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Abstract

We analyze health care option demand markets with vertical restraints divided along two dimensions: naked and conditional exclusion, and vertical integration; applicable to the upstream, the downstream, and both markets. Our unified framework includes forward and backward integration, and joint ventures. We show that conditional exclusion has the same bargaining effects as vertical integration, but without the joint profit optimization. There are no individual incentives for exclusive dealing, but hospital-insurer pairs can find it jointly profitable to apply downstream vertical restraints on third parties. Outright downstream monopolization arises only when consumers have strong enough preferences for free provider choice.

JEL Classification Numbers: G22, G34, I11, L14, L42

Keywords: insurer-provider networks, vertical integration, exclusive contracts

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1 Introduction

Selective contracting and vertical integration between health care providers and health insurers are important features of market oriented health care systems. The United States, and recently also European countries such as the Netherlands, have allowed for these contractual relations between providers and insurers in the health care industry. Under selective contracting, insurers provide their enrollees access to a network of contracted providers. Patients typically receive full reimbursement for services from providers within the network, but face steep co-payments when visiting providers outside the network. Such restrictions on hospital access can be further facilitated by exclusive contracts or vertical mergers between providers and insurers. These vertical relations can be a tool for insurers to stimulate efficiency and quality improvements by providers, but they may also reduce welfare if these relations are adopted for anti-competitive reasons.

This paper analyzes individual and joint incentives for vertical relations between health insurers and providers and the corresponding welfare effects. The paper is structured as follows. We begin with a summary of the relevant literature followed by a paragraph on our contributions. In section 2, we describe our model setup, and illustrate some of the computations involved for a specific duopoly market structure. In section 3, we indicate how vertical restraints alter the bargaining positions of the various firms in the industry. In section 4, we show the main results from our Mathematica package that partly automates the systematic comparison of the effects of the various vertical restraints on the market structure. We finish with our conclusions. In two appendices, we give some background on the generalized Myerson-Shapley value that we employ as our bargaining solution, as well as an outlook to possible empirical applications of our analytical model.

Literature

Our paper is connected to several strands of literature. First, we follow the prevalent convention in the health economics literature of denoting the insurance market as downstream and the hospital market as upstream. The underlying intuition is that insurance policies are sold directly to consumers in retail markets. Each insurance policy is a bundle of access options to hospitals. Upon falling ill, each consumer is provided with a unit of hospital care from one of the contracted hospitals in the wholesale market.

The health economics literature has relatively few theoretical papers discussing exclusive dealing, selective contracting or vertical integration in a bilateral bargaining context. Some notable exceptions are listed below. Gaynor and Ma (1996) study exclusive dealing in a model of two homogeneous insurers and two differentiated hospitals. They assume a situation where insurers can grant an exclusively contract to a single hospital to treat all its enrollees. Gaynor and Ma find that neither insurers nor hospitals have individual incentives for this type of exclusive dealing. When such customer foreclosure of the non-contracted hospitals would have occurred, however, the reduced choice would have been detrimental to consumer surplus.

Gal-Or (1997) studies a bargaining model of two insurers and two hospitals that each are differentiated along Hotelling lines. On the downstream market,

insurers simultaneously choose the networks that they contract, as well as the premiums for the associated policies. For each pair of insurer strategies in the downstream market, the insurers' profits are determined through simultaneous bilateral Nash bargaining between the various hospital-insurer pairs. Even though hospitals and insurers are treated symmetrically in each bargaining subgame, only insurers are strategic players that can optimize between the various bargaining subgames. Hospitals, in contrast, take the insurers' choice of network and premium as given.

Gal-Or finds that selective contracting can arise in equilibrium. In particular, foreclosure of a hospital is profitable in a small range of parameters where hospital differentiation is much smaller than insurer differentiation. In this exclusionary outcome, consumers are better off because insurers obtain a more favorable price from offering exclusivity to the hospital and partly transfer these gains to consumers. In a subsequent paper, Gal-Or (1999) extends her model to arbitrary numbers of hospitals and insurers located on Salop circles, largely confirming the results of the bilateral duopoly case.

Capps et al. (2003) show that in their option demand framework with a perfectly competitive insurance market, where insurers compete on price and the value of their provider networks, there is no exclusive dealing by insurers as long as there are no large cost or quality differences between hospitals and as long as consumer willingness to pay for ex-post hospital choice is homogeneous. Halbersma and Mikkers (2007) apply this option demand framework to a monopoly insurer using selective contracting as a tool to price discriminate between consumers with a different willingness to pay for hospital access. They show that welfare is lower in the separating equilibrium with an exclusive network for consumers with a low willingness to pay for hospital access, than in the pooling equilibrium with equal access for both types of consumers.

Bijlsma et al. (2009) analyze a market of non-mandatory insurance. In their model, exclusive contracting of hospitals by insurers raises the costs of self-insurance by consumers.¹ This mechanism for "raising rival's costs" by insurers is, however, not detrimental to consumer welfare. These results are in line with the standard reply to Chicago-school arguments, which states that exclusive dealing can only occur in the presence of contracting externalities, in which case the effect on consumer welfare is a priori ambiguous.

Similar market behavior as generated by exclusive contracts, can also occur through vertical integration. Ma (1997) analyzes vertical integration in a model of two homogeneous insurers and two differentiated hospitals similar to the one of Gaynor and Ma (1996). He demonstrates that a vertical merger can result in the competing insurer being excluded from upstream inputs. Such input foreclosure can subsequently lead to downstream monopolization, in which case Ma (1997) shows that the effect on consumer welfare is ambiguous.

Apart from this paper by Ma (1997) the theoretical health economics literature, to the best of our knowledge, focuses on upstream exclusion, in which the insurer is prevented from contracting other hospitals, but in which hospitals can still serve all insurers. We are not aware of any theoretical papers discussing downstream exclusion or mutually exclusive arrangements such as the Kaiser-Permanente system.

¹Self-insurance here is defined as creating a private financial buffer against unexpectedly high health care costs. Whereas health care insurers pool contemporaneous inter-personal risks, self-insurance pools inter-temporal individual risks.

The second strand of literature our paper builds on is the property rights theory of the firm (Grossman and Hart, 1986; Hart and Moore, 1990) in which an asset's owner is given both residual claimancy over the asset's profits, as well as residual control over the asset's usage. The property rights literature encompasses both vertical integration and exclusive dealing.

Hart et al. (1990) distinguish between "scarce needs" and "scarce supplies" as motives for vertical integration. When upstream marginal costs are constant and symmetric, there are scarce needs, and there is an incentive for forward integration. In contrast, when upstream firms are capacity constrained and downstream firms are perfectly substitutable, there are scarce supplies, and there is an incentive for backward integration. These results are generalized by de Fontenay and Gans (2007) who show that vertical integration occurs from the more competitive segment into the less competitive segment.

Hart (1995) predicts an asymmetric allocation of residual control rights for vertical mergers, in which the decision rights are given to a single party without veto rights for its partner. In contrast, joint ownership would give veto rights to both partners. Since the residual rights should be given to the party with the highest incentives for investments (or for other actions that improve the net gain from the relationship), joint ownership is deemed suboptimal. As in Hart et al. (1990), either backward or forward integration is optimal, but no intermediate form.

Nevertheless, a few papers on joint ownership have recently appeared. The analysis of such mergers of equals is inspired by the high proportion of merged organizations that share the residual control rights equally.² Hauswald and Hege (2003) argue that majority ownership has not only benefits (such as incentives for investments) but it also has costs in the form of unilateral expropriation of benefits. He assumes that the majority owner is able to extract private benefits, thereby decreasing the net gain from the relation. In the case of 50-50 ownership, the partners can control each other, and private expropriation of gains does not arise. Comparing majority ownership and equal equity-sharing, the tradeoff is between the enhanced incentives for investment and the costs of unilateral value expropriation.

Cai (2003) focuses on an other aspect of joint ownership, namely potential contracts with third parties. He defines two type of investments: general investments that increase the value of cooperation with third parties, and specific investments that make the relationship between the observed pair more valuable. Cai finds that joint ownership is suboptimal if general and specific investments are complements, while it is the optimal ownership structure when the two type of investments are substitutes.

de Fontenay and Gans (2005) analyze incentives for vertical integration and foreclosure in a multilateral bargaining model. Their model derives a cooperative division of a non-cooperative surplus as a perfect Bayesian-Nash equilibrium with fully specified beliefs for all players in all contingencies. Furthermore, de Fontenay and Gans (2007) show that there exists a convenient generating function for their bargaining solution called the generalized Myerson-Shapley value (Myerson, 1977). The disentanglement of two effects of vertical restraints, the change in relative bargaining position and the internalization of competitive

²Both in the United States and in Europe, about two-thirds of the joint ventures chooses a 50-50 equity allocation (Hauswald and Hege, 2003).

externalities, allows for a careful separation of the anti-competitive effects and efficiency gains. Another convenient feature of the analysis of de Fontenay and Gans (2005) is the use of joint incentives for integration or foreclosure. For instance, if an upstream firm would be worse off individually by a vertical restraint, it is still possible for that firm to be compensated through side payments from its contractual partner if the joint gains from the restraint were large enough.

The third topic in the literature that our paper builds upon is naked exclusion, a vertical restraint closely related to foreclosure after vertical integration (Rasmusen et al., 1991). In a health care context, Douven et al. (2009) analyze joint incentives for naked exclusion. They find that a hospital-insurer pair can jointly profit from excluding the competing insurer. In line with the general conclusions of de Fontenay and Gans (2005), the exclusion occurs in the more competitive downstream insurance market.

In multilateral bargaining, naked exclusion is an unconditional form of exclusive dealing, since it specifies that one contract partner is exclusive to the other before all negotiations with third parties have been concluded. Segal and Whinston (2000) analyze a conditional form of exclusive dealing. Under so-called conditional exclusion, a firm that has signed an exclusive contract is allowed by his contract partner to negotiate with third parties if and only if such an outside contract would be jointly profitable for them.

Segal and Whinston (2000) note that conditionally exclusive contracts have the same effects on the bargaining outcomes as the shifting of property rights that accompany vertical integration. In effect, conditional exclusion is a step towards vertical integration, since the industry profits are distributed in the same way as in case of a vertical merger, but the competitive externalities that determine the size of the industry profit are the same as without vertical integration. In particular, Segal and Whinston (2000) note that a conditional exclusive contract does not change the incentives for a bilateral investment. This irrelevance result is confirmed by de Fontenay et al. (2009) in the context of the multilateral bargaining model of de Fontenay and Gans (2005).

Contributions

Our paper makes the following contributions to the literature. We extend the multilateral bargaining game of de Fontenay and Gans (2007) to an option demand market in a health care environment. In particular, we apply their model to vertical markets with downstream price competition and perfectly complementary inputs in the upstream market. This reflects the institutional settings of health care markets, namely the fact that insurers provide a bundle of hospital access options that are complementary for consumers before they know their precise illness.

The paper most closely related to ours is Douven et al. (2009). We modify their modeling approach by looking at a health insurance market with non-mandatory insurance using a linear demand model that is more easily extendible to multiple players and empirical estimation.³ Furthermore, we abstract from the precise consumer preferences on the hospital market (a random location assignment on a Hotelling line in Douven et al. (2009)) through the parsimonious

³We recover the mandatory insurance market of Douven et al. (2009) as a special limit.

use of a single upstream product differentiation parameter. Finally, we allow for a fully general two-part tariff rather than restricting the variable reimbursement to an exogenously regulated tariff.

Within our bargaining framework, we analyze various vertical restraints along two dimensions. First, we analyze the effects of three forms of vertical restraints of increasing tightness of integration: naked exclusion, conditional exclusion and vertical integration. Second, for all three forms of restraint, we analyze their impact depending on the market where they apply: upstream, downstream or mutual. In case of vertical integration this classification corresponds to forward integration (upstream exclusion), backward integration (downstream exclusion) and joint ownership (mutual exclusion). This allows for a systematic comparison of the effects of nine different vertical restraints in a unified model.

To keep this paper readable, we display only the essential computations for a specific example of the industry structure. On the website of this paper, we have made available a documented Mathematica package containing the full computations of all the graphs and vertical restraints mentioned in this paper, as well as code to generate and display the various graphs and figures.

2 The model

We focus on a particular example of vertically related health care industries with hospitals as upstream firms, and health insurers as downstream firms engaged in price competition. A health insurance policy can be regarded as a bundle of access rights to hospital care, conditionally on becoming ill. In effect, health insurance is an option demand for hospital care (Capps et al., 2003). Consumers can only visit the providers in their insurer’s network of contracted hospitals. However, insurers cannot steer patients to any particular provider within their hospital network. A hospital’s demand from an insurer is determined by the insurer’s demand and by consumer preferences, conditional on the network of accessible hospitals. The downstream production function can therefore be characterized as a many-to-one assembly of perfectly complementary inputs in fixed proportions.⁴

2.1 The insurance market

We consider differentiated price competition between n downstream health insurers. Furthermore, there exists a continuum of representative consumers of health insurance, with each consumer having probability $\theta \in (0, 1)$ of needing hospital treatment.⁵ We employ the parsimonious yet flexible linear demand system of Shubik and Levitan (1980)

$$q_i = \frac{1}{n} \left[\theta v(G_i) - (1 + \mu)p_i + \frac{\mu}{n} \sum_{i'=1}^n p_{i'} \right] \quad (1)$$

⁴In appendix B.3, we discuss the use of out-of-pocket payments (or ‘co-payments’) that would allow insurers to influence upstream demand. This would make hospitals more substitutable. To keep our model analytically tractable, we ignore this possibility throughout our paper.

⁵We stress that each individual consumer has a discrete demand function as he can only buy up to one unit of health insurance. The market demand, however, is continuous.

Here we have introduced the option value $v(G_i)$ of an insurance policy that provides access to a hospital network G_i . The premiums charged by insurers are denoted as p_i . Finally, we allow for downstream product differentiation parameterized through the degree of substitutability μ . For $\mu = 0$, we obtain a monopoly insurance market, whereas for $\mu \rightarrow \infty$ a perfectly competitive insurance market is obtained.

The above demand system can be derived from a consumer maximization program subject to a budget constraint with the following utility function

$$U(q_i) = \theta \sum_{i=1}^n v(G_i) q_i - \frac{n}{2(1+\mu)} \left[\sum_{i=1}^n q_i^2 + \frac{\mu}{2} \left(\sum_{i=1}^n q_i \right)^2 \right] \quad (2)$$

We refer to (Motta, 2004) for a more detailed discussion of the above demand system and corresponding utility function.

Our demand system (1) is not easily amenable to empirical estimation. In appendix B.1, however, we show that in the limit of symmetric networks and catastrophic health insurance (for which paying the health care costs fully out-of-pocket is not affordable) our demand system and an empirically more suitable random choice framework coincide to linear order in prices. It is an interesting avenue for future research whether empirical applications of our framework will have similar qualitative conclusions on the profitability of the various vertical restraints. Given the non-linear form of logit choice models, such analysis would require numerical rather than analytical solutions that we are able to obtain below.

In the subsequent analysis, we will focus on the case of $n = 2$ with a downstream duopoly of health insurers I_1 and I_2 . This reduces the downstream demand system (1) to

$$q_i = \frac{1}{2} \left[\theta v_i(G_i) - \left(1 + \frac{\mu}{2} \right) p_i + \frac{\mu}{2} p_{-i} \right] \quad (3)$$

Since we have a single consumer type and no co-payments, the hospital market shares are fully determined by consumer preferences conditional on the insurers' networks: $s_{ij} = s_j(G_i)$, and hospital demand is given by $q_{ij} = \theta q_i s_j(G_i)$. Following the discussion in appendix A.6, hospital j 's reimbursement from insurer i is given by a two-part tariff $T_{ij} = t_{ij} + w_{ij} q_{ij}$. An insurer's profit function is then given by

$$\begin{aligned} \Pi_i &= q_i \left(p_i - \theta \sum_{j \in G_i} w_{ij} s_j(G_i) \right) - \sum_{j \in G_i} t_{ij} \\ &= q_i (p_i - \theta w_i) - \sum_{j \in G_i} t_{ij} \end{aligned} \quad (4)$$

where we have defined an insurer's weighted average wholesale price as $w_i = \sum_{j \in G_i} w_{ij} s_j(G_i)$.

2.2 The hospital market

Throughout our paper, we consider upstream competition between two hospitals, H_A and H_B with marginal costs equal to $c_A = c_B = c$. The hospitals

are symmetric in all ex post observable aspects (such as quality of treatment). However, consumers value the ex ante freedom of choice of being able to go to both hospitals should they fall ill. This means that there are only three inequivalent insurance networks: with zero, one or two contracted hospitals. In our model, consumer demand for hospital care is completely determined through the demand for insurance (3) and the hospital market shares $q_{ij} = \theta q_i s_j(G_i)$. As we discuss in more detail in appendix B.2, this does not preclude incorporation of endogenously determined of hospital market shares in empirical applications (through the use of co-payments).

Consumer preferences for hospital choice can be captured with a single parameter τ in the following way. First, without loss of generalization, we normalize the option value v_\emptyset of the empty network to zero. Second, we denote the option of an exclusive network with a single hospital as v_E and the option value a non-exclusive network of two hospitals as v_{NE} . Comparing the difference of these option values to the added value of hospital care compared to marginal costs, we define the our parameter τ for hospital choice preferences through the expression

$$\tau = \frac{v_{NE} - v_E}{v_E - c} \quad (5)$$

For $\tau = 0$, insured consumers only care for hospital access but not for a choice between hospitals once they fall ill. For positive values of τ , consumers not only care for hospital care itself, but they also experience diminished utility when having to commit before falling ill to which hospital they will have access to.

With hospital j 's reimbursement from insurer i given by a two-part tariff $T_{ij} = t_{ij} + w_{ij}q_{ij}$, with $q_{ij} = \theta q_i s_j(G_i)$, a hospital's profit function is given by

$$\Pi_j = \theta \sum_{i \in G_j} q_i s_j(G_i)(w_{ij} - c) + \sum_{i \in G_j} t_{ij} \quad (6)$$

2.3 The bargaining game

Our model consists of the following multi-stage game

0. Determination of the assets' residual control rights and the allowed communications between the various upstream and downstream firms.
1. Multilateral bargaining along the lines of the model of de Fontenay and Gans (2007) resulting in contracted hospital networks G_i with corresponding lump sum transfers t_{ij} and wholesale prices w_{ij} .
2. Simultaneous price setting by the downstream insurers of their insurance premiums p_i .
3. Realization of consumer demand for insurance q_i and subsequently for hospital treatment $q_{ij} = \theta q_i s_j(G_i)$.

We will not analyze the zeroth stage with fully endogenous determination of the residual control rights and allowed communications. Instead, in the next section, we will discuss partial incentives for various vertical restraints that have an effect on both structures of our model. Similarly, the outcomes in the third stage are fully determined by the consumer preferences and the strategic choices by hospitals or insurers in the preceding stages. We solve the two-stage proper

subgame of multilateral bargaining followed by simultaneous downstream price setting through backward induction.

The equilibrium values for the wholesale prices w_{ij} and retail prices p_i determine the firms' profits modulo the lump sum transfers t_{ij} . Since these fixed fees sum to zero for every industry structure, we will not have to compute them explicitly. Instead, we can use the generalized Myerson-Shapley value (A.4) as a generating function for individual firms profits as linear combinations of industry profits for various industry structures.

Insurance competition

In the second stage of our game, insurers engage in simultaneous price setting by optimizing their profit functions (4) with respect to p_i . Downstream prices are strategic complements as

$$\frac{\partial^2 \Pi_i(p_i, p_{-i})}{\partial p_i \partial p_{-i}} = \frac{\mu^2}{4} > 0 \quad (7)$$

Solving the corresponding first order conditions yields

$$p_i^* - \theta w_i = \frac{\theta((8 + 4\mu)(v_i - w_i) + 2\mu(v_{-i} - w_{-i}) - \mu(4 + \mu)(w_i - w_{-i}))}{(4 + \mu)(4 + 3\mu)} \quad (8)$$

Substituting the optimal prices (8) into the insurers' profit functions (4) and the hospitals profit functions (6), yields a set of reduced profit functions that implicitly depend on the option values for the contracted hospital networks and the average wholesale prices. A straightforward computation shows that the insurers' reduced profit functions are strategic complements in the networks' option values and strategic substitutes in the insurers' average wholesale prices

$$\frac{\partial^2 \Pi_i(v_i, v_{-i}, w_i, w_{-i})}{\theta^2 \partial v_i \partial v_{-i}} = \frac{4\mu(2 + \mu)^2}{(4 + \mu)^2(4 + 3\mu)^2} > 0 \quad (9)$$

$$\frac{\partial^2 \Pi_i(v_i, v_{-i}, w_i, w_{-i})}{\theta^2 \partial w_i \partial w_{-i}} = -\frac{\mu(2 + \mu)^2(8 + \mu(8 + \mu))}{2(4 + \mu)^2(4 + 3\mu)^2} < 0 \quad (10)$$

These equations mean that an insurer's marginal profit from a network improvement is increasing in his competitor's network. However, in the limit $\mu \rightarrow \infty$, the marginal profitability of network improvements goes to zero. This means that competition on the insurers' network option values is softer than price competition. On the other hand, the marginal profitability of a discount in the negotiated wholesale prices is increasing in the competitor's wholesale prices. Furthermore, this marginal profitability is linear in μ in the limit $\mu \rightarrow \infty$. This means that insurers have incentives to raise their rivals' costs, albeit that this incentive is weaker than the incentive to lower prices (which is quadratically increasing in μ). The above results that insurance profits are more sensitive to their premiums than their contracted networks give some support to the general notion in the health economics literature that health insurance markets are more competitive than health care provision markets.⁶

⁶This is for instance the approach taken by Gaynor and Ma (1996), who consider homogeneous insurers and differentiated providers.

Hospital-insurer bargaining

In the first stage of our game, hospitals and insurers engage in a multilateral bargaining game which is described in more detail in appendix A. Let the G be the graph of allowed communications, and let insurer I_i and hospital H_j have outside options $\tilde{\Pi}_i(G \setminus (i, j))$ and $\tilde{\Pi}_j(G \setminus (i, j))$, respectively, in case they cannot reach an agreement. The bargaining equations characterizing the unique equilibrium can be derived from maximizing the Nash product $\Pi_{ij} = (\Pi_i - \tilde{\Pi}_i)(\Pi_j - \tilde{\Pi}_j)$, with respect to t_{ij} and w_{ij} . In appendix A.2, we show that the bargaining equations take the form of a recursive system of simultaneous equations.

Figure 1 depicts the six inequivalent graphs in our bilateral hospital-insurer duopoly. We illustrate the relevant computations when both insurers offer a non-exclusive network. This corresponds to the lower right graph in figure 1; we denote the graph of this connected duopoly as G_{CD} . This graph has four different hospital-insurer pairs. The bargaining equations (A.1) that optimize the bilateral profits for the various hospital-insurer pairs reduce to the following system of four coupled equations

$$0 = \frac{\partial(\Pi_1 + \Pi_A)}{\partial w_{1A}} = \frac{\partial(\Pi_1 + \Pi_B)}{\partial w_{1B}} = \frac{\partial(\Pi_2 + \Pi_A)}{\partial w_{2A}} = \frac{\partial(\Pi_2 + \Pi_B)}{\partial w_{2B}} \quad (11)$$

A straightforward but tedious computation yields the following wholesale prices

$$\frac{w_{ij}^* - c}{(v_E - c)} = \frac{\mu^2(1 + \tau)}{s_j(G_{CD})(16 + \mu(16 + 5\mu))} \quad (12)$$

Note that the model of mandatory insurance of Douven et al. (2009) does not allow for endogenous determination of the wholesale prices in case of a connected duopoly with symmetric hospitals. The reason is that the total market demand is not downward sloping in retail prices. Hospitals will get their share of the insured consumers no matter from which insurer they come. Only if wholesale prices influence the total market demand, as in our model, is the simultaneous optimization program for the wholesale prices well-defined. Otherwise, exogenously regulated wholesale prices need to be used. Substituting the above solution for the wholesale prices into (8) yields the following insurance premiums

$$\frac{p_i^* - \theta w_i^*}{\theta(v_E - c)} = \frac{(8 + 6\mu)(1 + \tau)}{16 + \mu(16 + 5\mu)} \quad (13)$$

2.4 Industry profits and consumer surplus

The total industry profits are given by the sum of all firms' profits, in which all the fixed fee and variable transfer payments cancel each other

$$\Pi(G) = \sum_i \Pi_i(G) + \sum_j \Pi_j(G) = \sum_i q_i(p_i - \theta c) \quad (14)$$

The consumer surplus for a differentiated product market is most conveniently expressed through the indirect utility function

$$CS(G) = U(q_i) - \sum_i q_i p_i \quad (15)$$

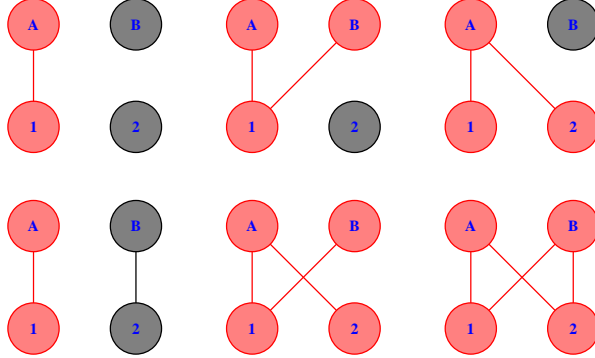


Figure 1: *The six inequivalent graphs for a bilateral hospital-insurer duopoly. On the top row from left to right: a bilateral monopoly (BM), a downstream monopoly (DM) and an upstream monopoly (UM); on the bottom row from left to right: a disconnected duopoly (DD), an asymmetric duopoly (AD) and a connected duopoly (CD).*

Substituting the equilibrium retail prices into the hospitals' and insurers' profits functions yields for the industry profits

$$\frac{\Pi(G_{CD})}{(\theta(v_E - c))^2} = \frac{(4 + 2\mu)(4 + 3\mu)(4 + \mu(3 + \mu))(1 + \tau)^2}{(16 + \mu(16 + 5\mu))^2} \quad (16)$$

Note that the industry profits divided by the total added value squared only depend on two parameters: the downstream insurer differentiation μ , and the consumer preferences τ for upstream freedom of hospital choice. Similarly, we find for the consumer surplus

$$\frac{CS(G_{CD})}{(\theta(v_E - c))^2} = \frac{(2 + \mu)^2(4 + 3\mu)^2(1 + \tau)^2}{2(16 + \mu(16 + 5\mu))^2} \quad (17)$$

2.5 Profit distribution

The outside options for each of the four bargaining agreements are given in terms of profits in an asymmetric duopoly. Recursively solving the bargaining equations (A.2) would necessitate the computations of the profits of all six graphs (including all permutations of symmetric players). Fortunately, as discussed in more detail in appendix A.3, the recursive structure of the bargaining equations also eliminates some intermediate subgraphs from the expressions for the equilibrium payoffs. The profits for the various firms are given by the generalized Myerson-Shapley value (A.4), which expresses the firms' profits in the connected duopoly as a linear combination of industry profits of only three graphs

$$\Pi_A(G_{CD}) = \Pi_B(G_{CD}) = \frac{1}{12} (3\Pi(G_{CD}) + 2\Pi(G_{DM}) - 2\Pi(G_{UM})) \quad (18)$$

$$\Pi_1(G_{CD}) = \Pi_2(G_{CD}) = \frac{1}{12} (3\Pi(G_{CD}) - 2\Pi(G_{DM}) + 2\Pi(G_{UM})) \quad (19)$$

where the the industry profits for the upstream and downstream monopoly can be determined from similar computations as shown above. The resulting expression are given by the following functions of our two parameters μ and τ

$$\frac{\Pi(G_{\text{DM}})}{(\theta(v_E - c))^2} = \frac{(1 + \tau)^2}{4}, \quad \frac{\Pi(G_{\text{UM}})}{(\theta(v_E - c))^2} = \frac{(4 + \mu)(4 + 3\mu)}{16(2 + \mu)^2} \quad (20)$$

Note the following intuitive observations for the firms' profits above. First, the sum of the upstream and downstream profits is equal to the industry profit. Second, when upstream firms are closer substitutes than downstream firms, the downstream monopoly's industry profits $\Pi(G_{\text{DM}})$ are smaller than the upstream monopoly's industry profits $\Pi(G_{\text{UM}})$. Hence, upstream competition benefits lowers upstream firms' profits through an increase in downstream firms' bargaining power.

3 Vertical restraints

In this section, we briefly outline three related vertical restraints: vertical integration, conditional exclusion and naked exclusion. We use our bargaining framework in combination with the various assets residual control rights as a unified framework to compare the various restraints. Our discussion closely follows the analysis of vertical integration in de Fontenay and Gans (2005), of conditional exclusion in de Fontenay et al. (2009), and of vertical integration and naked exclusion in Douven et al. (2009). We stress that, as in the papers cited above, we only look at partial and joint incentives for vertical restraints. We do not analyze a complete game with fully endogenous choices of vertical restraints, nor do we analyze bandwagon effects and counter-moves of third parties. In 2 we have listed a taxonomy of the various vertical restraints discussed in this paper.

3.1 Vertical integration

Vertical integration is a contract involving a change in asset ownership between an upstream and a downstream manager. As in the property rights literature, the acquiring firm becomes the residual claimant to the earnings of an asset and has residual control rights as to what it is used for (Hart and Moore, 1990). However, each manager continues to be essential for the productive use of the asset. Importantly, the acquiring firm rather than its target negotiates supply agreements with the remaining firms in the acquiring firm's market. This is because the residual control rights of the target's assets have been transferred to the acquiring firm. Thus, in the event of a breakdown in negotiations between the acquiring firm and the manager of the target firm, no supply will occur between the acquiring firm and any other firm in the target's market. Hence, integration rules out the participation of an asset's manager in a coalition that does not include the owner.

Since vertical integration involves an acquiring firm bargaining on behalf of its target, this requires modifying the residual profits of an acquiring firm to be the sum of the residual income from both its own and its acquired assets, and subsequently replacing a target firm's index by its acquiring firm's index in the bargaining equations (A.1), (A.2) and (A.3). This modification allows for

	Tightness of integration \rightarrow		
Affected market \downarrow	Naked Upstream Exclusion	Conditional Upstream Exclusion	Forward Integration
	Naked Mutual Exclusion	Conditional Mutual Exclusion	Joint Ownership
	Naked Downstream Exclusion	Conditional Downstream Exclusion	Backward Integration

Figure 2: A taxonomy of vertical restraints along two dimensions. The horizontal axis displays the tightness of integration, and the vertical axis the affected market.

the solution for individual firms profits in the presence of vertical integration. However, in appendix A.4 we show that a slight modification of the generalized Myerson-Shapley value (A.4) continues to be a generating function for the individual firms payoffs. In all three forms of vertical integration (backward, forward and jointly), two firms will only enter into a merger if they are jointly better off, in which case the firm with the largest incentive can compensate his partner to share the gains from vertical integration equally.

3.2 Conditional exclusion

Conditional exclusion is a contract between two firms on the conditional exclusion of third parties by one or both contracting parties (Segal and Whinston, 2000). When the upstream contract party conditionally agrees not to contract his downstream partner's competitors, we speak of downstream conditional exclusion. Similarly, when it is the downstream party who is conditionally restricted from contracts with his upstream partner's competitors, we speak of upstream conditional exclusion. Finally, when both firms conditionally agree not to contract third parties, we speak of mutual conditional exclusion. In all three cases, firms will only enter into exclusionary contracts if they are jointly better off, in which case the firm with the largest individual incentive can, in principle, compensate his partner to share the gains from exclusive contracting equally.

The exclusionary agreements in Segal and Whinston (2000) are conditional in the sense that a firm contractually bound to be exclusive to another firm, can

still contract with third parties under penalty of a limited fine. Such economically efficient breaches of contracts are equivalent to contracting third parties conditional on the joint profitability of such outside contracts. This amounts to shifting the residual control rights of the previously exclusively bound firm to his partner. However, an exclusive firm is still independently maximizing its own profits. In this sense, conditional exclusion is an intermediate form of vertical restraint between vertical integration and naked exclusion.

The mathematical structure of conditional exclusive contracts is very similar to those of vertical integration. We again represent the exclusionary agreements through a directed graph R , with an edge from each firm to the partner which it is exclusive to. The generalized Myerson-Shapley value (A.4) is again the generating function for firm profits, although in this case there is no joint profit maximization among exclusively contracted firms in the various industry structures.

3.3 Naked exclusion

Naked exclusion is a contract between two firms on the unconditional and outright exclusion of third parties by one or both contracting parties (Rasmusen et al., 1991). When the upstream contract party unconditionally agrees not to contract his downstream partner's competitors, we speak of downstream naked exclusion. Similarly, when it is the downstream party who is unconditionally restricted from contracts with his upstream partner's competitors, we speak of upstream naked exclusion. Finally, when both firms unconditionally agree not to contract third parties, we speak of mutual naked exclusion. In all three cases, firms will only enter into exclusionary contracts if they are jointly better off, in which case the firm with the largest incentive can compensate his partner to share the gains from exclusive contracting equally.

Such unconditional exclusionary agreements do not have the same effect as vertical integration and conditional exclusionary contracts. Instead, the contracting partners bilaterally restrict the communication graph G to a subgraph G' in which all communications between third parties mentioned in the exclusive agreement have been severed. The full multilateral bargaining game then proceeds with the subgraph G' , with no room for renegotiation as in conditional exclusion or joint profit optimization as in vertical integration. As an example, the absence of a contract between H_B and I_2 in the graph G_{AD} of the asymmetric duopoly in figure 1 can be interpreted in two ways: either as upstream naked exclusion with I_2 becoming exclusive to H_A , or as downstream naked exclusion with H_B becoming exclusive to I_1 .

4 Results

In this section, we analyze the equilibrium outcomes of our model for the connected duopoly in which both insurers offer a non-exclusive network. We analyze these outcomes both in the absence and in the presence of vertical restraints. We express all our results in terms of two-dimensional graphs along the following two parameters: the downstream differentiation μ and the consumer preference for hospital choice τ . We have developed a Mathematica package that partly

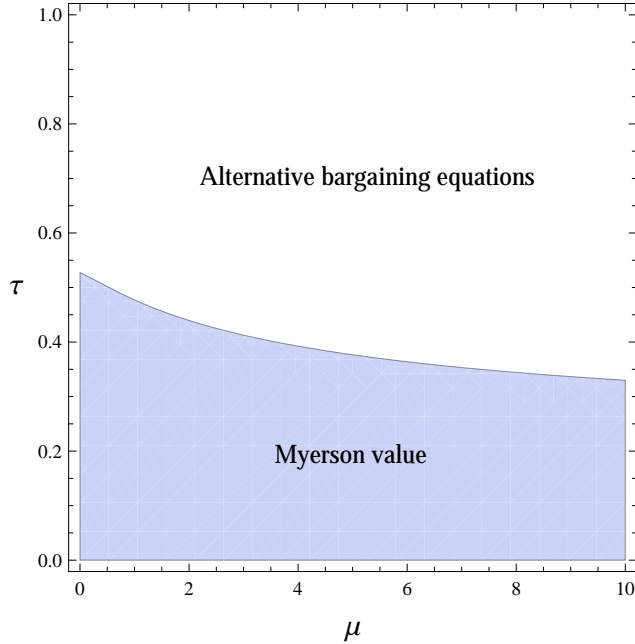


Figure 3: *Two distributions of industry profits for the connected duopoly. In the blue, the generalized Myerson-Shapley value (A.4) is applicable, whereas in the white area the stabilized bargaining equations have to be solved explicitly.*

automates the computation each firm's payoffs for all six graphs from Figure 1.⁷

4.1 Equilibrium without vertical restraints

In the absence of vertical restraints, both insurers contract with both hospitals regardless of the level of differentiation on the downstream market μ and the extent consumers value hospital choice τ . This means that the participation constraints called the feasibility conditions (A.3) are satisfied for all players in all subgraphs of Figure 1. This implies that there are no individual incentives for naked exclusion in the absence of vertical restraints.

There are however two different equilibrium divisions of the industry profit depending on the value of τ and μ . Figure 3 shows the critical value of τ as a function of μ . In the parameter ranges of the shaded area on Figure 3, the generalized Myerson-Shapley value (A.4) generates the distribution of the industry profits computed in section 2.5. In the white area, one of the feasibility conditions for an asymmetric duopoly is not satisfied, and the asymmetric duopoly will always break down to a downstream monopoly. This means that an insurer exits the market. This breakdown of the asymmetric duopoly subgraph occurs precisely when consumers have strong preferences for unrestricted hos-

⁷This Mathematica package is available upon request from the authors.

pital choice, i.e. when τ is high. In the white region of Figure 3, the stabilized bargaining equations have to be solved in order to compute the distribution of industry profits. For details, we refer to appendix A.5. The alternative bargaining equations allocate a higher share of the industry profit to the hospitals than the generalized Myerson-Shapley value does. This reflects the increased bargaining power of hospitals owing to the more serious consequences of not contracting one of them. If τ is low, the insurer has the possibility to contract only one hospital, while in case of high τ , the insurer is forced from the market if he fails to agree with both of the hospitals.

These results are in line with the findings of Gaynor and Ma (1996), namely none of the parties has individual incentives to entry in a naked exclusive contract. Even when consumers are relatively indifferent to unrestricted choice of health care providers (i.e. low τ), both insurers will contract both hospitals. Our conclusions on consumer welfare are, however, contradictory to Gaynor and Ma (1996) who state that if exclusion arose, it would be detrimental for consumers. We find that exclusion could be beneficial for consumers when they do not care too strongly for broad provider networks (low τ). The industry profit would be lower in the whole range of μ and τ , but the higher consumer welfare could compensate it in a small range of τ values, and there the social welfare would go up owing to exclusive dealing.

4.2 Effects of vertical restraints

In this section, we study the effects of vertical restraints on our market outcomes. In particular, we analyze under which conditions the various restraints are jointly profitable so that firms can, in principle, compensate each other for possible individual losses owing to the restraint. We study three different vertical relations: vertical integration, conditional and naked exclusion; and we distinguish all three restraints along a second dimension corresponding to the market segment the restraint has an effect on: the upstream, the downstream or both markets. In this way, we get nine different possibilities.

Our approach is as follows. First, we describe what the market structure is if insurer I_1 and hospital H_A engage in that restraint. Second, we describe the equilibrium payoffs that I_1 and H_A jointly can obtain. Finally, we study if the restraint is jointly profitable for them, i.e. if there are joint incentives to apply the restraint. We stress that we do not compute equilibria in the strategy space of vertical restraints; instead, we compute equilibria in wholesale and retail prices conditional on the vertical restraints.

Equilibrium market structures

When consumers attach high enough value to free provider choice, input foreclosure through a vertical restraint is enough for inducing a competing insurer's exit, since insurer I_2 cannot survive by dealing with a single hospital. Consequently, there is downstream monopolization in equilibrium. For six of the nine vertical restraints (backward integration, joint ownership, downstream and mutual conditional exclusion and downstream and upstream naked exclusion), there are two equilibrium industry structures depending on the parameter values. For high values of τ one of the insurers is able to monopolize the downstream market, while for low values of τ all potential contracts are signed and

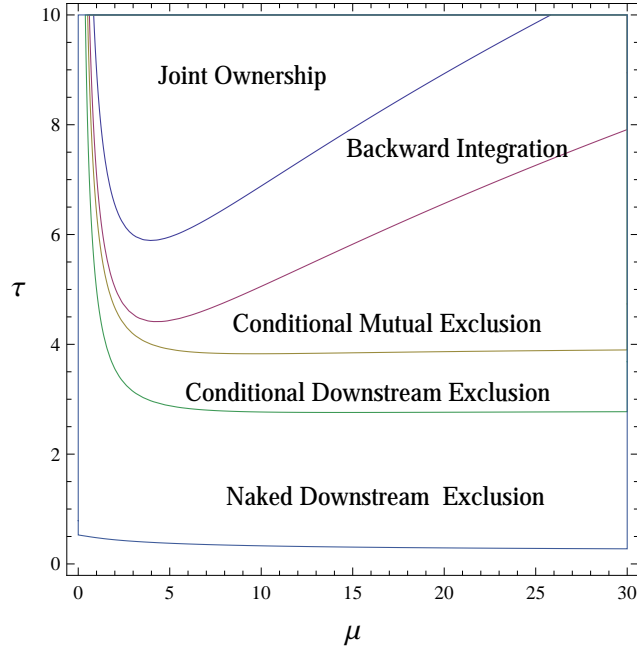


Figure 4: *Lowest critical values for the consumer preferences for hospital choice τ for which downstream monopolization, through each of six different restraints, is the most profitable equilibrium.*

no monopolization occurs. In that case, the asymmetric duopoly survives as the equilibrium market structure.

Figure 4 shows the ranges for different restraints for which monopolization is the equilibrium market structure. Although exclusion of one of the insurers may arise in all cases, the range of feasible parameter values may vary. Furthermore, while naked downstream exclusion may be a tool to induce the exit of the rival insurer (I_2), naked upstream exclusion has precise the opposite result. Insurer I_1 has to leave the market since it is restrained to contract a single hospital which is a disadvantageous situation compared to I_2 . Thus, the equilibrium market structure is in both cases downstream monopolization, but the insurer leaving the market is a different one.

Ma (1997) also finds that downstream monopolization occurs in equilibrium after vertical integration. In his model, insurers are homogeneous and compete á la Bertrand which yields that an insurer is able to conquer the whole market by the smallest value difference. Since one of the insurers has control rights on a hospital, and a non-restricted network is always superior to a single hospital network, there are always incentives to induce a rival insurer to exit from the market by excluding him from a hospital. In our model, we find that this effect is mitigated when downstream product differentiation is introduced: downstream monopolization only arises for high enough consumer preferences for unrestricted hospital choice.

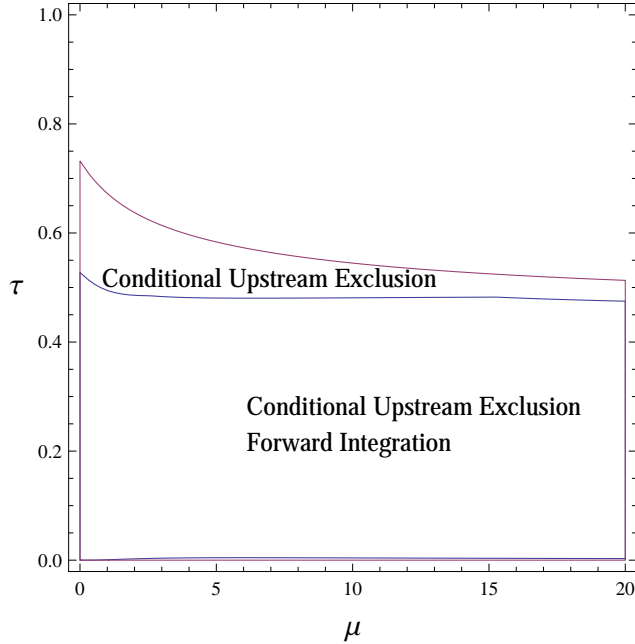


Figure 5: *Lowest critical values for the consumer preferences for hospital choice τ for which there is an equilibrium in pure strategies for forward integration and upstream conditional exclusion.*

For the three other vertical restraints (forward integration, upstream conditional exclusion and mutual naked exclusion) there is only one equilibrium outcome. Both insurers keep contracting both hospitals after forward integration or after signing an upstream conditionally exclusive contract in the low range of parameter τ (see Figure 5). For higher τ values there is no equilibrium in pure strategies for these two restraints. Mutual naked exclusion yields the disconnected duopoly in the whole parameter range. Interestingly, for most of the six vertical restraints mentioned in Figure 4, except for naked exclusion, there is also a range of parameters where no equilibrium in pure strategies exists. In these cases, stabilizing the bargaining equations through replacing incredible outside options does not yield a market outcome that itself satisfies all the feasibility conditions. For more details, see appendix A.5. In neither of these cases have we attempted to find an equilibrium in mixed strategies.

Equilibrium payoffs

The joint equilibrium payoff of I_1 and H_A depends on the industry profit in equilibrium and the share that they can obtain from it. The industry profit is determined by the equilibrium market structure and it does not vary by the market where exclusion potentially arises. In contrast, downstream, upstream and mutual exclusions differ in the distribution of the industry profits, and each

of the nine restraints has a different effect on the payoff of the individual firms I_1 and H_A .

Downstream monopolization ensures the highest industry profits, while a disconnected duopoly generate the lowest industry profits. The latter market structure is even more competitive than the connected duopoly case. This interesting phenomenon is a form of common agency (Bernheim and Whinston, 1986) in which the coordination of downstream players through common upstream players significantly softens inter-brand competition. The asymmetric duopoly generates industry profits in between the disconnected and the connected duopoly.⁸ Vertical integration increases the industry profit due to the joint profit maximization of the merged firms I_1 and H_A even if the contracting with third parties does not change. Conditional exclusion, however, does not influence the level of the industry profits as long as the contracting with third parties does not change.

Backward integration, downstream conditional or naked exclusion guarantee an insurer access to a valuable resource and furthermore gives the right to exclude insurer I_2 from the utilization of that resource. Even for low τ values when no exclusion arises, I_1 and H_A together obtain a higher share from the industry profit than in case of non-integration due to their improved joint bargaining position. With forward integration, upstream conditional or naked exclusion, however, their bargaining position worsens. Hospital H_A deprives I_1 from a valuable resource by restricting the contracting with hospital H_B . Hospital H_A benefits from the exclusive contract, but its gain is less than the loss of insurer I_1 .

The key in this situation is that the competition is fiercer between the insurers than between the hospitals. By signing an exclusive contract, the party whose competitor is (conditionally) excluded increases its market power. At the same time, the market position of the party that is restricted worsens. Jointly they are better off with the vertical restraint if the improved situation of one party increases its profit more than what the other loses. de Fontenay and Gans (2007) show that in general there is more incentive to initiate a vertical merger from the more competitive market. In our model, the downstream market is more competitive; that is why we find downstream exclusion is generally more profitable.

Joint ownership and mutual conditional exclusion restrains both I_1 and H_A and the effects are in between the results of upstream and downstream restraints. The insurer and the hospital involved in the vertical restraint are better off, but they gain less than it would be possible with a same type downstream restraint. With mutual naked exclusion, there are two independent vertical chains in the market. I_1 and H_A do not contract with I_2 and H_B , and each pair divide their own gains equally between the insurer and the hospital.

4.3 Most profitable restraints

The changed bargaining positions and the possibly changed industry profit together determine the profitability of the various vertical restraints. Since many restraints have two equilibrium market structures depending on the parameter

⁸Gal-Or (1997) finds a similar effect when she concludes that insurers are better off to contract the same hospital when they both restricts their provider network.

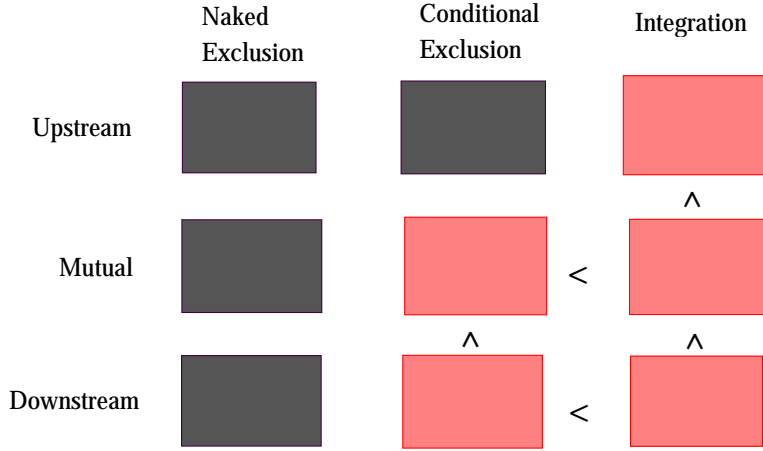


Figure 6: Profitability of restraints and their comparison. Each rectangle symbolizes a restraint; the lighter, pink color signs profitability, the darker, gray color means unprofitability. The inequality signs show the ordering between the various profitable restraints. In the absence of downstream monopolization, the most profitable vertical restraint is backward integration.

values, we also distinguish two cases in the analysis. First, we study profitability in the parameter ranges where none of the restraints triggers monopolization of the downstream market. Second, we compare the profitability of restraints in case of monopolization.

For backward integration and conditional downstream exclusion, both the bargaining effect and the change in industry profit are either positive or neutral. Thus, these restraints are always jointly profitable for I_1 and H_A . There is a trade off between these two effects for naked downstream exclusion, and only in a very small range of our parameters μ and τ it is profitable. Upstream restraints are not profitable in our model when the industry profit does not change (conditional exclusion) or decreases (naked exclusion). In case of forward integration, the increase in industry profit is enough to compensate for the disadvantageous redistribution of gains. Thus, forward integration is profitable in our model. Among the three mutual restraints, the redistribution of the profit is advantageous to I_1 and H_A for joint ownership and mutual conditional exclusion. Since the industry profit also increases or does not change, these two forms are profitable. Mutual naked exclusion is unprofitable in the whole parameter range.

Figure 6 compares the relative profitability of the various restraints in the parameter range where no monopolization is possible. The five restraints that are profitable are signed with lighter, pink rectangles in Figure 6. Looking at the matrix, lower rows are always better for the contracting parties. This ordering is due to the level of the industry profit. With the exception of naked exclusion, there is also a clear trend in the columns; the benefits of I_1 and H_A are increasing from left to right. This trend reflects that in our model imposing downstream restraints on competitors improves the bargaining position of the upstream firms. In contrast, upstream firms are worse off if they apply upstream

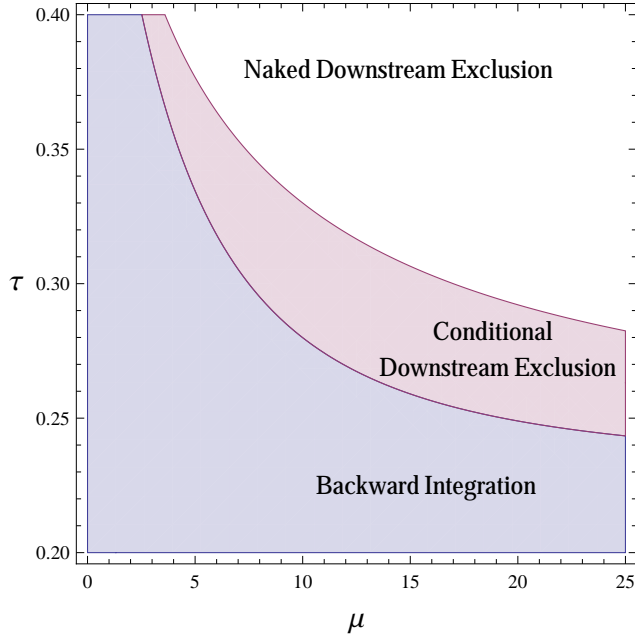


Figure 7: *The most profitable vertical restraint for I_1 and H_A in different parameter ranges.*

restraints as explained in the previous section. The most profitable form of restraint in this parameter range is backward integration.

Monopolization arises for high values of τ , since the insurer that is constrained to contract a single hospital is excluded from the market. The benefits after monopolization are the same for all restraints, except for naked upstream exclusion. As Figure 4 shows, naked downstream exclusion is an effective threat to make the rival insurer I_1 exit even for relatively low τ values. When consumers value choice a bit more, other restraints also become effective for exclusion. Naked upstream exclusion is never profitable in our model. A hospital does not gain enough by the higher industry profit to be able to counterbalance the losses from the exclusion of I_1 .

Ordering the restraints, we can conclude that monopolization is always the best option if it is feasible with one of the restraints. In the parameter range where no monopolization can arise, backward integration gives the highest payoffs to I_1 and H_A due to the high industry profit and advantageous division of the gains. Naked exclusion allows monopolization for the lowest τ values, thus for higher τ values it is the best choice. There is a small range where integration has no equilibrium and naked exclusion does not result in monopolization. In that range conditional downstream exclusion is the most profitable restraint. Figure 7 illustrates the best restraint for I_1 and H_A for different τ values.⁹

⁹Note that the range of τ in Figure 7 is chosen considerably smaller compared to the range used in Figures 4 and 5.

4.4 Consumer surplus and total welfare

When monopolization is the equilibrium market structure, consumers are always worse off. In the parameter range where pure strategy equilibrium exists and both insurers contract both hospitals, integration is always detrimental to consumer surplus and total welfare. The advantage due to improved bargaining position of backward integration and joint ownership is achievable for the parties by conditional exclusion as well. While the insurer-hospital pair can enjoy some of the benefits (yet giving up higher industry profit), the consumer surplus and total welfare are not reduced since in case of conditional exclusion, the prices in the downstream market do not change.

The best form of downstream restraint from the consumers' perspective is mutual naked exclusion. Naked upstream and downstream exclusion in the range where no monopolization arises may be beneficial for the consumers. The lower prices of health insurance can compensate for the restricted choice when hospitals are perceived to be almost similar (low values of τ). In a small range, the increase of the consumer welfare is enough high to counterbalance the losses in industry profit, and the change in social welfare will be positive. Naked exclusion in this parameter range is, however, never the best option for providers.

5 Conclusion

We have analyzed individual and joint incentives for vertical relations between health insurers and providers and the corresponding welfare effects. We find that neither downstream nor upstream firms have individual incentives for exclusive dealing, a result similar to that of Gaynor and Ma (1996). There are, however, joint incentives for vertical restraints in which one contract party compensates his counter party through side payments. In general, downstream restraints are jointly most profitably for the contracting parties. Since the downstream insurance market is more competitive than the upstream hospital market, this result is in accordance with de Fontenay and Gans (2005). However, firms also derive positive profits from the various upstream and mutual restraints for broad ranges of our model's parameters.

We also identify the parameter range where a given restraint triggers the exit of the competing insurer. In contrast to Ma (1997), who finds that downstream monopolization is an automatic consequence of vertical integration in case of homogeneous Bertrand competition downstream, we conclude that in the case of differentiated Bertrand competition downstream an exclusive contract or integration only induces the rival insurer to exit if consumers valuation for unrestricted provider networks is high enough. If a restraint makes monopolization of the insurance market possible, it is generally also the most profitable course of action for a hospital-insurer pair.

We find that consumer and social welfare are not directly affected by the different forms of the vertical restraints. Instead, the only determining factor is the resulting equilibrium industry structure. Downstream monopolization is the worst situation both for consumers and for social welfare, regardless of the vertical restraint that induced it. In absence of monopolization, conditional exclusion does not affect welfare, while naked exclusion will increase welfare for a small range of parameters, in which case it is not profitable for the parties involved.

In our model, vertical integration decreases welfare, even if both insurers keep contracting with both hospitals.¹⁰ The reason for this a priori counter-intuitive effect is that the elimination of double marginalization between one hospital-insurer pair also softens price competition with the competing insurer through a common agency effect.

For purposes of analytical tractability, our model was limited to a bilateral duopoly with symmetric hospitals with constant marginal costs and no capacity constraints. This makes our model of limited importance for empirical applications. However, in appendix B, we outline the extension of our model to a more suitable random choice framework, that also includes the presence of co-payments for consumers.

Acknowledgements

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¹⁰However, we do not model possible efficiency gains from economies of scale or scope.

A Bargaining framework

A.1 Industry structure

We follow de Fontenay and Gans (2005) by examining a vertically organized industry with upstream and downstream assets. The upstream assets produce inputs that are used by downstream assets to make final goods. Inputs from at least one upstream asset are necessary for valuable production downstream. We follow the literature on the property rights theory of the firm by associating with each asset a manager endowed with asset-specific human capital that is necessary to generate valuable goods and services from that asset. We denote the respective managers of downstream firms ("health insurers") by I_i and upstream managers ("hospitals") by H_j . Vertical integration changes the ownership of these assets. However, the manager associated with an asset will not change, as each remains necessary for its use. This general framework is applicable for a large class of industries, and below we indicate how the substitutability of upstream inputs and the nature of downstream competition in specific cases influences the formalism.

An upstream asset H_j can produce input quantities q_{ij} for the various downstream firms I_i . A downstream firm I_i charges retail prices p_{ij} for its final goods \hat{q}_{ij} , which are produced from its inputs q_{ij} through a production function $\hat{q}_{ij} = f_{ij}(q_{ij})$. In multi-product retail industries with a simple pass-through of goods, the downstream production function can be characterized as $\hat{q}_{ij} = q_{ij}$. In single-product manufacturing industries with inputs assembled in relative proportions $q_{ij} = s_{ij}\hat{q}_i$ with $\sum_{j \in G_i} s_{ij} = 1$, the production function $\hat{q}_i = f(q_{ij})$ is a priori completely general. In particular, both perfect substitutes in variable proportions, $\hat{q}_i = \sum_{j \in G_i} q_{ij}$, as well as perfect complements in fixed proportions, $\hat{q}_i = \min_{j \in G_i} s_{ij}^{-1} q_{ij}$, can be accommodated. Under downstream quantity competition, retail prices are determined through the inverse demand functions $p_{ij} = D_{ij}^{-1}(\hat{q}_{ij}, \hat{q}_{-ij})$. Under downstream price competition, retail quantities follow similarly from the demand functions $\hat{q}_{ij} = D_{ij}(p_{ij}, p_{-ij})$. In both cases, we used the notation $-i$ to denote the quantities and prices of the competitors of I_i .

We denote the set of contracted partners of I_i and H_j as G_i and G_j , respectively, where we use the notation $G_i = \{j : i \text{ and } j \text{ have a contract}\}$. The union of all sets of supply arrangements G_i and G_j is denoted as $G = \{(i, j) : i \in G_j, j \in G_i\}$. This means that G contains all pairs of firms that have a contract. In mathematical terms, G is an *undirected graph*.¹¹ Each firm represents a vertex of the graph, and each contract can be drawn as an edge between the corresponding vertices of the firms. We do not impose any a priori constraints on vertical links in the graph G . However, horizontal arrangements among firms are prevented by competition law.

Let downstream revenues be equal to R_i , and let upstream production costs be given by $C_j(q_{ij})$, which are assumed to be weakly convex in all the quantities q_{ij} .¹² For both modes of competition, there is a transfer $T_{ij}(q_{ij})$ from I_i to H_j conditional on the supplied quantity. Under these conditions, the downstream and upstream profits are given by $\Pi_i = R_i - \sum_{j \in G_i} T_{ij}$ and $\Pi_j = \sum_{i \in G_j} T_{ij} - C_j$, respectively.

¹¹ G is undirected since if I_i is negotiating with H_j , then the converse is also true.

¹²In particular, we allow for constant marginal costs.

A.2 Bargaining equations

To model the bargaining between upstream and downstream firms, we first introduce some notation. The set of all joint actions is denoted by $\{x_{ij}\}$. Let the profits of the downstream and upstream firms, $\Pi_i(\{x_{ij}\}, T_{ij}, G)$ and $\Pi_j(\{x_{ij}\}, T_{ij}, G)$, respectively, depend on the set of all joint actions $\{x_{ij}\}$, their bilateral transfer payment T_{ij} , and on the graph of all supply arrangements G . Furthermore, let the transfer payment T_{ij} be a fixed fee t_{ij} , independent of x_{ij} . Finally, let both firms have outside options $\tilde{\Pi}_i(G \setminus (i, j))$ and $\tilde{\Pi}_j(G \setminus (i, j))$, respectively, in case they cannot reach an agreement.

de Fontenay and Gans (2007) analyze a non-cooperative pairwise bargaining game between agents in a network. The precise structure of the game is as follows. The various hospitals and insurers negotiate sequentially in pairs.¹³ Pairs of agents negotiate over jointly observable actions x_{ij} and a transfer t_{ij} . Pairwise negotiations follow the alternating offer game of Binmore et al. (1986), where offers and acceptances are made in anticipation of deals reached later in the sequence. Moreover, those negotiations take place with full knowledge of the network structure G and how terms relate to that structure should it change. Specifically, the network may become smaller should other pairs of agents fail to reach an agreement. The precise agreement terms cannot be directly observed outside a pair. Thus, agents can observe the network of potential agreements but not the details of agreements they are not a party to.

With some restrictions on otherwise fully specified beliefs, de Fontenay and Gans (2007) establish that there is a unique Bayesian-Nash equilibrium of the above incomplete information game. Beliefs are assumed to be passive in the sense that they are not updated when an out-of-equilibrium action is encountered. That outcome involves agents negotiating actions that maximize their joint surplus as in Nash bargaining, taking all other actions as given.

The bargaining equations characterizing the unique equilibrium can be derived from maximizing the Nash product $\Pi_{ij} = (\Pi_i - \tilde{\Pi}_i)(\Pi_j - \tilde{\Pi}_j)$, with respect to x_{ij} and t_{ij}

$$0 = \frac{\partial \Pi_{ij}}{\partial x_{ij}} \rightarrow \frac{\partial(\Pi_i + \Pi_j)}{\partial x_{ij}} = 0 \quad (\text{A.1})$$

$$0 = \frac{\partial \Pi_{ij}}{\partial t_{ij}} \rightarrow \Pi_i - \tilde{\Pi}_i = \Pi_j - \tilde{\Pi}_j \quad (\text{A.2})$$

$$\Pi_i \geq \tilde{\Pi}_i, \quad \Pi_j \geq \tilde{\Pi}_j \quad (\text{A.3})$$

The first equation expresses that joint profits are maximized through the choice of the joint action x_{ij} . Hence, with externalities, outcomes are bilaterally efficient rather than socially efficient. The second equation states that the fixed fee transfer is set such that each firm benefits equally from reaching an agreement. The inequalities (A.3) express the individual participation constraints of the negotiating parties. If the gains from trade are negative, then no trade will be made.

The coalitional bargaining division of the reduced surplus arises as a result of externalities between agents. As a result, the realization of the industry profits is completely decoupled from its distribution over the various firms in

¹³The equilibrium is independent of the order of the pairs.

the industry. This allows for a careful separation of anti-competitive effects and efficiency gains for various vertical restraints such as mergers and exclusion. The unique Bayesian-Nash equilibrium derived by de Fontenay and Gans (2007) provides a rigorous mathematical justification for this cooperative division of the non-cooperative surplus.

A.3 The generalized Myerson-Shapley value

The structure of the bargaining equations (A.1) and (A.2) is deceptively simple. However, in the presence of downstream competitive externalities, the equations do not decouple for different hospital-insurer pairs (i, j) since the profits of each downstream firm will depend on the actions of its competitors. Hence, for any given graph G of supply arrangements, the bargaining equations (A.1) and (A.2) have to be solved simultaneously for all contracts $(i, j) \in G$. Moreover, to account for all the outside options, these equations have to be solved recursively for all edges in all subgraphs of G . The number of relevant subgraphs for a given coalitional structure increases exponentially in the number of firms. Solving the bargaining equations analytically is therefore intractable for large markets.¹⁴

Fortunately, the recursive combinatorial structure of the bargaining equations also eliminates some intermediate subgraphs from the expressions for the equilibrium payoffs. In particular, configurations where one supply relationship has been severed but otherwise all firms remain connected to each other do not appear in the equilibrium payoffs; those terms are only relevant in bargaining off the equilibrium path.¹⁵ The explicit expression for the unique equilibrium payoffs is given by a weighted sum of values of particular coalitions of agents called the generalized Myerson-Shapley value (Myerson, 1977)

$$\Pi_i(G) = \sum_{P \in P^N} \sum_{S \in P} (-1)^{|P|-1} (|P|-1)! \left[\frac{1}{N} - \sum_{\substack{i \notin S' \in P \\ S' \neq S}} \frac{1}{(|P|-1)(N-|S'|)} \right] \Pi_S(G^P). \quad (\text{A.4})$$

In this expression, we have introduced some more notation from graph theory. Here, P denotes a partition of N players into non-overlapping coalitions. The set of all such partitions is denoted as P^N . The coalitions S and S' are members of P . The partitioned graph G^P contains only edges of the graph G that connect the members of the same coalition within P , but excludes links that connect members of different coalitions.¹⁶ Finally, $\Pi_S(G^P)$ denotes the joint surplus of coalition S in the partitioned graph G^P .

Since the expression (A.4) for a firm's profits only involves coalitions of which that firm is a member, it follows that there are no inter-coalitional transfers, and that the intra-coalitional transfers add to zero. Hence, the total coalitional payoffs $\Pi_S(G^P)$ can be computed from the bilateral profit-maximizing equations (A.1) alone. The individual payoffs $\Pi_i(G)$ are then uniquely determined

¹⁴On the other hand, price-taking should be a more realistic description than bilateral bargaining in vertical industries with a large number of firms on each side of the market.

¹⁵Here, connectedness is defined in the graph-theoretic sense: firm i is connected to firm j if there exist a chain of edges in the graph from the vertices of firms i and j .

¹⁶In effect, G^P is the set of edges in G consistent with the partition P .

from the generalized Myerson-Shapley value (A.4).¹⁷ This greatly simplifies the computation of the equilibrium payoffs. Nevertheless, the number of terms in the generalized Myerson-Shapley value (A.4) still grows exponentially in the number of firms.

A.4 Effects of vertical restraints

The mathematical structure of our bargaining game in the presence of vertical restraints is the following. The allowed communications between the various firms in the industry is denoted by an *undirected* graph G . Similarly, we represent the residual control rights as edges in a supplementary *directed* graph R . In the absence of vertical integration, the independency of the various upstream and downstream firms is represented by the trivial graph with m isolated upstream and n isolated downstream vertices. In the presence of vertical integration, the residual control rights graph R contains a directed edge from each targeted firm to its acquiring firm. In particular, the directed graph R allows the expression of both forward and backward integration. Surprisingly, mergers of equals and joint ventures with a 50-50 ownership division can also be represented. In this case, the directed graph R contains two edges between each pair of merging firms: both running in opposite directions.

Recall that the effect on a graph G of dividing the firms into a partition P of non-overlapping coalitions of firms as the elimination of all inter-coalition edges in G . We denote the resulting partitioned graph as G^P . Similarly, we can define the effect on a graph G of a set of mergers depicted by a residual control rights graph R as the shifting all edges previously running towards targeted firms, towards their acquiring firms. We denote the resulting merged graph as $R(G)$. Finally, the combined effect of a partition P and a merger R on a graph G is given by first partitioning the graph G , then performing the merger R , and finally applying the partition P one more time. The effect is a graph denoted as $R(G^P)^P$. It turns out that the replacement of G^P by $R(G^P)^P$ in the generalized Myerson-Shapley value (A.4) generates identical firm profits as explicitly solving the recursive set of bargaining equations. Our Mathematica package performs the various manipulations on the communication graph G for arbitrary mergers R and partitions P .¹⁸

A.5 Feasibility conditions

It is important to stress that the generalized Myerson-Shapley value (A.4) is a valid solution of the bargaining equations (A.1) and (A.2) if and only if the individual participation constraints (A.3) are satisfied for all edges of all sub-graphs. Stole and Zwiebel (1996) term the absence of unilateral breakdowns of negotiations *feasibility*. For applications with competitive externalities, feasibility is something that will have to be explicitly verified in order to directly apply the equilibrium characterization above. If feasibility does not hold, then the

¹⁷However, if the number of contracts exceeds the number of firms, there can be some indeterminacy in solving the equations for the transfer payments.

¹⁸The Mathematica routine can compute the generalized Myerson-Shapley value for arbitrary graphs. On a desktop computer, the generalized Myerson-Shapley value for a supply graph of 4 upstream and 4 downstream firms can be computed in a few minutes, but larger graphs can take several hours.

bargaining game will have an equilibrium where not all links are maintained. de Fontenay and Gans (2007) demonstrate that a technical condition called *component superadditivity* is sufficient for feasibility to hold even in the case of competitive externalities. Unfortunately, our application does not satisfy this condition, and we have to verify feasibility explicitly.

Whenever feasibility does not hold, a modified set of recursive bargaining equations has to be solved explicitly. Let G' be a graph with a single edge $(i', j') \subset G'$ for which the individual participation constraints (A.3) are not satisfied. This means that the subgraph $G'' \equiv G' \setminus (i', j') \subset G'$ will be formed in equilibrium. In particular, G' itself cannot be a credible threat in the negotiations of an edge (i, j) in a graph G for which $G \setminus (i, j) = G'$. The replacement of an infeasible graph G' by its largest feasible subgraph G'' has to be performed in every bargaining equation (A.2) in which G' occurs as an outside option. Moreover, the procedure of checking for feasibility and replacing infeasible subgraphs has to be iterated until complete feasibility has been demonstrated. In particular, it is possible no equilibrium candidate satisfying all the individual participation constraints will survive this iterative procedure.

A.6 Bargaining parameters and two-part tariffs

The specific joint action x_{ij} that I_i and H_j bargain over is application dependent. A necessary and sufficient condition for x_{ij} to be a suitable bargaining parameter is that the joint surplus maximization (A.1) and the (inverse) demand equations uniquely determine both the upstream and downstream production levels. If the downstream production function is a simple pass-through of upstream goods, firms can jointly engage in resale price maintenance by negotiating retail prices p_{ij} in case of downstream price competition. Similarly, they can bargain directly over the retail quantities \hat{q}_{ij} in case of downstream quantity competition. Such downstream quantity fixing through bilateral negotiations is also possible in case of assembly of multiple upstream inputs into a single downstream good, with arbitrary degrees of substitution between the inputs, as was shown in an example of de Fontenay and Gans (2005).

We extend these possibilities by allowing for downstream price competition with a many-to-one production function with complementary inputs in *fixed* proportions s_{ij} . We modify the bargaining game of de Fontenay and Gans (2007) with respect to two dimensions. First, we introduce a two-part tariff $T_{ij} = t_{ij} + w_{ij}q_{ij}$. Here, the fixed fee t_{ij} is a lump-sum transfer which can either be negative or positive. The wholesale price w_{ij} is paid for every unit of the supplied quantity q_{ij} . Second, we let the first stage of multilateral bargaining be followed by a second stage of downstream price competition. Using backward induction, the profit-maximizing downstream prices $p_i^*(w_{ij})$ and the downstream demand $\hat{q}_i(p_i^*(w_{ij}))$ are both implicit functions of the whole-sale prices. Hence, in the first stage, the joint surplus maximization (A.1) over the whole-sale prices w_{ij} completely determines the downstream prices and demand.

If downstream products are assembled from perfectly complementary inputs, the upstream factor demands are then uniquely determined. For the remaining case of price competition for downstream goods assembled from substitutable inputs, the upstream factor demands cannot be uniquely determined from the downstream production parameters. Instead, firms will have to simultaneously bargain over the reimbursement rates and the relative shares: $x_{ij} = \{w_{ij}, s_{ij}\}$.

B Towards an empirical framework

In this appendix we sketch some empirical aspects of the models that we employ in the main text. We also establish that in the limit of symmetric networks and catastrophic health insurance, the demand system (1) that we employ in the main text of this paper has the same functional form to linear order in prices as the more empirically viable logit demand framework. We leave the full development of such an empirical framework to future research.

B.1 Insurance demand

An often used empirical framework for products with differentiated price competition is a logit demand system (Berry et al., 1995). Below we apply this to the case of a consumer with a vector of characteristics $X = \{H, I, Z\}$ consisting of his health status H , income I and socio-demographic and clinical characteristics Z . His characteristics predispose him with probability θ_X to an illness with a drop in health status ΔH , that can be fully cured with probability one if treated in any of the available hospitals. The relevant choice set is a number of $i = 1 \dots n$ health plans with premiums $p_{i,X}$ and networks of contracted hospitals $G_{i,X}$ that can be conditional on the consumer characteristics X .¹⁹

A consumer X derives the following utility from buying a health plan i

$$\begin{aligned} V_{i,X} &= H + u(I - p_{i,X}) + \theta_X v_X(G_{i,X}) + \varepsilon_{i,X} \\ &\approx H + u(I) + \theta_X v_X(G_{i,X}) - u'(I)p_{i,X} + \varepsilon_{i,X} \end{aligned} \quad (\text{B.1})$$

Here, $u(I)$ is a concave function of income, $v_X(G_{i,X})$ is a concave function in the option value of the network of contracted hospitals, and $\varepsilon_{i,X}$ is an idiosyncratic error assumed to be i.i.d. Type 1 extreme value.

Similarly, we denote the choice of being uninsured but covering any health care costs c completely out-of-pocket as a dummy insurer with label $i = 0$ and the unrestricted network G_{\max} , with corresponding utility equal to

$$\begin{aligned} V_{0,X} &= H + (1 - \theta_X)u(I) + \theta_X [u(I - c) + v_X(G_{\max})] + \varepsilon_{0,X} \\ &\approx H + u(I) + \theta_X v_X(G_{\max}) - u'(I)\theta_X c + \frac{1}{2}\theta_X c^2 u''(I) + \varepsilon_{0,X} \end{aligned} \quad (\text{B.2})$$

Finally, we denote the choice of being uninsured and foregoing treatment altogether as a dummy insurer with label $i = -1$ with an empty network and zero price, with corresponding utility equal to

$$V_{-1,X} = H + u(I) - \theta_X \Delta H + \varepsilon_{-1,X} \quad (\text{B.3})$$

We denote the marginal utility of income as $\mu_I \equiv u'(I)$ and the coefficient of absolute risk-aversion as $\gamma_I \equiv -\frac{u''(I)}{u'(I)}$. This allows us to combine the utilities of being insured or uninsured with or without treatment as a single equation (upon dropping health status and the utility of income, which are equal across choices)

$$V_{i,X} \approx \theta_X v_X(G_{i,X}) - \mu_I p_{i,X} + \varepsilon_{i,X} \quad i = -1, 0, 1 \dots n \quad (\text{B.4})$$

¹⁹In practice, there can be legal restrictions on the amount of price and value discrimination that insurers are allowed to apply to their policies.

where we have defined $p_{-1,X} = 0$ and $G_{-1} = \emptyset$ and the utility of having no access to hospital care equal to the drop in health status: $v_{-1,X}(\emptyset) = -\Delta H$. Similarly, we have defined $G_0 = G_{\max}$, and $p_{0,X} = \theta_X c + \frac{1}{2}\theta_X c^2 \gamma_I$. In effect, paying health care fully out-of-pocket gives access to the unrestricted network G_{\max} but this freedom of choice has a price greater than the expected costs $\theta_X c$ by an amount equal to the risk premium $\frac{1}{2}\theta_X c^2 \gamma_I$.

The above framework is applicable under the following assumptions. First, in order for health insurance to exist at all, the participation constraints for the insurer and consumer need to hold, implying that the premium is at least actuarially fair and strictly less than the cost of treatment. Furthermore the illness has to be an insurable risk in the first place, and not a chronic disease or long-term care with $\theta = 1$. These constraints can be expressed by the inequalities

$$\theta_X c \leq p_{i,X} < c \quad (\text{B.5})$$

Second, the choice set itself is subject to the consumer's budget constraint. If neither health care nor health insurance are affordable

$$I < p < c \quad (\text{B.6})$$

then there is only a single choice $i = -1$ available.

A second regime is when health insurance is affordable but health care itself is not

$$p < I < c \quad (\text{B.7})$$

In this situation, a consumer has the choice set $i = -1, 1 \dots n$.

If both buying health insurance and paying for health care fully out-of-pocket are affordable, one has

$$p < c < I \quad (\text{B.8})$$

and the choice set is equal to $i = -1, 0, 1 \dots n$.

In all three cases, each insurer's market share $s_{i,X}$ can be expressed as

$$s_{i,X} = \frac{\exp(\theta_X v_X(G_{i,X}) - \mu_I p_{i,X})}{\sum_{i' \in \text{affordable}} \exp(\theta_X v_X(G_{i',X}) - \mu_I p_{i',X})} \quad (\text{B.9})$$

The last two regimes both have a special case: in the limit where the drop in health status from foregoing treatment is much larger than the added value of an insurance policy or of self-insurance, the exponentiated utility of the $i = -1$ option goes to zero. In this case, the relevant choice set is $i = 1 \dots n$ and $i = 0, 1 \dots n$. The above random choice model captures health insurance where there can be different reasons for the uninsured: either because they cannot afford health insurance or when they prefer not to be insured.

B.2 Hospital demand

The option value of an insurer's contracted hospital network $v_X(G_{i,X})$ can in turn be derived from a random choice framework for hospital demand (Capps et al., 2003). Let a patient X from insurer i derive a random utility $U_{ij,X}$ from receiving treatment from a hospital j and being charged a co-payment $\beta_{ij,X}$

$$U_{ij,X} = U_{j,Z} - \nu_I \beta_{ij,X} + \varepsilon_{ij,X} \quad (\text{B.10})$$

Here, the price-sensitivity for co-payments is denoted by ν_I , and $\varepsilon_{ij,X}$ is again an idiosyncratic error assumed to be i.i.d. Type 1 extreme value. We consider m competing hospitals, and normalize the systematic component of the utility of receiving no treatment to minus infinity.²⁰ A consumer X 's option value $v_X(G_{i,X})$ of having access to insurer i 's network of contracted hospitals $G_{i,X}$ is (up to an arbitrary constant) given by

$$v_X(G_{i,X}) = \ln \sum_{j \in G_{i,X}} \exp(U_{j,Z} - \nu_I \beta_{ij,X}) \quad (\text{B.11})$$

Similarly, a hospital j 's market share $s_{ij,X}$ of insurer i 's consumers X is given by

$$s_{ij,X} = \frac{\exp(U_{j,Z} - \nu_I \beta_{ij,X})}{\sum_{j' \in G_{i,X}} \exp(U_{j',Z} - \nu_I \beta_{ij',X})} \quad (\text{B.12})$$

B.3 Patient steering and co-payments

Insurers can bargain with hospital over the co-payments $\beta_{ij,X}$ to steer patients to specific hospitals within the insurer's contracted network $G_{i,X}$. However, the insurer's average level of co-payment $\bar{\beta}_{i,X} = \sum_{j \in G_{i,X}} \beta_{ij,X}$ does not influence a hospital's market share $s_{ij,X}$. Instead, it decreases the option value of the insurer's network, or, equivalently, increases the effective insurance premium to

$$p'_{i,X} = p_{i,X} + \frac{\theta_X \nu_I}{\mu_I} \bar{\beta}_{i,X} \quad (\text{B.13})$$

If we restrict ourselves to a single consumer segment (or, equivalently, to a continuum of representative consumers), we can drop the consumer's label X .²¹ Furthermore, in the absence of consumer moral hazard, the co-payments β_{ij} have no influence on the probability of illness θ and the average level of co-payments $\bar{\beta}_i$ can be absorbed into the premium without loss of generality. Effectively, insurers and hospitals will bargain over co-payments that sum to zero. The joint action over which each hospital-insurer pair bargains is then given by the reimbursement rate and the level of the co-payment: $x_{ij} = \{w_{ij}, \beta_{ij}\}$.

Note that if hospitals have constant marginal costs and no capacity constraints, then it is optimal for insurers to steer their patients to the cheapest hospital. This generates so-called bang-bang solutions with infinitely large co-payments. Only with strictly convex hospital costs or with hospital capacity constraints do the co-payments have an interior solution in the multilateral optimization program. In a recent application, Ho (2009) empirically models capacity constrained hospitals using the insight of Kreps and Scheinkman (1983) that allowing firms to choose capacity levels before bargaining begins, permits them to move from Bertrand to Cournot competition. However, it has been known that such results can be sensitive to the precise rationing rule of the residual demand (Davidson and Deneckere, 1986).

²⁰This limit corresponds to the case of acute medical care for which foregoing treatment means certain death. For elective care, the systematic component of the utility of receiving no treatment is again equal to the drop in health status.

²¹If an almost perfect risk adjustment system is in place, the insurer's net expected expenditure is also independent of consumer characteristics, and there are no incentives for either premium differentiation or risk selection.

To keep our model analytically tractable, we do not consider bargaining over co-payments. Similarly, we use a continuum of representative consumers, dropping the consumer label e throughout our paper.

B.4 Estimating the bargaining outcomes

Estimating consumer preferences for insurance and hospital services is in itself a relatively straightforward exercise given insurers' enrollment data, premiums and co-payments; hospitals' costs and patient discharge data; as well as the observed insurer networks and the actual negotiated reimbursement rates. In particular, such data allows estimation of the equilibrium firm profits. The difficulty lies in estimating the outside options in the various bargaining equations and the participation constraints. Ho (2009) estimates outside options that occur one deviation away from the equilibrium path. However, our bargaining game is fully recursive and firm profits for all subgraphs have to be estimated. This is a formidable computational burden for computers and humans alike, raising the question whether the bargaining equations should be truncated in a bounded rationality framework (Dranove et al., 2009), or whether idiosyncratic bargaining abilities could play a role (Grennan, 2009).

B.5 Reduction to linear demand systems

If we restrict (B.9) to a single consumer segment (or, equivalently, to a continuum of representative consumers), drop the consumer's label X , restrict ourselves to symmetric insurers (i.e. $v_i = v$), and take the limit $\theta v \rightarrow \infty$, we get to a linear approximation in prices

$$s_i = \frac{1}{n} \left[1 - \mu p_i + \frac{\mu}{n} \sum_{i'=1}^n p_{i'} \right] \quad (\text{B.14})$$

On the other hand, our linear demand system (1) also reduces to the above form if we again restrict ourselves to the symmetric case $v_i = v$ in the limit $\theta v \rightarrow \infty$, provided we perform the following redefinitions

$$s_i = \frac{q_i}{\theta v}, \quad p_i \rightarrow p'_i = \frac{p_i}{\theta v} \quad (\text{B.15})$$

Note that in this particular limit, the insurance market is fully covered (i.e. $\sum_i s_i = 1$) since the utility of being uninsured is very low compared to all existing insurance plans. Note that this does not necessarily imply that health insurance is mandatory. Also the case of catastrophic health insurance (for which the corresponding health care costs are not affordable out-of-pockets) is contained in this limit. Moreover, for the special case of $n = 2$, the market shares (B.9) reduce to those of the case of Hotelling competition on a line of unit length with transport parameter M , provided we make the identification $\frac{\mu}{2} = \frac{1}{M}$

$$s_i = \frac{1}{2} - \frac{\mu(p_i - p_{-i})}{4} \quad (\text{B.16})$$

This establishes that in the limit of symmetric networks and catastrophic health insurance, the demand system (1) that we employ in the main text of this paper has the same functional form to linear order in prices as the more

empirically viable logit demand framework (B.9). Moreover, for $n = 2$ our demand system (3) can be transformed into the model of downstream Hotelling competition (Gal-Or, 1997; Douven et al., 2009).

B.6 Examples of hospital demand

Consider the following two examples of hospital demand. First, consider m symmetric hospitals (i.e. $U_{j,Z} = U_Z$), and set the co-payments equal to zero, to find that the option value (B.11) is logarithmically increasing in the network's size

$$v_X(G_{i,X}) = U_Z + \ln |G_{i,X}| \quad (\text{B.17})$$

Note that the above expression states that the option value of an insurance policy is the sum of the utility of hospital treatment and a choice premium with diminishing marginal returns in the number of choices. Halbersma and Mikkers (2007) apply the above approximation by considering two consumer types with different values for the ratio $\frac{\theta}{\mu}$ and transforming (B.1) into a framework where selective contracting serves as a price discrimination device for a monopoly insurer.

As a second example, again set the co-payments equal to zero and consider the special case of $m = 2$, with two otherwise symmetric hospitals located on the ends of a line of unit length in product space. Furthermore, consumers are uniformly distributed along the Hotelling line, facing travel costs t . For a consumer on location x in product space, treatment in a hospital located at $x = 0$ generates utility according to (B.10)

$$U_{ij,x} = U - tx + \varepsilon_{ij,x} \quad (\text{B.18})$$

A consumer's location is not known when choosing insurance. Hence, the option value v_E of having exclusively access to a single hospital is given by integrating (B.11) over all possible locations x

$$v_E = \int_0^1 dx \ln e^{U-tx} = U - \frac{t}{2} \quad (\text{B.19})$$

Similarly, the option value v_{NE} of having unrestricted access to both hospitals located at $x = 0$ and $x = 1$ is given by

$$\begin{aligned} v_{NE} &= \int_0^1 dx \ln \left(e^{U-tx} + e^{U-t(1-x)} \right) \\ &= v_E + \frac{\text{Li}_2(-e^{-t}) - \text{Li}_2(-e^t)}{2t} \end{aligned} \quad (\text{B.20})$$

where the dilogarithm function is defined by

$$\text{Li}_2(z) = - \int_0^z dt \frac{\ln(1-t)}{t} \quad (\text{B.21})$$

In the limit $t \rightarrow \infty$, the particular combination of dilogarithms in (B.20) asymptotically approaches $\frac{t}{4}$. In that case, the option values (B.19) and (B.20) both coincide with the expressions derived by Gal-Or (1997); Douven et al. (2009). These papers only take the deterministic part of the utility function (B.18) into account, ignoring the stochastic component. This establishes that the empirically suitable option demand framework of (Capps et al., 2003) is general enough to encompass several theoretically more tractable models of hospital choice.

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NZa

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