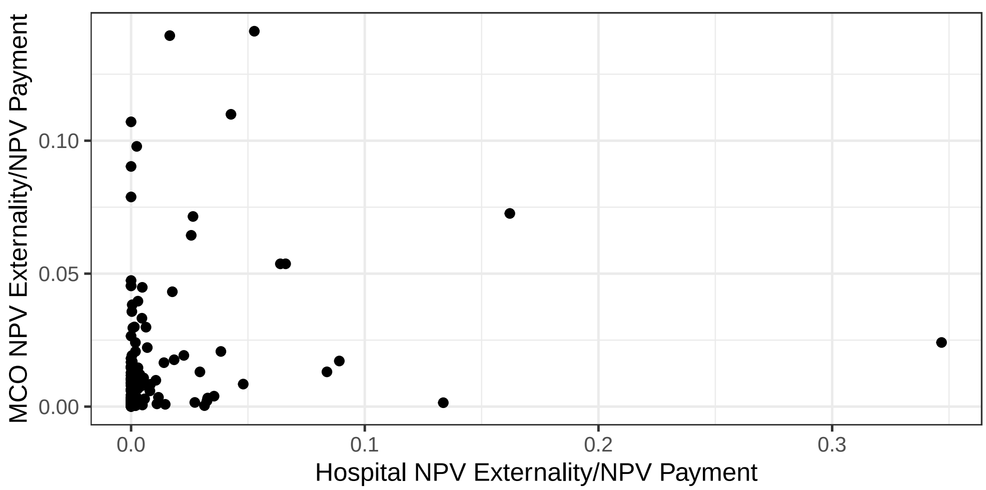


Figure 9: The estimated direct spillovers of each bargained contract on hospital (x axis) and insurer (y axis) payments relative to direct payments under the contract. All estimated insurer spillovers and all but three estimated hospital spillovers are less than 10% of payments under the contract, so that the marginal ratio term in Nash bargaining's gain from trade split would be close to one.

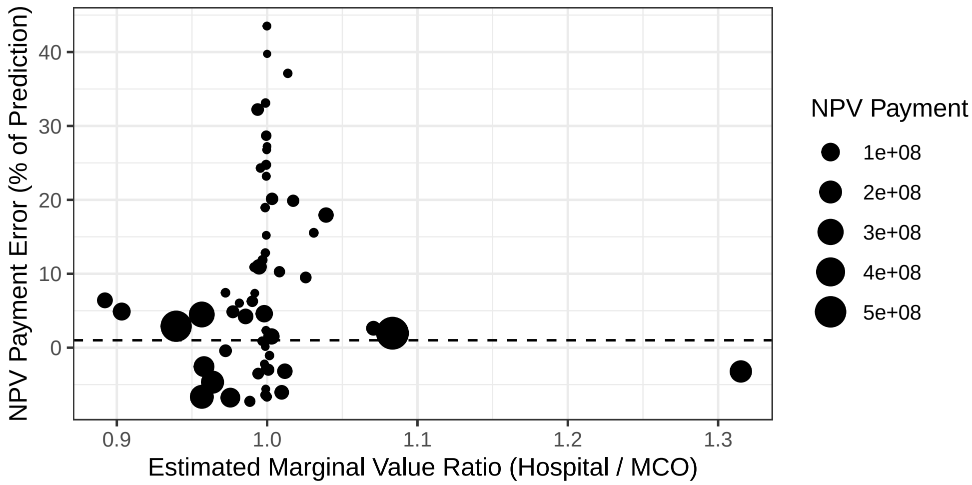


Figure 10: The net present value payment residual as a percentage of predicted payment (y axis) and marginal value ratio (x axis) for estimation bargains. Size corresponds to the net present value payment (weight in bargaining moment). Most marginal value ratios are close to one (x axis near one) corresponding to similar predicted Nash and Kalai proportional splits of gains from trade. A true Nash bargaining model would predict a positive correlation between marginal value ratio (x axis) and realized payments net of Kalai proportional prediction (y axis). The handful of contracts with larger marginal value ratios have residuals close to zero (y values near horizontal line), and if anything exhibits a negative correlation.

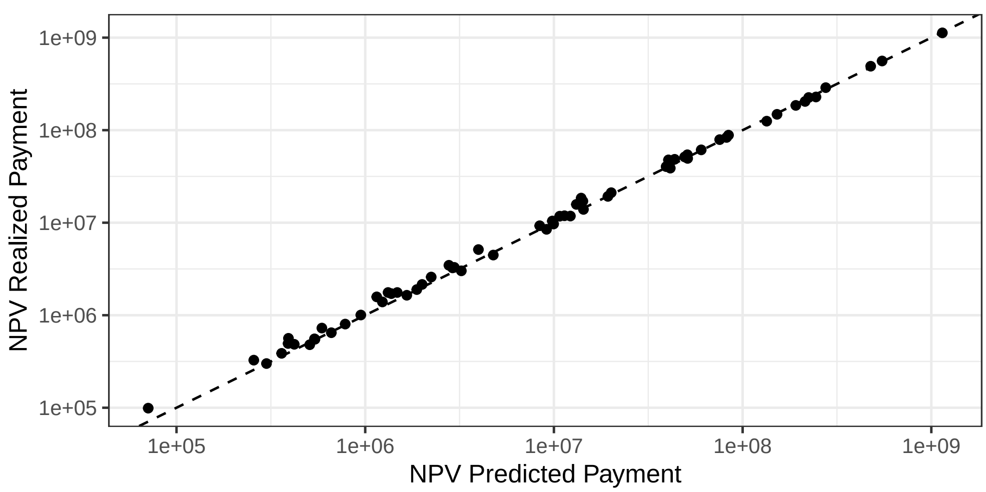


Figure 11: For the 63 estimation bargains, the predicted (x axis) and realized (y axis) net present value payment within the finite horizon used in estimation. Net present values are calculated using the estimated $\beta = 0.899$. Axes are log-scaled for comparability. Perfect prediction fit is indicated with the dashed line. There may be some bias for small contracts (generally non-Highmark-BCBS contracts at small-to-medium hospitals) that get little weight in the estimation procedure, but otherwise the model fit seems to be quite good.

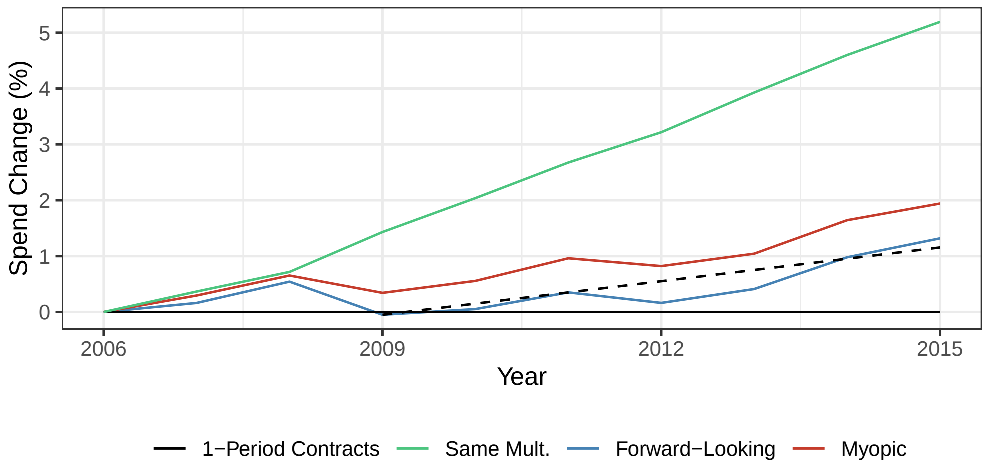


Figure 12: Comparison of estimated effects to a same-multiple model (light blue) in which bargainers keep their original benchmark multiple in place. The models mainly diverge due to contracts renegotiating a lower share of Medicare prices (myopic model, red) and firms responding to expected future price increases by negotiating lower starting prices (forward looking model, blue). There are also smaller equilibrium spillover effects in boyh the forward-looking and myopic models.

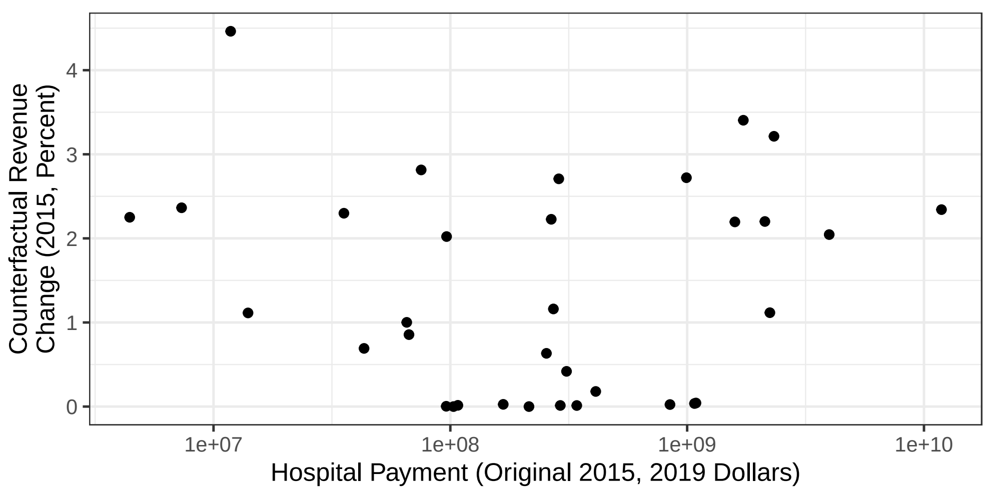


Figure 13: Estimated effects of increased Medicare cost reimbursement on each hospital's received payments in 2015. There is some indication that smaller hospitals would see larger private payment increases.

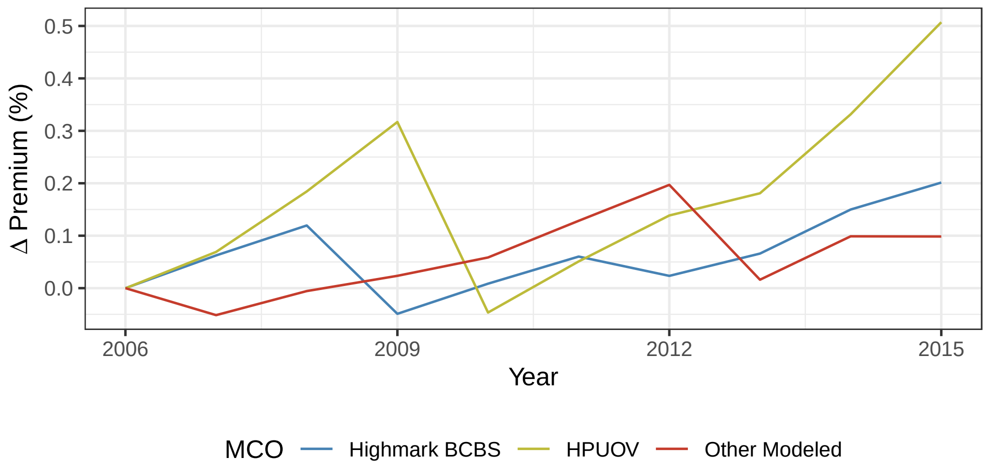


Figure 14: Estimated effects on premiums by insurer for Highmark BCBS (red), HPUOV (green), and the other modeled insurers (blue). Among the other modeled insurers, only Carelink and Aetna have large payment effects, and those effects are reduced after 2012 (see Figure 6).

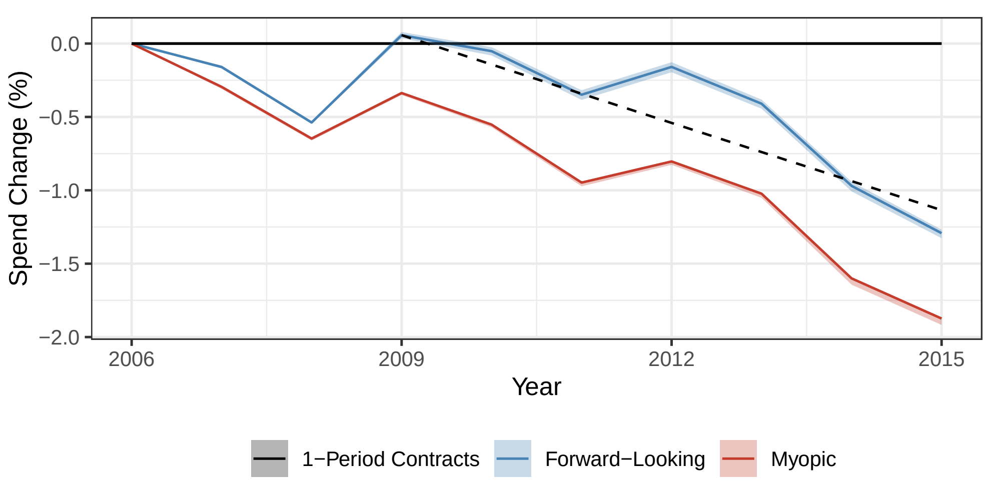


Figure 15: Counterfactual changes in commercially insured hospital spending from a one-percentage-point annual *reduction* in Medicare benchmark prices under a forward-looking (red) and myopic (blue) bargaining model. The dashed line indicates an 0.20 percentage point annual reduction in spending starting in 2009.

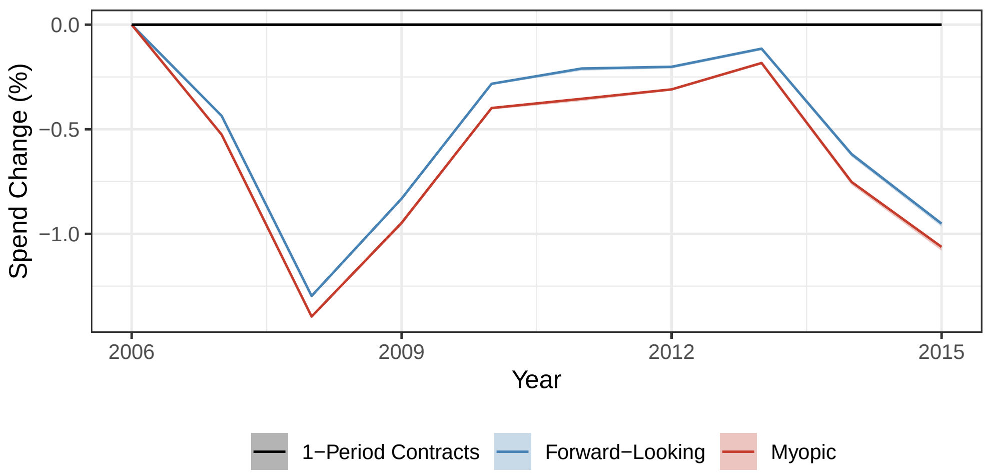


Figure 16: Counterfactual changes in commercially insured hospital spending from the counterfactual restriction on list prices under the estimated forward-looking (red) and myopic (blue) bargaining models.

# B Additional Literature

There is a long literature explicitly using the Kalai bargaining solution outside vertical markets. The Kalai proportional bargaining solution or similar proportional solution concepts have has been applied to study liquidity constraints in monetary economics (Boragan Aruoba et al., 2007, Lagos et al., 2017, Hu and Rocheteau, 2020, Duffy et al., 2021), in social choice theory (Myerson, 1981), and occasionally in labor economics (Sestini, 1999, Jacquet et al., 2014). The Kalai proportional bargaining solution has been critiqued as not being scale invariant (what I sometimes call "scale varying" for concision), so that it can only be microfounded through von Neumann-Morgenstern utility if bargainers care about outcomes besides the utility being divided (Serrano, 2005). Evidence from the lab suggests the Kalai proportional solution may be more accurate in monetary bargaining when the two disagree and utility can be expressed in dollars (Nydegger and Owen, 1974, Duffy et al., 2021). Andreoni and Bernheim (2009) argue that negotiators often care about being perceived as fair.

There is also a literature that uses bargaining solutions with the same predictions as Kalai proportional bargaining in games that are transferable utility (TU). The theoretical single-period-contract Nash-in-Nash literature and the empirical literature on coalitional bargaining with more than two parties to agreements typically studies TU games in which participants have access to zero-sum utility transfers (Lee and Fong, 2013, Collard-Wexler et al., 2019, Ho and Lee, 2019, Yu and Waehrer, 2019, Galichon et al., 2019). Under these games, the Nash and Kalai proportional bargaining solutions coincide. I discuss my application of the Kalai proportional bargaining solution further in Appendix D.2.

There is other relevant work on vertical market bargaining. Davidson (1988) introduced the Nash-in-Nash solution for multiunit bargaining between many employers and many insurers at roughly the same time as Horn and Wolinsky (1988). To my limited knowledge, the multiunit bargaining literature generally models bargaining as static, although Hermo (2024) is an exception. There is a theoretical in industrial organization on overlapping contracts in triangular markets (De Fraja, 1993, Bárcena-Ruiz and Casado-Izaga, 2008, Do and Miklós-Thal, 2022). Such work is highly stylized and inapplicable for empirical markets like West Virginia with many asymmetric firms. Note also that Lee et al. (2021) refer to the mechanism I call spillovers as contracting externalities.

There is an important relevant applied dynamic bargaining literature that studies search on the job. In the associated models, contracts formed at the start of employment affect the subsequent path of wages. Early examples include Diamond and Maskin (1979), Diamond (1982). Shimer (2006) pointed out that when workers cannot fully leverage their employer when considering changing firms, then higher wages can prevent a worker from leaving to a less-productive firm, the bargaining utility set can be nonconvex, and the Nash bargaining approach may not generate unique contracts absent randomization may be nonunique. As a result, the empirical search-on-the-job literature has used models in which initial wages do not affect the path of employment (Cahuc et al., 2006, Bagger et al., 2014) and has generally assumed transferable utility (Bilal et al., 2022, Gottfries, 2022). In the associated applied models, the Nash and Kalai proportional bargaining solutions agree. Jarosch et al. (2019) independently discovered the implications of path-invariance of zero-sum bargains in a special case of their model of post-disagreement threats. (Similar results were found for a stationary vertical market by Shapiro (2021).) The TU search-on-the-job approach is inapplicable to vertical markets with asymmetric and time-varying spillovers. Not all search models can be viewed as using Kalai proportional bargaining solution. In more recent work, Gottfries (2022) proposes a search model that nests the TU case, but allows for NTU bargaining. Gertler and Trigari (2009) propose a model of staggered firm Nash bargaining over multiperiod wages, in which wages reset (and have no subsequent effect) after the next bargain, workers have quasilinear utility, and the firm has a linear and known externality on wages paid to employees hired before the next bargain. They show that this case yields a tractable solution incorporating the externality and calibrate the model to monthly jobs data. That approach is applied to an empirical setting with overlapping contracts in Gertler et al. (2008). However, in search on the job, overlapping contracts interact through aggregate market states rather than based on heterogenous substitution patterns.

This paper's counterfactual caps on hospital list prices and increases to Medicare reimbursement are relevant to the ongoing literature on payment reform. Proposals around Medicare reimbursement reform have generally focused on the direct payments to hospitals (AHA, 2022). I focus on the effects on Medicare's role as a benchmark in private insurer negotiations. Clemens and Gottlieb (2017) point out that Medicare can also be relevant to the outside option for capacity-constrained physicians. Clemens et al. (2017)'s descriptive analysis of Texas BCBS 2010 claims suggests Medicare may play a similar role as a benchmark for negotiated physician payments.

There are a set of proposals that argue for list price caps, related to the list price growth caps I consider. These proposals generally are based on one of two static motivations: either to cap the highest negotiated payments (Liu et al., 2021, Chernew et al., 2020) or to limit hospitals' ability to exert leverage through out-of-network payments from disagreeing insurers (Duffy et al., 2020, Prager and Tilipman, 2022, Berenson and Murray, 2022). Prager and Tilipman (2022) explicitly model the leverage effect of list prices for outpatient care, a setting with more common out-of-network care. Fiedler (2020) points out that out-of-network leverage effects are limited if hospitals can refuse to provide out-of-network care.

The existence of multiyear hospital–insurer contracts begs the question of why the contracts exist in the first place. Early health insurance plans took the form of either indemnity plans without negotiated discounts or hospital-sold prepaid plans that aimed to reduce marginal costs during the Great Depression. In later years, negotiated discounts can be viewed as the insurer offering to steer patients towards a given hospital in exchange for the favorable payment rate,[9] with the insurer using the discounts to sell more plans (Morrisey, 2013). Viewed from this framework, hospital–insurer contracts resolve a potential holdup problem (Goldberg, 1976, MacLeod and Malcomson, 1993). Without a contract, a hospital could drum up business with the promise of discounts, and then renege and raise prices. In this framework, multiyear contracts might exist to mitigate holdup created if in-network hospitals become more valuable to consumers through learning. Such dynamic demand processes or a full analysis of the drivers of contract length are outside the scope of this work.

There is a rich literature in health economics on mechanisms I do not model. As is standard in this literature that focuses on negotiated prices (Ho and Lee, 2017, Ghili, 2022), I assume insurer demand is actively chosen and allow insurer demand to be selected only on observables, which misses any inertia and switching costs (Handel, 2013, Polyakova, 2016, Handel et al., 2019), unmodeled adverse selection on hospital networks (Shepard, 2022), or unmodeled selection on other plan characteristics like cost-sharing (Bundorf et al., 2012, Einav et al., 2013). Data limitations prevent me from separately modeling self-funded market incentives (Craig et al., 2021), changes in patient steering through physician integration (Baker et al., 2016), or variation in individual market insurer entry within rating areas (Fang and Ko, 2020). I abstract from any effects of negotiated prices on quantities supplied because consumer cost-sharing at practical inpatient levels has generally limited effects (Gowrisankaran et al., 2015) and provider incentives run in an offsetting direction (Clemens and Gottlieb, 2014). The limited effects of cost-sharing may be due to a lack of price transparency (Brown (2019) finds price transparency effects for more shoppable and simpler outpatient care) or payments predictably exceeding deductible and stoploss levels (Ellis et al. (2017) cannot precisely estimate inpatient demand elasticities due to lack of variation in effective prices). I focus on counterfactuals that allow me to abstract from the network formation process, but future work could study counterfactuals that change networks by combining the multiperiod Kalai proportional approach here with Lee and Fong (2013)'s model of vertical market network formation or models of vertical market bargaining with exclusion (Ho and Lee, 2019, Liebman, 2022, Ghili, 2022). This paper's approach to insurer demand, which identifies the contribution of network quality from variation in

[9] In practice, inpatient steering is typically achieved by treating a hospital as in-network rather than by steering between in-network hospitals.

sales within ACA rating areas, has a nuanced parallel with Tebaldi (2023). Tebaldi employs individual-level plan choice to identify premium responsiveness from sales variation across rating areas.

I study West Virginia's outcomes under a rate review system. Murray and Berenson (2015) offer an excellent description of the West Virginia and Maryland rate review systems from the year before the West Virginia system ended. McDonough (1997) has more on the history of rate review systems generally from after other state systems ended. There is a literature studying rate review systems more generally — for example, Cromwell (1987), Atkinson (2009), Pauly and Town (2012), Diebel and Diebel (2017), Sharfstein et al. (2018b,a), Roberts et al. (2018a,b,c), and Clemens and Ippolito (2019) — largely with a focus around changes to Maryland's rate-setting system in 2014.

This work also touches on several strands of theoretical literature that are outside of its scope. There is a small and generally theoretical literature on dynamic recursive bargaining solutions. In that literature, contracts and choices today affect the outcome under the same bargaining solution in the future. My model is a dynamic recursive bargaining solution. There is relevant work under specific bargaining solutions in non-vertical settings (e.g. Sorger, 2006, Hoof, 2018, Flamini, 2020, Dutta, 2021); dynamic foundations of static bargaining solutions (e.g. Binmore et al., 1986, Stole and Zwiebel, 1996, Coles and Muthoo, 2003, Brügemann et al., 2018, Collard-Wexler et al., 2019, Backus et al., 2020, Maskin et al., 2021, Dutta, 2022); and relational contracting under potential enforcement and restrictions (Levin, 2003, Miller and Watson, 2013, Watson et al., 2020, Kostadinov, 2021). "Dynamic bargaining" is sometimes used to refer to bargaining in settings that change over time rather than bargaining with contract outcomes that are dynamic (Fuchs and Skrzypacz, 2022), a related concept that to my knowledge has not been applied in vertical market settings except in dynamic bargaining models that lead to simultaneous formation of single-period contracts (Lee and Fong, 2013, Collard-Wexler et al., 2019). It is likely that the price system I describe can be exactly or approximately viewed as a linear rational expectations system. The corresponding literature is outside the scope of this work and generally focuses on different properties. (In the notation of Sims (2002), from my understanding the linear rational expectations literature must solve for $\Gamma_0$ and $\Gamma_1$, whereas I estimate $\Gamma_0$ and $\Gamma_1$ from the bargaining model and am interested in counterfactual changes to $\Gamma_0$.) I find that forward-looking bargainers reduce starting prices. There is a related literature on inflation expectations (Taylor, 1980, Calvo, 1983) and capping the inflation of pharmaceutical prices with forward-looking responses in price setting (Abbott, 1995, Ridley and Zhang, 2017).

# C Additional Discussion

## C.1 Data Appendix

The first step of data processing is cleaning the contract reports. I discuss this cleaning in Dorn (2024). Networks are inferred by calendar year of submission, with missing years inferred from the closest report breaking ties to previous reports. There is a small amount of manual network handling. I drop contracts for nonstandard care like psychiatric care, lab fees, or professional fees. When an insurer reports multiple contracts (for example Highmark BCBS separately reports their indemnity and PPO contracts), I aggregate payments using the closest available reported number of discharges where possible. (I take an unweighted average if I never have estimated number of discharges per contract.) In this paper, I include First Health contracts as HPUOV contracts based on HPUOV's description of First Health as a "strategic partner" (Wayback Machine, 2021).

I focus on the regulated hospitals and treat the remote Critical Access Hospitals (CAHs) that were deregulated after 2000 as negligible. The state also allowed border hospitals to keep their contracts private. I use the fiscal year 2016 report to infer list price payment rates for Weirton Medical Center, and treat the small Williamson Memorial Hospital as equivalent to a CAH.

The West Virginia bargains for estimation were identified manually. The main source was reported contract start and end dates in the panel contract dataset, but regulator contract decisions were also used as a supplement. I mitigate the bias introduced by Aetna's acquisition of Carelink at the start of 2015 by not including any contracts which lasted into 2016 (under the finite horizon) in bargaining estimation. I identify likely bargains for use in counterfactuals but not estimation based on remaining occasions on which either a contract was introduced, a share of charges contract was changed or replaced, a first year after expiration (with a change in discount rates), manual research suggests a change in payments, or the year after a contract was reported as being expected to expire, so long as the automatic processing identification does not happen in the last period in which I observe the contract. I treating the effective date as January 1 (except for one case in which other data suggests the contract began January 2).

In the inpatient data, I exclude rehab, long-term, and psychiatric hospitals; exclude newborns, residents of other states, and noncommercially insured patients (but including public employees who chose HPUOV to align with the fully insured sales data); take the hospital's main location from Medicare cost reports; and identify systems that reported joint contracts based on personal research. I assign patients locations by county geographic centroid. I estimate probabilities of patients having misclassified insurance status based on reported care frequencies where typos seem likely.

I infer diagnosis categories based on Ho (2006)'s classification of ICD-9 codes. The West Virginia inpatient data lacks ICD-9 codes and only has ICD-10 codes for 59% of discharges, so I convert the data's MS-DRG codes to ICD-10 codes using CMS (2020) and then into ICD-9 codes using NBER (2021). I supplement this conversion with additional research for common DRG codes this method fails to classify. I drop the 2% of cases for which the DRG conversion did not yield an ICD code and I did not reach an active category determination. Where this process maps multiple ICD-9 codes to the same DRG category, I choose the most common ICD-9 code's category. I calculate Medicare payment-to-cost ratios from state uniform financial reports (UFRs) and linearly interpolate payment-to-cost ratios where missing in the available data.

There are some subtleties to my insurer data. Fully insured sales by insurer and self-funded sales estimates come from reports like Offices of the Insurance Commissioner (2008, 2016) for the comprehensive market. Insurer sales are aggregated by group code where possible and outliers are cleaned. In 2008-09, sales were not reported. As a result, I linearly interpolate the missing lives and inflation-adjusted premiums. I similarly linearly interpolate the sales estimates for the ERISA (self-funded) market for missing years. I calculate MLRs from 2011-2018 CMS reports for West Virginia business in the individual, small-group, and large-group markets. I aggregate MLRs by NAIC company code where available and by name where NAIC codes are not available and take the numerators and denominators from the MLR_NUMERATOR and MLR_DENOMINATOR variables in part 5 (for 2011–13) or part 3 (for 2014 and later) of the reports. I aggregate medical loss and premium revenue across insurance products by group code. Inflation rates are calculated using World Bank CPI inflation over years relative to 2019 from the `priceR` package: 2017 nominal payments are inflation-adjusted based on the inflation rates reported for 2017 and 2018.

Hospital demand and ex ante WTP are calculated as follows. I calculate the probability of any diagnosis in the inpatient data in 2016 conditional on age, assuming each person has at most one inpatient discharge per year. I then obtain the potential hospitals each Highmark BCBS patient could have visited and run a weighted logit regression of choice on hospital and $\nu$ characteristics by diagnosis. The regression is weighted to include probability-of-Blue-Cross-weighted choices at hospitals that misclassified Blue Cross care. I then extrapolate the estimates to calculate the ex post willingness to pay for every conceivable county-age-hospital combination conditional on diagnosis and aggregate the measure into an ex ante WTP measure for every hospital-insurer-age-location-year combination. The WTP measure is calculated as follows:

$$WTP_{j,k,c} = \sum_{\ell} \mathbb{P}(\text{Diagnosis } \ell \mid \text{Age group } k) \log \left( \sum_{h \in \mathcal{G}_j^M} exp(u^H_{c,h,\ell}) \right),$$

where the $u_{c,h,\ell}$ ex ante hospital utility to a consumer in county $c$ with diagnosis $\ell$ is from the hospital choice model.

Insurer demand estimation is an involved process involving substantial data cleaning for 2016 alone. I first estimate insurer sales based on the fraction of commercially insured inpatient diagnoses from an age group in a county in the inpatient data. The county commercially insured population is taken as the Census intercensal population estimate multiplied by the state estimated fraction of age group with commercial insurance in the inpatient data. I then adjust the inpatient data to ensure every insurer has at least one estimated sale per age-county (taking the needed population from other sales estimates proportionally) and then include non-Highmark (other state) Blue Cross in the outside option. I infer state-level insurer sales in the self-funded market in 2016 for Aetna, Highmark BCBS, and HPUOV based on the difference between state-level sales estimates and state-level fully insured sales. I extrapolated self-funded sales for the two insurers not identified in the inpatient data, Cigna and UnitedHealth, by assuming the sales ratio between the markets is equal to the median estimated ratio. I scale down estimated sales to insure the modeled insurers never exceed 85% of a county-age group's estimated sales individually or exceed 90% in aggregate.

Once sales are estimated, I estimate insurer demand with an outer loop–inner loop algorithm. I An outer loop proposes Cigna and UnitedHealth $\tilde{\delta}^M$ fixed effects (including state-level premiums) and an inner loop produces county-age-insurer implied values of $\gamma_k WTP_k + \xi$ to fit age-insurer-county ales estimates for the modeled insurers. I then iteratively update the Cigna and UnitedHealth fixed effects based on the current WTP coefficient estimates until conversion. The WTP coefficients are calculated by market-size-weighted regression of $\gamma_k WTP_k + \xi$ (inferred from 2016 sales estimates) on $WTP_k$ (from hospital demand and sickness probabilities). To calculate pre-2016 demand, I calculate pre-2016 WTP in utility by insurer, county, and age. I solve for changes to state-level insurer value (inclusive of state-level premiums) to match state-level sales after adjusting for county-level population changes and ASO market size changes changes. I assume that Carelink's $\xi$ values before its acquisition by Aetna at the end of 2014 were equal to Aetna's values in those same markets.

For bargaining, I estimate the effect of insurer network on hospital and insurer sales as follows. I predict sales under both the observed networks and under counterfactual networks that drop the insurer–system pair at the observed premiums. (Premium changes would be measured in $\text{Pay}_{IRT}$, which estimation currently sets to zero.) I measure the effects for a bargain year as a weighted average of calendar years: if a bargain began 3/4 of the way through 2010, then the first year of gains from trade under the bargain will be a weighted average of 1/4 of the gains from 2010 and 3/4 of the gains from 2011. I calculate the inputs to gains from trade, like the change in hospital costs, for the bargaining estimator. For calculating $\tau_{ij}$ hospital heterogeneity, I calculate hospital costs incurred in 2006 as the sum of reported list prices multiplied by the estimated cost-to-charge ratio. I calculate demand estimates from the estimated models to mitigate reporting endogeneity.

The bargaining optimization proceeds as follows. For constructing $\tau_{ij}$, I normalize log hospital system size by the mean log system size in bargaining to report $\tau_j$ at the mean. The hospital groups in the price instruments $Z^p$ are chosen to group hospitals by approximate size while ensuring a reasonable number of bargains for each hospital group: the hospitals are first ordered by the quantity of net present value realized payments in estimation bargains if $\beta$ were equal to 0.8, and then split into six groups based on quantiles of payments taken to the power of 0.3, a quantity which was chosen to balance information with group size. Bargaining parameters are optimized over a simple moment weighting that tries to make the scales roughly comparable across moments: it weights MLR squared moments by $10^5$ and normalized payment squared moments by the average net present value payment if $\beta$ were equal to 0.8 (with the $\omega$-style denominator normalization) by the relevant hospital group or insurer. The optimization attempts to re-optimize 10 times before returning the estimated parameters. Standard errors are calculated by bootstrap by resampling inpatient cases and state-level insurance choices 100 times. The bootstrapped confidence intervals for counterfactuals take the estimated demand functions as fixed and incorporate the uncertainty in bargaining parameters.

The payment residual Appendix Figures 7, 9, and 10 are constructed as follows. The validation in Appendix Figure 7 scales the initial payment rate at the level needed to match the given model's prediction perfectly in net present value terms. This approach intuitively corresponds to holding benchmark price increases constant. In Appendix Figures 9 and 10, I take the marginal effect of a dollar negotiated under a contract on each future contract in the model and then evaluate the change in net present value profits over the finite horizon.

The counterfactual calculation process is as follows. I take the estimated $\hat{\tau}_{ij}$ from the relevant bargaining models, calculate payment multiples to infer the realized counterfactual ratio of starting price to net present value payment, and add 2016 data based on 2015 for computing counterfactual effects on late inferred bargains. There is some further data handling around the Aetna-Carelink acquisition at Davis Medical Center, which had a contract with Carelink but not Aetna before the acquisition. On the rare occasion that a midyear negotiation led to a change of benchmark, I infer the smaller starting price, which increases the forward-looking offsets slightly. I construct realized price transition matrices and matrices of the ex post effect of future prices on bargained prices, calculate the realized residual (including demand-driven components of gains from trade) which is held fixed in counterfactuals, confirm that geometric sum estimates of effects would converge, calculate counterfactuals by matrix inversion, and calculate some summary statistics for later analysis.

The implementation of counterfactuals involves substantial data cleaning. I calculate when contract terms were changed under a modeled or inferred bargain. Counterfactual prices are adjusted at the start the year of negotiation or inferred change. Negotiations inferred from an expected expiration date past the final contract report are implemented at the start of the next calendar year to allow for potential roll-over. There is further data cleaning, for example ensuring that new bargains are not inferred during years that are a part of an estimation sample bargain, ensuring inferred benchmark choice by year is consistent with the inferred negotiation dates around the Aetna/Carelink acquisition, and holding fixed some small hospitals that did not provide inpatient data in 2016 that was used to estimate hospital demand. There is substantial further data cleaning for the list price capping counterfactual that I discuss in Appendix C.5.

I estimate back-of-the-envelope downstream premium effects based on Ho (2006)'s estimated own-price elasticity. I calibrate a coefficient on inflation-adjusted premiums to match the estimated average own-price elasticity of -1.4. I solve for the wedge in insurer-year marginal cost needed to make realized premiums optimal under simultaneous annual Nash-Bertrand premium-setting. I then find the new equilibrium premiums under that change in insurer-year marginal cost and the new predicted negotiated premiums, inclusive of any patient reallocation in response to the new premiums. I do not model how the increased premiums further increase the negotiated prices.

## C.2 Additional Descriptive Statistics

I also present descriptive statistics on the underlying hospitals and insurers. Figure 17 presents the share of reported hospital revenue and costs accounted for by various sources for West Virginia hospitals over time. Private care typically represented 45% of revenue on only around 25% of costs, and private care became increasingly important to profitability in later years. Outpatient care was a larger share of hospital care in West Virginia than other states, likely reflecting the list price capping system's incentives (Murray and Berenson, 2015).

The largest hospital referral regions (HRRs) in West Virginia are the Charleston region, the Morgantown region, the Huntington region, and parts of the Pittsburgh region.

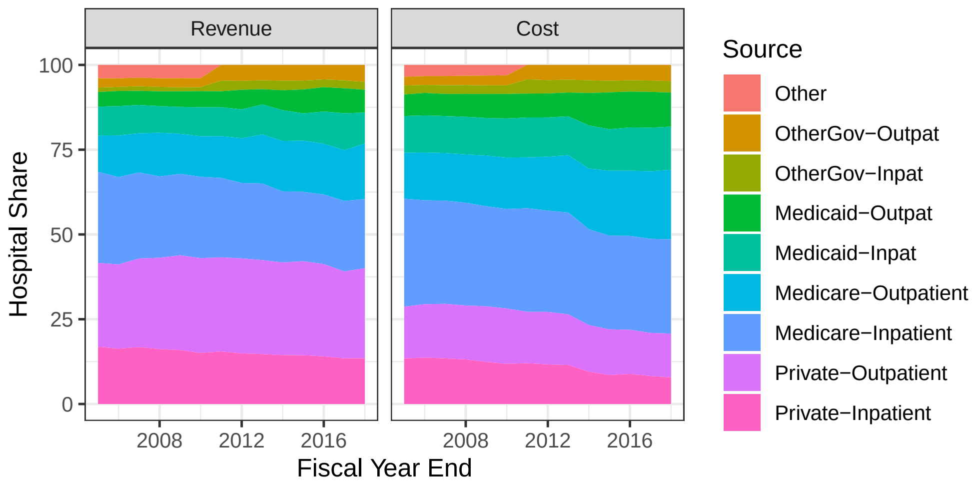


Figure 17: Percentage of hospital reported net revenue (left) and costs (right) across various payment sources and inpatient versus outpatient care.

Charleston is the state capitol and contains the state's largest hospital, CAMC (22.1% of 2016 nongovernmental revenue). The Morgantown region contains the main campus of West Virginia University and the flagships of both the WVU Health system (25.5% including jointly reporting affiliates in other regions) and the Mon Health system (5.7% including affiliates). Huntington borders Ohio and is near Ashland, Kentucky; the region contains Cabell Huntington (14.3%) and Saint Mary's (8.5%) hospitals which merged in 2018 after my study period ends. A few hospitals are in the state's northern panhandle like Wheeling Hospital (0.5%) in the Pittsburgh HRR. Small parts of southeastern West Virginia are in Virginia HRRs.

The estimated market shares of modeled insurers over time are presented in Appendix Figure 18. Highmark BCBS generally controlled half of the state insurance market. I also study the national insurers Aetna, Cigna, and UnitedHealth, the regional for-profit Carelink which was acquired by Aetna at the end of 2014, and the nonprofit HPUOV. Humana was present in West Virginia but was smaller than the insurers I do use in 2016 and is not identified in the inpatient data. I also summarize insurer sales in the fully insured market, in which I have complete data, in Appendix Figure 19. There are many fewer outside option sales in the fully insured market, which is consistent with my inclusion of insurers based on their size in the fully insured market. Altogether, I estimate that 3.5% of fully-insured consumers and 40% of all insured consumers were enrolled in the outside option of smaller insurers I do not actively model.

I plot the estimated insurer spending per life (including inpatient and noninpatient costs) in Appendix Figure 20. Cigna has some of the highest costs, consistent with their higher

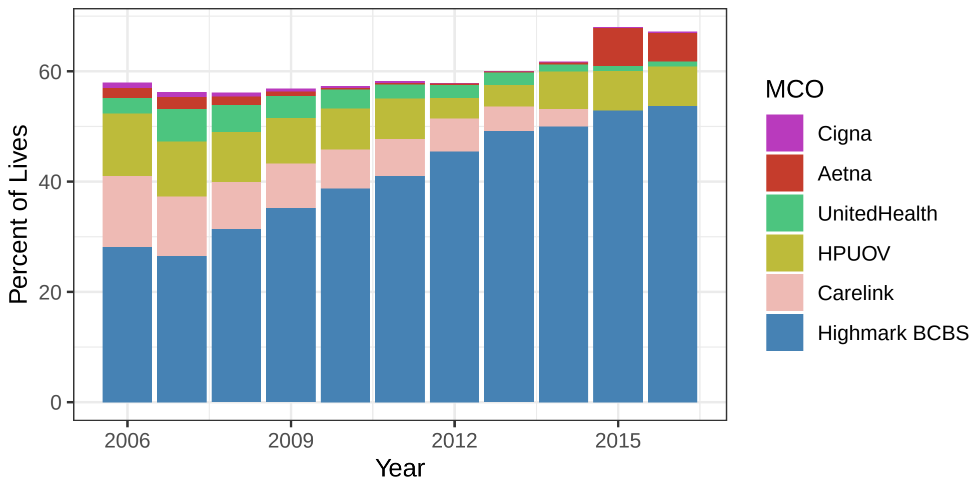


Figure 18: Estimated percent of commercial insurance market covered by each modeled insurer; the remaining share is the outside option of smaller insurers. Aetna grew substantially after its acquisition of Carelink closed at the start of 2015. Highmark BCBS was generally the largest insurer and gained market share in the era I study.

premiums (Appendix Figure 21). HPUOV has a more regional network and lower costs, which is seen in lower premiums.

Insurer market shares were correlated with network strength. I plot estimated insurer market shares by county for Highmark BCBS and HPUOV in Appendix Figure 22. Highmark BCBS generally has large sales in all of the state. Conversely, HPUOV is a major player only in those areas where it had a strong network (Appendix Figure 23), especially the state's northern panhandle.

Table 9 summarizes the scale of hospital–insurer years for modeled insurers and for years used in bargaining. Estimation contracts were on average more than twice as large as the average year of data, had a lower average markup over reported costs, and were more likely to be prospective than the average contract, all of which are consistent with larger insurers negotiating more often. Average markups above reported costs are 102% for all contract years (i.e. average payments were 202% of reported costs), lower than the 135% reported nationally in 2019 (Whaley et al., 2022) and potentially representing the larger modeled insurers obtaining more favorable payment rates.

Table 10 summarizes the diversity of firms in the data. It presents counts of the number of hospitals, hospital systems, and insurers in the underlying contract data, in the set of cleaned negotiations used for estimation, and the set of imputed negotiations that lack clean end dates. Altogether I have 1,610 hospital system-insurer years, with 30 hospital systems representing 35 hospitals. (A few hospitals were acquired in the middle of my data.) Almost every hospital and hospital system was included in at least one of the 63 bargains included

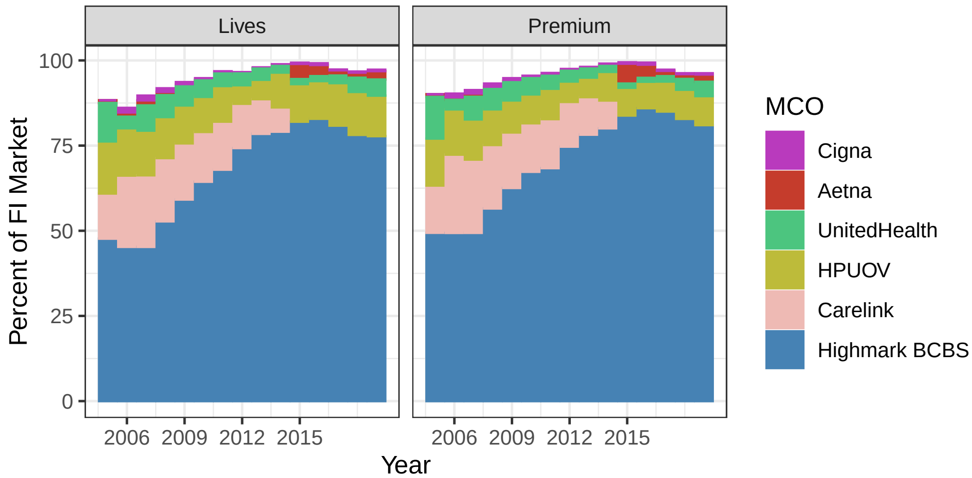


Figure 19: Insurer share of fully insured lives (left) and premiums (right) by year from Offices of the Insurance Commissioner (2008, 2016) Data excludes estimated ERISA/self-insured sales which I infer from inpatient data.

in parameter estimation, and a similar result holds for the 133 bargains I impute for the purposes of constructing counterfactuals.

I summarize the number of bargains used in estimation per hospital in Appendix Figure 24 and the number of bargains per insurer in Figure 25. Most payments were at hospitals that included in either four (CAMC) or six (the WVU Health System) estimation bargains. Highmark BCBS accounted for more than half of contracts used in model estimation and a substantially larger fraction of payments.

## C.3 Discussion of Cooper et al.'s Work on Prospective Contracts

This work owes a tremendous debt to Cooper et al. (2019). In this section, I discuss how their work on prospective contracts relates to my analysis.

Cooper et al. (2019) estimate 74% of large for-profit insurers' prospective contract cases are paid as a fixed markup over Medicare and find that Medicare benchmarks are associated with larger hospitals. Negotiations of prospective contracts in West Virginia were more likely and more important at larger hospitals, both of which are associated with Medicare benchmark usage in Cooper et al. (2019)'s analysis. Reinhardt (2006) also claims that heterogeneous DRG weights were more typical. I cannot directly compare payment schemes in West Virginia to Medicare reimbursements without access to claims or pricing data by insurer, but as mentioned in footnote 7, Highmark BCBS often used customized DRG weights in inpatient prices disclosed after my dataset ended, but used Medicare rates directly in outpatient calculations at the start of the era I study.

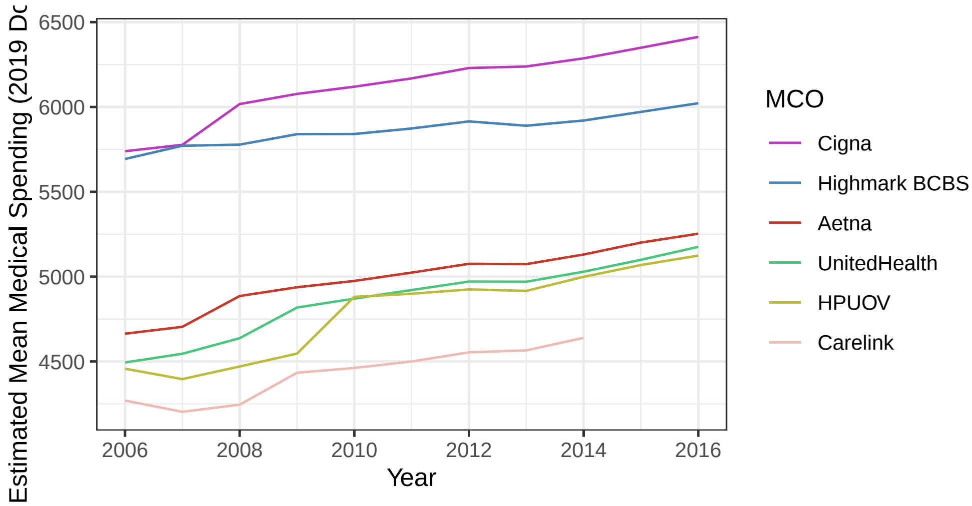


Figure 20: Estimated medical costs (including noninpatient costs and hospital payments) by year for each insurer I model.

I do not have service-level price disclosures in the era I look at or reliable measures of Highmark BCBS price increases during the post-2021 price disclosure era. I therefore proceed in my main analysis assuming that Highmark BCBS DRG weight increases tracked Medicare payments whether Highmark directly used Medicare weights or used customized weights in the era I study. My analysis can also be interpreted as a counterfactual in which Highmark BCBS payment rates were required to increase one percentage point faster annually than in the status quo, regardless of how the payments were calculated. The choice of benchmark only enters the bargaining model through the realized prices. The distinction between Medicare as a benchmark and Medicare-based benchmarks with heterogeneous weights does matter to comparing services (that I aggregate into a generic unit of care) and the interpretation of the counterfactual for policy purposes.

Cooper et al. also argue that Medicare-benchmarked contracts were likely to be boilerplate take it or leave it offers. Cooper et al. do not directly measure boilerplate usage, but large insurers often make such offers to physicians (Abbey, 2012) and Highmark BCBS used shared markups over Medicare for outpatient care at some hospitals (Highmark West Virginia, 2011). That said, stakeholders did not recall boilerplate Highmark BCBS contracts, I have found qualitatively that Highmark BCBS prices disclosed under post-2021 regulations are often calculated as hospital-specific markups over a shared diagnosis-based schedule, and Highmark BCBS contracts were typically implemented at different times (Figure 1). I therefore conclude the use of boilerplate contracts in West Virginia was likely limited.

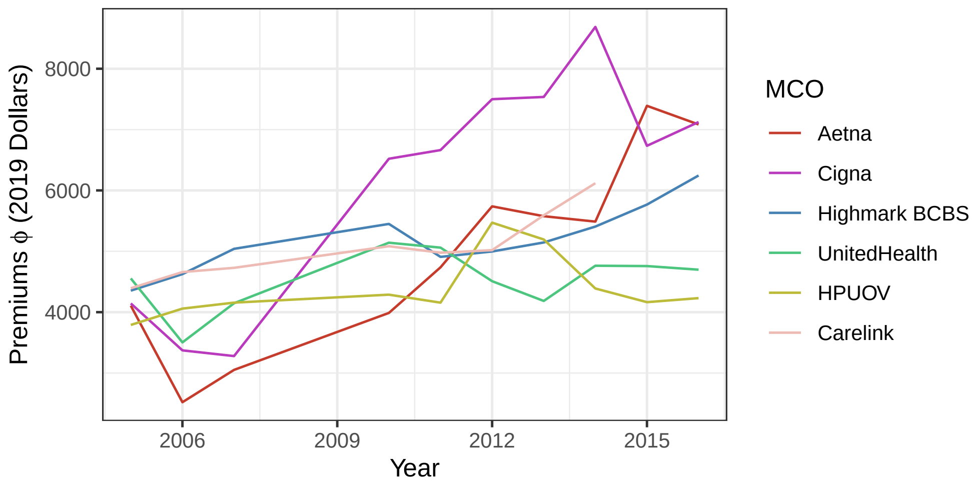


Figure 21: Insurer reported average premiums per life by year in 2019 dollars. Whereas Highmark BCBS had the largest networks, it was not an especially high-premium option. Cigna appeared to be especially focused on the large-group market and reported higher premiums than the other insurers in 2010-2015.

## C.4 Caveats and Limitations

My hospital demand model abstracts from various features to focus on price-setting. Insurers can differ systematically and between plans based on cost-sharing and can put hospitals in separate tiers, but as discussed in Appendix B, the effects of inpatient cost-sharing at common American levels are generally small. I assume 2016 hospital demand was equal to previous hospital demand and as a result do not capture historical hospital investment or changes in patient steering through physician integration. Discussions with stakeholders suggest hospital perceptions were mostly time-invariant. I do not model separate hospital demand by sex, which leads to less precision and could introduce bias by missing premium discrimination before 2014. I do not capture any supply incentives introduced by the choice between prospective Medicare-based payments (which pay based on diagnosis) and list-price-based payments (which pay based on services) or the level of prices, though I hold benchmark choice constant in counterfactuals.

I only model hospital demand by West Virginia residents for West Virginia hospitals. Some degree of state bias at borders is inevitable when data ends at state lines that real humans can cross, and I likely miss some competition in the state's northern panhandle (due to the proximity of Pittsburgh area hospitals), eastern panhandle (due to the proximity of larger cities in Maryland and Virginia), in Wheeling (due to the proximity of East Ohio Regional Hospital in Ohio), in Huntington (due to the proximity of King's Daughters hospital in Kentucky), and for the Health Plan of the Upper Ohio Valley (which had a comparable

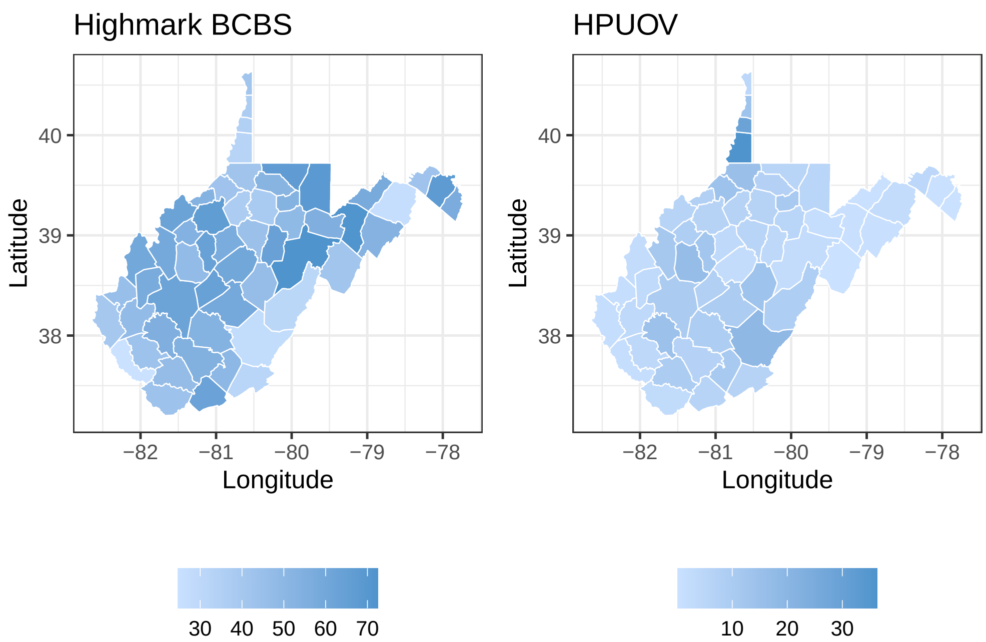


Figure 22: Percent of estimated 2016 commercial sales by county for Highmark BCBS (left) and HPUOV (right).

line of business in Ohio).

I abstract away from some small potential responses to dropping a contract. I assume there was no out-of-network care by insured patients in West Virginia. Out-of-network care is more common for outpatient care, but can happen for emergency inpatient care and might have become more common if a desirable hospital left an insurer's network. I model consumer substitution to small rural critical access hospitals in response to an insurer dropping a modeled hospital, but treat those payments (which by construction are small) as zero.

The premium data is limited relative to other settings. Large-group premiums were not regulated by the ACA and could reflect different age-based price discrimination or idiosyncratic rating areas than in the ACA-regulated market. It is possible for there to be an unmodeled interaction of age-based premiums with market area that is not captured by market-insurer fixed effects; residual correlation of outpatient and inpatient networks; unmodeled heterogeneity in Cigna, UnitedHealth, and small insurer quality across rating areas; variation in insurer entry in the individual market within rating areas; and variation within rating area in the self-insured market. Aetna premiums in 2015 and 2016 may be mismeasured due to misalignment of premium payments and insurance dates after the insurer acquired Carelink in 2015. I only observe premiums annually. Intrayear premium-setting could be accommodated in the model with appropriate data.

My insurer demand model is highly stylized. I do not have data on choices by family

Table 9: Scale-related summary statistics for all contract years (Contract Data) and contract years with a bargain used in bargaining model estimation after cleaning ("Estimation Bargains"). Markups are the ratio of real payments to hospital reported costs. Revenue measures reflect model estimates to interpolate small contracts and pre-2011 sales. Negative markups correspond to a few contracts with small hospitals that made up for negative inpatient markups with outpatient profit.

| Data | Measure | mean | min | p10 | p25 | p50 | p75 | p90 | max |
|---|---|---|---|---|---|---|---|---|---|
| Contract Data | Payments ($M) | 2.38 | 0.00 | 0.01 | 0.04 | 0.23 | 1.19 | 4.65 | 128.16 |
| Contract Data | List Payment ($M) | 2.94 | 0.00 | 0.01 | 0.05 | 0.30 | 1.70 | 5.78 | 136.34 |
| Contract Data | True:List Payment | 0.81 | 0.22 | 0.49 | 0.75 | 0.90 | 0.95 | 0.95 | 0.99 |
| Contract Data | Markup | 1.02 | -0.46 | 0.16 | 0.75 | 1.05 | 1.33 | 1.67 | 2.65 |
| Estimation Bargains | Initial Payments ($M) | 5.26 | 0.03 | 0.06 | 0.18 | 0.65 | 5.14 | 11.21 | 69.42 |
| Estimation Bargains | Initial List Payment ($M) | 6.50 | 0.03 | 0.09 | 0.31 | 1.44 | 6.58 | 14.75 | 86.58 |
| Estimation Bargains | Initial True:List Payment | 0.73 | 0.30 | 0.44 | 0.59 | 0.80 | 0.89 | 0.94 | 0.99 |
| Estimation Bargains | Initial Markup | 0.73 | -0.27 | 0.00 | 0.38 | 0.76 | 1.08 | 1.39 | 1.71 |
| Estimation Bargains | Avg. True:List Payment | 0.72 | 0.31 | 0.41 | 0.59 | 0.78 | 0.89 | 0.94 | 0.99 |
| Estimation Bargains | NPV Payment ($M) | 20.15 | 0.05 | 0.17 | 0.53 | 3.03 | 17.40 | 50.06 | 305.45 |
| Estimation Bargains | Prospective | 0.52 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Estimation Bargains | Prospective (Wtd.) | 0.60 | 0.00 | 0.00 | 0.00 | 0.01 | 0.30 | 1.42 | 8.23 |

Table 10: Count statistics for all hospital–insurer years with modeled insurers (Contract Data), hospital-insure-years used in bargaining estimation (Estimation Bargains), and hospital-insurer-years for imputed bargains used in counterfactuals but not in estimation due to unreliable formation dates.

| Data | Hospitals | Hosp. Systems | MCOs | System-MCO Pairs | System-MCO Years | Bargain Count |
|---|---|---|---|---|---|---|
| Modeled Contracts | 35 | 30 | 6 | 159 | 1482 | |
| Estimation Bargains | 32 | 27 | 6 | 53 | 289 | 63 |
| Imputed Bargains | 32 | 29 | 6 | 70 | 326 | 133 |

or by employer, so I model the reduced-form selection of insurance by individual based on individual diagnoses probabilities. As discussed in Appendix B, the model of plan choice allows selection only on observables and I treat self-funded and fully insured plans as equally profitable to insurers despite their different business practices. I do not precisely measure outside options across multiple insurers due to lack of identifiers of small insurers. I also do not model the outside option of no insurance or how insurance rates might vary across different areas in West Virginia. I do not model "BlueCard" incentives created by Blue Cross pooling networks: in a border hospital, part of the hospital's value of contracting with Highmark Blue Cross might include the value of additional consumers from CareFirst (Maryland and Virginia) and Anthem (Kentucky and parts of Ohio) Blue Cross in a way that Highmark does not value. There also may be asymmetric value created in other states, but the insurers I model are present on the other sides of West Virginia's more populous Ohio and Pennsylvania borders. That said, the key goal of my model is accurately capturing dynamic bargaining incentives, so the largest concerns reflect any unmodeled changes in these incentives over time during the era I study.

I capture benchmark usage imperfectly. Both one-off repeated discounts and one-off round-number discounts can reflect coincidence or typographical errors, so each imputation approach has tradeoffs. I generate similar estimated benchmark usage whether I use my main definition or alternatively infer share of charges contracts from round-number discounts. I summarize the concordance across measures in Appendix Figure 26. Both approaches treat as fully prospective any contracts that were benchmarked to list prices with different discounts within inpatient care, which may have included a few Highmark BCBS contracts in early years of my data (Rivard, 2010); any use of per diems for subsets of care like labor cases (Weber et al., 2019); or any use of list prices in outlier payments.

My stylized approach to hospital pricing is standard but abstracts from the relative prices of services. For example, insurers could use list prices for different services to price-discriminate between share of charges payors, though I found no evidence they actually did so. I assume that units of care are proportional to hospital list prices to align with the reported contract data. I inflation-adjust based on CPI which is imperfectly aligned with both hospital care and specific West Virginia conditions. The CPI inflation adjustment may be particularly problematic for noninpatient costs ($\eta$) and hospital costs ($c$), with offsetting effects. It is unclear how these offsetting issues would bias estimates of the patience parameter $\beta$, if at all.

I treat benchmark prices as stylized prices per unit of care and treat them as updated annually. It is standard in this literature to aggregate multiple services to a generic unit of care. Firms could apply separate multiples to different care aggregates within a contract, but the average should be a reasonable summary statistic. Firms could commit to time-varying multiples, but to my knowledge they rarely (if ever) do so in practice. List price multiples are theoretically bounded above by one, but generally list prices are intentionally set far above what any contract could reach. I abstract from some other roles of benchmark prices to focus on price negotiation dynamics. I discuss these other mechanisms further in Appendix B. I do not model chargemaster and Medicare timing within a calendar year. List prices governed by the chargemaster could be updated at frequencies other than annually, though such higher frequencies are not standard (Reinhardt, 2006, Tompkins et al., 2006, Jahn, 2017). In principle, chargemasters can be used to price discriminate among insurers that use list prices as a benchmark, but I found no indication that hospitals do so (Reinhardt, 2006, Abbey, 2012, Kidder, 2013).

The model abstracts from many potential aspects of bargaining. I apply the Kalai proportional bargaining solution, which I discuss further in Appendix D.2.3. I impose a finite horizon model under the view that it is part of an increasingly long-term approximation to a true infinite horizon model. The finite horizon is an approximation — for example, it might be more appropriate to place extra weight on the fifth year as a proxy for subsequent profits. The theoretical arguments deriving estimation moments would not hold if the negotiators had asymmetric patience parameters, risk aversion, or different expectations of the future. Whether these sorts of informational differences can be incorporated in dynamic bargaining is an interesting avenue for future work. It is possible for the bargainers to implicitly or explicitly bargain over nonprice objects like adjudication processes or cooperation, although such objects are generally viewed as secondary (Abbey, 2012, Vega, 2013, Gooch, 2019). I assume that disagreement does not affect subsequent demand functions; disagreement is a dynamic process that affects consumer inertia which I hope to explore in future work.

The model's timing abstracts from many real-world subtleties around timing in the service of empirical tractability. I model bargaining as succeeding at the start of the day on which it was accepted by the regulator and ending on an unambiguous day of the year. In practice, contracts are agreed to before they go into effect and occasionally expired contracts would remain in place on a short-term basis while negotiations remained ongoing. Short-term extensions are equivalent to auto-renew contracts in my model, but I will miss extensions that began and ended between contract reports. Impasse is assumed to affect insurer demand in a static process throughout the year; insurance contracts with employers and individuals are reached at staggered times, a process that does not correspond perfectly with this paper's static insurer demand model. I attempt to capture annual patience with an annual patience parameter, using contract dates within a year when estimating the bargaining model but treating profits as equally profitable within a year, which is a convenient but unrealistic simplification. For counterfactuals, I simplify prices and treat bargaining as being conducted at the start of the year to focus on the counterfactual effects at the cost of some precision.

There are also a few other places wherein the bargaining model is currently simplified for convenience. The bargaining model is estimated with a high-dimensional optimization that may not reach a global optimum. The estimation procedure is somewhat affect by initial conditions; most notably, negotiation cost contributions to payments do not always move much from their initial value of $10,000. I use state-level premiums to calculate insurer gains from trade, which may introduce some bias from relative age discrimination between insurers. As discussed, I do not currently estimate an impasse repricing transfer term (with unclear effect), I hold premiums constant in counterfactuals (with conservative effect), and do not have the sufficient variation to statistically test a Nash bargaining model (which likely would produce similar estimates as the model I estimate).

I do not model the network formation process. As argued in the literature referenced in Appendix B, a frictionless Nash-in-Nash bargaining model rarely speaks persuasively to why networks are not complete — for example, an insurer might exclude a hospital to increase their leverage in other negotiations. In my model, networks are theoretically restricted by hospital costs and negotiation costs. I do not view those bargaining frictions as a fully compelling model of network formation. Other disagreement models could be accommodated by adjusting the impasse repricing transfer term to include other disagreement effects. I focus on changes to benchmark price increases that are comparable to normal levels of benchmark price increases. As a result, the counterfactuals would be unlikely to affect network formation substantially.

There are various limitations on counterfactuals. The one percentage point payment increase is based on West Virginia data, but a national equivalent might be closer to 0.7 percentage point annual increase. It is possible that my deterministic stance on uncertainty in counterfactuals introduces bias if the uncertainty over benchmark prices was first-order relative to the changes that would be incurred in the counterfactual I consider. As mentioned in Appendix B, I do not model any effects on how much care would be reported or how hospital investment might change in counterfactuals due to the limited effects of prices on supply. The set of benchmarks used has changed over time and has shifted towards prospective payments, making out-of-sample extrapolation unclear but potentially meaning national effects of Medicare-based benchmark prices would be larger in years after 2015. West Virginia is a small market, so it is possible that bargaining is less frequent than in large markets that constitute a lot of, but by no means all of, American hospital care. The contract data I use is partial in the earliest and latest years, and as a result I may miss some bargains that were not reported. The downstream estimates of effects on premiums is highly stylized.

## C.5 List Price Counterfactual

I begin the list price capping counterfactual with a state-level guideline: list prices should be increased by at most 102% plus the positive part of the average Medicare payment change from the previous year. Medicare attempts to track average costs, so the hope is that two percentage points of extra capacity will be more than enough to contain idiosyncratic cost variation.

Where the state financial cost data seems reliable, I pull up to 50% of the allowed increase towards the hospital's previous year Medicare payment-to-cost ratio change, with the change capped at ten percentage points to avoid over-use of potential reporting errors. The hospital weights are scaled by the square root of previous-year costs, relative to the largest hospital cost in the previous year. I then set a floor that the previous year's list price is always allowed.

I assume that hospitals attempt to increase their list price to the lower of the real list price and the regulation's largest allowed list price. It is possible the regulation would generate some slight incentive for hospitals to stockpile list price increases, but it seems likely to be minor where they are already profit maximizing under a corridor constraint. A real-world implementation would be more complicated: for example, West Virginia's corridor system created incentives to shift care towards outpatient care. On the other hand, other states have lower charge-to-cost ratios, and so may have more scope to reduce payments through analogous regulations.

### C.6 Description of Additional Models

The rows in Appendix Table 8 are as follows. The first row is the main forward-looking model. The second row does not include the $\tau^{Size}$ hospital size interaction. The third row normalizes payments by the average value of $\sum \beta^t$. The fourth row estimated hospital costs as a multiple of list prices rather than calibrating hospital costs. (The estimated multiple is 1.45.) The fifth, sixth, and, seventh rows multiply hospital costs by a fixed scalar. The eighth row multiplies hospital costs by the hospital's reported Medicare payment-to-cost ratio to proxy for the outside option of Medicare patients if hospitals are capacity-constrained. The ninth row takes $\eta$ values to fit MLR reports rather than calculating them. The tenth row multiplies insurer gains from trade by the hospital's reported share of commercial costs from inpatient care. The eleventh row fixes $\beta$. Rows twelve, thirteen, and fourteen fix $\tau$. Rows fourteen and fifteen are the only-2015 and myopic bargaining models I present in the main text's Table 4. Rows sixteen and seventeen are the only-2015 and myopic bargaining models without $\tau^{Size}$ size interactions.

# D Additional Theoretical Analysis

This appendix includes a simple model of benchmark price inflation in a triangular market (Appendix D.1), a description of the proposed dynamic model relative to the literature's static approach (Appendix D.2), a microfoundation for Kalai proportional bargaining in vertical markets (Appendix D.3), an example showing how ignorable uncertainty can easily introduce estimation bias under Nash bargaining (Appendix D.4), and proofs of the theoretical claims from this work other than Theorem 1 (Appendix D.6).

## D.1 One Insurer, Two Hospital Model

I illustrate that if a monopolist insurer bargains two-period contracts with two symmetric downstream hospitals, the effect of changes to benchmark price dynamics on payments depends on the precise timing of negotiations. I describe hospital–insurer negotiation, but the ideas carry over in a more generic vertical market, in which the insurer is a generic downstream retailer and hospitals are generic upstream suppliers.

The monopolist insurer sells insurance for \$10,000 per life. The insurer will sell 6,000 units of insurance with both hospitals in their network, 4,000 units with one hospital in their network, and no one will purchase insurance with an empty hospital network. After choosing insurance, enrollees become patients and distribute evenly among hospitals in the insurer's network. The number of patients at a hospital depends on the realized network, so contracts are over a price per patient rather than a payment directly.

A contract takes the form of a multiple $\alpha$ on the benchmark price per patient that will remain in place for $\ell$ periods. The price per unit of care is $p_{b,t}$ and continues to inflate at a rate of $\pi$. I write $\mathbb{C}_t = (\mathbb{C}_{1t}, \mathbb{C}_{2t})$ for the realized period $t$ contracts, where $\mathbb{C}_{ht} = (\ell_{ht}, p_{ht})$ is hospital $h$'s contract in period $t$ (the number of remaining periods $\ell_{ht}$ and the current period price per patient $p_{ht} = \alpha_{ht} p_{b,t}$). If hospital $h$ fails to agree to a contract in period $t$, I write $\mathbb{C}_{ht} = (0, 0)$. The insurer and hospital flow profits in terms of insurer demand $D^M$ and hospital patient count $D_h^H$ is as follows:

$$\pi^M(\mathbb{C}_t) = D^M(\mathbb{C}_t) - \sum_h D_h^H(\mathbb{C}_t) p_{ht} \text{ and } \pi_h^H(\mathbb{C}_t) = D_h^H(\mathbb{C}_t) p_{ht}.$$

All firms play Markov (memoryless) strategies and optimize net present value profits. In the interest of clarity I keep most regularity conditions, for example that bargained multiples are a differentiable functions and that the feasible payoff Pareto frontier is a well-defined convex curve, implicit in this toy model.

Contracts in this setting have spillovers. Suppose the insurer expects hospital $-h$ will agree to a multiple $\alpha_{-ht} = p_{-ht}/p_{b,t}$ whether the bargain with hospital $h$ succeeds or fails. With an agreement, the insurer will earn $\$60m$ in premium revenue, pay $3,000 p_{ht}$ to hospital $h$, and pay $3,000 p_{-ht}$ to hospital $-h$. With a failed bargain with hospital $h$, the insurer will earn $\$40m$ in premium revenue and pay $4,000 p_{-ht}$ to hospital $-h$. The insurer's gains of $\$20m - 3,000 p_{ht} + 1,000 p_{-ht}$ are increasing in the price they will agree to pay hospital $-h$: the more the insurer agrees to pay hospital $-h$, the more the insurer will be willing to pay to hospital $h$ to divert patients from the more expensive hospital. I write $p^*_{Static} = \$20,000 \frac{(1-\tau)}{2+\tau}$ as the unique equilibrium in simultaneous one-period contracting where prices are $p^*_{ht} =$

$(1-\tau)(\$20m + 1{,}000p_{-h,t})$ under both Nash and Kalai proportional bargaining.

Contracts remain in place for two periods. If the firms are myopic and care only about the current period when bargaining, then the firms reach the same starting prices regardless of benchmark price increases. The myopic bargained starting price in response to an anticipated hospital $-h$ starting price of $p_{-ht_0}$ will be $p_{ht_0} = \frac{1-\tau}{3{,}000}(\$20m + 1{,}000p_{-ht_0})$. The equilibrium negotiated multiple will be $\alpha^*_{ht_0} = p^*_{Static}/p_{b,t_0}$ and offsets the benchmark price level just as in the monopolist hospital context. If firms myopically and simultaneously bargain in period $t_0$, the insurer will pay $6{,}000p^*_{Static}$ in period $t_0$ and $6{,}000(1+\pi)p^*_{Static}$ in period $t_0+1$. If the benchmark price increase rate $\pi$ tends to infinity, the insurer may become predictably insolvent because the myopic bargainers in period $t_0$ did not care about profits in period $t_0+1$. These are unappealing features to require a priori when studying benchmark price dynamics.

I consider two potential bargaining models and two potential timing assumptions. The bargaining models are Nash bargaining and Kalai proportional bargaining, both with insurer bargaining weight $\tau \in [0,1]$. The timing assumptions are good-faith disagreement where contracts are bargained wherever Pareto-improving and two-period exclusion where contracts are only bargained at the same time.

I begin with the bargaining solution with simultaneous bargaining.

**Proposition 1.** *Suppose price responses are a (well-defined) linear increasing function of anticipated or current price, $\tau \in (0,1)$, $\beta > 0$, and disagreement is followed by either one or two periods of exclusion followed by a return to contracting. When contracting is simultaneous, Nash bargaining produces the net present value payment $3{,}000p^*(1+\beta(1+\pi)) = (1-\tau)\left(\$20m(1+\beta) + 1{,}000p_{-ht}(1+\beta(1+\pi))\right)$ if and only if disagreement is followed by two periods of exclusion. Kalai proportional bargaining produces that net present value payment whether disagreement is followed by one or two periods of exclusion.*

*Proof.* The proof (like proofs of all other claims in the appendices) can be found in Appendix D.6. □

The intuition from the monopolist context in Section 2 carries through when bargaining is conducted simultaneously under Kalai proportional bargaining. The simultaneous bargaining response to an anticipated starting competitor price of $p_{-ht}$ is:

$$p^*_{h,\text{Kalai}} \overbrace{3{,}000(1+\beta(1+\pi))}^{\substack{\text{NPV payment} \\ \text{per starting price}}} = (1-\tau)\left( \overbrace{\$20m(1+\beta)}^{\substack{\text{NPV premium and} \\ \text{enrollment effect}}} + \overbrace{1{,}000p_{-ht}(1+\beta(1+\pi))}^{\substack{\text{NPV price} \\ \text{reinforcement effect}}} \right).$$

This net present value payment is the static Nash-in-Nash bargaining solution in net present value terms.

Dynamic Nash bargaining diverges from static Nash bargaining even in the case where $\pi = 0$ and benchmark prices are constant. If the firms attempt to bargain one period after a failed agreement in period $t_0$, then the disagreement point bargain in period $t_0+1$ internalizes the spillovers on the insurer's payment to hospital $-h$ in period $t_0+2$, as well as the spillovers from the hospital $-h$ agreed price in period $t_0 + 2$ on the price formed with hospital $h$ in period $t_0 + 3$, and so on. Nash bargainers would choose a disagreement gain from trade split to favors the insurer with a lower disagreement price. The equilibrium price is reduced by adding a chance to bargain after disagreement. For empirical practice, such models can easily generate complex predictions based on complex states with complicated predictions. I find that in my context, that sort of complicated dynamic Nash bargaining model would likely be well-approximated by the dynamic Kalai proportional model that I propose.

The intuition from the monopolist context in Section 2 carries through in a more complicated way when firms bargain in alternating periods.

**Lemma 1.** *Under this subsection's model, the stationary Kalai proportional bargaining starting price when bargaining in alternating periods and one period of exclusion for any disagreement is:*

$$p^*_{Alt} = \$20,000\frac{1-\tau}{2+\tau}\frac{(1+\beta)\,(2+\tau+4\beta(1-\tau))}{(1-\tau)\,(3\beta\,(1+\beta(1+\pi)) - (1-\beta)^2(1+\pi)) + 3\,(1+\beta(1+\pi))}. \quad (8)$$

*If* $\tau \in [0,1)$ *and* $\beta \in [0,1)$*, then the effect of the benchmark price increase rate* $\pi$ *on equilibrium insurer payments* $3,000(2+\pi)p^*_{Alt}$ *and net present value payments* $3,000(2+\pi)p^*_{Alt}/(1-\beta)$ *is a strictly increasing function of* $\pi$ *given* $\tau$ *and* $\beta$*.*

Forward-looking firms offset benchmark price increases even when bargaining in different periods. As $\pi$ increases, the denominator of Equation (8) increases and the stationary starting price falls. However, there are still real effects on payments. Forward-looking firms that discount future periods respond to benchmark price increases with a smaller price reduction in period $t_0$ than the corresponding price increase in period $t_0 + 1$. When the other hospital bargains in period $t_0 + 1$, benchmark prices introduces a double whammy: price spillovers increase in the now-current period $t_0 + 1$ and the current spillover increase is larger than the period $t_0+2$ spillover decrease. As a result, benchmark price increases generally increase equilibrium payments in vertical markets in which contracts are formed at different times. Similar dynamics are present in a Taylor (1980) model of firm price-setting responses to anticipated inflation.

## D.2 Comparison to Static Model

I compare the Kalai proportional bargaining model I use to Nash bargaining alternatives. The existing single-period-contract model fails to allow bargainers to respond to the incentives created by contract dynamics. Whereas dynamic Nash bargaining is an ostensibly natural bargaining model for dynamic contracts, dynamic Nash predictions depend on precise off-equilibrium timing and diverge from the predictions under Nash bargaining for single-period contracts. The Kalai proportional bargaining solution I use generates dynamic predictions that uniquely retain the tractability of the literature's static model.

### D.2.1 The Literature's Static Model

The "workhorse" model for choosing contracts in vertical markets with spillovers is Nash-in-Nash bargaining over static contracts that are simultaneously formed in each period (Collard-Wexler et al., 2019, Bagwell et al., 2020).

Nash-in-Nash bargaining is a model in which contracts reach a Nash equilibrium in Nash bargains. The Nash equilibrium lens holds fixed the outcome of simultaneous bargains. Nash bargaining maximizes an asymmetric product of gains from trade relative to the value of a disagreement point in which no contract is reached.[10] In this section, I adapt the notation of Lee et al. (2021) for the gains from trade for hospital $h$ negotiating with insurer $j$ in period $t$:

$$\mathbb{C}^*_{hj,t,\text{Nash}} = \underset{\mathbb{C}_{hj,t}}{\text{argmax}} \left(GFT^H(\mathbb{C}_{hj,t} \mid \mathbb{C}_{-hj,t})\right)^{1-\tau} \left(GFT^M(\mathbb{C}_{hj,t} \mid \mathbb{C}_{-hj,t})\right)^{\tau},$$

where $\tau \in [0,1]$ is the insurer's bargaining weight and $GFT(\mathbb{C}_{ht,t} \mid \mathbb{C}_{-hj,t})$ is the gain in payoffs by reaching the contract $\mathbb{C}_{ht,t}$ relative to reaching the disagreement contract $\mathbb{C} = \emptyset$. $\tau = 1$ and $\tau = 0$ correspond to the insurer and hospital, respectively, making take it or leave it offers. In the interest of clarity I keep most regularity conditions, for example that bargained multiples are a differentiable functions and that feasible payoffs are convex, implicit in this discussion.

My bargaining model is a generalization of the Ho and Lee (2017) Nash-in-Nash model to include dynamic considerations. I add the use of benchmarks and the capacity for contracts to renew for multiple periods in Stages 1–4, require only some contracts to be bargained in Stage 3, use a Nash-Bertrand premium setting model to adjust for my lack of employer premium setting data, include a contract negotiation cost that is paid after a successful

[10] In a dynamic model, the disagreement point is not uniquely defined because the firms could reach disagreement through one or both sides vetoing a contract (Miller and Watson, 2013). However, the Markov strategies is more than sufficient to define a unique disagreement point.

bargain in Stage 4 flow profits, and allow new contracts to be associated with a chosen benchmark and expiration. In addition, I describe new contracts as formed through Kalai proportional rather than Nash bargaining. The two bargaining models are equivalent in the Ho and Lee (2017) static setting.

Asymmetric Nash bargaining has become the dominant bargaining tool in fields like labor economics (Haake et al., 2023) and the industrial organization of vertical markets (Lee et al., 2021). Symmetric ($\tau = 1/2$) Nash bargaining is the only symmetric bargaining solution that satisfies the axioms of Pareto efficiency, independence of irrelevant alternatives, and scale invariance (Nash, 1950). Nash bargaining can also be microfounded through alternating offers models (Binmore et al., 1986).

By taking first-order conditions, the Nash bargaining price splits the joint gains from trade proportionally to the product of the ratio of bargaining weights and the ratio of marginal values of the price chosen. Suppose a contract $\mathbb{C}_{ht,t}$ can be written as a price $p_{hj,t}$ and other characteristics (in my context, benchmark and length) $B_{hj,t}$. Then the Nash bargaining first-order condition with respect to price is:

$$\frac{GFT^M(\mathbb{C}^*_{hj,t,\text{Nash}} \mid \mathbb{C}_{-hj,t})}{GFT^H(\mathbb{C}^*_{hj,t,\text{Nash}} \mid \mathbb{C}_{-hj,t})} = \underbrace{\frac{\tau}{1-\tau}}_{\substack{\text{Ratio of}\\ \text{bargaining weights}}} \underbrace{\frac{-\frac{\partial GFT^M((p_{hj,t}, B^*_{ht,t}) \mid \mathbb{C}_{-hj,t})}{\partial p_{hj,t}} \Big|_{p_{hj,t}=p^*_{hj,t,\text{Nash}}}}{\frac{\partial GFT^H((p_{hj,t}, B^*_{ht,t}) \mid \mathbb{C}_{-hj,t})}{\partial p_{hj,t}} \Big|_{p_{hj,t}=p^*_{hj,t,\text{Nash}}}}}_{\substack{\text{Ratio of}\\ \text{marginal values}}}. \tag{9}$$

In many models like the Ho and Lee (2017) model I build on, the ratio of marginal values in the first-order condition (9) is one.

A price paid by an insurer to a hospital has spillovers on how other pairs bargain and premiums are set. These spillovers are not internalized with single-period contracts, because all prices and premiums are set simultaneously. When the ratio of marginal values in Equation (9) is equal to one, the Nash bargaining solution splits gains from trade proportionally to the Nash bargaining weights:

$$\frac{GFT^M((\ell^*_{ht,\text{Nash}}, p^*_{h,\text{Nash}}) \mid \mathbb{C}_{-h,t})}{GFT^H((\ell^*_{ht,\text{Nash}}, p^*_{h,\text{Nash}}) \mid \mathbb{C}_{-h,t})} = \frac{\tau}{1-\tau}.$$

Zero-sum bargains with this property one are often called *transferable utility* (TU) bargaining problems. Zero-sum bargaining problems, where the sides have access to a lump-sum transfer, are common in the vertical market literature (Lee and Fong, 2013, Ho and Lee, 2017, 2019, Collard-Wexler et al., 2019, Yu and Waehrer, 2019, Vincent, 2020). Other empirical models have single-period contracts with spillovers on a downstream competition stage that has no explicit uncertainty and is typically easy to compute up to a small number of parameters (Crawford and Yurukoglu, 2012, Grennan, 2013, Gowrisankaran et al., 2015, los Santos et al., 2018, Yang, 2020, Ellickson et al., 2022). A few theoretical models include dynamic spillovers either with one-period contracts (Deng et al., 2023) or with take it or leave it offers (Do and Miklós-Thal, 2022), in which case the Nash and Kalai proportional bargaining solutions coincide.

It is undesirable to impose a static model when needing to account for contract timing (as Dorn (2024) argues) or for dynamic questions (like the proposed Medicare reimbursement reform I study). As I discuss in Section 2, models in which contracts are revised in every period enable bargainers to complete undo any effects of benchmark price increases. When contracts are truly formed for multiple periods, firms can undo the effects of benchmark price increases in net present value terms but cannot undo the dynamic implications with fixed multiples. As Appendix D.1 shows, when contract formation is staggered, the resulting dynamic process can lead benchmark payment reforms to have real effects on spending.

### D.2.2 The Literature's Static Model Is Inconvenient for Dynamic Questions

While dynamic Nash bargaining is an ostensibly natural extension of static Nash bargaining to dynamic bargaining settings, dynamic Nash predictions depend on precise off-equilibrium timing and diverge from static Nash predictions.

The most immediate extension of the static model to dynamic bargaining questions would be myopic bargaining. A contract negotiated today for five years will have spillovers on other bargains conducted in the next four years. When firms are myopic and do not care about future periods, firms do not care to internalize their spillovers on future bargains and still think about bargaining for one period at a time. As I show in Section 2, myopic assumptions applied to forward-looking bargainers would lead to overestimating the effect of interest (Section 2). It is undesirable to require myopia a priori for dynamic questions.

Forward-looking Nash bargainers must internalize the effect of bargained prices when contracts are formed at different times. As demonstrated in Section 4.1, contracts are multiyear and contract formation is staggered rather than bargained simultaneously. A forward-looking bargainer will care about how their chosen contract affects future terms. When bargains have spillovers on future contracts, forward-looking Nash bargainers internalize those spillovers.

The ratio of marginal values in Equation (9) is quickly disturbed when firms internalize spillovers. Imagine insurer $j$ and hospital $h$ Nash bargain knowing their price will affect how the insurer bargains with hospital $-h$ in the future. The ratio of marginal values and bargaining predictions would depend on how the marginal hospital $h$ price affects future hospital $-h$ prices. The bargaining solution's predictions would recursively depend on the bargaining solution (Sorger, 2006). The recursion can snowball to infinity: hospital $-h$ would bargain knowing their price would affect a price formed with hospital $h$, and hospital $h$ would then bargain knowing their price would affect hospital $-h$ in the future, and so on. In realistic markets with more than three firms, internalized spillovers can quickly snowball out of control. These internalized spillovers are unavoidable when forward-looking firms bargain contracts with overlapping terms.

Dynamic Nash bargaining diverges from static Nash bargaining in subtle ways that depend on precise off-equilibrium timing. Added chances to bargain under impasse with realistic timing will have time-varying spillovers and change the model's predicted payments. Even when bargaining is simultaneous in equilibrium, I show in Appendix D.1 that dynamic Nash bargaining can resemble static Nash bargaining or be unlike static Nash bargaining depending on the exact timing of when bargaining is attempted under impasse. As I show in Appendix D.4, even ignorable uncertainty can introduce bias under a dynamic Nash bargaining model.

In this work, I attempt to make progress while avoiding bargaining models that depend on precise off-equilibrium impasse timing. Ad hoc solutions like assuming knife-edge timing for tractability may not always be possible and often require the firms to avoid Pareto-improving contracts. A principled dynamic Nash bargaining approach would likely yield a differential equation (Coles and Muthoo, 2003) and potentially require a high-dimensional state space. I propose a dynamic bargaining model that can produce the same insights whether the firms exclude for one period or two periods. The bargaining solution I use also generalizes static Nash bargaining, fits researcher intuition, and aligns more closely than Nash bargaining with empirical results from the lab.

### D.2.3 The Dynamic Kalai Proportional Bargaining Solution I Use

I use the Kalai (1977) proportional bargaining solution to generalize the literature's analysis of static contracts to dynamic bargaining over multiperiod contracts. The Kalai proportional bargaining solution generates dynamic predictions that uniquely retain the tractability of the literature's static model and tractably generalize many natural generalizations of static Nash.

Kalai proportional bargaining is the bargaining solution that splits gains from trade proportionally to bargaining weights regardless of the ratio of marginal values:

$$\frac{GFT^M(p^*_{h,\text{Kalai}})}{GFT^H(p^*_{h,\text{Kalai}})} = \frac{\tau}{1-\tau}.$$

The Kalai proportional bargaining solution is exactly the same as the Nash bargaining solution if bargaining is TU, as in the Ho and Lee (2017) model I build on. Kalai proportional bargaining cannot generalize Nash bargaining when the ratio of marginal values differs over time, for example due to spillovers on future negotiations that change as the future negotiations approach and are passed.

Kalai proportional bargaining is the only bargaining solution that produces the same predicted payments across off-equilibrium impasse timing assumptions. If firms Kalai proportionally bargain over $A$ relative to a disagreement point bargain $B$ and $B$ involves Kalai proportionally bargaining relative to $C$ with the same bargaining weights, then the gains from agreeing to $B$ rather than $C$ are already split proportionally to the firms' bargaining weights. The firms can treat the disagreement point as $C$ for the purposes of finding the equilibrium contract. This prediction invariance is Kalai (1977)'s "step-by-step" and Roth (1979)'s "path-invariance" properties, but with the logic adapted from static utility to a dynamic bargaining game. Kalai and Roth show that this property is unique to the predictions of Kalai proportional bargaining: similar invariance properties have occasionally been found for TU dynamic Nash bargaining games (Eberwein, 2001, Jarosch et al., 2019, Shapiro, 2021) in which Nash and Kalai proportional bargaining coincide.

Kalai proportional bargaining has favorable justifications based on axioms, researcher intuition, and laboratory evidence. Axiomatically, Kalai proportional bargaining can be derived as the unique solution that replaces the scale invariance Nash assumption with a resource monotonicity assumption that Pareto expansions be Pareto improving (Kalai, 1977). Intuitively, researchers often interpret bargaining concepts using Kalai proportional bargaining (Brügemann et al., 2018, Ghili, 2022). In the lab, Kalai proportional bargaining often outperforms Nash bargaining (Nydegger and Owen, 1974, Duffy et al., 2021).

I do not endorse Kalai proportional bargaining prescriptively because it is scale varying. When the scale of utility changes, Kalai proportional bargaining predicts different payments. Suppose two people symmetrically bargain over 60 chips. If the chips are worth one penny and the bargainers are quasilinear, then both Nash and Kalai proportional bargaining predict the players will agree to 30 chips each. If instead the chips are worth two cents to the first player, Nash bargaining predicts the players will split the chips evenly while Kalai proportional bargaining predicts the players will split the *gains* equally by giving the second player 40 chips. Kalai proportional bargaining does a far better job of predicting lab behavior in the chip game I described (Nydegger and Owen, 1974) and other scale varying games (Duffy et al., 2021). However, scale varying solution concepts are difficult to microfound (Dagan and Serrano, 1998). I propose a microfoundation based on Dutta (2012, 2022)'s demands games in Appendix D.3, but it is not fully compelling for that reason.

Kalai proportional bargaining is subtle in settings in which one side's optimal contract still yields positive gains from trade to their partner. For example, consider a simplified version of Villas-Boas (2007)'s setting in which a monopolist manufacturer negotiates with a monopolist retailer over the retailer's input price without access to side payments. The manufacturer's most profitable outcome is a price that leads the retailer to make positive profit. A Kalai proportional bargaining model that gives the manufacturer all the bargaining power would predict setting the retailer indifferent to disagreement and lead to a Pareto-inefficient outcome. Such a bargaining problem violates Kalai (1977)'s assumption that the set of feasible utilities is comprehensive. Even still, this paper provides useful insights for such sequential bargaining. If the supplier take-it-or-leave-it offers generate a similar share of gains from trade over time, my results show that a Kalai proportional model can tractably approximate the resulting dynamic problem. If such offers generate important variation in the split of gains from trade, then my results say that it may be difficult to accurately capture the true dynamic bargaining process within a tractable model.

Whether Kalai proportional bargaining is the correct model or a convenient model is largely academic in my context. In Appendix Figure 9, I find that Kalai proportional bargaining likely approximates Nash bargaining closely. I therefore leave any potential internally consistent dynamic scale invariant bargaining model to future work.

## D.3 A Microfoundation for Dynamic Kalai Proportional Bargaining

This subsection offers a microfoundation for dynamic Kalai proportional bargaining. The microfoundation is a demands game with revocation costs based on Dutta (2012) and Dutta (2022). As opportunities to contract become instantaneous, gains from trade tend to zero and the bargaining solution tends to an instantaneous (and by extension a discrete) dynamic Kalai proportional bargaining solution. The game extends Dutta (2012)'s setup to enable repeated bargaining over small effective gains from trade.

In the model's equilibrium, all contracts in a period will be reached simultaneously. In this game, there are two stages at which contracts can be reached: in initial demands and after conceding. I assume that at the margin, hospitals prefer still higher prices and insurers prefer lower prices. Under the model, any pure strategy equilibrium with this property leads to all agreements being reached simultaneously in any given period without conceding. As a result, the sides hold fixed any contracts that are bargained simultaneously.

I first describe a sequence of demands games in continuous time outside steady state. I then show that as the frequency of bargaining opportunities tends to infinity, any pure strategies Markov Perfect equilibrium of the demands game tends to Kalai proportional bargaining.[11] I then show that a corresponding sequence of discrete time bargaining solutions of the instantaneous bargaining game correspond to the dynamic Kalai proportional bargaining solution in discrete time.

### D.3.1 The Demands Game

The sequence of discretely timed games is indexed by $n$.

In game $n$, time runs from $t = 0$ to infinity. At time $t$, a contract structure $\mathbb{C}_t$ emerges. In period $t$, the contract structure which emerges is a set of lengths hospital $i$-insurer $j$ lengths $\ell_{ijt,(n)}$ and a set of $i - j$ prices $p_{ijt,(n)} \subseteq \mathcal{P}$, where $\mathcal{P}$ is a closed, convex subset of $\mathbb{R}$.[12] If $i$ and $j$ do not reach a contract, the $\ell_{ijt,(n)} = p_{ijt,(n)} = 0$. I write the set of contracts that emerge as $\mathbb{C}_t$. I assume that at every stage of negotiations, upstream hospitals prefer higher prices while downstream insurers prefer lower prices. Prices remain in place for the full length of the contract: for example, lump-sum payments would fit in the model as a price per period amortized over the contract.

There is no uncertainty. The set of insurer and hospital indices remains the same in every game. I assume that if $i$ and $j$ contract in period $t$, the length is the known, exogenous value $\ell^*_{ijt,(n)}$.

Timing in period $t$ is as follows:

1. The board of directors of every hospital $i$ and insurer $j$ meet with their delegates, who simultaneously bargain with every potential partner with whom they do not have an agreement.

    - Hospital delegates and insurer delegates choose a price demand to state publicly. The demand is chosen to maximize a weighted average of their employer's net present value profits and a personal concession cost they face if they agree to a contract that is worse than their demand. The hospital delegates demand a minimum price $\underline{p}^H_{Demand}$ and the insurer delegates demand a maximum price $\bar{p}^M_{Demand}$.

2. The corresponding delegates for each $ij$ pair without a contract in place from the previous period simultaneously meet with their authorized demands.

[11] I mainly use the Markov assumption to prevent renegotiation in equilibrium. Without it, the sides could sustain an equilibrium with painful concessions by punishing forming the same contracts without concession. Dutta (2022) shows that the Kalai result only requires renegotiation-proof strategies when repeatedly attempting to bargain over a fixed asset. I might be able to replace Markov strategies with renegotiation-proof strategies in my setting in a similar way, though renegotiation proofness would be more subtle in the nonstationary environment I study.

[12] The game immediately generalizes to other vertical markets by treating hospitals as an upstream market, insurers as a downstream market, and prices as a real-valued numeraire the sides bargain over.

- If an $ijt$ pair has jointly feasible demands $\underline{p}^H_{ijt,Demand} \leq \bar{p}^M_{ijt,Demand}$, the delegates reach a jointly feasible contract by Nash bargaining over firm profits, treating their demands as disagreement points and taking equilibrium strategies of other pairs as given.
- If the delegates arrive with jointly infeasible demands, they have the simultaneous opportunity to concede to the other side's demands. Conceding means adopting the other delegate's demand. Without loss of generality, I write concession costs in units of employer net present value profits. Conceding has an associated cost of $c^H_{ijt,(n)}(\underline{p}^H_{Demand} - \bar{p}^M_{Demand})$ and $c^H_{ijt,(n)}(\underline{p}^H_{Demand} - \bar{p}^M_{Demand})$. The concession cost functions are continuous, strictly increasing for positive concessions, equal to zero and have an infinite right-differentiable at zero, and are lower-bounded by cost functions with these properties.

3. Each $ijt$ pair without a contract meets simultaneously.
   - If the new demands are jointly feasible, they reenter the same joint bargaining process as in the previous stage.
   - If the new demands are jointly infeasible, they do not form a contract.
4. The hospitals and insurers obtain flow profits: $v^H_{it}(\mathbb{C}_t, R_t) = \pi^H_{it,(n)}(\mathbb{C}_t) + r^H_{i,(n)} R_{ijt}$ for hospital $i$ where $r^H_i$ is any new contract negotiation cost, and analogously $v^M_{jt}(\mathbb{C}_t, R_t) = \pi^M_{jt,(n)}(\mathbb{C}_t) + r^M_{j,(n)} R_{ijt}$ for insurer $j$.

When the delegates arrive with jointly-unachievable demands, they play a one-shot game with a simultaneous payoff matrix adapted from Dutta and depicted in Appendix Table 11. In Appendix Table 11, I write the value functions with agreement (at the anticipated concession decisions) as $V^H$ and $V^M$ and the value with disagreement as $V^H_D$ and $V^M_D$. The $V$ agreement value functions include any effect of the negotiated contract on any other agreements reached through concession. I later show that there is no concession in equilibrium, so that the relevant value functions are also the value functions at the equilibrium simultaneous agreements. If concession costs are too high, neither delegate will be willing to concede to a contract that only improves their employer's profits slightly. The infinite right-derivative at zero ensures that if the demands are close enough, then both delegates will prefer to concede despite the incurred concession cost.

Table 11: After incompatible demands in Stage 2 ($\underline{p}^H > \bar{p}^M$), payoffs depending on whether hospital delegate (rows) and insurer delegate (columns) concedes or sticks to their initial demands. Table is adapted from Dutta (2022). I omit the $ijt$ subscripts for brevity. $p^*$ is the hypothetical Nash bargained price if both delegates concede and the demands are reversed.

| | Concede ($C$) | Stick ($S$) |
|---|---|---|
| $C$ | $(V^H(p^*) - c^H(\underline{p}^H - \bar{p}^M), V^M(p^*) - c^M(\underline{p}^H - \bar{p}^M))$ | $(V^H(\underline{p}^H) - c^H(\underline{p}^H - \bar{p}^M), V^M(\underline{p}^H))$ |
| $S$ | $(V^H(\bar{p}^M), V^M(\bar{p}^M) - c^M(\underline{p}^H - \bar{p}^M))$ | $(V_D^H, V_D^M)$ |

The concession costs constrain the contracts that can emerge in equilibrium. Suppose jointly compatible demands lead to the hospital getting the most favorable deal: a take it or leave it deal that gives the hospital all surplus and leaves the insurer with their disagreement value. Consider a subgame in which the insurer deviates and demands a slightly better deal. The insurer's delegate will not pay a concession cost to concede to obtain the disagreement value they could obtain anyway. But if the new demand is close enough, the hospital's delegate will prefer to concede rather than lose all the surplus. Extending this logic to lopsided deals, the concession costs constrain how much surplus each side can obtain. The higher a side's concession costs, the better of a deal they guarantee themselves in equilibrium. In the limit as the game becomes instantaneous and gains from trade tend to zero, the constraint becomes driven by the derivative of the cost functions at zero.

The particular form of concession costs enables a scale varying solution in the limit. The concession costs are paid in terms of prices rather than net present value profits. As a result, constraints in the instantaneous game limit are driven by the ratio of marginal costs alone. If the ratio of marginal costs changed over time, the solution would be instantaneous but not discrete Kalai proportional bargaining. If the concession costs were a function of value conceded, it appears the equilibrium would correspond to Nash bargaining at the margin in a similar manner to Coles and Muthoo (2003). If the concession costs were borne by the delegates but set by firms that were indifferent to conceding, then there would be equilibria with concession and the concession costs might not have any bite. The lower bound rules out a sequence of cost functions with infinite right-derivatives at zero that tend to irrelevancy.

The model could be generalized in a few directions at the cost of additional notation. I use Nash bargaining in Stage 2 to be tongue-in-cheek. Any other bargaining solution would work. I make contract lengths exogenous to ensure that the space of feasible contract values is convex. The model could likely be extended to enable endogenous contract lengths. Under this game and Dutta (2022)'s game, a delegate pays the same concession cost whether or not the other side concedes; in Dutta (2012)'s original game, the concession cost is paid based on the difference between demanded and realized price, with the same result.

I now write out value functions for the realized contract state. I assume players follow Markov strategies, so that value functions only depend on realized contracts and negotiation costs (i.e. realized contracts and the previous period's realized contracts). Suppose the players follow strategies $\hat{\sigma}$ which generate period $t+1$ contracts $\hat{\sigma}_{t+1}(\mathbb{C}_t)$. I define the corresponding value functions as:

$$V^H_{it,(n)}(\mathbb{C}_t \mid \mathbb{C}_{t-1}) = \frac{\pi^H_{it,(n)}(\mathbb{C}_t) - \sum_j r^H_{i,(n)} R_{ijt} + \beta_{(n)} V^H_{it+1,(n)}(\hat{\sigma}_{t+1}(\mathbb{C}_t) \mid \mathbb{C}_t)}{1-\beta}$$
$$V^M_{it,(n)}(\mathbb{C}_t \mid \mathbb{C}_{t-1}) = \frac{\pi^M_{jt,(n)}(\mathbb{C}_t) - \sum_i r^M_{j,(n)} R_{ijt} + \beta_{(n)} V^M_{jt+1,(n)}(\hat{\sigma}_{t+1}(\mathbb{C}_t) \mid \mathbb{C}_t)}{1-\beta}.$$

In that equation, $R_{ijt}$ is an indicator for $ij$ forming a new contract in period $t$.

I will make use of the value of $ij$ deviating to a new contract $p$ while holding fixed the outcome of other bargains. I write these unilateral deviation value functions as $V^H_{ijt}(p_{ijt} \mid \hat{\sigma}, \mathbb{C}_{t-1})$ and $V^M_{ijt}(p \mid \hat{\sigma}, \mathbb{C}_{t-1})$. It is not immediately obvious that these are the relevant value functions in this bargaining game since in principle the choice of contract could affect later concession decisions. I show there is no concession in equilibrium so that these are the relevant value functions.

I will assume some structure on the value functions which I expect to hold in many vertical market bargaining models.

**Assumption 3** (Monotone and differentiable value function)**.** When bargaining in Stage 2 or choosing whether or not to concede in Item 2, hospitals strictly prefer higher prices and insurers strictly prefer lower prices inclusive of any response through subsequent concession decisions and negotiations in period $t$. The expected value functions of a bargained initial price $p$ at the expected other equilibrium contracts in the same period is written as $V(p \mid \hat{\sigma}, \mathbb{C}_{t-1})$ and is differentiable with bounded derivatives as follows:

$$0 < \varepsilon B \leq \frac{-\partial V^H_{ijt}(p_{ijt} \mid \hat{\sigma}, \mathbb{C}_{t-1})}{\partial p_{ijt}}, \frac{\partial V^H_{ijt}(p_{ijt} \mid \hat{\sigma}, \mathbb{C}_{t-1})}{\partial p_{ijt}} \leq B$$

for uniformly bounding constants $\varepsilon, B > 0$.

Since one side strictly prefers and the other one strictly does not prefer higher prices, Assumption 3 enables me to write the value concession game as a value-based price concession game. Assumption 3 could be relaxed to a Lipschitz continuity-type assumption.

The substantive idea of this assumption is that prices have monotonic effects. The first half that includes downstream effects rules out the delegates choosing to form a contract through jointly feasible demands in order to sustain an equilibrium in other simultaneous demands. Under Assumption 3, if a hospital and insurer arrive with jointly feasible demands, they could do better by deviating to the other's demand despite any effects on the downstream contracts.

The value function derivative component of Assumption 3 ensures the hold-fixed contract deviation value functions are differentiable.[13] As a result, the value functions are invertible in bargained prices. For example, if the price domain $\mathcal{P}$ includes only weakly positive prices, then equilibrium hospitals generally prefer strictly higher prices and insurers prefer strictly lower prices. The property is likely to hold in other settings if which higher prices have positive spillovers on other prices for appropriately defined price domains $\mathcal{P}$.

**Lemma 2.** *Under Assumption 3, for every game $n$, subgame $\mathbb{C}_{t-1}$, triplet $ijt$ without a contract in place under that subgame, and associated equilibrium strategies $\hat{\sigma}_{(n)}$, there are prices $p^H_{ijt,(n),D}$ and $p^M_{ijt,(n),D}$ that make the hospital and insurer, respectively, indifferent between agreement at that price and disagreement under the expected contracts formed by other pairs in equilibrium.*

I add an assumption to rule out certain nuisance behavior.

**Assumption 4.** If $hjt$ do not reach a contract in a period $t$ subgame and $ijt$ do reach a contract through negotiation after initial jointly-feasible demands, then $hnt$ continue to not reach a contract if either $i$ or $j$ strengthens their demand.

Assumption 4 rules out a certain edge case in which pairs reach a contract through Nash bargaining between jointly feasible contracts, but neither side can make a stronger demand because it would lead to an anticipated contract that changes other pairs' concession decision. Without Assumption 4, there is no concession in equilibrium, but the contract outcome may be driven by the effect on others' concession decisions in the same period. The content is minimal if, as in my setting, equilibrium networks are fairly complete.

The following lemma shows that there is no concession in equilibrium. As a result, in any equilibrium the firms must negotiate over an individual contract in a way that is optimal taking the outcome of other bargains as fixed. The best deviation over all demands is at least as good as the best deviation over a single demand.

**Lemma 3.** *Under Assumptions 3 and 4, for every game $n$ with a pure strategy Markov perfect equilibrium $\hat{\sigma}_{(n)}$, every subgame contract is formed through equal demands.*

[13]The hold-fixed value functions will be the relevant value functions because there is no concession in equilibrium and no firm will pay a cost to send a negotiator to predictably fail when contracts are formed expecting the negotiation to fail.

I obtain Kalai bargaining strategies as the game tends to instantaneous offers and the ratio of first marginal costs tends to some proportion.

**Assumption 5** (Sequence of PSMPE tending to instantaneous)**.** As the game index $n$ tends to infinity, bargaining becomes instantaneous in the sense that $\beta(n) \to 1$ and the effect of disagreement becomes negligible: $\max\{V^H(p_D^M) - V^H(p_D^H), 0\}, \max\{V^M(p_D^H) - V^M(p_D^M), 0\} = o_n(1)$ uniformly in subgames and potential bargainers.

This is plausible in many games: the difference between agreeing to a contract now and waiting a second and agreeing to essentially the same contract should be essentially nil.

**Assumption 6** (First marginal costs tend to proportional)**.** As the game index $n$ tends to infinity, the ratio of first marginal costs tend to a fixed proportion in the sense that there are finite $w_i^H, w_j^M > 0$ and a sequence of $\delta_n \to 0$ such that $\max_{ij} \sup_{x \in (0, \max\{p_{ijt,D}^M - p_{ijt,D}^H, \delta_n\}]} \frac{c_{ijt,(n)^M}(x)}{c_{ijt,(n)^H}(x)} - \frac{w_i^H}{w_j^M} = o_n(1)$.

The cost proportionality around zero is important to extending the Kalai proportional results from instantaneous to discrete time. It will be important for the microfoundation that as the contract shifts under impasse, the ratio of first marginal costs between the hospital and insurer retain the same proportions. It is not important that the costs be proportional on a price scale — costs could be formed under a payment scale and I would obtain the same result.

The following result follows from an adapted version of Dutta (2012)'s argument.

**Proposition 2.** *Suppose Assumptions 3, 4, 5, and 6 hold. Then the bargains tend to an instantaneous Kalai proportional solution:*

$$\sup_{\mathbb{C}_{t-1}, R_{ijt,(n)}=1, p_D^M > p_D^H} \left| \frac{V_{ijt}^M\left(\hat{p}_{ijt}(\mathbb{C}_{t-1}) \mid \hat{\mathbb{C}}_{t-ij,(n)}\right) - V_{ijt}^M\left(p_{ijt,D}^M \mid \hat{\mathbb{C}}_{t-ij,(n)}\right)}{V_{ijt}^H\left(\hat{p}_{ijt}(\mathbb{C}_{t-1}) \mid \hat{\mathbb{C}}_{t-ij,(n)}\right) - V_{ijt}^H\left(p_{ijt,D}^H \mid \hat{\mathbb{C}}_{t-ij,(n)}\right)} - \frac{w_i^H}{w_j^M} \right| \to^n 0.$$

I offer the following intuition. The concession costs ensure that in every pure strategy Nash equilibrium, there is no concession and both sides get sufficiently more than their disagreement value that they cannot guarantee a better outcome by demanding more. As the game tends to instantaneous, the gains from trade relative to waiting a period become small and the infinite first marginal costs become binding. The particular form of the constraint is that the ratio of gains from trade tend to the ratio of first marginal costs. This is a scale varying solution concept because the concession costs are made based on prices rather than profits; fixing the ratio of concession costs fixes the relative value of profits.

### D.3.2 Discrete Time Results

The result in Proposition 2 gives a result about disagreeing over an ignorable period of time. Kalai proportional bargaining has a special path-invariance property that makes this instantaneous-bargaining limit extend to discrete time.

**Proposition 3.** *Suppose Assumptions 3, 4, 5, and 6 hold. Let $\tilde{V}^H_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})$ and $\tilde{V}^M_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})$ be the expected values if $ij$ disagree in period $t$ and remain in impasse until the next period where another pair forms a contract. Suppose the value of agreement relative to impasse is bounded. Then the bargains tend to an* discrete-*time Kalai proportional solution:*

$$\sup_{\mathbb{C}_{t-1}, R_{ijt,(n)}=1, V^M(p)>V^M(0)} \left| \frac{V^H_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^H_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})}{V^M_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^M_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})} - \tau_{ij} \right| \to^n 0.$$

Proposition 3 justifies using a discrete-timed dynamic Kalai proportional bargaining model even when real bargaining is conducted in continuous time. This is very useful for empirical work, where bargaining strategies in continuous time will often be intractable.

Only Kalai proportional bargaining justifies estimating a discrete timed bargaining model with a continuous timed underlying microfoundation in general nonstationary games. A bargaining solution that generally returns the same contract after adding an additional post-disagreement chance to bargain must have proportional character (Roth, 1979). As a result, a comparable result for Nash-in-Nash bargaining would generally yield a differential equation at the margin (Coles and Muthoo, 2003, O'Neill et al., 2004). Nash-in-Nash bargaining in nonstationary environments with access to lump-sum transfers might be able to be microfounded, but only because Nash bargaining with access to lump-sum transfers has the same predictions as Kalai proportional bargaining.

## D.4 Uncertainty Can Introduce Bias under Nash Bargaining

In this subsection, I use a toy model to show that an empirical researcher must accurately model uncertainty under Nash bargaining even if uncertainty is completely at random.

Imagine a researcher has access to an infinite number of samples from the following bargaining process. A fair coin is flipped. If the coin comes up heads, the insurer's realized gains relative to the status quo of 0 profits are $\widehat{GFT}^M(p) = 30 - p$ and the hospital's realized gains are $\widehat{GFT}^H(p)$. If the coin comes up tails, the insurer's realized gains are $\widehat{GFT}^M(p) = 10 - p$ and the insurer's realized gains are $\widehat{GFT}^H(p) = 2p$. (To emphasize the role of uncertainty, in this section, I write the realized gains from trade as $\widehat{GFT}$ and the gains from trade as $E[\widehat{GFT}]$ rather than $GFT$.)

After taking first-order conditions, the Nash bargaining solution over price $p$ in terms of gains from trade $E[\widehat{GFT}(p)]$ can be written as

$$0 = (1-\tau)E[\widehat{GFT}^M(p^*)]\frac{\partial E[\widehat{GFT}^H(p)]}{\partial p}\mid_{p=p^*} + \tau E[\widehat{GFT}^H(p^*)]\frac{\partial E[\widehat{GFT}^M(p)]}{\partial p}\mid_{p=p^*}.$$

The game is transferable utility in expectation, so that both the symmetric Nash and Kalai proportional bargaining solutions yield $p^* = 10$.

Note that if price is viewed as a treatment, uncertainty in this process is strongly ignorable. The coin toss outcome is completely independent of the price that is chosen. There are no unobservables that the negotiators use to choose contracts.

Suppose a naive researcher presumes they can form a moment based on the realized gains. In particular, they exactly observe the realized $\widehat{GFT}$ functions. The naive researcher unfortunately constructs a Nash bargaining moment

$$0 = E\left[Z\left((1-\hat{\tau}^{Nash})\widehat{GFT}^M(p)\frac{\partial \widehat{GFT}^H(p)}{\partial p}\mid_{p=p^*} + \hat{\tau}^{Nash}\widehat{GFT}^H(p)\frac{\partial \widehat{GFT}^M(p)}{\partial p}\mid_{p=p^*}\right)\right],$$

where the instrument $Z$ is a dummy. When the coin comes out tails, $\widehat{GFT}^M(p^*) = 0$. When the coin comes out heads, $\frac{\partial \widehat{GFT}^H(p)}{\partial p}\mid_{p=p^*} = 0$. As a result, the researcher correctly observes the insurer only gains when the hospital is indifferent to payments, and incorrectly concludes that $\hat{\tau}^{Nash} = 0$. Conversely, the Kalai proportional bargaining moment will set

$$0 = E\left[Z\left((1-\hat{\tau}^{Kalai})\widehat{GFT}^M(p^*) - \hat{\tau}^{Kalai}\widehat{GFT}^H(p^*)\right)\right] = E\left[(1-\hat{\tau}^{Kalai})(20-p^*) - \hat{\tau}^{Kalai}p^*\right],$$

which is satisfied at the correct bargaining weight $\hat{\tau}^{Kalai} = 1/2$.

At a high level, the methodological issue emerges when there can be a correlation between one side's gains and the other side's marginal value based on uncertainty resolved after the negotiation. The Nash bargaining process that just cares about expected values at the moment of negotiation. If the correlation is incurred from uncertainty after negotiation, then a plug-in moment will be biased. If the correlation is observed and incorporated by the negotiators before bargaining, than a plug-in moment will be unbiased.

## D.5 Additional Claims for Proofs

I begin with the scaling that corresponds to cutting period lengths in half in Corollary 1.

**Assumption 7.** The new game quantities will be denoted by til$\tilde{\text{d}}$es. In the new game, in all periods $\tilde{t} \geq \tilde{t}_0$, the demand functions are the same as in the original period $t_0 + \lfloor(\tilde{t} - \tilde{t}_0)/2\rfloor$, but scaled downwards by $1+\sqrt{\beta}$; benchmark prices are unchanged in $t_0+v$ for odd-numbered $v$ and increase the same way as previously for even-numbered $v$ the new discounting rate is $\tilde{\beta} = \sqrt{\beta}$; current contract formed and anticipated lengths are doubled; the time until the next year start and between year starts is doubled; no further information is revealed in periods $\mathcal{I}_{\tilde{t}_0+v}$ for odd-numbered $v$ but new information and benchmark prices are drawn from the same conditional distribution (after appropriate translation of definitions) as for the original period $t_0 + v/2$ for even-numbered $v$; contracting attempted in period $t_0 + t$ is now attempted in period $\tilde{t}_0 + 2t$; premiums are updated twice as many periods in the future; and the distribution of future contract responses are unchanged, except contract lengths double.

**Lemma 4.** *Let $s_a, s_b > 0$ be putative slopes such that sign$(\log(s_a))$ = sign$(\log(s_a))$ and $|\log(s_a)| < |\log(s_b)|$. Then there is an $s_1$ with sign$(\log(s_1))$ = sign$(\log(s_a))$ and a pair of games wherein $ij$ bargain under a repeated a bargaining solution $f$ as in Corollary 1 with no uncertainty, such that if I write $G^{(1),H,Sup}$ for hospital 1's maximal gains from trade (its supremum of gains from trade subject to making insurer 1 weakly prefer an agreement in the original first period of one of the pair), $G^{(1),M,Sup}$ the same but with the roles flipped, and $G^{(2),H,Sup}$ and $G^{(2),M,Sup}$ are the same but for the game's split-in-half bargaining opportunity, then $\frac{G^{(1),M,Sup}}{G^{(1),H,Sup}} = s_1$, in the first of the pair the split-in-half game satisfies $\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = s_a$, in the second of the pair the split-in-half game satisfies $\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = s_b$, and the Pareto frontiers in both the original period 1 and the split-in-half period 2 are linear.*

**Lemma 5.** *Let $f$ be a homogeneous and Pareto-optimal bargaining solution. Let $S_1$ be a bargaining game wherein disagreement point utility is equal to zero and the Pareto frontier intersected with weakly positive gains from trade is the line segment from $(0, G^{1,M})$ to $(G^{1,H}, 0)$ for some $G^{1,M}, G^{1,H} > 0$. Let $S_2$ be a bargaining game that has the same slope, i.e. the Pareto line segment goes from $(0, G^{2,M})$ to $(G^{2,M}\frac{G^{1,H}}{G^{1,M}}, 0)$ for some $G^{2,M} > 0$. Then the shares of gains from trade under $f$ are equal in both games.*

**Lemma 6.** *Let $d^M, d^H \geq 0$ be given. Let $S_1$ be a bargaining game wherein disagreement point utility is equal to zero and the Pareto frontier intersected with weakly positive gains from trade is the line segment from $(0, G^{1,M})$ to $(G^{1,H}, 0)$ for some $G^{1,M}, G^{1,H} > 0$. Let $G^{2,M}$ and $G^{2,H}$ be the maximal further gains from trade available to the second and first player while making the other side weakly better off than $d^H$ and $d^M$, respectively. Then $\frac{G^{2,M}}{G^{2,H}} = \frac{G^{1,M}}{G^{1,H}}$.*

Next, I state three lemmas for the microfoundation.

**Lemma 7** (Dutta (2012), Proposition 2)**.** *Suppose $\hat{\sigma}$ is a pure strategy Markov perfect equilibrium of the game I have described in Proposition 2 under Assumption 3 but not necessarily*

*5 and 6. Suppose $i$ and $j$ could form a strictly Pareto-improving contract in period $t$. For brevity, I omit the $ijt,(n)$ subscripts. Then there is a unique $y_1, y_2 \in (0,1)$ that satisfies $y_1 + y_2 \geq 1$ and the following property about gains relative to disagreement*

$$V^H\left(y_2 p_D^H + (1-y_2)p_D^M\right) - V^H(p_D^H) = c^H\left((p_D^M - p_D^H)(y_1 + y_2 - 1)\right)$$
$$V^M\left(y_1 p_D^M + (1-y_1)p_D^H\right) - V^M(p_D^M) = c^M\left((p_D^M - p_D^H)(y_1 + y_2 - 1)\right),$$

*then the pair $(y_1, y_2)$ is unique.*

Intuitively, $y_1$ and $y_2$ both decrease the left-hand sides to zero but increase the right-hand sides, so there should be a fixed point. In addition, only one of $y_1$ and $y_2$ appear on the left-hand side of any given equation. Consider the function $\hat{y}_1(y_2)$ that chooses a $\hat{y}_1$ to hold the first equation with equality at any given $y_2$. As $y_2$ increases, the left-hand side of the first equation decreases so $\hat{y}_1 + y_2$ must decrease. Therefore $\hat{y}_1(y_2)$ must decrease faster than $y_2$. Applying a similar argument to the other equation ensures any fixed point is unique. The next proposition shows the fixed point constrains the equilibrium bargain.

**Lemma 8** (Dutta (2012), Proposition 3)**.** *Suppose $\hat{\sigma}$ is a pure strategy Markov perfect equilibrium of the game I have described in Proposition 2 under Assumption 3 but not necessarily 5 and 6. Suppose $i$ and $j$ could form a Pareto-improving contract in period $t$. Then their equilibrium demands are equal and are bounded above and below by $y_1 p_D^M + (1-y_1)p_D^H$ and $y_2 p_D^H + (1-y_2)p_D^M$, respectively, where $y_1$ and $y_2$ come from Lemma 7.*

**Lemma 9.** *For a given $ij$ pair, let $y_{1,(n)}$, $y_{2,(n)}$ be the $y_1, y_2$ corresponding to Lemma 7 in game $n$ for a given $ij$ pair. (If $ij$ does not have a strictly Pareto-improving pair, choose some $y_1, y_2 \in (0,1)$ satisfying $y_1 + y_2 = 1$.) Under the conditions of Proposition 2, $y_{1,(n)} + y_{2,(n)} \to 1$ with a convergence rate that is uniform in $(i,j)$.*

## D.6 Proofs

*Proof of Proposition 1.* There are really three cases: Kalai proportional bargaining with two periods of exclusion, Kalai proportional bargaining with one period of exclusion, and Nash bargaining with one period of exclusion. Nash and Kalai proportional bargaining produce the same predictions with two periods of exclusion.

I begin with Kalai (or Nash) bargaining with two periods of exclusion. Two-period bargaining with two periods of exclusion is equivalent to static bargaining but prices are scaled by $1 + \beta(1+\pi)$ and insurer gains are scaled by $1 + \pi$. The proposed bargaining solution is a Kalai proportional solution when $p \geq 0$ so that both sides get weakly positive gains from trade. Any higher (lower) price would produce lower (higher) gains for the insurer and higher (lower) gains for the hospital and not be a Kalai proportional bargaining solution. Therefore this is the unique bargaining solution.

Kalai proportional bargaining solution with one period of exclusion has the same solution by the Kalai proportional path-invariance property. Suppose the insurer bargains with hospital $h$ in period $t_0$ relative to negotiating in period $t_0+1$. Write $V^{(d),H}(p_0,p_1,p_2)$ and $V^{(d),M}(p_0,p_1,p_2)$ as the value of disagreeing $d$ times with anticipated hospital $h$ prices $p_0,p_1,p_2$. Let $\hat{p}_0$ be the proposed price and $\hat{p}_1^{(1)}$ be the Kalai proportional response after one disagreement. By construction, the proposed price satisfies

$$\begin{aligned}
&(1-\tau)\left(V^{(0),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(2),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right)\\
=\quad&(\tau)\quad\left(V^{(0),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(2),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right).
\end{aligned}$$

By definition, the Kalai proportional bargaining price after 1 disagreement satisfies:

$$\begin{aligned}
&(1-\tau)\left(V^{(1),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(2),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right)\\
=\quad&(\tau)\quad\left(V^{(1),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(2),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right).
\end{aligned}$$

By subtraction:

$$\begin{aligned}
&(1-\tau)\left(V^{(0),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(1),M}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right)\\
=\quad&(\tau)\quad\left(V^{(0),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})-V^{(1),H}(\hat{p}_0,\hat{p}_1^{(1)},p^*_{Simult})\right),
\end{aligned}$$

so that $p^*_{Simult}=\hat{p}_0$ is a Kalai proportional bargaining solution. It is the unique simultaneous bargaining solution by the same arguments as the two-period exclusion case.

I finally show show that the Nash bargaining solution with one period of disagreement has a different equilibrium by contradiction in the $\pi=0$ case. Suppose not, and the simultaneous bargaining price was the same. Write $p^*_{Prop}$ as the price from the Kalai proportional solution from the proposition. I wish to show that $p^*_{Simult}\neq p^*_{Prop}$. When bargaining in alternating periods, by assumption the firms have an internalized externality on hospital $-h$ bargaining with a response to starting $h$ price of the linear form $p_{-h}(p_h)=p^*_{Alt}+\alpha_1(p_h-p^*_{Alt})$. In the alternating period bargaining process, a marginal increase to $p_h$ increases hospital $h$'s net present value profits proportionally to $3,000\sum_{u=0}^{\infty}(\beta\alpha_1)^{2u}/(1-\beta)=3,000/\left((1-\beta)(1-\beta^2\alpha_1^2)\right)$ and decreases the insurer's profits by $3,000(1+\beta\alpha_1)/\left((1-\beta)(1-\beta^2\alpha_1^2)\right)$. Therefore gains from trade are split at a ratio of $\frac{\tau(1+\beta\alpha_1)}{1-\tau}$. Notice also that the marginal $p_{-h}$ increase the insurer's gains from trade by $3,000$ conditional on the new negotiated $p_h$.

The alternating period bargaining solution converges to equilibrium. The gains from trade must satisfy:

$$
\begin{aligned}
&(1-\tau)\left((p_{-h}-p^*_{Alt}) - \frac{1+\beta\alpha_1}{(1-\beta)(1-\beta^2\alpha_1^2)}\left(p_h(p_{-h})-p^*_{Alt}\right)\right) \\
= \quad &(\tau) \quad (1+\beta\alpha_1)\frac{1}{(1-\beta)(1-\beta^2\alpha_1^2)}\left(p_h(p_{-h})-p^*_{Alt}\right).
\end{aligned}
$$

Write $\hat{p}_{-h} = p_{-h} - p^*_{Alt}$ and $\hat{p}_h = p_h(p_{-h}) - p^*_{Alt}$ for the previous hospital $-h$ and current hospital $h$ price differences from equilibrium. By combining terms, I obtain:

$$
(1-\tau)\hat{p}_{-h} = \frac{1}{(1-\beta)(1-\beta\alpha_1)}\hat{p}_h,
$$

so that $\alpha_1 = (1-\tau)(1-\beta)(1-\beta\alpha_1)$. It is clear that the assumptions imply $\alpha_1 > 0$. As a result, they also imply $\alpha_1 < 1$. Notice as a result that $p^*_{Alt} \neq p^*_{Simult}$; if $p^*_{Alt} = p^*_{Simult}$, then alternating period bargaining would split gains from trade proportionally to bargaining weights rather than the adjusted shares.

Therefore the good-faith Nash disagreement point will involve permanent prices strictly between $p^*_{Simult}$ and $p^*_{Alt}$. At least one of the two is not equal to $p^*_{Prop}$: if both were equal to $p^*_{Prop}$, then $p^*_{Alt}$ would split alternating period equilibrium gains proportionally to bargaining weights (Lemma 1) rather than the Nash solution split. If $p^*_{Simult} = p^*_{Prop}$ but $p^*_{Alt} \neq p^*_{Prop}$, then simultaneous bargaining disagreement will lead to permanent prices that are not equal to $p^*_{Prop}$. If $p^*_{Alt} < p^*_{Prop}$, then Lemma 1 implies that $p^*_{Simult}$ gives the insurer too much gains; if the opposite holds, it is the reverse. Regardless, $p^*_{Simult} \neq p^*_{Prop}$ if the bargainers simultaneously Nash bargain with good-faith disagreement. □

*Proof of Lemma 1.* Suppose hospital 1 bargains with the insurer after hospital 2 reached the price $p^*_{Alt}$ last period. In the current period, hospital 2's price is $(1+\pi)p^*_{Alt}$.

With an agreement, the insurer will gain \$20m + 1,000 $p^*_{Alt}$ this period and pay $3,000p^*_{Alt}(2+\pi)$ in every period. With a disagreement, the insurer will pay $4,000(1+\pi)p^*_{Alt}$ this period and $6,000p^*_{Simult}$ in all future periods, where $3,000p^*_{Simult} = \frac{1-\tau}{1+\beta(1+\pi)}(\$20m(1+\beta)) + 1,000(1-\tau)p^*_{Simult}$ by Proposition 1.

With an agreement, the hospital will receive a net present value payment of $3,000p^*_{Alt}/(1-\beta)$. With disagreement, the hospital will receive a net present value payment of $3,000p^*_{Simult}\beta/(1-\beta)$.

The remainder of the proof is algebra to verify the proposed form of $p^*_{Alt}$ splits gains from trade proportionally. I omit the details for brevity. □

*Proof of Lemma 2.* Intermediate value theorem applied to the continuous $GFT$ functions.

$\square$

*Proof of Lemma 3.* First, I show there is no concession in equilibrium. Suppose $ij$ concede in equilibrium. If both sides concede, then by Assumption 3, one delegate could do better by improving their demand and this is not an equilibrium. Suppose only one side concedes. Consider that side instead deviating at the demands stage to demand the contract reached. This does not change the demands by any other delegate. This deviation also does not change the expected profit for any other concession decision. Therefore since the strategies are Markov, all other concession decisions are unaffected. Therefore resulting firm profits are unaffected, but the delegate avoids the concession cost and the demand is strictly dominated. Therefore there is no concession in equilibrium.

Now I show by contradiction that there is never a subgame agreement reached by a hospital delegate demanding a strictly lower price than the insurer delegate and then negotiating. By the argument so far, there is no concession in equilibrium. By Assumption 4, both parties could strictly improve their profits by demanding the contract the other side demands. Contradiction. Therefore demands are equal in equilibrium of any pair that successfully reaches a contract.

$\square$

*Proof of Lemma 4.* I proceed with the two cases for $sign(\log(s_2))$.

$s_b > s_a > 1$. I first show that for any $s_2 \geq s_a$, there is a $s_1 > 1$ such that the desired gains from trade apply with $\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = s_2$. Choose some $s_1 \in (1, \frac{1+3s_a}{4})$ and let $s_2 \in (\frac{4s_1-1}{3}, \infty)$. Note that $\frac{4s_1-1}{3} < s_a$, so that $s_a$ and $s_b$ could both be values of $s_2$.

Consider the following original subgame. It is the first of two periods that constitute the second half of the single-market game's single year. Market 1 is normalized to be of size one. Insurer 1 is a monopolist, and may contract with hospital 1 and hospital 2. Insurer 1 has already set premiums of $\phi = 1$, insurer 1 has a one-period contract remaining with hospital 2 paying a price of zero, neither hospital has any marginal costs, all negotiation costs are equal to zero, and benchmark prices are constant. In period 1, insurer 1 has the opportunity to negotiate a two-period contract with hospital 1. In period 2, insurer 1 has the opportunity to negotiate a one-period contract with hospital 2 under Kalai proportional bargaining with $\tau = 1/2$ and, if period-one negotiations failed, can form a one-period contract with hospital 1 if needed.

Demand functions are as follows. For $i = 1, 2$, there is a fraction $\rho_i$ of consumers purchase the insurer's insurance if hospital $i$ is in the network, get sick, and receive care at hospital $i$ if they have insurance. Another fraction $\rho_0$ of consumers purchase insurer 1's insurance if the network contains any hospital, get sick, and then choose hospital $i$ with probability $\frac{\rho_i}{\sum_{h \in \mathcal{G}_1} \rho_h}$.

The remaining mass of consumers, of size $\rho_{-1}$, does not purchase insurance.

Parameters are as follows. Let $\beta$ be chosen to solve:

$$\beta^{1/2} + \beta + \beta^{3/2} = \frac{s_1 - 1}{s_2 - s_1}.$$

This is well-defined: $s_1 \in \left(1, \frac{3s_a - 1}{4}\right)$ and $s_2 \in (\frac{4s_1-1}{3}, \infty)$, so that the right-hand side is strictly between 0 and $\frac{s_1-1}{\frac{s_1-1}{3}} = 3$, so that there is some $\beta \in (0,1)$ that satisfies these conditions by intermediate value theorem. Choose some $\rho_0, \rho_1, \rho_2 > 0$ such that $\rho_0 + \rho_1 + \rho_2 < 1$ and:

$$\frac{\rho_0 \rho_2}{2\rho_1(\rho_0 + \rho_1 + \rho_2)} = (s_1 - 1)\frac{1+\beta}{\beta}.$$

This has many feasible solutions: for example, start with $\rho_0 = \rho_1 = \rho_2 = 1/4$, and then scale either $\rho_1$ or $\rho_2$ downward to achieve the desired ratio.

I conjecture (and verify) that networks are complete in both period subgames, for now ignoring the discounting rate. Consider the negotiation between insurer 1 and hospital 2 in period 2 at an anticipated hospital 1 price of $p_{11}$. By reaching an agreement, insurer 1 gains an additional $\rho_2$ of premium revenue, reduces its payment to hospital 1 by $p_{11}\frac{\rho_0\rho_2}{\rho_1+\rho_2}$, incurs a negotiation cost of 0, and pays its negotiated payment $p^*_{12}(p_{11})\rho_2\frac{(1-\rho_{-0})}{\rho_1+\rho_2}$ to hospital 2, while the hospital receives the negotiated payment and pays its negotiation cost of 0. The equilibrium payment is $p^*_{12}(p_{11})(1-\rho_{-1})\frac{\rho_2}{\rho_1+\rho_2} = \frac{1}{2}\left(\rho_2 + p_{11}\rho_0\frac{\rho_2}{\rho_1+\rho_2}\right)$, which generates positive surplus so long as $p_{11} \geq 0$, as it is in equilibrium under any agreement reached in any sub-subgame considered here. Symmetrically, the equilibrium payment when negotiating with hospital 1 in period 2 is $p^{*,D}_{11}(p_{12})(1-\rho_{-1})\frac{\rho_1}{\rho_1+\rho_2} = \frac{1}{2}\left(\rho_1 + p_{12}\rho_0\frac{\rho_1}{\rho_1+\rho_2}\right)$. Write the solution to the disagreement point bargain as $p^*_{12}(p^{*,D}_{11}(p_{12}))$ as $p^{*,D}_{12}$ and write $p^{*,D}_{11} = p^{*,D}_{11}(p^{*,D}_{12})$.

Now consider the shape of gains from trade available in period 1. Let $p^{(1),M}_{11}$ be the price that makes hospital 1 indifferent from disagreeing. Every marginal increase in $p_{11}$ above $p^{(1),M}_{11}$ increase hospital 1's net present value profit by $\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}(1+\beta)$. The price $p^{(1),H}_{11}$ that makes insurer 1 indifferent from disagreeing for the original first period is slightly more subtle: by agreeing, the insurer gains an additional $\rho_2$ of premium revenue, pays an additional $\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}p^{(1),H}_{11}(1+\beta) - \beta\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}p^{*,D}_{11}$ to hospital 1, and changes the hospital 2 net present value payments by $\beta\frac{\rho_2(\rho_0+\rho_1+\rho_2)}{2(\rho_1+\rho_2)(\rho_0+\rho_1+\rho_2)}(p^{(1),H}_{11} - p^{*,D}_{11}) = \beta\frac{\rho_2}{2(\rho_1+\rho_2)}(p^{(1),H}_{11} - p^{*,D}_{11})$. Let $p^{(1),H}_{11}$ be the price that maximizes hospital 1's profit, subject to making insurer 1 weakly prefer agreement. Every marginal decrease in $p_{11}$ below $p^{(1),H}_{11}$ increases insurer 1's net present value profit by $(1+\beta)\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + \beta\frac{\rho_0\rho_2}{2(\rho_1+\rho_2)}$. By linearity,

$$G^{(1),H,Sup} = \left(p^{(1),H}_{11} - p^{(1),M}_{11}\right)\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}(1+\beta)$$

$$G^{(1),M,Sup} = \left(p_{11}^{(1),H} - p_{11}^{(1),M}\right)\left((1+\beta)\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + \beta\frac{\rho_0\rho_2}{2(\rho_1+\rho_2)}\right),$$

so that:

$$\frac{G^{(1),M,Sup}}{G^{(1),H,Sup}} = \frac{(1+\beta)2\rho_1(\rho_0+\rho_1+\rho_2)+\beta\rho_0\rho_2}{(1+\beta)2\rho_1(\rho_0+\rho_1+\rho_2)} = 1 + \frac{\beta}{1+\beta}\frac{\rho_0\rho_2}{2\rho_1(\rho_0+\rho_1+\rho_2)} = s_1.$$

Now consider the bargaining problem between hospital 1 and insurer 1 in period 2 of the split-in-half game. If they disagree, they go to period 3, which is the same as the original period 2 except now there is a remaining half-period. The non-11 bargains follow fixed Kalai proportional bargaining, so the new period 4 does not change their bargaining outcome. The 11 bargain is transferable utility in both period 3 and period 4 of impasse, so that by homogeneity of $f$ the 11 bargaining solution is unaffected by treating period 4 as having no agreement.

Now consider the marginal value of prices in period 2 of the split-in-half game, wherein time is now discounted by $\tilde{\beta} = \sqrt{\beta}$ and per-period demand is scaled downward by $1 + \sqrt{\beta} = 1 + \tilde{\beta}$. For every marginal increase in $p_{11}$, hospital 1 gains net present value profit of $\frac{1+\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}}\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$. For every marginal decrease in $p_{11}$, insurer 1 gains net present value profit of $\frac{1+\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}}\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + \tilde{\beta}\frac{\rho_0\rho_2}{2(\rho_1+\rho_2)}$. Therefore the ratio of maximal gains is:

$$\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = 1 + \frac{\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}+\tilde{\beta}^2}\frac{\rho_0\rho_2}{2\rho_1(\rho_0+\rho_1+\rho_2)}.$$

Notice also that:

$$\begin{aligned}
\frac{\frac{G^{(1),M,Sup}}{G^{(1),H,Sup}} - 1}{\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} - \frac{G^{(1),M,Sup}}{G^{(1),H,Sup}}} &= \frac{\beta/(1+\beta)}{\frac{\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}+\tilde{\beta}^2} - \beta/(1+\beta)} \\
&= \frac{\tilde{\beta}^2(1+\tilde{\beta}+\tilde{\beta}^2)}{(1+\tilde{\beta}^2)(\tilde{\beta}+\tilde{\beta}^2) - \tilde{\beta}^2(1+\tilde{\beta}+\tilde{\beta}^2)} \\
&= \frac{\tilde{\beta}^2(1+\tilde{\beta}+\tilde{\beta}^2)}{\tilde{\beta}} \\
&= \beta^{1/2} + \beta + \beta^{3/2} = \frac{s_1 - 1}{s_2 - s_1}.
\end{aligned}$$

Therefore $\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = s_2$, as desired.

$s_b < s_a < 1$. Consider similar games, but now there are two insurers instead of two hospitals, and hospital 1 negotiates with insurer 2 in the original period two.

Choose some $s_1 \in \left(\frac{4}{3s_a^{-1}+1}, 1\right)$, which is non-empty because $s_a < 1$. Consider an arbitrarily

$s_2 \in \left(0, \frac{3}{4s_1^{-1}-1}\right)$. Note that both $s_a$ and $s_b$ are feasible values of $s_2$. Choose $\beta$ to solve:

$$\beta^{1/2} + \beta + \beta^{3/2} = \frac{s_1^{-1} - 1}{s_2^{-1} - s_1^{-1}},$$

which is feasible because I have essentially exchanged the roles of $s$ and $s^{-1}$ in the construction so far. Also choose $\rho_0, \rho_1, \rho_2 > 0$ such that $\rho_0 + \rho_1 + \rho_2 < 1$ and:

$$\frac{\rho_0 \rho_2}{2\rho_1(\rho_0 + \rho_1 + \rho_2)} = (s_1^{-1} - 1)\frac{1+\beta}{\beta},$$

which is feasible by the same argument as in the other case.

Each insurer requires an agreement with the hospital to sell any insurance. As the only insurer with a contract, the insurer would sell $\rho_0 + \rho_j$ units of insurance at the fixed premium of 1. If both insurers have a contract with hospital 1, then each insurer sells $\rho_j(1 + \frac{\rho_0}{\rho_1+\rho_2}) = \frac{\rho_j(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$.

Consider the negotiation between hospital 1 and insurer 2 in period 2, under the expected 11 price of $p_{11}$. By agreeing, hospital 1 gains a payment $p_{12}\frac{\rho_2(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$ from insurer 2 and loses a payment $p_{11}\frac{\rho_0\rho_2}{\rho_1+\rho_2}$ from insurer 1. By agreeing, insurer 2 gains premium revenue of $\frac{\rho_2(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$ and pays the negotiated payment. Under Kalai proportional bargaining with equal bargaining weights, the negotiated payment is $p_{12}^*\frac{\rho_2(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} = \frac{1}{2}\left(\frac{\rho_2(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + p_{11}\frac{\rho_0\rho_2}{\rho_1+\rho_2}\right)$.

Next, consider the 11 bargain in the original period 1. For every marginal increase in $p_{11}$, hospital 1 gains $(1+\beta)\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + \beta\frac{\rho_0\rho_2}{2(\rho_1+\rho_2)}$ and insurer 1 loses $(1+\beta)\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$. As a result:

$$\frac{G^{(1),H,Sup}}{G^{(1),M,Sup}} = 1 + \frac{\beta}{1+\beta}\frac{\rho_0\rho_2}{2\rho_1(\rho_0+\rho_1+\rho_2)} = 1 + (s_1^{-1} - 1) = s_1^{-1}$$
$$\frac{G^{(1),M,Sup}}{G^{(1),H,Sup}} = s_1.$$

Next, consider the split-in-half bargain in the new period 2. For every marginal increase in $p_{11}$, hospital 1 gains $\frac{1+\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}}\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2} + \tilde{\beta}\frac{\rho_0\rho_2}{2(\rho_1+\rho_2)}$ and insurer 1 loses $\frac{1+\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}}\frac{\rho_1(\rho_0+\rho_1+\rho_2)}{\rho_1+\rho_2}$. As a result, the Pareto frontier is linear (within Pareto-improving 11 contracts) and:

$$\frac{G^{(2),H,Sup}}{G^{(2),M,Sup}} = 1 + \frac{\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}+\tilde{\beta}^2}\frac{\rho_0\rho_2}{2\rho_1(\rho_0+\rho_1+\rho_2)}.$$

Note that:

$$\begin{aligned}
\frac{\frac{G^{(1),H,Sup}}{G^{(1),M,Sup}}-1}{\frac{G^{(2),H,Sup}}{G^{(2),M,Sup}}-\frac{G^{(1),H,Sup}}{G^{(1),M,Sup}}} &= \frac{\frac{\tilde{\beta}^2}{1+\tilde{\beta}^2}}{\frac{\tilde{\beta}+\tilde{\beta}^2}{1+\tilde{\beta}+\tilde{\beta}^2}-\frac{\tilde{\beta}^2}{1+\tilde{\beta}^2}} \\
&= \frac{\tilde{\beta}^2+\tilde{\beta}^3+\tilde{\beta}^4}{\tilde{\beta}+\tilde{\beta}^2+\tilde{\beta}^3+\tilde{\beta}^4-(\tilde{\beta}^2+\tilde{\beta}^3+\tilde{\beta}^4)} \\
&= \tilde{\beta}+\tilde{\beta}^2+\tilde{\beta}^3 \\
&= \frac{s_1^{-1}-1}{s_2^{-1}-s_1^{-1}}.
\end{aligned}$$

Therefore $\frac{G^{(2),M,Sup}}{G^{(2),H,Sup}} = s_2$, completing the proof. □

*Proof of Lemma 5.* Because $f$ is Pareto-optimal and I am only interested in the output of $f$, I without loss of generality assume that $S_1$ and $S_2$ include the convex combination of their Pareto frontiers and $(0,0)$.

Note that the $S_2$ Pareto frontier runs from $(0, G^{1,M}\frac{G^{2,M}}{G^{1,M}})$ to $(G^{1,H}\frac{G^{2,M}}{G^{1,M}}, 0)$. Therefore $S_2 = \frac{G^{2,M}}{G^{1,M}} S_1$.

By homogeneity, $f((0,0), S_2) = f(\frac{G^{2,M}}{G^{1,M}}(0,0), \frac{G^{2,M}}{G^{1,M}} S_1) = \frac{G^{2,M}}{G^{1,M}} f((0,0), S_1)$. Therefore the ratio of gains from trade are equal. □

*Proof of Lemma 6.* The claim holds because the slope is unchanged, which I verify via algebra. The Pareto frontier is $G^M(G^H) = G^{1,M}\frac{G^{1,H}-G^H}{G^{1,H}}$, or written in the opposite direction, $G^H(G^M) = G^{1,H}\frac{G^{1,M}-G^M}{G^{1,M}}$.

The values are:

$$\begin{aligned}
G^{2,M} &= G^M(d^H) - d^M = \frac{G^{1,M}G^{1,H} - G^{1,M}d^H - G^{1,H}d^M}{G^{1,H}} \\
G^{2,H} &= G^H(d^M) - d^H = \frac{G^{1,H}G^{1,M} - G^{1,H}d^M - G^{1,M}d^H}{G^{1,M}} \\
\frac{G^{2,M}}{G^{2,H}} &= \frac{G^{1,M}}{G^{1,H}},
\end{aligned}$$

completing the proof. □

*Proof of Corollary 1.* **Kalai implies simplification**. I proceed with a formal argument, but this property is essentially immediate by Kalai (1977)'s step-by-step property. To show that the new negotiated contract is as described, I show (i) the expected net present value profits of a particular contract with positive length $c_{t_0}$ (benchmark $B$, length $\ell$, and starting price $p$) are unchanged in the new game's associated contract $\tilde{c}_{t_0}$ (with benchmark $\tilde{B} = B$, length $\tilde{\ell} = 2\ell$, and starting price $\tilde{p} = p$); (ii) the value of disagreeing twice in the new game is the same as the value of disagreeing once in the old game; and (iii) the added chance to disagree once does not affect the negotiated contract.

For the value of agreement (i), let $\mathbb{C}_t$ and $\phi_t$ be the original (potentially random) agreements and premiums that emerge in the original game in response to $c_{t_0}$. I abuse notation and let $\tilde{\mathbb{C}}_{\tilde{t}}$ and $\tilde{\phi}_{\tilde{t}}$ be the associated responses in the new game in response to $\tilde{c}_{t_0}$, and $\mathbb{C}_t$ and $\phi_t$ be the responses in the original game. By Assumption 7, for every $v \geq 0$, $\tilde{\mathbb{C}}_{t_0+2v}$ is the same as $\mathbb{C}_{t_0+v}$ contract lengths are doubled; $\tilde{\mathbb{C}}_{t_0+2v+1}$ is the same as $\tilde{\mathbb{C}}_{t_0+2v}$ except lengths are reduced by one; and $\tilde{\phi}_{\tilde{t}_0+2v}$ and $\tilde{\phi}_{\tilde{t}_0+2v+1}$ are equal to $\phi_{t_0+v}$. The associated realized profit for the hospital is:

$$\sum_{\tilde{t}=\tilde{t}_0}^{\infty} \tilde{\beta}^{\tilde{t}-\tilde{t}_0} \sum_{n \in \tilde{\mathcal{G}}_{i\tilde{t}}^H} \tilde{D}_{in\tilde{t}}^H(\tilde{\mathcal{G}}_{\tilde{t}}, \tilde{\phi}_{\tilde{t}}) - \tilde{r}_i^H \tilde{R}_{in\tilde{t}}$$

$$= \sum_{t=t_0}^{\infty} (\tilde{\beta}^{2(t-t_0)} \left\{ (1+\tilde{\beta}) \left( \sum_{n \in \mathcal{G}_{it}^H} D_{int}^H(\mathcal{G}_t, \phi_t)/(1+\tilde{\beta}) \right) - r_i^H R_{int} \right\},$$

which is the original realized profit in the original game. By Assumption 7, expectations are unchanged so that expected profits are unchanged. Insurer expected profits at the equilibrium agreement are similarly unchanged. Therefore, the Pareto frontier of agreements that split gains from trade proportionally to bargaining weights is unchanged.

Next we consider the value of disagreeing two times (ii). Let the (potentially random) expected value $d$ periods in the future of disagreeing $d$ times be $V_{ijt_0}^{H,(d)}$ and $V_{ijt_0}^{M,(d)}$ to hospital $i$ and insurer $j$, respectively, in the old game, and $\tilde{V}_{ij\tilde{t}_0}^{H,(d)}$ and $\tilde{V}_{ij\tilde{t}_0}^{M,(d)}$, respectively, in the new game. Consider the distribution of negotiation subgames of the new game after two disagreements and the subgames of the old game after one disagreement. By Assumption 7, there is a mapping such that the distribution of information, benchmark prices, and equilibrium agreements is the same in the two games, except that contract lengths are doubled. As a result, there is a mapping over random variables such that $\tilde{t}_0$, $V_{ijt_0}^{H,(1)} = \tilde{V}_{ij\tilde{t}_0}^{H,(2)}$ and $V_{ijt_0}^{M,(1)} = \tilde{V}_{ij\tilde{t}_0}^{M,(2)}$.

Now I show that the chosen contract is unchanged (iii). By assumption, the chosen contracts are unique. The chosen contracts $c^* = (B^*, \ell^*, p^*)$ and $\tilde{c}^*(\tilde{B}^*, \tilde{\ell}^*, \tilde{p}^*)$ satisfy:

$$c^* = \operatorname*{argmax}_{c} V_{ijt_0}^H(c) + V_{ijt_0}^M(c) \text{ s.t. } \tau_{ij}(V_{ijt_0}^H(c) - E_{t_0}[V_{ijt_0}^{H,(1)}]) = (1-\tau_{ij})(V_{ijt_0}^M(c) - E_{t_0}[V_{ijt_0}^{M,(1)}])$$

$$\tilde{c}^* = \operatorname*{argmax}_{\tilde{c}} V_{ijt_0}^H(\tilde{c}) + V_{ijt_0}^M(\tilde{c}) \text{ s.t. } \tau_{ij}(\tilde{V}_{ij\tilde{t}_0}^H(\tilde{c}) - E_{\tilde{t}_0}[\tilde{V}_{ij\tilde{t}_0}^{H,(1)}]) = (1-\tau_{ij})(\tilde{V}_{ij\tilde{t}_0}^M(\tilde{c}) - E_{\tilde{t}_0}[\tilde{V}_{ij\tilde{t}_0}^{M,(1)}]).$$

By construction of the bargaining solution after one disagreement,

$$\tau_{ij}\left(\tilde{V}^{H,(1)}_{ij\tilde{t}_0} - E_{\tilde{t}_0+1}[\tilde{V}^{H,(2)}_{ij\tilde{t}_0}]\right) = (1-\tau_{ij})\left(\tilde{V}^{M,(1)}_{ij\tilde{t}_0} - E_{\tilde{t}_0+1}[\tilde{V}^{M,(2)}_{ij\tilde{t}_0}]\right).$$

By rational expectations, I obtain:

$$\tilde{c}^* = \underset{\tilde{c}}{\operatorname{argmax}}\, V^H_{ijt_0}(\tilde{c}) + V^M_{ijt_0}(\tilde{c}) \text{ s.t. } \tau_{ij}(\tilde{V}^H_{ij\tilde{t}_0}(\tilde{c}) - E_{\tilde{t}_0}[\tilde{V}^{H,(2)}_{ij\tilde{t}_0}]) = (1-\tau_{ij})(\tilde{V}^M_{ij\tilde{t}_0}(\tilde{c}) - E_{\tilde{t}_0}[\tilde{V}^{M,(2)}_{ij\tilde{t}_0}])$$
$$\Leftrightarrow \tilde{c}^* = \underset{\tilde{c}}{\operatorname{argmax}}\, V^H_{ijt_0}(\tilde{c}) + V^M_{ijt_0}(\tilde{c}) \text{ s.t. } \tau_{ij}(\tilde{V}^H_{ij\tilde{t}_0}(\tilde{c}) - E_{t_0}[\tilde{V}^{H,(1)}_{ijt_0}]) = (1-\tau_{ij})(\tilde{V}^M_{ij\tilde{t}_0}(\tilde{c}) - E_{t_0}[V^{M,(1)}_{ijt_0}]).$$

The space of agreement expected net present value profits is unchanged, so that the expected net present value of the chosen agreement is unchanged. Because the agreements are unique and the contract $\tilde{c} = (B^*, 2\ell^*, p^*)$ achieves the maximal expected net present value profits within the constraint set, the chosen contract is as described.

**Other direction**. Choose some $s_b < s_a < 1$ and let $f$ be a bargaining solution that satisfies the conditions of this corollary. Apply the construction of Lemma 4 to obtain a pair of two-period games with the ratio of $\frac{G^{(1),H,Sup}}{G^{(1),M,Sup}} = s_1$ and $\frac{G^{(2),H,Sup}}{G^{(2),M,Sup}}$ either equal to $s_a$ or $s_b$, where $G$ is a firm's maximal gains from trade.

I show that the share of gains from trade are equal for both $s_a$ and $s_b$. Let $\tau_{11}$ and $\tau^{(2)}_{11}$ be insurer 1's share of gains from trade in the split-in-half period 1 and period 2, respectively. Consider the problem of negotiating over period 1, relative to weighting one split-in-half period and negotiating and achieving some surplus. By Lemma 5 and Lemma 6, $\tau_{11}$ is also insurer 1's share of 11 gains from trade relative to waiting until the split-in-half period 2. By adding gains from trade, $\tau_{11} = \tau^{(2)}_{11}$. Therefore $\tau_{11}$ is the share of insurer 1's gains from trade for both $s_a$ and $s_b$.

Next, take $s_a \to 1^-$, so that $s_1 \to 1^-$. By the argument above, $\tau_{11}$ is unchanged on this path. By continuity, $\tau_{11}$ is also insurer 1's share of gains from trade under transferable utility. By an analogous argument, $\tau_{11}$ is also insurer 1's share of gains from trade for any $s_a > 1$. Therefore there is a $\tau_{ij} = \tau_{11} \in [0,1]$ such that $f$ and Kalai proportional with $\tau_{ij}$ bargaining weight have the same predictions for all linear Pareto frontiers. $\square$

*Proof of Lemma 7.* I am proceeding assuming there is at least one $y_1$ and $y_2$ such that $y_1 + y_2 > 1$ and:

$$V^H\left(y_2 p^H_D + (1-y_2)p^M_D\right) - V^H(p^H_D) = c^H\left((p^M_D - p^H_D)(y_1+y_2-1)\right)$$
$$V^M\left(y_1 p^M_D + (1-y_1)p^H_D\right) - V^M(p^M_D) = c^M\left((p^M_D - p^H_D)(y_1+y_2-1)\right).$$

Since $y_1 + y_2 > 1$ and $c$ is increasing for values above 0, the right-hand side of both equations is positive. Therefore the left-hand side is positive, i.e. $y_1, y_2 < 1$.

Now consider more generally the function $\hat{y}_1(y_2) : [0,1] \to [0,1]$ to solve $V^H\left(y_2 p_D^H + (1-y_2)p_D^M\right) - V^H(p_D^H) = c^H\left((p_D^M - p_D^H)(\hat{y}_1(y_2) + y_2 - 1)\right)$, i.e:

$$\hat{y}_1(y_2) = \frac{(c^H)^{-1}\left(V^H\left(y_2 p_D^H + (1-y_2)p_D^M\right) - V^H(p_D^H)\right)}{p_D^M - p_D^H} + 1 - y_2$$

As pointed out by Dutta in the differentiable case, $\hat{y}_1$ is a continuous function, $\hat{y}_1(1) = 0$, $\hat{y}_1(0) > 1$, and $\hat{y}_1(y_2)$ decreases strictly faster than $y_2$ since an increase in $y_2$ by a unit and a decrease in $y_1$ by one unit leaves $c^H((p_D^M - p_D^H)(y_1 + y_2 - 1))$ unchanged but reduces $V^H(y_2 p_D^H + (1-y_2)p_D^M)$. The function $\hat{y}_2(y_1)$ has the same properties.

By the intermediate value theorem, there there is a fixed point to the function $\hat{y}_1(\hat{y}_2(y_1))$. Since increasing $y_1$ by $\varepsilon$ increases $\hat{y}_1(\hat{y}_2(y_1))$ by strictly more than $\varepsilon$, that fixed point is unique. Since the fixed point $(y_1^*, y_2^*)$ is in $(0,1)$, it must generate positive left-hand sides so that $y_1^* + y_2^* > 1$. □

*Proof of Lemma 8.* This claim is almost exactly Dutta (2012)'s Proposition 3. Suppose the hospital delegate demands price at least $z_1 p_D^M + (1-z_1)p_D^H$ and the insurer delegate demands price at most $z_2 p_D^H + (1-z_2)p_D^M$. Since there is no concession in equilibrium (Lemma 3), it must be $z_1 = (1-z_2)$, so that $z_1 + z_2 = 1$. $z_1 = 1$ and $z_2 = 0$ corresponds to the hospital getting all of the surplus, whereas $z_2 = 1$ and $z_1 = 0$ corresponds to the insurer getting all of the surplus.

After appropriate notation changes, the claim is almost in the setup of Dutta (2012). There is a change to concession costs if both concede, but since that requires bilateral deviation it is irrelevant to the equilibrium and the same result holds. □

*Proof of Lemma 9.* I proceed for some $ij$ and a sequence of games $n$ satisfying $p_D^M > p_D^H$ and $y_1 + y_2 > 1$; the claim is immediate for the other $n$.

Recall that $V^H(p_D^M) - V^H(p_D^H), V^M(p_D^H) - V^M(p_D^M) \to_n 0$ by Assumption 5 and $V' \geq \varepsilon B > 0$ by Assumption 3, so that $p_D^M - p_D^H \to_n 0$.

Recall that $y_{1,(n)}$, $y_{2,(n)}$ are defined as the solution to:

$$\begin{aligned} V^H\left(y_{2,(n)} p_D^H + (1-y_{2,(n)})p_D^M\right) - V^H(p_D^H) &= c^H\left((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)\right) \\ V^M\left(y_{1,(n)} p_D^M + (1-y_{1,(n)})p_D^H\right) - V^M(p_D^M) &= c^M\left((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)\right). \end{aligned}$$

Costs go to zero quickly enough that the infinite right-derivative at zero dominates. The cost functions must tend to zero because $p_D^M - p_D^H \to_n 0$ and $y_{1,(n)} + y_{2,(n)} - 1$ is bounded. The cost functions are also lower-bounded by a function with an infinite right-derivative (Assumption 5). As a result, there is a sequence of $\epsilon_n \to_n 0$ such that $c\left((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)\right) > B(p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)/(2\epsilon_n)$ for all $n$ large enough and all $i, j$ with $y_{1,(n)} + y_{2,(n)} > 1$.

Note that by construction, $V^H\left(y_{2,(n)} p_D^H + (1 - y_{2,(n)}) p_D^M\right) - V^H(p_D^H) \leq B(1 - y_{2,(n)})(p_D^M - p_D^H)$ and $V^M\left(y_{2,(n)} p_D^H + (1 - y_{2,(n)}) p_D^M\right) - V^H(p_D^H) \leq B(1 - y_{1,(n)})(p_D^M - p_D^H)$. As a result:

$$B(p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)/\epsilon_n < B(2 - y_{1,(n)} - y_{2,(n)})(p_D^M - p_D^H)$$
$$y_{1,(n)} + y_{2,(n)} - 1 < 2\epsilon_n \to_n 0.$$

Since $1 \leq y_{1,(n)} + y_{2,(n)} \leq 1 + o_n(\epsilon_n)$ for $\epsilon_n$ independent of $i, j$, this completes the proof.

□

*Proof of Proposition 2.* I focus on an $ijt, (n), \mathbb{C}_{t-1}$ potential bargain (so $p_D^H \leq p_D^M$) and omit the subscripts and previous contract for clarity. If $p_D^H = p_D^M$, then every Pareto improving bargain under Assumption 3 splits the zero gain from trade of zero according to any weight. I therefore proceed assuming $p_D^H < p_D^M$.

If $y_{1,(n)} + y_{2,(n)} = 1$, the proof holds immediately, so I proceed for $n$ such that $y_{1,(n)} + y_{2,(n)} > 1$.

By Assumption 3, for any $a \in [0, 1]$:

$$V^H(a p_D^H + (1-a) p_D^M) - V^H(p_D^H) \in \left[(1-a) B\varepsilon(p_D^M - p_D^H), (1-a) B(p_D^M - p_D^H)\right]$$
$$V^M(a p_D^M + (1-a) p_D^H) - V^M(p_D^M) \in \left[(1-a) B\varepsilon(p_D^M - p_D^H), (1-a) B(p_D^M - p_D^H)\right].$$

The $y_{1,(n)}$ and $y_{2,(n)}$ from Lemma 7 must satisfy:

$$C^H((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)) \in \left[(1 - y_{2,(n)}) B\varepsilon(p_D^M - p_D^H), (1 - y_{2,(n)}) B(p_D^M - p_D^H)\right]$$
$$C^M((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1)) \in \left[(1 - y_{1,(n)}) B\varepsilon(p_D^M - p_D^H), (1 - y_{1,(n)}) B(p_D^M - p_D^H)\right].$$

Because of the strict derivatives of Assumption 3 and the gains from trade going to zero under Assumption 5 and $y_{1,(n)}, y_{2,(n)}$ are bounded above by one, it must be $(p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1) \to_n 0$.

Now define the ratio of gains from trade corresponding to an arbitrary $y_1, y_2 \in (0, 1)$ as:

$$R_{(n)}(y_1, y_2) = \frac{V^M(y_1 p_D^M + (1 - y_1) p_D^H) - V^M(p_D^M)}{V^H(y_2 p_D^H + (1 - y_2) p_D^M) - V^H(p_D^H)}.$$

I show that the ratio of gains at the demand bounding $y_{1,(n)}$, $y_{2,(n)}$ tend to the Kalai proportional limit. Note that $(p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1) \in (0, p_D^M - p_D^H]$. Recall that by Assumption 6, $x \in (0, p_D^M - p_D^H]$ implies $\frac{c^M(x)}{c^H(x)} - \frac{w^M}{w^H} = o_n(n)$. Recall by Lemma 7,

$R_{(n)}(y_{1,(n)}, y_{2,(n)}) = \frac{c^M((p_D^M - p_D^H)(y_{1,(n)}+y_{2,(n)}-1))}{c^H((p_D^M - p_D^H)(y_{1,(n)}+y_{2,(n)}-1))}$. As a result:

$$R_{(n)}(y_{1,(n)}, y_{2,(n)}) - \frac{w_j^M}{w_j^H} = \frac{c^M((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1))}{c^H((p_D^M - p_D^H)(y_{1,(n)} + y_{2,(n)} - 1))} - \frac{w_j^M}{w_j^H} = o_n(1).$$

As a corollary, $y_{2,(n)}$ cannot tend to one. The sum $y_{1,(n)} + y_{2,(n)} \to 1$ (Lemma 9) so that for $n$ large enough that $y_{1,(n)} + y_{2,(n)} \in [1, 1+\epsilon]$ for some $\epsilon > 0$:

$$R_{(n)}(y_{1,(n)}, y_{2,(n)}) \geq R_{(n)}(1 - y_{2,(n)} + \epsilon, y_{2,(n)}) \geq \frac{B\varepsilon(y_{2,(n)} - \epsilon)(p_D^M - p_D^H)}{B(1 - y_{2,(n)})(p_D^M - p_D^H)}.$$

As a result, $R_{(n)}(y_{1,(n)}, y_{2,(n)})$ can only tend to the finite $\frac{w_j^M}{w_i^H}$ if $y_{2,(n)}$ does not tend to one.

Let the equilibrium contract be $z_1^* p_D^M + z_2^* p_D^H$, where $z_2^* = 1 - z_1^*$. The relative split of the jointly reached contract at price $z_1^* p_D^M + z_2^* p_D^H$ is $R_{(n)}(z_1^*, z_2^*)$. Notice that $R_{(n)}(y_1, y_2)$ is strictly increasing in $y_2$ and strictly decreasing in $y_1$. Recall by Lemma 8 that

$$z_1^* p_D^M + z_2^* p_D^H \in \left[y_{2,(n)} p_D^H + (1 - y_{2,(n)}) p_D^M, y_{1,(n)} p_D^M + (1 - y_{1,(n)}) p_D^H\right]$$

. As a result, $z_1^* \in \left[1 - y_{2,(n)}, y_{1,(n)}\right]$ and $z_2^* \in \left[1 - y_{1,(n)}, y_{2,(n)}\right]$. Combining these inequalities:

$$R_{(n)}(z_1^*, z_2^*) \in \left[R_{(n)}\left(y_{1,(n)}, 1 - y_{1,(n)}\right), R_{(n)}\left(1 - y_{2,(n)}, y_{2,(n)}\right)\right].$$

Consider the upper bound and normalize by the $(y_{1,(n)}, y_{2,(n)})$ split:

$$\begin{aligned}
R_{(n)}(z_1^*, z_2^*) - R_{(n)}(y_{1,(n)}, y_{2,(n)}) &\leq R_{(n)}\left(1 - y_{2,(n)}, y_{2,(n)}\right) - R_{(n)}(y_{1,(n)}, y_{2,(n)}) \\
&= \frac{v^M((1 - y_{2,(n)}) p_D^M + y_{2,(n)} p_D^H) - v^M(y_{1,(n)} p_D^M + (1 - y_{1,(n)}) p_D^H)}{v^H(y_{2,(n)} p_D^H + (1 - y_{2,(n)}) p_D^M) - v^H(p_D^H)} \\
&\leq \frac{B(y_{1,(n)} + y_{2,(n)} - 1)}{B\varepsilon(1 - y_{2,(n)})} \to_n 0.
\end{aligned}$$

Therefore:

$$R_{(n)}(z_1^*, z_2^*) \leq R_{(n)}(y_{1,(n)}, y_{2,(n)}) + o_n(1) = \frac{w_j^M}{w_i^H} + o_n(1).$$

By a symmetric argument:

$$R_{(n)}(z_1^*, z_2^*)^{-1} \geq R_{(n)}(y_{1,(n)}, y_{2,(n)})^{-1} - o_n(1).$$

Since $R_{(n)}(y_{1,(n)}, y_{2,(n)})$ tends to a nonzero constant, the combination implies:

$$\frac{V^M(p^*)}{v^H(p^*)} = R_{(n)}(z_1^*, z_2^*) = \frac{w_j^M}{w_i^H} + o_n(1).$$

Since the $o_n(1)$ bound is independent of $(i, j, t, \mathbb{C}_{t-1})$, this completes the proof. $\square$

*Proof of Proposition 3.* Begin with some $ijt_0$ where $i$ and $j$ form a contract. If the next contract is formed in period $t_0+1$, the claim is immediate. Otherwise, say the next contract is formed in a period $t^*+1$. The period $t^*$ is the last period in which the $\tilde{V}$ functions enforce disagreement.

For the sake of conciseness, I say that $\hat{\sigma}(\mathbb{C}_{t-1}) = 0$ if $ij$ do not form a contract in period $t \in [t_0, t^*]$ on this disagreement path. Then by Proposition 2, it is generally the case for $ijt, (n)$ (with separate arguments depending on whether or not a contract emerges):

$$\begin{aligned} w_j^M \left(V_{ijt,(n)}^H(\hat{\sigma}(\mathbb{C}_{t-1})) - V_{ijt,(n)}^H(0 \mid \mathbb{C}_{t-1})\right) = w_i^H &\left(V_{ijt,(n)}^M(\hat{\sigma}(\mathbb{C}_{t-1})) - V_{ijt,(n)}^M(0 \mid \mathbb{C}_{t-1})\right) \\ &+ o\left(V_{ijt,(n)}^M(\hat{\sigma}(\mathbb{C}_{t-1})) - V_{ijt,(n)}^M(0 \mid \mathbb{C}_{t-1})\right). \end{aligned}$$

Let $\tilde{V}^H(t-t_0)$ be the value to hospital $i$ of disagreeing $t-t_0$ times and then behaving on the equilibrium path starting in period $t$, and let $\tilde{V}^M(t-t_0)$ be defined similarly. By construction:

$$\begin{aligned} &w_j^M \left(V_{ijt,(n)}^H(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}_{ijt,(n)}^H(0 \mid \mathbb{C}_{t-1})\right) + w_i^H \left(V_{ijt,(n)}^M(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}_{ijt,(n)}^M(0 \mid \mathbb{C}_{t-1})\right) \\ =&w_j^M \left(\tilde{V}^H(0) - \tilde{V}^H(t^*+1-t_0)\right) + w_i^H \left(\tilde{V}^M(0) - \tilde{V}^M(t^*+1-t_0)\right) \\ =&w_j^M \left(\sum_{t=t_0}^{t^*} \tilde{V}^H(t-t_0) - \tilde{V}^H(t+1-t_0)\right) + w_i^H \left(\sum_{t=t_0}^{t^*} \tilde{V}^M(t-t_0) - \tilde{V}^M(t+1-t_0)\right) \\ =&\sum_{t=t_0}^{t^*} \left(w_j^M \left(\tilde{V}^H(t-t_0) - \tilde{V}^H(t+1-t_0)\right) + w_i^H \left(\tilde{V}^M(t-t_0) - \tilde{V}^M(t+1-t_0)\right)\right). \end{aligned}$$

Recall that $\tilde{V}^M$ reflects a bargain after $t-t_0$ disagreements, so that there is a bound on the instantaneous disagreement split. Let the contract that is put in place with an agreement after $t-t_0$ disagreements be written as $\tilde{\mathbb{C}}_t$. Let the contract state if they disagree again be $\tilde{\mathbb{C}}_t/ij$. Then since the $w_i^H$ and $w_j^M$ are fixed and finite, the value difference from $t^*-t_0$ disagreements can be bounded as:

$$w_j^M \left(V_{ijt,(n)}^H(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}_{ijt,(n)}^H(0 \mid \mathbb{C}_{t-1})\right) + w_i^H \left(V_{ijt,(n)}^M(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}_{ijt,(n)}^M(0 \mid \mathbb{C}_{t-1})\right)$$

$$
\begin{aligned}
&\leq \sum_{t=t_0}^{t^*} o\left(\beta^{t-t_0}\left(V^M_{ijt,(n)}(\tilde{\mathbb{C}}_t) - V^M_{ijt,(n)}(\tilde{\mathbb{C}}_t/ij)\right)\right) \\
&= o\left(\sum_{t=t_0}^{t^*} \beta^{t-t_0}\left(V^M_{ijt,(n)}(\tilde{\mathbb{C}}_t) - V^M_{ijt,(n)}(\tilde{\mathbb{C}}_t/ij)\right)\right).
\end{aligned}
$$

By construction, the value of disagreeing once more is the value of the impasse point this period and the value of the optimal contract next period. That is to say:

$$
V^M_{ijt,(n)}(\tilde{C}_t/ij) = \pi^M_{jt,(n)}(\mathbb{C}_t/ij) + \beta V^M_{ijt+1,(n)}(\tilde{C}_{t+1}).
$$

As a result:

$$
\begin{aligned}
& w^M_j\left(V^H_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^H_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})\right) + w^H_i\left(V^M_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^M_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})\right) \\
&= o\left(V_{ijt_0,(n)}(\tilde{C}_t) - \sum_{t=t_0}^{t^*} \beta^{t-t_0}\pi^M_{jt,(n)}(\mathbb{C}_t/ij) - \beta V_{ijt^*+1,(n)}(\tilde{C}_{t+1})\right) \\
&= o\left(V^M_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^M_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})\right) = o_n(1).
\end{aligned}
$$

The final line holds because $V^M_{ijt,(n)}(\hat{\sigma}(\mathbb{C}_{t-1})) - \tilde{V}^M_{ijt,(n)}(0 \mid \mathbb{C}_{t-1})$ is bounded by assumption. $\square$

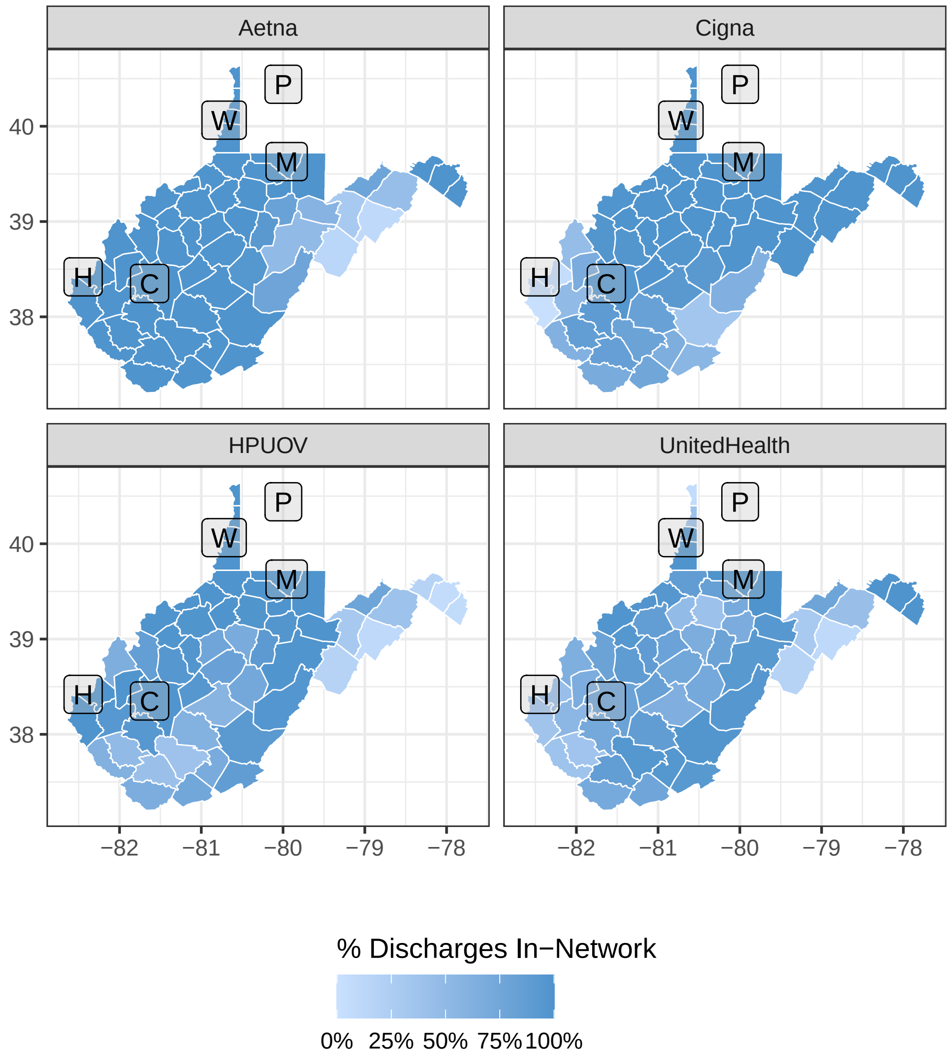


Figure 23: Percent of 2016 inpatient discharges by county of residence that are in the 2015 reported network of (clockwise from top-left) Aetna, Cigna, UnitedHealth, and the Health Plan of the Upper Ohio Valley. Highmark BCBS (omitted) is in-network in all West Virginia hospital reports. The large cities of Charleston, Huntington, Morgantown, Wheeling, and Pittsburgh, PA are indicated by letter labels.

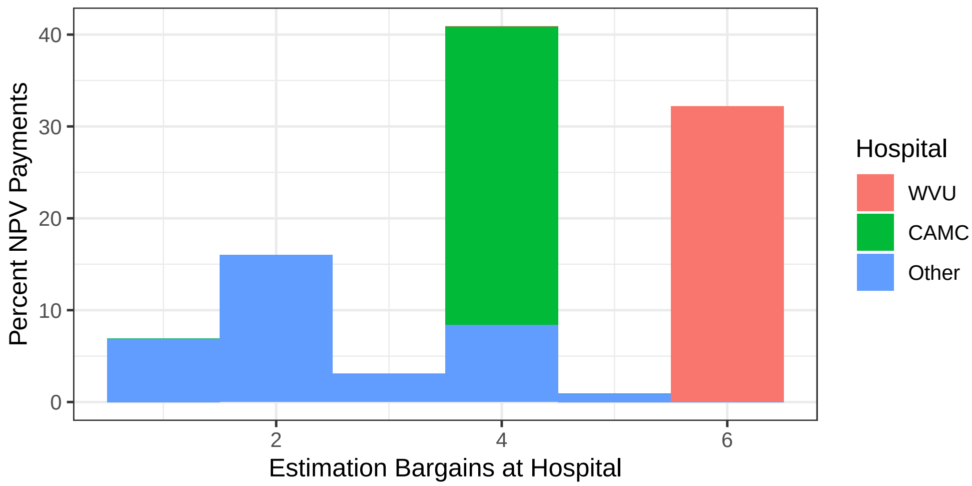


Figure 24: Fraction of modeled bargain net present value payments (and as a result, bargaining optimization importance) accounted for by number of bargains at the hospital. The largest contributors are WVU Health System (six bargains in red) and CAMC (four bargains in green), though many other hospitals had two or four bargains.

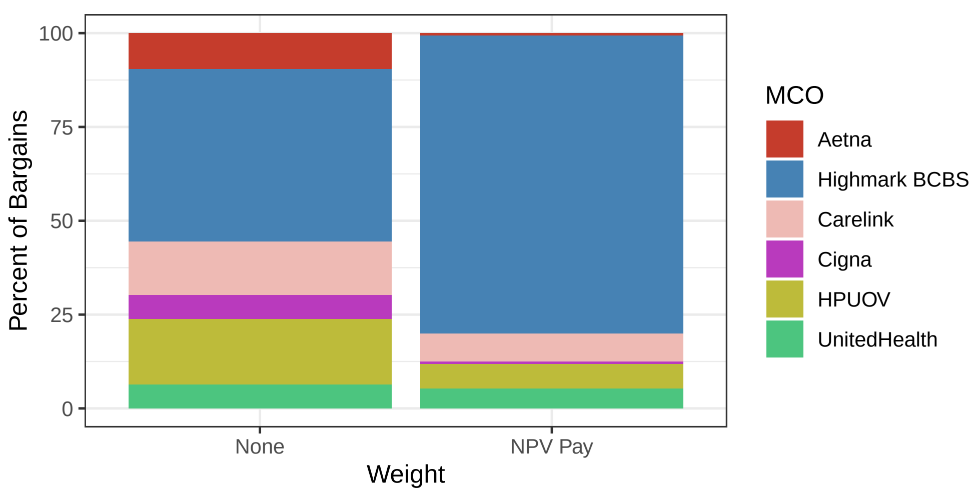


Figure 25: Fraction of modeled bargain net present value payments (and as a result, bargaining optimization importance) accounted for by insurer. Highmark BCBS accounted for roughly one-half of bargains (left) and more than three-quarters of net present value payments (right).

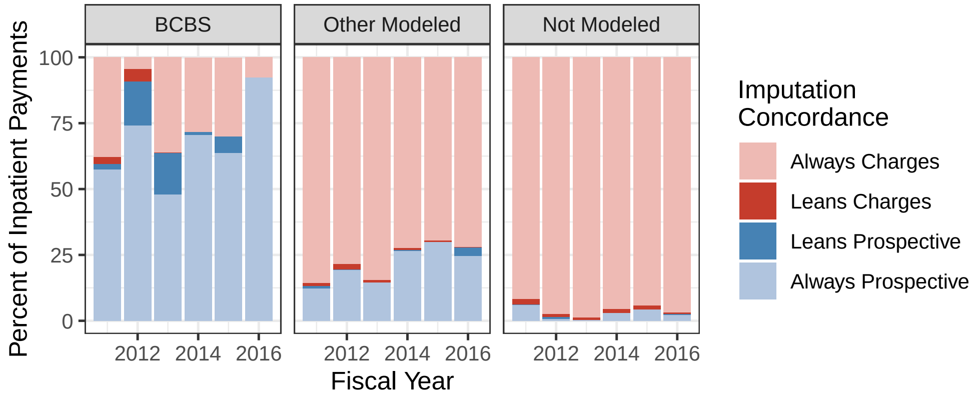


Figure 26: Estimated concordance of benchmark classification by insurer and fiscal year starting with larger contract scale reports in 2011. Blue and red contracts are classified by my algorithm as prospective and share of charges, respectively. Dark colors correspond to round-number discounts reaching the opposite conclusion. An estimated 94.2% of inpatient payments have the same imputation across methods, 1.1% are assigned as share of charges by only repeating non-round-number discounts, and 4.8% are assigned as prospective by only reporting varying round-number discounts (driven by Highmark BCBS-Cabell Huntington in 2011–13).

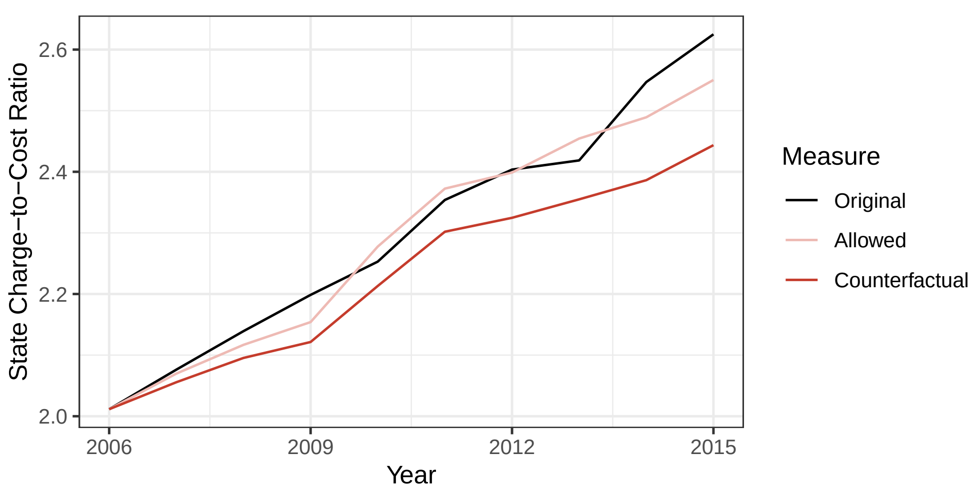


Figure 27: Counterfactual charge-to-cost ratios under original charges (red), maximum allowed list prices ("charges") under cumulative regulation (green), and counterfactual charges (blue). The regulation is lax and list prices are able to increase more quickly than costs, but the state-level list price markup only increases by 22% rather than 32%.