Sticking Points: Common-Agency Problems and Contracting in the U.S. Healthcare System

Brigham Frandsen   Michael Powell   James B. Rebitzer

January 30, 2017

Abstract

We propose a "common-agency" model for explaining inefficient contracting in the U.S. healthcare system. In our setting, common-agency problems arise when multiple payers seek to motivate a shared provider to invest in improved care coordination. Our approach differs from other common-agency models in that we analyze "sticking points," that is, equilibria in which payers coordinate around Pareto-dominated contracts that do not offer providers incentives to implement efficient investments. These sticking points offer a straightforward explanation for three long-observed but hard to explain features of the U.S. healthcare system: the ubiquity of fee-for-service contracting arrangements outside of Medicare; problematic care coordination; and the historic reliance on small, single specialty practices rather than larger multi-specialty group practices to deliver care. The common-agency model also provides insights on the effects of policies, such as Accountable Care Organizations, that aim to promote more efficient forms of contracting between payers and providers.

Keywords: Accountable Care Organizations, Common Agency, Moral Hazard

JEL classifications: D8, I10, I18

1 Introduction

The U.S. healthcare system is famously inefficient, but the causes are poorly understood (Baicker and Chandra, 2011). One candidate explanation that has received considerable attention from analysts and policy makers is inefficient contracting between payers and providers, in particular the near total reliance on fee-for-service contracts. This paper proposes a "common agency" model for explaining the puzzling prevalence of such inefficient contracts in the U.S. healthcare system.

Our analysis focuses on the common agency problems that arise when multiple payers seek to motivate a provider to invest in improved care coordination. The provider in this case acts as a "common agent" to the various payers. Strategic interactions among payers introduce two distortions that shape the equilibrium contracts offered to the agent. The first distortion, which has been extensively analyzed in other contexts but only rarely in healthcare, is free-riding.[1] Free-riding causes payers to offer weak incentives to the provider because any given payer reaps only a fraction of the marginal benefit of stronger incentives. The second distortion is a coordination failure between payers. Unlike free-riding, coordination failures lead to the emergence of what we refer to as "sticking points," that is, Pareto-dominated equilibria in which all payers offer contracts that may entirely omit incentives for making efficient investments.

Previous analyses of common-agency problems have not emphasized the role of coordination failures among payers and the resulting sticking-point equilibria. A central contribution of this paper is to trace out the implications these equilibria have for the U.S. healthcare system and healthcare policy. In brief, we find that sticking-point equilibria offer a straightforward explanation for three long-observed but difficult-to to-explain features of the U.S. healthcare system: the ubiquity of fee-for-service contracting arrangements outside of Medicare;[2] poor care coordination across providers;[3] and the historic reliance on small,

[1] For an important exception see Glazer and McGuire (2002), which is, to the best of our knowledge, the first application of common-agency models to the study of the US healthcare system.

[2] Outside of health maintenance organizations (HMOs), fee-for-service contracts are ubiquitous in commercial insurance markets—so much so that Blue Cross Blue Shield of Massachusetts's move away from fee-for-service towards its Alternative Quality Contract attracted nationwide attention (Song et al., 2011). This pattern is noteworthy because fee-for-service contracts provide weaker incentives to providers to control costs than do other feasible contracting arrangements. Gaynor, Rebitzer and Taylor (2004), for example, study shared savings incentives implemented by an HMO and estimate that medical expenditures were 5 percent lower than they would have been in the absence of incentives with no apparent decline in care quality.

[3] The Institute of Medicine's assessment of care quality in the U.S. healthcare system found that care delivery is often complex and poorly coordinated, leading to wasted resources, gaps in coverage, loss of

single-specialty practices rather than larger multi-specialty group practices.[4] The common-agency model we propose also provides insights on the effects of policies such as Accountable Care Organizations (ACOs) that aim to promote more efficient forms of contracting between payers and providers.

To illustrate the logic of our model, imagine two private payers who would like to encourage a common provider to improve care coordination by, say, implementing an electronic medical record system. Implementing such a system requires the provider to exert effort, but many of the benefits of the effort spent introducing the electronic system accrue to the payers not the provider.[5] A natural way to motivate the provider to implement the new system would be for payers to move away from traditional fee-for-service contracts and offer the provider a share of the savings that the electronic medical records system generates for the payer. In a common-agency setting, however, the shared savings incentives offered by one payer will also accrue to the patients covered by the other payer. Not surprisingly, this externality results in an equilibrium in which both payers offer weak incentives. As a result, the provider devotes low levels of effort and attention toward implementing the electronic medical records system.

If free-riding were the only common-agency induced market failure at work, we would expect to see an equilibrium in which private payers offered weak incentives for improved

---

information, and reductions in the speed and safety with which care is delivered (IOM, 2001). Many of the problems of poor coordination result either from mishandled referrals to specialists or from fragmented care delivery. Both problems are exacerbated by relatively weak investments in technology and process improvements that strengthen integration across providers and organizations. For a review of the problems resulting from poorly handled referrals, see Mehrotra, Forrest, and Lin (2011). For a review and discussion of the problem of care fragmentation, see Cebul, Rebitzer, Taylor, and Votruba (2008) and Rebitzer and Votruba (2011). For estimates of the costs resulting from fragmented care delivery, see Frandsen et al. (2015), Hussey et al. (2014), and Agha et al. (2016). For instances of investments in effective care coordination that deliver cost and quality benefits, see Milstein and Gilbertson (2009).

[4] Historically, medical care in the U.S. was delivered by practitioners operating out of their own offices or as attendings in hospitals. This arrangement granted physicians a great deal of professional autonomy which, as a group, they were loathe to surrender to larger organizations (Starr,1984; Robinson, 1999). Bundorf and Royalty (2014) estimate that as late as 1998, 29 percent of physicians worked in solo practices and 55 percent in practices of 9 or fewer physicians. In contrast, only 19 percent of physicians were employed in practices having 50 or more physicians. Since the beginning of this century, physicians have slowly migrated towards larger practices so that, by 2010, 18 percent were solo practitioners and only 40 percent worked in practices of 9 or fewer physicians. (Baker, Bundorf, and Royalty, 2014, Table 1). Despite this migration, a great deal of care is still delivered via small practices. According to the 2010 National Ambulatory Care Survey, 31.5% of office visits were to solo practices, and 67.5% were to offices with five or fewer physicians. Only 22.6% of office visits were to multi-specialty groups (Centers for Disease Control 2010, Table 2).

[5] For example, the electronic record system could allow the payer to track and discourage duplicative testing, treatments that are not cost-effective, excessive referrals to specialists or unwarranted emergency room visits.

care coordination. We would *not*, however, expect to find insurers and other private payers relying almost entirely on fee-for-service contracts that do not share any of the payer's gains from improved care coordination with providers. Yet this is the pattern historically observed in most of the US healthcare system.

To explain the anomalous reliance on fee-for-service contracts within a common-agency framework, we consider coordination failures among payers. We introduce coordination failures into our previous example by adding the reasonable assumption that the transition to electronic medical records also requires providers to purchase a new health information technology (HIT) system. The fixed, up-front costs of purchasing such a system subtly alters the common-agency problem and makes it more severe.[6] This is because the two payers will only deviate from traditional fee-for-service arrangements if they each believe that incentives jointly offered by *both* payers fully compensate the provider for these fixed up-front costs. If, in contrast, each payer believes that the other payer's contract includes weak incentives, then neither payer will find it optimal to shoulder the entire burden of motivating the provider to incur the fixed cost of the HIT system. In this case, the payers will stay with the traditional fee-for-service contract—even though such contracts are Pareto dominated by the relatively weak incentive contracts that common-agency supports. To the extent that many organizational innovations that improve care coordination involve sizeable fixed costs, sticking-point equilibria within a common-agency model offer a plausible account for the persistence of both fee for service payments and unsatisfactory care coordination.[7]

In a sticking-point equilibrium, providers also face weakened incentives to form integrated, multispecialty group practices and so to deliver care through small, single specialty practices. To see why, return again to the decision to invest in an HIT system. These systems enable superior coordination and information handoffs in referrals, but they typically do not allow for interoperability, that is, the easy exchange of information across organizations. In this setting, the gains from investing in HIT systems are greater when providers operate within a multi-specialty group practice, and the gains from forming multi-specialty group practices are similarly enhanced by investments in HIT systems. Put differently, because

[6] See Simon, et al., 2007 for evidence showing the most cited barrier to adopting HIT is up front costs

[7] A partial list of organizational innovations that improve the integration of care across providers includes: investments in clinical decision-making support; investments in managerial and financial systems such as payment methods, prospective budgets and resource planning, measures of provider performance, methods of disbursing shared savings to providers and back-office assistance; investments to create new standards of care and protocols that focus more on primary care physicians and non-physician providers as well as patient wellness and prevention. Each of these innovations plausibly involves a combination of up front fixed investments and ongoing expenditures of effort.

HIT investments and multi-specialty group practices are complementary, the failure to write incentive contracts that encourage efficient investments in HIT systems also depresses the returns to forming integrated multi-specialty group practices.[8]

Many others have observed that fee-for-service pay structures suppress investments in the technology and processes required for care coordination and integrated care delivery.[9] Our key contribution is to provide an explanation for the causes of these pay practices. By rooting the persistence of inefficient fee-for-service contracts in a specific market failure, our common-agency model also provides insights on the effects of public policies that aim to promote more efficient forms of contracting between payers and providers.

For example, under the Affordable Care Act, Medicare was empowered to write shared savings contracts with newly constituted Accountable Care Organizations (ACOs). Our common-agency model suggests two distinct mechanisms through which this policy can influence the contracts that private-payers write with providers. If there were no coordination failure so that contracts were shaped only by common-agency-induced free-riding among payers, Medicare's new incentive contracts will partially or fully crowd out already existing shared savings contracts. Things are different if common-agency also leads to a coordination failure among payers. In this case, introducing Medicare ACOs can "crowd-in" new, more efficient, private-sector contracts. Our model also suggests, however, that this jump-start effect will only manifest if Medicare's intervention is sufficiently aggressive.

The common-agency approach we develop in this paper has two distinctive implications that are not apparent in more familiar principal-agent models. First, in traditional principal-agent models, one might observe persistent fee-for-service contracts, but such contracts would persist only when they are efficient. As a result policies aimed at promoting shared saving incentives would be counterproductive in the sense that they would simply crowd-out efficient contracts. Secondly, common-agency problems become more severe as the number of payers increases: increasing the competitiveness of insurance markets may therefore not lead to more efficient contracting between insurers and providers.

Because common-agency models are less familiar than traditional principal-agent models, we conclude this introduction by briefly situating our approach within the larger literature. Common-agency models were first introduced by Bernheim and Whinston (1986b). Much

[8]Other sources of complementarity are also likely to be important, because multi-specialty groups typically confine their referrals to specialists and hospitals who are also in the group. Simon, et al. (2007) show that electronic health record adoption is significantly more common in larger, more integrated practices.

[9]See for example Crosson (2009), Burns and Pauly (2012) and Blumenthal (2011).

of the subsequent literature on common-agency models focuses on problems of lobbying and influence in political settings.[10] Ours is a complete-information moral-hazard model with risk-neutral parties and no negative transfers, so that the underlying source of agency costs arises from a trade-off between incentive provision and rent extraction (Sappington, 1983; Innes, 1990). Our set-up relies on public contracting variables, so that all payers' contracts depend on the same publicly observed variables, and the model is one of "delegated common agency," where the provider can reject any subset of the contracts she is offered.

Our model differs from the models commonly used in the literature in several ways. Imposing limits on transfers requires us to depart from the standard tools used to analyze the set of equilibria in common-agency models.[11] Our objective is also different. We seek to characterize the entire set of equilibrium action choices by the provider within a specific class of games. This differs from the more common approach of describing the distributional properties of a subset of equilibria in a general class of games. In contrast to existing common agency models of public contracting, multiplicity of equilibrium actions is not ubiquitous and does not result from parties' flexibility in specifying off-path contractual payments. (Bernheim and Whinston, 1986a; Kirchsteiger and Prat, 2001; Besley and Coate, 2001; Martimort and Stole, 2009). In our model, whether there are multiple equilibrium actions depends on features of the provider's cost function, and we provide necessary and sufficient conditions for there to be multiple equilibrium actions.

The remainder of the paper proceeds in five sections. In Section 2, we set up the model and describe necessary and sufficient conditions for equilibrium. In Section 3, we describe necessary and sufficient conditions under which our conclusions about sticking points hold. Section 4 considers the effects of policies (such as ACOs) aimed at promoting more efficient contracts. Section 5 considers the effects of common-agency on the formation of integrated, multi-specialty groups. Section 6 presents a set of testable hypotheses that derive from our model and relates them to stylized facts emerging from the empirical literature. We conclude by discussing limitations and directions for future research.

[10]See for example Dixit, Grossman, and Helpman (1997), Besley and Coate (2001), and Kirchsteiger and Prat (2001). To our knowledge, the only other heathcare application is Glazer and McGuire, 2002.

[11]In the terminology of Martimort and Stole (2012), our contracting space is not bijective, meaning that the payers cannot effectively "undo' the contracts put in place by others.

2 Theoretical Analysis

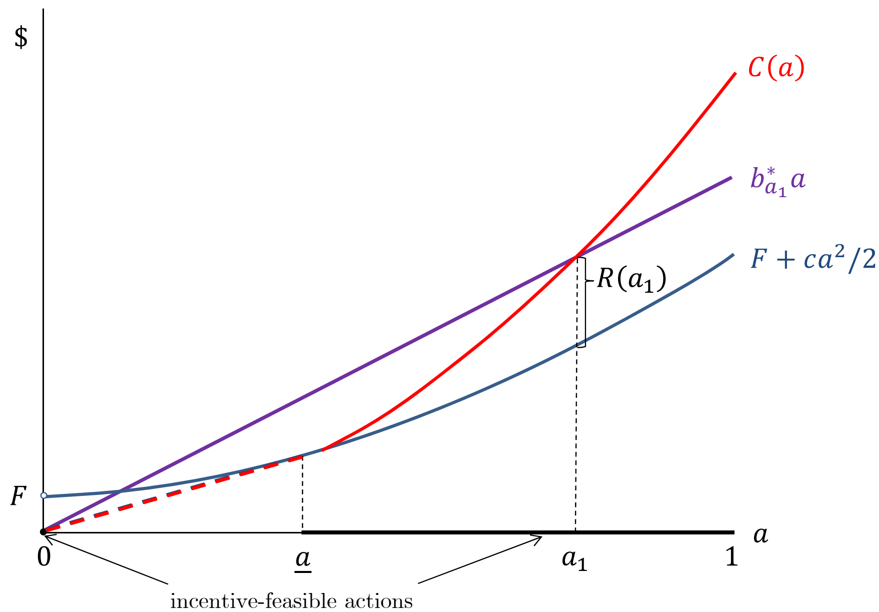
In this section, we develop a simple model that highlights both the "free-riding" and "coordination failures" that emerge under common agency. The principals in our model are the payers who wish to motivate a common agent (the provider) to invest in improved care coordination. Because the cost of these investments accrue to providers and many of the benefits accrue to payers, some sort of incentive contract is required. These contracts will typically not provide first-best incentives, because incentive contracts entail some agency costs.

In our set-up, introduced formally in Section 2.1, payers cannot reduce up-front payments to capture all the rents that the contract generates. Higher powered incentives create more surplus, but a limited-liability restriction causes some of the surplus to flow to the provider as rent. Agency costs therefore emerge as the result of a trade-off between incentive provision and rent extraction. In Section 2.2, we analyze equilibrium actions under our common-agency model. In comparison to the simpler and better known case of a single principal and agent, we find that the presence of multiple payers effectively amplifies agency costs. The magnitude of this amplification depends on what contracts payers expect other payers to offer.

To build intuition for our analysis, we use a running example in which payers seek to motivate a shared provider to invest in an electronic medical records system. This system reduces the cost of care delivery to payers by improving care coordination, but it imposes two costs on the provider. The first of these is the fixed cost of the HIT system. The second is the variable cost of the effort required to ensure successful implementation. Providers lack the knowledge to directly purchase or monitor implementation efforts. They therefore offer the provider a non-negative bonus if certain cost targets are met. This bonus is a vehicle for sharing the cost savings generated by the HIT system with the provider.

Figure 1 depicts the familiar incentive design problem that a unitary principal would face. The provider chooses the probability, a, that a binary contractible outcome is successful. The provider's choice of investment level is on the horizontal axis. In this context, since outcomes are binary, any contract can be represented as a straight line from the origin. Given a contract, the provider chooses an investment level to maximize the difference between his expected rewards and his action costs. Consistent with our HIT system example, Figure 1 depicts both a fixed cost (the purchase of the system) and a variable cost representing the effort and attention required for successful implementation.

Figure 1: Unitary Principal Incentive Problem



This figure illustrates the provider's cost function (blue), the cost-minimizing contract for a particular investment level (purple) and its associated incentive rents, the set of incentive-feasible levels of invesment—levels for which there is a contract that could get the provider to choose that level of investment—and the unitary principal cost function (red) for what we will refer to as the health-IT (HIT) example.

Given the depicted contract, the provider would choose investment level a_1 at cost $c(a_1) = F + ca_1^2/2$ if $a_1 > 0$ and $c(0) = 0$, and would receive expected rents $R(a_1)$ equal to the difference between his expected benefits and costs. The effective cost to the payer of getting the provider to choose investment level a_1, denoted $C(a_1)$, is therefore equal to the provider's costs, $c(a_1)$, plus the rents required to get him to choose a_1, $R(a_1)$. The need to give the provider rents is the source of agency costs that leads the payer to offer a contract that does not maximize total surplus.

When there are multiple payers, these agency costs are amplified by two additional sources of contracting frictions. The first additional source of friction is a free-rider problem among payers: at the margin, to get the provider to choose a higher level of investment, each payer has to effectively top off all the contracts she believes all others are putting in place, which means that she is effectively facing the entire marginal agency costs while receiving only a fraction of the marginal benefits. The second friction results from a coordination failure. If a payer believes no other payer will offer incentive contracts, then she has to shoulder the entire burden of getting the provider to choose any positive investment level, which can be substantial when the costs of the provider's actions are lumpy. However, if she believes the other payers are offering high-powered incentive contracts, she only has to shoulder a small part of the burden of getting the provider to choose a positive investment level. In this example, and as we demonstrate much more generally below, these coordination problems only emerge when there are fixed costs in addition to the standard variable costs.

2.1 The Model

There are N risk-neutral payers (denoted $P_1, \ldots, P_N$) and a single risk-neutral provider. There is a binary outcome, $y \in \{0, 1\}$, which can either be success at hitting a cost target, or failure, and the probability of success is determined by the provider's action choice a: $\Pr[y = 1 | a] = a \in \mathcal{A} \subseteq [0, 1]$, where $\mathcal{A}$ is a compact set. We refer to a as the provider's **care-coordination investment level**. A successful outcome yields a total benefit B to all the payers, and we assume this benefit is equally distributed among them, so that payer i receives benefit $B_i = B/N$ if $y = 1$ and 0 if $y = 0$. The action a is costly to the provider: choosing a costs $c(a)$, where c is lower semicontinuous and nonnegative.

Payers simultaneously and noncooperatively offer bonus contracts $b_i \geq 0$, which specify a nonnegative payment to be made from P_i to the provider if $y = 1$ and zero if $y = 0$. If $b_i = 0$, we will say that P_i offers a **fee-for-service contract**, and if $b_i > 0$, we will say that P_i offers a **shared savings contract**. The provider can decide whether to accept a subset of the contracts, and if he accepts no contracts, he receives 0. Since contracts must pay a nonnegative amount to the provider, we can without loss of generality assume he accepts all contracts. As a result, the provider cares about, and is motivated by, the **aggregate contract** $b = b_1 + \cdots + b_N$. If the provider is indifferent among several action choices, we assume he chooses the highest action he is indifferent among.

The timing of the game is as follows. First, $P_1, \ldots, P_N$ simultaneously offer $b_i \geq 0$ to the provider. The provider then chooses an action $a \in \mathcal{A}$ at cost $c(a)$. The outcome $y \in \{0, 1\}$ is realized, and $b_i y$ is paid from P_i to the provider.

A **subgame-perfect equilibrium** of this game is a set of nonnegative contracts $b_1^*, \ldots, b_N^*$ and an action-choice function a^* such that: (1) given b_{-i}^* and the provider's choice function, P_i optimally offers b_i^*, and (2) given $b_1^*, \ldots, b_N^*$, the provider optimally chooses a^*. We will say that $b^* = b_1^* + \cdots + b_N^*$ is an **equilibrium aggregate contract**, and a^* is an **equilibrium action** if they are part of an equilibrium. Denote $\mathcal{A}^* \subset \mathcal{A}$ to be the **set of equilibrium**

actions. Our objective is to characterize this set and to describe how it depends on properties of the function $c(\cdot)$. In particular, our general specification of the cost function will allow us to identify the precise properties of the cost function that are necessary for there to be multiple equilibrium actions.

2.2 Computing Equilibrium Actions

In order to compute the set of equilibrium actions, it will first be useful to solve the problem that a unitary principal would face if there were no other payers. The payer wants to choose an action a she wants the provider to undertake, and the cheapest contract b that gets him to take action a. Define the **unitary principal cost function** $C : \mathcal{A} \to \mathbb{R}_+$ to be the solution the unitary principal's cost-minimization problem

$$C(a) = \min_{b \geq 0} ba$$

subject to the provider's incentive-compatibility constraint

$$a \in \underset{a'}{\operatorname{argmax}}\, ba' - c(a').$$

Note that there may be some actions a for which no contract b could get the provider to choose a. We will refer to the actions that the payer could in principle get the provider to choose as **incentive-feasible actions**, and we will denote the set of such actions by $\mathcal{A}^{feas}$. Because the provider's preferences are additively separable in money and costs, we can always write the unitary principal's cost function as the sum of the provider's action costs and the agency costs, $C(a) = c(a) + R(a)$ for all $a \in \mathcal{A}^{feas}$, where $R(a)$ are the incentive rents required to get the provider to choose action a. For any action that is not incentive-feasible, the payer's objective function is $C(a) = +\infty$. We will say that a solution to this problem is a **cost-minimizing contract implementing action** a and denote the resulting contract by b_a^*. We show in Lemma 6 in the appendix that cost-minimizing contracts satisfy $b_a^* = \partial^- c(a)$, where $\partial^- c(a)$ is the smallest subgradient of c at a.

We begin by laying out two conditions that will be used in some of the results. The first condition allows us to generalize the first-order conditions to cases where the provider's cost function is not well behaved. We are specifically interested in cases where the providers cost function entails fixed or "lumpy" costs as this is precisely when common-agency problems generate coordination failures. Preliminary to stating this condition, we define the quantity

$$Z(a, a') = \frac{\partial^- c(a) - \partial^- c(a')}{a - a'}.$$

CONDITION CR (convex rents). *For each $a, a' \in \mathcal{A}^{feas}$ with $a \geq a'$, $Z(a, a')$ is increasing in a and a'.*

In our setup, to motivate the provider to take an action a, the payer has to give the provider **incentive rents** $R(a)$. In models of this sort with limited-liability constraints, inducing a higher action requires the principal to provide the agent with higher rents, implying that $R(a)$ is increasing. Condition CR further implies that the incentive rents schedule is not only increasing but is essentially a convex function.[12] Condition CR is implied by $c'''(a) \geq 0$, which is a standard condition invoked in moral-hazard models with limited liability and binary outcomes. We will say that c is **well behaved** if it satisfies the following condition.

CONDITION W (well-behaved). $\mathcal{A} = [0, 1]$, c is thrice-differentiable with $c', c'' > 0$, and $c''' \geq 0$.

When the provider's cost function is well-behaved, there will be a unique equilibrium action. When the provider's cost function is not well-behaved, there may be multiple equilibrium actions.

Figure 1 illustrates, for the HIT example, the provider's cost function, the set of incentive-feasible investment levels (actions), the cost-minimizing contract for investment level a_1 and its associated incentive rents $R(a_1)$, and the unitary principal's cost function $C(a)$. Because the provider must cover his fixed costs in order to be willing to choose any positive level of investment, there will be some set of investment levels $(0, \underline{a})$ that he would not be willing to choose for any contract he faces. For higher values of a, the gap between $C(a)$ and $c(a)$ is increasing and convex, since the cost function in the HIT example satisfies Condition CR.

The following efficiency benchmarks will help us to interpret the common-agency equilibrium actions derived below. A **first-best action** a social planner would choose is any action satisfying

$$a^{FB} \in \underset{a \in \mathcal{A}}{\operatorname{argmax}}\, Ba - c(a).$$

The first-best action is always incentive-feasible since it is an action the provider would be willing to choose if the aggregate bonus were $b = B$. Because actions are not directly contractible, the first-best action will typically not be an equilibrium action.

[12] More precisely, it ensures that $R(a)$ is convex-extensible on $[0, 1]$, where $R : \mathcal{A}^{feas} \to \mathbb{R}$ is **convex-extensible on** $[0, 1]$ if R is the restriction of a convex function $\tilde{R} : [0, 1] \to \mathbb{R}$ to the domain $\mathcal{A}^{feas}$. (See Kiselman and Samieinia (Forthcoming))

A **second-best action** is any action a unitary principal would implement or

$$a^{SB} \in \operatorname*{argmax}_{a \in \mathcal{A}} Ba - C(a),$$

where $C(a)$ is the unitary principal's cost function defined above. The second-best action differs from the first-best because of agency costs. Function $c(a)$ includes only the agent's cost of action while $C(a)$ includes as well the cost to the principal of rents earned by the provider. As we discuss below, actions under common agency (which may be termed "third-best") differ from the conventional principal-agent second-best action defined here because agency costs are typically higher in common-agency settings.

We can define the second-best action using marginal conditions. Define $MC(a)$ to be the set of subgradients of C at a. If C is everywhere differentiable, this set will be a singleton for all a. We refer to $MC(a)$ as the **unitary principal's marginal-cost correspondence**. The second-best action a^{SB} satisfies $B \in MC\left(a^{SB}\right)$ if Condition CR is satisfied. In general, the second-best action will be below the first-best action, because the incentive-rents schedule, $R(a)$, is an increasing function. Moreover, we will show below that the second-best action in general represents an upper bound on equilibrium actions in the common-agency game.

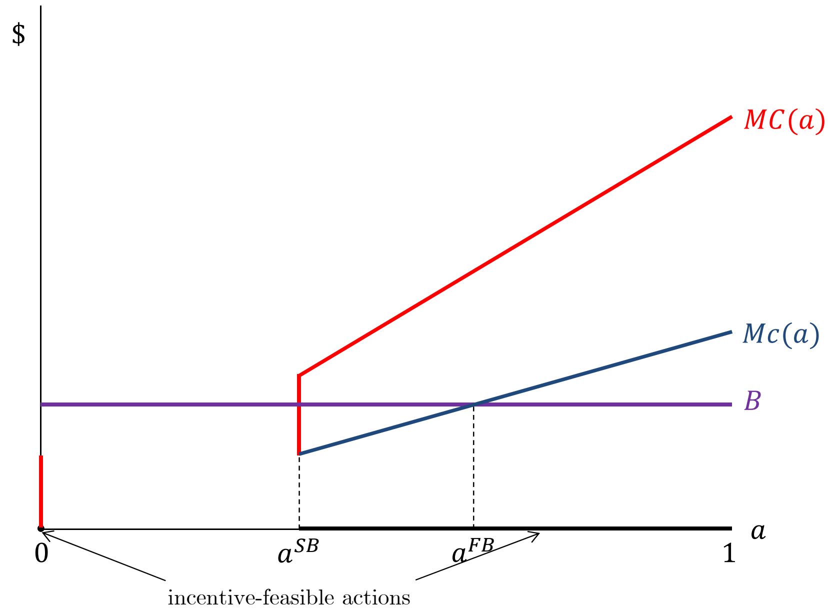
Figure 2 below illustrates, for the HIT example, the unitary principal's marginal-cost correspondence $MC(a)$ as well as the agent's marginal-cost correspondence, which we denote by $Mc(a)$ and the payer's marginal benefit B. B intersects $MC(a)$ at the second-best investment level, and it intersects $Mc(a)$ at the first-best investment level.

We are now in a position to describe the equilibrium conditions under common-agency; i.e., when there are $N \geq 2$ payers. We show in Corollary 1 in the appendix that when it comes to characterizing the set of equilibrium actions, $\mathcal{A}^*$, it is without loss of generality to focus on symmetric equilibria in which all payers offer the same contract to the provider. We will say that payer i **supports action** $\bar{a}$ if she offers the provider the contract $b_i = b^*_{\bar{a}}/N$. An action a^* will therefore be an equilibrium action if and only if, whenever all payers other than payer i support action a^*, payer i also wants to support action a^*. We refer to the function $C_N(a, \bar{a}, N)$ as a payer's **effective cost function** given others support $\bar{a}$. Theorem 1 below provides necessary and sufficient conditions for an action a^* to be an equilibrium action.

THEOREM 1. *There is at least one equilibrium action, and there exists a function $C_N(a, \bar{a}, N)$ such that action a^* is an equilibrium action if and only if*

$$a^* \in \operatorname*{argmax}_{a \in \mathcal{A}} Ba - C_N(a, a^*, N).$$

Figure 2: Marginal Conditions for Unitary Principal's Problem



This figure illustrates, for the HIT example, the agent's marginal-cost correspondence (blue), the unitary principal's marginal-cost correspondence (red), and the unitary principal's marginal benefit (purple). It also illustrates the first-best and second-best investment levels, a^{FB} and a^{SB}, respectively.

The function $C_N(a, \bar{a}, N)$ *exhibits increasing differences in* (a, N) *and decreasing differences in* $(a, \bar{a})$.

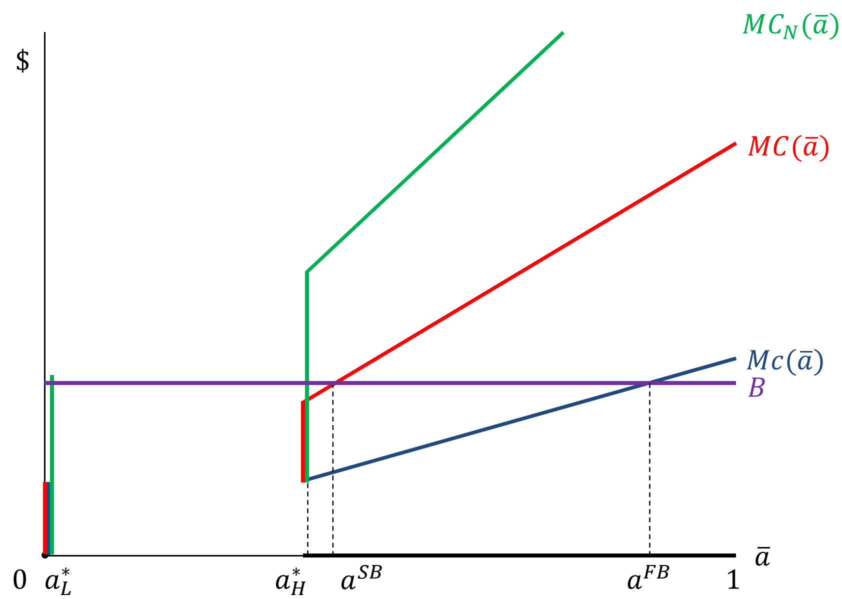
Proof of Theorem 1. See appendix.

Theorem 1 casts the common-agency game's set of equilibrium actions—which is a potentially complicated object involving the strategies of multiple principals—in terms of a decision made by a single optimizing player. The intuition allowing this simplification is that a single principal can be thought of as choosing not only her own contract, b_i, but—since she takes the other principals' contracts as given—the aggregate contract b and therefore the action, a. In particular, the theorem shows that we can characterize the set of equilibrium actions by looking for the solutions to a problem of a unitary principal choosing an action given a modified cost function, which in turn takes as a parameter a "proposed" equilibrium action. If the solution to the problem coincides with the proposed equilibrium action a^*, then a^* is indeed an equilibrium action.

Characterizing the common-agency game in terms of a unitary principal's decision allows us to draw an analogy with the single-principal setting and highlight the additional sources of inefficiency that arise from the common-agency problem. Analogous to the case with a unitary principal, we can define $MC_N(\bar{a})$ to be the set of subgradients of $C_N(a, \bar{a}, N)$ (with respect to a) evaluated at $\bar{a}$. We refer to $MC_N(\bar{a})$ as the **multiple-principal's marginal cost correspondence**. An action a^* is an equilibrium action if and only if the marginal cost correspondence $MC_N(a^*)$ contains the payers' aggregate marginal benefit, B.

Figure 3 illustrates, for the HIT example, the multiple-principal's marginal cost correspondence $MC_N(\bar{a})$ as well as the unitary principal's marginal-cost correspondence and the provider's marginal-cost correspondence. The payers' aggregate marginal benefit, B, intersects the $MC_N(\bar{a})$ curve twice, which implies that there are two equilibrium levels of investment: the low equilibrium level, a_L^*, and the high equilibrium level, a_H^*.

Figure 3: Marginal Conditions for the Common-Agency Problem



This figure illustrates, for the HIT example, the equilibria for three different games, which are each defined by the intersection of the marginal benefit curve (horizontal purple line B) and the respective marginal cost curves (blue, red, and green). The blue curve corresponds to the marginal cost of effort faced by a social planner (i.e., the agent's marginal cost), and the intersection with B corresponds to the first-best effort level, a^{FB}. The red curve includes marginal effort costs and agency costs and corresponds to the marginal cost faced by a unitary principal. The intersection with B corresponds to the equilibrium of a conventional principal-agent game. The green curve shows the marginal cost faced by a principal in a multiple-principal setting, and the intersections with B correspond to equilibria of the common-agency game. Action a_H^* is the third best action under common agency and a^{SB} is the second best action under traditional agency with a single principal. Action a_L^* is the action without any shared savings incentives.

As Figure 3 illustrates, both equilibrium levels of investment are below the second-best, which in turn is below the first-best level of investment. The difference between the low and the high equilibrium levels of investment results from a coordination failure. If payer i believes all other payers are supporting zero investment, then if payer i wants the provider to choose a higher investment level, she has to shoulder the entire burden of getting him to do so. However, if she believes all other payers are supporting action a_H^*, then she only has to shoulder a small part of the burden of getting him to choose a_H^*. As a result, payers can get stuck in a vicious cycle in which none of them offers high-powered shared savings contracts, because they think the others will not offer high-powered shared savings contracts. We now explore the implications of this result.

3 Equilibrium, Efficiency, and Coordination Failures

Common-agency problems amplify the agency costs that would arise in the interaction between a unitary principal and a provider. Our first result in this section is that the market failures in common-agency games are generally more severe than in conventional principal-agent models. Specifically, the highest equilibrium action in the common agency problem, a_H^*, is inefficient in that it results in actions that are no greater than second-best actions.

PROPOSITION 1. *The highest equilibrium action a_H^* is bounded from above by a^{SB}.*

Proof of Proposition 1. See appendix.

In general, the inefficiency in equilibrium actions arises from three sources. The difference between the first-best action and the second-best action is the standard distortion that arises because of agency costs resulting from the trade-off between incentive provision and rent extraction in the unitary principal problem. The second potential source of inefficiency is a free-rider problem among payers: at the margin, to get the provider to choose a higher action, each payer has to effectively top off all the contracts she believes all others are putting in place, which means that she is effectively facing the entire marginal cost while receiving only a fraction of the marginal benefit.

The third potential source of inefficiency is due to possible coordination failures, which arise when there are multiple equilibrium actions. Specifically, we will say $a_L^* = 0$ is a **sticking-point equilibrium** if $a_L^* = 0$ is an equilibrium action, and $a_H^* > 0$ is also an equilibrium action. In a sticking-point equilibrium, all payers offer fee-for-service contracts (i.e., $b_i^* = 0$ for all payers), and the provider does not undertake any care-coordination investment.

Not all common-agency games result in coordination failures. An important implication of our characterization of equilibrium actions is that if c is well behaved, there is a unique equilibrium action. When Condition W is satisfied, $MC_N(\bar{a})$ is a singleton and is equal to $c'(\bar{a}) + R'(\bar{a})$, both of which are increasing in $\bar{a}$. We will say that there is a **nondifferentiability at** a if $\partial^- c(a) < \partial^+ c(a)$, where $\partial^+ c(a)$ is the largest subgradient of c at a. The next proposition provides necessary and sufficient conditions for there to be multiple equilibrium actions.

PROPOSITION 2. *Suppose Condition CR holds. If there are multiple equilibrium actions* a_L^* *and* $a_H^* > a_L^*$*, then there is a nondifferentiability at* a_L^**. If there is a nondifferentiability at* $\hat{a}$*, then there exists a* B *for which* $a_L^* = \hat{a}$ *and* $a_H^* > \hat{a}$*. If Condition W holds, then there is a unique equilibrium action* a^**.*

Proof of Proposition 2. See appendix.

Proposition 2 implies that payers coordinating on an inefficient action when a more efficient equilibrium action exists can only occur when there is a nondifferentiability in the provider's cost function. In particular, this result implies that a sticking-point equilibrium can only arise if the provider's cost function is nondifferentiable at 0.

This nondifferentiability at 0 condition appears to be a narrow and technical one, but it has broad and important economic implications. For example, it is satisfied in the case of discrete investments or, as in our HIT example, when investments have a discrete component such as a fixed cost. In the healthcare context, innovations involving new care processes or information technologies appear likely to meet the nondifferentiability criterion. The criterion will manifestly not be satisfied, however, in the case most studied by prior common-agency models—when the provider's cost function is well-behaved. Thus, under a conventional setup with well-behaved cost functions, we should not observe private payers relying strictly on fee-for-service compensation systems.

The next proposition shows that equilibrium actions are, in some sense, Pareto ranked.

PROPOSITION 3. *Suppose Condition CR holds. If there are multiple equilibrium actions,* a_L^* *and* $a_H^* > a_L^*$*, then (i) there exists an equilibrium with* $a^* = a_H^*$ *that Pareto dominates an equilibrium with* $a^* = a_L^*$*, and (ii) there does not exist an equilibrium with* $a^* = a_L^*$ *that Pareto dominates any equilibrium with* $a^* = a_H^*$*.*

Proof of Proposition 3. See appendix.

For the first part of the proposition, note that symmetric equilibria are Pareto ranked, because each payer receives a share $(1/N)$ of the profits the unitary principal would receive, and the unitary principal's profits are increasing in the provider's action (among his incentive-feasible actions). Further, since incentive rents $R(a)$ are increasing in a for $a \in \mathcal{A}^{feas}$, the provider's profits are also increasing in the action he is induced to take. For the second part of the claim, since $R(a)$ is increasing in a for $a \in \mathcal{A}^{feas}$, the provider is worse off for lower actions, so it cannot be that any equilibrium with $a^* = a_L^*$ Pareto dominates any equilibrium with $a^* = a_H^*$.

The possibility of an inefficient equilibrium at zero investment depends crucially on the common-agency concerns arising with multiple payers $(N > 1)$. In a setting with a unitary principal, nondifferentiabilities in the provider's cost function at zero can certainly lead to an equilibrium with zero investment and zero incentives, but only when zero investment is efficient. To see this, note that if positive investment is efficient, there must be a level a' where average benefit Ba' exceeds the cost $c(a')$, which means there is some $b' < B$ for which $b'a'$ also exceeds $c(a')$. The provider will strictly prefer investing at the level a' to zero if given incentive b', and such a b' also makes the payer strictly better off than setting $b = 0$.

4 Common Agency and Public Policy to Improve Contracting

We have demonstrated that common-agency problems lead to third-best incentive contracts or, in the case of sticking-point equilibria, to incentive contracts that are Pareto dominated by the third-best outcomes. In this section we consider whether and how public policy interventions might be used to improve contracting. We will focus our discussion on a particular policy intervention that has gained a great deal of recent attention: Accountable Care Organizations (ACOs). Our findings, however, emerge from the fundamental logic of common-agency market failures and are not limited to this particular policy.

ACOs are entities composed of hospitals and/or other providers that contract with the Center for Medicate Services (CMS) to provide care to a large bloc of Medicare patients (5,000 or more). Although the details vary and are complex, ACOs that come in under their specified cost benchmarks keep a fraction of the savings conditional on meeting stringent quality standards.[13] As a public policy intervention, ACOs are essentially a commitment by

[13]ACOs can be formed by groups of tremendously varied size and integration, from integrated delivery systems such as Kaiser Permanente and Geisinger Health Systems, to loosely affiliated networks of providers. These latter ACOs typically lack a large, salaried multi-specialty group of physicians; they frequently lack a

Medicare to reduce reliance on fee-for-service and to engage in a new form of contracting with providers. By introducing shared savings contracts, ACOs seek to directly stimulate provider investments in more efficient, integrated care delivery. As the common agency problem makes clear, the efficacy of these incentives also depends on the contracts offered by private sector payers. An important goal of ACOs, therefore, is to use Medicare's contracts to jump-start the introduction of similarly efficient shared savings contracts by private payers. In this way ACOs offer the prospect of transforming incentives throughout the healthcare system. Whether ACOs can, in fact, play such a transformative role depends on the specifics of the market failures that inhibit efficient contracting. In the context of our common-agency model, we find that ACOs can either crowd-out or crowd-in efficient private sector contracting. As we detail below, the specific outcomes depend on the nature of the provider's cost function and the magnitude of the ACO intervention.

To model the effect of ACOs we return to our main model with a single provider and multiple private payers. In this setting, ACO contracts with Medicare act as an additional shared-savings payment, S, that is chosen exogenously via public policy. This payment is common knowledge to all other payers. In this setting, the provider's payoff is $b+S$ if $y=1$ and 0 if $y=0$. To make clear that equilibrium actions depend on the ACO shared-savings contract, denote the least equilibrium action by $a_L^*(S)$ and the greatest equilibrium action by $a_H^*(S)$, and denote equilibrium aggregate contracts by $b^*(S)$.

As in the main model, there exists a function $C_N(a, \bar{a}, N, S)$ such that an action a^* is an equilibrium action if and only if

$$a^* \in \underset{a \in \mathcal{A}}{\operatorname{argmax}}\, Ba - C_N(a, a^*, N, S),$$

and the function described in Theorem 1 is a special case of this function with $S=0$. Importantly, C_N satisfies decreasing differences in a and S: a higher-powered ACO contract decreases the payers' costs of getting the provider to undertake a higher action. The consequences of the ACO shared-savings payment S for equilibrium actions depends on what the equilibrium actions would be in the absence of an intervention. First, in settings in which

hospital as part of the entity; and may often have little experience in managing contracts that deviate from the fee-for-service norm. Allowing loosely affiliated networks to form ACOs greatly expands the potential reach of the policy. Moses et al. report that there are more than 300 ACOs in the United States with 8% of Medicare patients eligible to be served, with a goal to have one-third of the Medicare recipients enrolled by 2018. The effects of the program are not limited to Medicare. ACOs are also expected to develop similar contracts with private insurers – thereby spreading cost-effective, integrated care throughout the health care system.

there are no nondifferentiabilities in the provider's cost function, the ACO shared-savings contract has the perverse effect of reducing the incentives for payers to offer high-powered contracts, as the following proposition establishes.

PROPOSITION 4. *Suppose Condition W holds. Then for each S, there is a unique aggregate equilibrium contract $b^*(S)$, which is decreasing in S.*

Proof of Proposition 4. See Appendix.

When the provider's cost function is well-behaved, there is a unique equilibrium action. In this setting, the market failure responsible for inefficiently low-powered incentives for care-coordination investments is free riding among the multiple payers. Proposition 4 shows that ACO shared-savings payments will partially crowd out private shared savings incentive contracts in this case.

When coordination failures drive the inefficiency, however, even small ACO shared-savings contracts can *increase* private shared savings incentive contracts and improve social welfare. To make this point precise, let $W_L(S) = Ba_L^*(S) - c(a_L^*(S))$ denote aggregate surplus in the least equilibrium under ACO shared-savings payment S. We show that even small increases in S can substantially increase $W_L(S)$. Of course, this improvement comes at the cost of the expected subsidy expenditure $K(S) = S \cdot a_L^*(S)$. Since public funds may be costly to raise, due to distortionary taxes or other considerations, whether or not the ACO shared-savings contract improves social welfare depends on whether its social return, defined as $(W_L(S) - W_L(0))/K(S)$ clears some hurdle rate κ, which corresponds to the cost of raising public funds. Proposition 5 shows that when there are coordination failures, ACO shared-savings contracts can increase the strength of private-payer contracts and increase social welfare at a return greater than any given hurdle rate κ.

PROPOSITION 5. *Suppose Condition CR holds, and there is a sticking-point equilibrium. Then there exists a B and an ACO intervention $S > 0$ such that $b_L^*(S) > b_L^*(0)$. Additionally, for any value $\kappa > 0$, there exists a B for which the returns to an ACO intervention are greater than κ in the least equilibrium.*

Proof of Proposition 5. See Appendix.

In contrast to Proposition 4, Proposition 5 shows that when there are multiple equilibrium actions in the absence of an ACO shared-savings contract, an ACO shared-savings contract can in fact lead to an increase in the strength of the incentives in private-payer contracts. Thus, in a setting where prior to the introduction of ACOs, payers had been in a sticking point equilibrium, the introduction of ACOs has the potential to jump-start incentive provision by private payers. Moreover, the social returns of such a jump-start can potentially be very large relative to the cost of the intervention itself. Note that Proposition 5 provides a *lower* bound on the potential social returns to an ACO policy when the initial (pre-ACO policy) equilibrium is at a "sticking point," since the result bounds the social return corresponding to the lowest equilibrium; the return would be even higher if payers happened to coordinate on a different equilibrium following the introduction of the ACO contract.

The welfare-improving function of ACO contracts depends on two factors: nondifferentiabilities in the provider's cost function and common agency. As discussed above, nondifferentiabilities arise from fixed costs or lumpy investments of the sort often found in investments in organizational processes and technologies that aim to promote improved health care coordination and integrated care. The presence of fixed costs or other sources of nondifferentiability alone, however, is not sufficient for ACO-like subsidies to increase welfare. If there was only one payer, then ACO subsidies that jump-start investment above zero reduce welfare. This occurs because in the one-payer case with a nondifferentiability in the provider's cost function at zero, equilibrium investment is only zero if that is efficient, as noted above—a policy which increases investment above zero would in this case reduce welfare. Common-agency concerns are therefore an essential part of the theoretical rationale for ACO and other policy interventions aimed at improving contracting.

These two propositions highlight the different policy implications of the two different types of distortions introduced by the common-agency market failure. When "free-riding" prevails, Proposition 4 establishes that policy interventions aimed at subsidizing improved contracting crowds out private sector investments. When coordination failures prevail as they do in "sticking point" equilibria, Proposition 5 establishes that policies aimed at promoting improved contracting can "crowd in" new investments and generate a positive social return.

5 Common Agency and the Formation of Integrated, Multi-specialty Groups

This section of the paper considers the implications of the common-agency market failure for health care delivery organizations. Specifically, we argue that investments in care coordination are complements to the formation of multi-specialty integrated care delivery organizations. By discouraging the former, common-agency problems also discourages the latter. In this way, common-agency helps support a fragmented system of care delivery. The analysis in this section is based on the firm-boundaries model of Hart and Holmstrom (2010) and Legros and Newman (2013) and emphasizes the trade off between coordination under integration and professional autonomy under non-integration.

We introduce the problem of integrated care delivery through our now-familiar example of an HIT system investment. Specifically, we imagine a setting in which there are two doctors in different specialties who operate independent practices. By virtue of their different specialties, each has a preference for a different type of HIT system, but the benefits of care coordination are greatest when both physicians invest in the same system. One way to ensure that the doctors each choose the same system is for each doctor to join a multi-specialty integrated practice and to give the decision about which IT system to purchase to the integrated practice. By agreeing to unified control of the investment decision, the doctors are trading off professional autonomy for enhanced integration and coordination. To the extent that professional autonomy is valuable to physicians while many of the gains from enhanced coordination accrue to payers, the payers will wish to promote integration by offering such practices shared savings incentives contracts. The payoffs from these incentives can then be used to compensate physicians for the loss of professional autonomy integration entails.

To make this argument more formally, suppose there are two doctors, A and B, who must make a pair of **horizontal coordination decisions** $d_1, d_2 \in \{0,1\}$ and choose an action $a \in \mathcal{A} \subseteq [0,1]$ at financial cost $c(a)$. The action and the horizontal decisions determine the probability that a public outcome $y \in \{0,1\}$ is equal to 1, with $\Pr[y=1|\, a, d_1, d_2] = a(1-|d_1-d_2|)$. The public outcome, along with the aggregate bonus b offered by the payers determines the **monetary payoffs** the doctors receive, $\pi = by - c(a)$. Further, the doctors receive **private benefits** associated with the horizontal coordination decisions that are made. Doctor A receives $u_A = -d_1$ and therefore prefers $d_1 = 0$, and doctor B receives $u_B = -\alpha(1-d_2)$ and therefore prefers $d_2 = 1$. The parameter α scales the relative value the two doctors place on professional autonomy, and we assume without loss of generality that $\alpha \leq 1$, so that doctor A incurs a larger cost if her preferred horizontal decision is not made. The horizontal coordination decisions and the private benefits are non-contractible, while the rights to make the horizontal coordination decisions, the right to choose the action, and the monetary payoffs are alienable and ex ante contractible. Neither the decisions nor the action is ex post contractible.

We will consider two governance structures, which we denote by $g \in \{I, NI\}$, where $g = I$ denotes provider integration into a multi-specialty group practice, and $g = NI$ denotes non-integration (or two single-specialty practices). Under integration, doctor A receives the monetary payoffs, makes both horizontal coordination decisions, and chooses the action. Under non-integration, doctor A receives the monetary payoffs, makes horizontal decision d_1, and chooses the action. Doctor B makes horizontal decision d_2.[14]

The timing of the game with provider organizational choice is as follows. First, $P_1, \ldots, P_N$ simultaneously offer $b_i \geq 0$ to the doctors. The doctors then bargain over a governance structure $g \in \{I, NI\}$. Whoever possesses control under g makes decisions and chooses the action $a \in \mathcal{A}$, and whoever possesses the monetary payoffs incurs the associated cost, $c(a)$. The outcome $y \in \{0, 1\}$ is realized, $b_i y$ is paid from P_i to whomever possesses the monetary payoffs, and private costs are realized. A subgame-perfect equilibrium of this game is a set of contracts, a governance structure choice, horizontal decisions, and an action such that each player is choosing optimally given others' choices. Define $V(b)$ to be the maximized *monetary* payoffs attainable by the two doctors given aggregate bonus b:

$$V(b) = \max_a ba - c(a).$$

Note that by the envelope theorem $V(b)$ is non-decreasing.

Under non-integration, doctor B will choose $d_2 = 1$, so doctor A's problem is:

$$\max_{a, d_1} ba(1 - |d_1 - 1|) - d_1 - c(a).$$

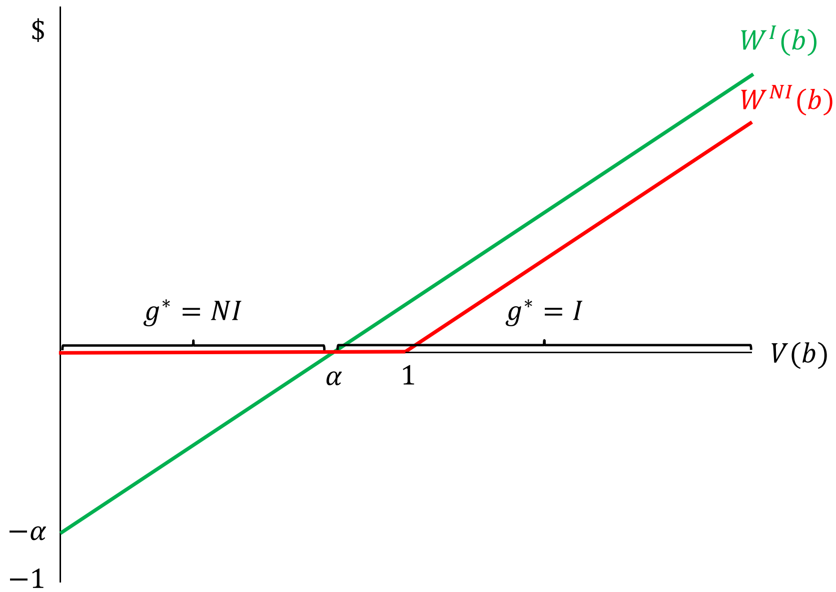
Her problem is therefore to choose whether to minimize her private costs by choosing $d_1 = 0$, in which case she will also prefer to choose $a = 0$, or to coordinate with doctor B by choosing $d_1 = 1$, in which case she will choose a to maximize the monetary payoffs. She will opt for the former if b is small and for the latter if b is large. We will denote total surplus for the doctors under non-integration by $W^{NI}(b)$, and by Lemma 11 in the appendix, we have that $W^{NI}(b) = \max\{V(b) - 1, 0\}$.

Under integration, doctor A will choose $d_1 = d_2 = 1$, and she will choose a to maximize the monetary payoffs. Total surplus for the doctors under integration is denoted by $W^I(b)$, and by Lemma 11 in the appendix, we have that $W^I(b) = V(b) - \alpha$. Given aggregate bonus

[14] Since there are four alienable items, there are sixteen possible governance structures (i.e., allocations of control, decisions, and monetary payoffs). We show in Lemma 10 in the appendix that if any governance structure is optimal, either integration or non-integration is optimal, so it is without loss of generality to focus on these two governance structures.

b, the optimal governance structure therefore solves $\max_{g \in \{I,NI\}} W^g(b)$. The solution to this problem is depicted in Figure 4 below. Provider incentives to form multi-specialty group

Figure 4: Provider Integration Decision



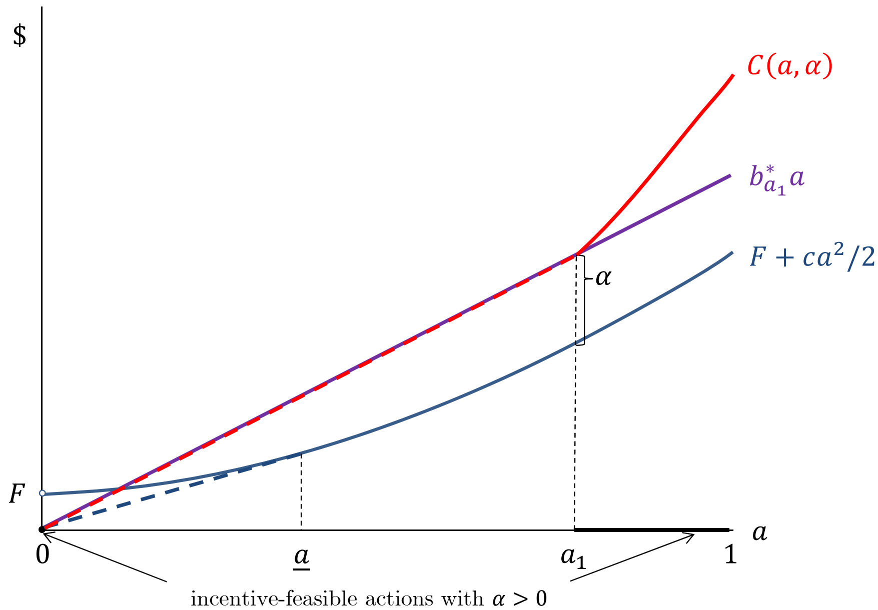
This figure illustrates the total benefits for the doctors under physician integration (green line) and under non-integration (red line) as a function of the maximized monetary payoffs attainable given an aggregate bonus level. To the left of α, these total benefits are higher under non-integration, and to the right of α, they are higher under integration.

practices arise from the incentive contracts providers have with their payers: as Figure 4 illustrates, when incentive contracts with payers are low-powered (i.e., b, and therefore $V(b)$ is small), providers will not find it optimal to forego the private benefits of professional autonomy. Moreover, integration increases the returns to coordinating horizontal decisions, and coordination of horizontal decisions complement care-coordination investments.

The complementarity between integrated organizations and the strength of shared-savings incentives also exacerbates the distortions resulting from common-agency problems. The reason for this is that the rents from selecting an integrated organizational form increases the magnitude of the non-differentiability in the provider's cost function. We illustrate this discontinuity in Figure 5 in the simple case of a unitary principal, but the same logic holds in the common-agency setting. Intuitively, for any $\alpha > 0$, the rents providers earn under an integrated care delivery organization must be at least α. This result implies that the set of incentive-feasible actions is smaller than it is in the main model (which in fact corresponds

$\alpha = 0$). This lacuna increases the scope for sticking-point equilibria.

Figure 5: Unitary Principal's Incentive Problem with Provider Integration Decision



This figure illustrates the unitary principal's cost function when $\alpha > 0$. Private costs of integration reduce the set of incentive-feasible actions, since if the incentive rents from a contract are smaller than α, the providers will opt for non-integration and will not invest.

We introduced our analysis of integrated multi-specialty groups through the example of investments in HIT systems, but the formal model indicates that complementarity between integrated care and investments in care coordination is far more general. If, for example, a PCP and a specialist develop procedures for jointly tracking and treating their shared patients, the returns to these investments will be higher within multi-specialty groups because the number of within-firm referrals and shared patients will be higher than if the PCP and specialist were not working in the same organization.[15]

[15]Stark laws and anti-kickback laws prohibit contractual arrangements ensuring that PCPs refer repeatedly to a particular set of specialists. Within-firm referrals, however, can be supported by profit-sharing arrangements that are allowed under the law: for example, a simple per capita division of profits is allowed within multi-specialty groups. Since specialist visits are typically more profitable than primary care visits, profit sharing would give PCPs incentives to refer patients to specialists within their firm. These financial incentives may become diluted in large groups, but this dilution is offset by mutual monitoring and peer pressure that is reinforced by the colocation of specialists and PCPs (Kandel and Lazear, 1992).

6 Discussion of Empirical Implications

Our model of common agency and shared-savings contracts can account for a number of otherwise hard to explain features of the US healthcare system. The model also has a number of additional empirical predictions. This section describes several of these predictions and shows—where possible—how they compare to stylized facts established by the empirical literature.

The first prediction is that heightened competition between insurers is unlikely to lead to more efficient contracting between insurers and payers. Intuitively, this results from the fact that both "free-riding" and "coordination failures" are exacerbated as the number of principals increases. More formally, this emerges from the result in Theorem 1 that $C_N(a, a^*, N)$ exhibits increasing differences in a, the level of investment, and N, the number of insurers. Thus as the number of insurers in a market increases, the marginal cost of increasing a increases. Standard results imply that the lowest and highest equilibrium level of incentives are decreasing in N.

The second prediction is that Medicare's introduction of shared-savings contracts will increase the overall incentives for physicians to invest in care coordination and these heightened incentives will lead to more investment. If cost functions are well behaved, as in Proposition 4, we show in the appendix that $b^*(S) + S$ is increasing in S even though $b^*(S)$ is falling in S. This means that Medicare's ACO incentives will only be partially crowded out by the private sector. If cost functions are not well-behaved and the common-agency game is at a sticking-point equilibrium, the appearance of ACOs can jump-start additional shared-savings contracts in the private sector. This result follows from Proposition 5 for a sufficiently large ACO incentive, S.

Finally, the complementarity between investments in care coordination and multi-specialty group practices suggests that markets with higher ACO penetration should experience an increase in these sorts of practices. This prediction follows from the results in Section 5.

Stylized facts emerging from the empirical health care literature provide indirect evidence consistent with our model's predictions. Consistent with the first prediction, Rosenthal, et al. (2006) find evidence showing that payers (in their case, HMOs) with a higher market share are more likely to enter into pay-for-performance contracts with providers. Consistent with the second prediction, Hsiao and Hing (2014) document dramatic increases in the adoption of electronic health records in the 2011-2013 period when ACOs were first introduced. It is, of course, hard to distinguish the effect of ACOs from direct subsidies to these systems resulting from the HITECH Act, but there is other evidence that Medicare's use of incentive-based contracting stimulates similar contracts in the private sector. For example Baker, Bundorf, Devlin and Kessler (2016) find that increases in the prevalence of Medicare's Prospective Payment System lead to greater use of prospective payments by commercial insurers. Evidence supporting the complementarity between investments in care coordination and integrated practices comes from Simon et al. (2007). They show that measures of integration, namely practice size and hospital affiliation, significantly predict adoption of electronic health records. They also find that among practices that have not adopted electronic health records, the most-cited barrier was prohibitive start-up costs. This is consistent with our assumption that up-front fixed costs play an important role in provider cost functions.

7 Conclusion

In this paper we have developed a common-agency model for explaining inefficient contracting in the U.S. healthcare system. In our setting, common agency problems arise when multiple payers seek to motivate a shared provider to invest in improved care coordination. Our approach differs from other common-agency models in that we analyze sticking points, that is, equilibria in which payers coordinate around Pareto dominated contracts that do not offer providers incentives to implement efficient investments. These sticking points offer a straightforward explanation for three long-observed but hard to explain features of the US healthcare system: the ubiquity of fee-for-service contracting arrangements outside of Medicare; problematic care coordination; and the historic reliance on small single-specialty practices rather than larger multi-specialty group practices to deliver care. The common-agency model also provides insights on the effects of policies (such as Accountable Care Organizations) that aim to promote more efficient forms of contracting between payers and providers.

We have examined the common-agency market failure in the context of payers trying to induce providers to make efficient investments in care coordination. We focused on incentives for these investments because they have played an important role in recent health care reform initiatives. The common-agency market failure is, however, much broader than this specific application and is likely to play a role wherever multiple payers seek to influence the actions of a shared provider.

Given the number and diversity of payers, exploring more broadly the implications of common-agency problems in the U.S. healthcare system is likely to be a fruitful avenue for future research. For example, Cutler and Ly (2011) remarks that "insurers have little incentive to coordinate their credentialing and billing requirements, because the costs of imposing different rules are spread across insurers as a whole, not partitioned to any single insurer," leading to persistently high administrative expenses.

Our results also have implications for the applied theory literature on common-agency. Most provocative is our finding that the outcome of common-agency market failures depend critically on the sort of actions incentive contracts seek to elicit. When principals wish to encourage more effort, attention or similarly continuous actions, equilibria involve third-best incentive contracts. When agent actions involve fixed costs or lumpy investments, as is often the case when agents are asked to implement new technology and management systems, equilibria can also involve coordination failures. In this case outcomes can be much worse than third-best. The implications of these coordination failures for management and for public policy have not been fully worked out and this may be an important direction for future theoretical research.

Appendix

The first two subsections of this appendix develop the arguments to prove the results in Section 2.2, including equilibrium existence and our characterization of the set of equilibrium actions. The first subsection develops Theorem 1A, which characterizes the set of equilibrium actions $\mathcal{A}^*$ as the solution to a self-generating maximization program. In particular, we show that $a^* \in \mathcal{A}^*$ if and only if

$$a^* \in \hat{a}\left(a^*\right) \equiv \underset{a \in \mathcal{A}^{feas}}{\operatorname{argmax}} \tilde{\Lambda}\left(a, a^*\right)$$

for some function $\tilde{\Lambda}\left(a, a^*\right)$. The second subsection shows that the operator $\hat{a}\left(\cdot\right)$ is monotone, so it always has at least one fixed point—and therefore an equilibrium action exists. In the process of proving these two results, we establish Theorem 1. The remaining subsections establish the results in Sections 3, 4, and 5.

Aggregate Representation

In this subsection, we develop necessary and sufficient conditions for an action a^* to be an equilibrium action. The results of this subsection hold for more general output spaces and more general contracting spaces than we assume in our main model. The results in the following subsections make use of our assumptions that the output space is binary and contracts are nonnegative and nondecreasing.

Before we outline the argument, we define some notation and terms that will be convenient in the arguments. First, denote the provider's **optimal action given aggregate contract** b by $a\left(b\right)$. Recall our tie-breaking assumption on the provider's choice: if the provider is indifferent among two or more actions, he chooses the highest action he is indifferent among. The **set of feasible contracts that support action** a is the subdifferential of c at a:

$$\partial c\left(a\right) = \left\{b \geq 0 : ba - c\left(a\right) \geq ba' - c\left(a'\right) \text{ for all } a' \in \mathcal{A}\right\}.$$

A **cost-minimizing contract for** a is denoted by b_a^*, and it solves

$$b_a^* \in \underset{b \geq 0}{\operatorname{argmin}} \left\{ba : b \in \partial c\left(a\right)\right\}.$$

The set of **feasible actions relative to** $\bar{b}$ is denoted by

$$\mathcal{A}_{\bar{b}}^{feas} = \left\{a \in \mathcal{A}^{feas} : b \in \partial c\left(a\right) \text{ for some } b \geq \left(1 - 1/N\right)\bar{b}\right\}.$$

A **cost-minimizing contract for** $a \in \mathcal{A}_{\bar{b}}^{feas}$ **relative to** $\bar{b}$, denoted by $b_{a,\bar{b}}^*$, solves

$$b_{a,\bar{b}}^* \in \underset{b \geq \left(1-1/N\right)\bar{b}}{\operatorname{argmin}} \left\{ba : w \in \partial c\left(a\right)\right\}.$$

Finally, if P_j, $j \neq i$ each choose $b_{\bar{a}}^*/N$, then we define the **minimum action relative to** $\bar{a}$, denoted $a_{\min}(\bar{a})$, is the action that the provider will choose if P_i chooses $b_i = 0$.

Our analysis in this subsection proceeds in four steps. We first show that b^* is an equilibrium aggregate contract if and only if

$$b^* \in \hat{b}(b^*) = \underset{b \geq (1-1/N)b^*}{\operatorname{argmax}} \frac{1}{N} Ba(b) - \left(b - \left(1 - \frac{1}{N}\right) b^*\right) a(b).$$

An implication of this step is that b^* is an equilibrium aggregate contract if and only if there is a symmetric equilibrium in which b^* is the resulting aggregate contract. We then show that if $b^* \in \hat{b}(b^*)$, then b^* is a cost-minimizing contract for some action $a \in \mathcal{A}^{feas}$, and given any aggregate contract $\bar{b}$, any $b \in \hat{b}(\bar{b})$ will be a cost-minimizing contract for some action relative to $\bar{b}$. Finally, we show that $b^* \in \hat{b}(b^*)$ if and only if $b^* = b^*_{a^*}$, where

$$a^* \in \hat{a}(a^*) = \underset{a \in \mathcal{A}^{feas}}{\operatorname{argmax}} \frac{1}{N} Ba - C_N(a, a^*, N).$$

In proceeding from the self-generating maximization program derived in Step 1 to the simpler self-generating maximization program derived in Step 4, Step 2 restricts the domain of the contracting space that needs to be searched over, and Step 3 restricts the range. In particular, Steps 2 and 3 show that both the domain and the range can, without loss of generality, be restricted to a set that is isomorphic to the set of incentive-feasible actions, which is a compact subset of $[0, 1]$.

Step 1 Given b_{-i}, P_i chooses b_i to solve

$$\max_{b_i \geq 0} \left(\frac{1}{N} B - b_i\right) a(b) = \max_{b_i \geq 0} u_i(b_i, b)$$

We can instead think of P_i as choosing $b = b_i + b_{-i}$. Then $b_i \geq 0$ if and only if $b \geq b_{-i}$. P_i's problem is therefore

$$\max_{b \geq b_{-i}} u_i(b - b_{-i}, b).$$

If b^* is an equilibrium aggregate contract, then there exists $b^*_1, \ldots, b^*_N$ such that $b^*_j \geq 0$, $\sum_{j=1}^N b^*_j = b^*$ and, for each i,

$$b^* \in \underset{b \geq b^* - b^*_i}{\operatorname{argmax}} u_i\left(b - \sum_{j \neq i} b^*_j, b\right).$$

Since b^* solves this program for each i, it is therefore feasible for each i, and it also solves these programs on average:

$$b^* \in \underset{b \geq b^* - \min_j b^*_j}{\operatorname{argmax}} \frac{1}{N} \sum_{i=1}^N u_i\left(b - \sum_{j \neq i} b^*_j, b\right).$$

Define the quantity

$$\Lambda\left(b,\bar{b}\right)=\frac{1}{N}\sum_{i=1}^{N}u_i\left(b-\sum_{j\neq i}\bar{b}_j,b\right)=\frac{1}{N}\sum_{i=1}^{N}\left(\frac{1}{N}B-\left(b-\sum_{j\neq i}\bar{b}_j\right)\right)a\left(b\right),$$

or

$$\Lambda\left(b,\bar{b}\right)=\left(\frac{1}{N}B-b+\left(1-\frac{1}{N}\right)\bar{b}\right)a\left(b\right).$$

Therefore, if $b^*\geq 0$ is an aggregate equilibrium contract, then

$$b^*\in\underset{b\geq b^*-\min_j b_j^*}{\operatorname{argmax}}\ \Lambda\left(b,b^*\right)$$

for some $b_1^*,\ldots,b_N^*$ such that $\sum_{i=1}^N b_i^*=b^*$. This leads to the following Lemma.

LEMMA 1. *If b^* is an equilibrium aggregate contract, then for some $b_1^*,\ldots,b_N^*\geq 0$ such that $\sum_{i=1}^N b_i^*=b^*$,*

$$b^*\in\underset{b\geq b^*-\min_j b_j^*}{\operatorname{argmax}}\ \Lambda\left(b,b^*\right).$$

The next lemma shows that we can replace the set of feasible contracts in this maximization problem by $b\geq\left(1-1/N\right)b^*$.

LEMMA 2. *If* b^* is an equilibrium aggregate contract, then

$$b^*\in\underset{b\geq(1-1/N)b^*}{\operatorname{argmax}}\ \Lambda\left(b,b^*\right).$$

Proof of Lemma 2. Lemma 2 is not directly implied by Lemma 1, because the objective in Lemma 2 involves a larger domain. Nevertheless, in order to get a contradiction, suppose b^* is an equilibrium aggregate contract, and suppose there is some b' such that $\left(1-1/N\right)b^*\leq b'\leq b^*-\min_j b_j^*$ and $\Lambda\left(b',b^*\right)>\Lambda\left(b^*,b^*\right)$. Then there must be some P_k such that

$$\left(\frac{1}{N}B-b'\right)a\left(b'\right)+b_{-j}^*a\left(b'\right)>\left(\frac{1}{N}B-b^*\right)a\left(b^*\right)+b_{-j}^*a\left(b^*\right),$$

but since P_k was optimizing, for P_k not to have chosen b', it must be the case that $b_j^*=0$, and therefore,

$$b^*\in\underset{b\geq b^*}{\operatorname{argmax}}\left(\frac{1}{N}B-b\right)a\left(b\right)+b^*a\left(b\right).\tag{1}$$

Since $b_j^*=0$, there must be some ℓ for which $b_{-\ell}^*\leq\left(1-1/N\right)b^*$ and for which

$$b^*\in\underset{b\geq b_{-\ell}^*}{\operatorname{argmax}}\left(\frac{1}{N}B-b\right)a\left(b\right)+b_{-\ell}^*a\left(b\right).\tag{2}$$

Since $a(b)$ is weakly increasing in b, (1) and (2) imply that

$$b^* \in \underset{b \geq b^*_{-\ell}}{\operatorname{argmax}} \Lambda(b, b^*),$$

and if b^* maximizes $\Lambda(b, b^*)$ over all $b \geq b^*_{-\ell}$, it also maximizes $\Lambda(b, b^*)$ over all $b \geq (1 - 1/N) b^*$, which contradicts the assumption that $\Lambda(b', b^*) > \Lambda(b^*, b^*)$.■

The following Lemma establishes the converse of Lemma 2.

LEMMA 3. $b^* \geq 0$ *is an equilibrium aggregate contract if and only if*

$$b^* \in \underset{b \geq (1-1/N)b^*}{\operatorname{argmax}} \Lambda(b, b^*).$$

Proof of Lemma 3. Necessity follows from Lemma 2. Now, suppose b^* solves this program. Let $b_i^* = \frac{1}{N} b^*$ for $i = 1, \ldots, N$. P_i's program is therefore

$$\max_{b \geq (1-1/N)b^*} \left(\frac{1}{N} B - \left(b - b^*_{-i} \right) \right) a(b) = \max_{b \geq (1-1/N)b^*} \left(\frac{1}{N} B - \left(b - \left(1 - \frac{1}{N} \right) b^* \right) \right) a(b),$$

which is the aggregate problem described in Lemma 2. Since b^* solves the aggregate problem, it therefore also solves each payer's problem.■

Lemma 3 completes the first step of the analysis. One immediate Corollary of Lemma 3 is that if b^* is an equilibrium aggregate contract, there is a symmetric equilibrium in which b^* is the associated equilibrium aggregate contract.

COROLLARY 1. *If b^* is an equilibrium aggregate contract, there is a symmetric equilibrium in which each Principal chooses $b_i^* = \frac{1}{N} b^*$.*

Step 2 We now turn to the second step, showing that any equilibrium aggregate contract must be a cost-minimizing contract for some action. This result is captured in Lemma 4.

LEMMA 4. *Suppose*

$$b^* \in \underset{b \geq (1-1/N)b^*}{\operatorname{argmax}} \Lambda(b, b^*).$$

Then $b^* = b_a^*$ for some $a \in A^{feas}$.

Proof of Lemma 4. Suppose

$$b^* \in \underset{b \geq (1-1/N)b^*}{\operatorname{argmax}} \left(\frac{1}{N} B - b + \left(1 - \frac{1}{N} \right) b^* \right) a(b^*).$$

Then b^* implements some action $a^* = a(b^*)$. In order to get a contradiction, suppose there is some contract $\tilde{b} \geq 0$ that also implements a^* but $\tilde{b} a^* < b^* a^*$. First, note that if $a(b^*) = a\left(\tilde{b}\right) = a^*$, then for any $\lambda \in [0, 1]$, $a\left((1 - \lambda) \tilde{b} + \lambda b^*\right) = a$. That is, if two contracts implement the same action, then so does any convex combination. This is because the agent is risk-neutral.

There are then two cases. First, if $\hat{b} \geq (1-1/N)\, b^*$, then $\hat{b}$ is feasible and does better than b^* in the aggregate program, so $b^* \notin \hat{b}\,(b^*)$. Next, suppose $\hat{b} < (1-1/N)\, b^*$. Then, the contract $(1-1/N)\, b^*$ implements the same action and does better in the aggregate program, so $b^* \notin \hat{b}\,(b^*)$.■

Lemma 4 effectively restricts the domain over which we have to search when looking for fixed points of the $\hat{b}\,(\cdot)$ operator. In particular, we only have to look for b_a^* such that $b_a^* \in \hat{b}\,(b_a^*)$.

Step 3 We will now proceed to the third step, which shows that any contract in $\hat{b}\left(\bar{b}\right)$ is cost-minimizing relative to $\bar{b}$. This result is described in the following Lemma.

LEMMA 5. *Suppose $b \in \hat{b}\left(\bar{b}\right)$. Then b is cost-minimizing for some a relative to $\bar{b}$.*

Proof of Lemma 5. To get a contradiction, suppose b is not cost-minimizing for any action relative to $\bar{b}$. Let $a = a\,(b)$. Since $b^*_{a,\bar{b}}$ is a cost-minimizing contract for a relative to $\bar{b}$, it is feasible, and we have $b^*_{a,\bar{b}}a < ba$, which implies that

$$\left(\frac{1}{N}B - b^*_{a,\bar{b}} + \left(1-\frac{1}{N}\right)\bar{b}\right)a > \left(\frac{1}{N}B - b + \left(1-\frac{1}{N}\right)\bar{b}\right)a,$$

which contradicts the claim that $b \in \hat{b}\left(\bar{b}\right)$.■

The main implication of Lemma 5 is that in solving for $\hat{b}\left(\bar{b}\right)$, it is without loss of generality to consider cost-minimizing contracts relative to $\bar{b}$. That is,

$$\underset{b \geq (1-1/N)\bar{b}}{\operatorname{argmax}}\ \Lambda\left(b, \bar{b}\right) = \underset{b^*_{a,\bar{b}} \geq (1-1/N)\bar{b}}{\operatorname{argmax}}\ \Lambda\left(b, \bar{b}\right).$$

Lemma 4 restricts the domain over which we have to search when looking for fixed points of the $\hat{b}\,(\cdot)$ operator. Lemma 5 shows that, given a cost-minimizing contract $b^*_{\bar{a}}$, we can restrict attention to looking for cost-minimizing contracts relative to $b^*_{\bar{a}}$. Denote a cost-minimizing contract for action a relative to $b^*_{\bar{a}}$ by $b^*_{a,\bar{a}}$, and denote the set of feasible actions relative to $b^*_{\bar{a}}$ by $\mathcal{A}^{feas}_{\bar{a}}$. Without loss of generality, we can therefore restrict attention to a domain and a range that are each isomorophic to $\mathcal{A}^{feas}$.

Step 4 Before we can state and prove Theorem 1A, define the function

$$\bar{C}_N\,(a, \bar{a}, N) = N b^*_{a,\bar{a}} a - (N-1)\, b^*_{\bar{a}} a.$$

Our main characterization theorem follows.

THEOREM 1A. a^* *is an equilibrium action if and only if*

$$a^* \in \hat{a}(a^*) = \underset{a \in \mathcal{A}^{feas}_{a^*}}{\operatorname{argmax}} Ba - \bar{C}_N(a, a^*, N). \tag{1}$$

Proof of Theorem 1A. Suppose a^* is an equilibrium action. Then $b^*_{a^*}$ is an equilibrium aggregate contract (Lemma 4), which in turn implies that $b^*_{a^*} \in \hat{b}(b^*_{a^*})$ (Lemma 1). Since all $b \in \hat{b}(b^*_{a^*})$ are cost-minimizing relative to $b^*_{a^*}$ (Lemma 5), $b^*_{a^*} \in \hat{b}(b^*_{a^*})$ implies that $a^* \in \hat{a}(a^*)$. Conversely, suppose $a^* \in \hat{a}(a^*)$. Then $b^*_{a^*}$ is the best cost-minimizing contract relative to $b^*_{a^*}$, which implies that $b^*_{a^*} \in \hat{b}(b^*_{a^*})$ (Lemma 5).■

Theorem 1A shows that instead of solving for fixed points of $\hat{b}(\cdot)$, an equivalent problem is the simpler problem of solving for fixed points of $\hat{a}(\cdot)$. This problem is simpler, because the action space is simpler than the contracting space.

Monotonicity

In this subsection, we show that the operator $\hat{a}(\cdot)$ is increasing, which in turn allows us to make use of monotonicity-based fixed-point theorems to establish the existence of an equilibrium action and to derive some properties of the set of equilibrium effort levels. The analysis of this subsection proceeds in four steps. Recall that we have denoted $\partial^- c(a)$ and $\partial^+ c(a)$ to be the smallest and largest subgradients of c at a. By convention, we will denote $\partial^- c(0) = 0$.

First, we will show that for all $a \in \mathcal{A}^{feas}$, $b^*_a = \partial^- c(a)$. We will then show that

$$\hat{a}(\bar{a}) = \underset{a \in \mathcal{A}^{feas}}{\operatorname{argmax}} Ba - C_N(a, \bar{a}, N),$$

where

$$C_N(a, \bar{a}, N) = \max\{NC(a), (N-1) b^*_{\bar{a}} a_{\min}(\bar{a})\} - (N-1) b^*_{\bar{a}} a,$$

and we will establish that $C_N(a, \bar{a}, N)$ satisfies decreasing differences in $(a, \bar{a})$ on $\mathcal{A}^{feas}$. By Topkis's (1998) theorem, this result implies that $\hat{a}(\cdot)$ is increasing, so by Zhou's (1994) extension of Tarski's (1955) fixed-point theorem, the set of fixed points of $\hat{a}(\cdot)$ is nonempty and compact.

Step 1 Lemma 6 establishes the first result, solving for the set of cost-minimizing contracts of the unitary-principal problem in our setting.

LEMMA 6. $b^*_a = \partial^- c(a)$.

Proof of Lemma 6. In order for $b \in \partial c(a)$, it has to be the case that $\partial^- c(a) \leq b \leq \partial^+ c(a)$. Given any $\tilde{b}$ such that $a\left(\tilde{b}\right) = a$, then setting $\tilde{b} = \partial^- c(a)$ implements the same action at weakly lower cost, and therefore $b^*_a = \partial^- c(a)$.■

Step 2 We now show that the maximization program (1) defined in Theorem 1A is solution-equivalent to an unconstrained maximization program obtained by replacing $\bar{C}_N(a,\bar{a},N)$ with

$$C_N(a,\bar{a},N) = \max\{NC(a), (N-1)\, b^*_{\bar{a}} a_{\min}(\bar{a})\} - (N-1)\, b^*_{\bar{a}} a.$$

LEMMA 7. *For all $\bar{a} \in A^{feas}$, the solutions to maximization program defined in* (1)*, $\hat{a}(\bar{a})$, coincide with*

$$\underset{a\in\mathcal{A}^{feas}}{\operatorname{argmax}}\, Ba - C_N(a,\bar{a},N).$$

Proof of Lemma 7. In this setting, we have $\mathcal{A}^{feas}_{\bar{a}} = \mathcal{A}^{feas} \cap [a_{\min}(\bar{a}), 1]$, $\bar{C}_N(a,\bar{a},N) = N b^*_{a,\bar{a}} a - (N-1)\, b^*_{\bar{a}} a$, and

$$b^*_{a,\bar{a}} a = \begin{cases} (1-1/N)\, b^*_{\bar{a}} a & a = a_{\min}(\bar{a}) \\ C(a) & a > a_{\min}(\bar{a}). \end{cases}$$

By definition of $a_{\min}(\bar{a})$, for all $a \le a_{\min}(\bar{a})$, $b^*_a \le (1-1/N)\, b^*_{\bar{a}}$. We therefore have that for all $a \in \mathcal{A}^{feas}_{\bar{a}}$, $\bar{C}_N(a,\bar{a},N) = C_N(a,\bar{a},N)$. Finally, for all $a < a_{\min}(\bar{a})$,

$$C_N(a,\bar{a},N) \ge C_N(a_{\min}(\bar{a}),\bar{a},N),$$

so that

$$\underset{a\in\mathcal{A}^{feas}_{\bar{a}}}{\operatorname{argmax}}\, Ba - C_N(a,\bar{a},N) = \underset{a\in\mathcal{A}^{feas}}{\operatorname{argmax}}\, Ba - C_N(a,\bar{a},N),$$

which completes the proof.■

Step 3 If $C_N(a,\bar{a},N)$ satisfies decreasing differences in $(a,\bar{a})$ on $\mathcal{A}^{feas}$, then $\tilde{\Lambda}(a,\bar{a})$ satisfies increasing differences in $(a,\bar{a})$ on $\mathcal{A}^{feas}$. This is the case, as the following Lemma shows.

LEMMA 8. *$C_N(a,\bar{a},N)$ satisfies decreasing differences in $(a,\bar{a})$ and increasing differences in (a,N) on A^{feas}. Consequently, $\tilde{\Lambda}(a,\bar{a})$ satisfies increasing differences in $(a,\bar{a})$ and decreasing differences in (a,N) on A^{feas}.*

Proof of Lemma 8. Let $a \ge a'$ and $\bar{a} \ge \bar{a}'$ with $a, a', \bar{a}, \bar{a}' \in \mathcal{A}^{feas}$. Define the difference $\Delta(\bar{a}) \equiv C_N(a,\bar{a},N) - C_N(a',\bar{a},N)$ and the value $\delta = (b^*_{\bar{a}} - b^*_{\bar{a}'})(a-a') \ge 0$. There are six cases we need to consider. They are tedious but straightforward.
Case 1. If $C(a) \ge C(a') \ge (1-1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \ge (1-1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = -\delta \le 0$$

Case 2. If $C(a) \ge (1-1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \ge C(a') \ge (1-1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = C(a') - (1-1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) - \delta \le 0$$

Case 3. If $C(a) \geq (1 - 1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \geq (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}') \geq C(a')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}') - b^*_{\bar{a}} a_{\min}(\bar{a}) - \delta \leq 0$$

Case 4. If $(1 - 1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \geq C(a) \geq C(a') \geq (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = C(a') - C(a) - \delta \leq 0$$

Case 5. If $(1 - 1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \geq C(a) \geq (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}') \geq C(a')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}') - C(a) - \delta \leq 0$$

Case 6. If $(1 - 1/N)\, b^*_{\bar{a}} a_{\min}(\bar{a}) \geq (1 - 1/N)\, b^*_{\bar{a}'} a_{\min}(\bar{a}') \geq C(a) \geq C(a')$, then

$$\Delta(\bar{a}) - \Delta(\bar{a}') = -\delta \leq 0.$$

Since $\tilde{\Lambda}(a, \bar{a}) = \frac{1}{N} Ba - C_N(a, \bar{a}, N)$, $\tilde{\Lambda}(a, \bar{a})$ satisfies increasing differences in $(a, \bar{a})$ on $\mathcal{A}^{feas}$. The argument that $C_N(a, \bar{a}, N)$ satisfies increasing differences in (a, N) is similar.■

We can therefore apply Topkis's theorem to show that $\hat{a}(\cdot)$ is increasing.

LEMMA 9. $\hat{a}(\cdot)$ is increasing on $\mathcal{A}^{feas}$.

Proof of Lemma 9. Follows directly from Topkis's theorem.

The intuition behind Lemma 9 is that, given any cost-minimizing target contract, $b^*_{\bar{a}}$, each payer P_i either wants to leave $(1 - 1/N)\, b^*_{\bar{a}}$ in place by contributing $b_i = 0$, or they want to top up $(1 - 1/N)\, b^*_{\bar{a}}$. If they choose to top it up, they will top it up to a cost-minimizing contract, which is feasible, because b^*_a is increasing in a.

Step 4 Our second theorem follows from Lemma 9.

THEOREM 2A. *The set of equilibrium actions A^* is nonempty and compact.*

Proof of Theorem 2A. By Lemma 9 and the fact that $\mathcal{A}^{feas}$ is a compact subset of $[0, 1]$, $\hat{a}(\cdot)$ is a monotone operator on a complete lattice. By Zhou's (1994) extension of Tarki's fixed-point theorem to correspondences, the set of fixed points of $\hat{a}(\cdot)$ is a nonempty complete lattice, which in turn implies that $\mathcal{A}^*$ is a compact subset of $[0, 1]$.■

Putting all these results together, we get Theorem 1.

THEOREM 1. *There is at least one equilibrium action, and there exists a function $C_N(a, \bar{a}, N)$ such that action a^* is an equilibrium action if and only if*

$$a^* \in \underset{a \in \mathcal{A}}{\operatorname{argmax}}\, Ba - C_N(a, a^*, N).$$

The function $C_N(a, \bar{a}, N)$ exhibits increasing differences in (a, N) and decreasing differences in $(a, \bar{a})$.

Equilibrium, Efficiency, and Coordination Failures

PROPOSITION 1. *The highest equilibrium action a_H^* is bounded from above by a^{SB}.*

Proof of Proposition 1. By Lemma 8, $C_N(a, \bar{a}, N)$ satisfies increasing differences in (a, N), which implies that for any $\bar{a}$, $\hat{a}(\bar{a}, N)$ is smaller for larger values of N. By Topkis's theorem, this in turn implies that the set of fixed points to $a^* \in \hat{a}(a^*, N)$ is decreasing in strong set order in N. Since a^{SB} is the unique solution to $a^* \in \hat{a}(a^*, 1)$, the result follows.■

PROPOSITION 2. *Suppose Condition CR holds. If there are multiple equilibrium actions a_L^* and $a_H^* > a_L^*$, then there is a nondifferentiability. If there is a nondifferentiability at $\hat{a}$, then there exists a B for which $a_L^* = \hat{a}$ and $a_H^* > \hat{a}$. If Condition W holds, then there is a unique equilibrium action a^*.*

Proof of Proposition 2. For the first part of the proposition, define the quantity $H(a) = b_a^* + a\partial^- b_a^*$ on $a \in \mathcal{A}^{feas}$, where $\partial^- b_a^* = \lim_{a' \uparrow a} (\partial^- c(a) - \partial^- c(a')) / (a - a')$. $H(a)$ is strictly increasing in a, because b_a^* is strictly increasing in a on $\mathcal{A}^{feas}$ and $\partial^- b_a^*$ is weakly increasing in a by Condition CR. For a_L^* and $a_H^* > a_L^*$ to be equilibrium actions, it has to be the case that

$$\begin{aligned} \partial^- C_N(a_L^*) &\leq B \leq \partial^+ C_N(a_L^*) \\ \partial^- C_N(a_H^*) &\leq B \leq \partial^+ C_N(a_H^*), \end{aligned}$$

which implies that $\partial^+ C_N(a_L^*) \geq \partial^- C_N(a_H^*)$. Define $\Delta(a_L^*) = \partial^+ C_N(a_L^*) - \partial^- C_N(a_L^*)$. Then this last inequality implies that

$$N\Delta(a_L^*) \geq H(a_H^*) - H(a_L^*) > 0,$$

where the strict inequality follows from the argument above that $H(a)$ is strictly increasing in a. The result that $\Delta(a_L^*) > 0$ means that C is not differentiable at a_L^*.

For the second part of the proposition, suppose $\Delta(\bar{a}) > 0$ for some $\bar{a}$. Set $B = \partial^+ C_N(\bar{a})$ and define $\bar{a}^+ = \lim_{a \downarrow \bar{a}, a \in \mathcal{A}^{feas}} a$ to be the smallest incentive-feasible action larger than $\bar{a}$. Since

$$\begin{aligned} \partial^+ C_N(\bar{a}) &= N\partial^+ C(\bar{a}) - (N-1) b_{\bar{a}}^* = N\partial^- C\left(\bar{a}^+\right) - (N-1) b_{\bar{a}}^* \\ &> N\partial^- C\left(\bar{a}^+\right) - (N-1) b_{\bar{a}^+}^* = \partial^- C_N\left(\bar{a}^+\right), \end{aligned}$$

and since $\partial^+ C_N(a)$ is increasing in a, this implies that $\partial^- C_N(\bar{a}^+) < B \leq \partial^+ C_N(\bar{a}^+)$, and therefore $\bar{a}^+ > \bar{a}$ is also an equilibrium action.

For the last part of the proposition, note that if Condition W holds, then $MC_N(\bar{a})$ is a singleton and is equal to $c'(\bar{a}) + N\bar{a}c''(\bar{a})$, which is strictly increasing. $B \in MC(a^*)$ therefore has a unique solution a^*.■

PROPOSITION 3. *Suppose Condition CR holds. If there are multiple equilibrium actions, a_L^* and $a_H^* > a_L^*$, then (i) there exists an equilibrium with $a^* = a_H^*$ that Pareto dominates* *an equilibrium with $a^* = a_L^*$, and (ii) there does not exist an equilibrium with $a^* = a_L^*$ that Pareto dominates any equilibrium with $a^* = a_H^*$.*

Proof of Proposition 3. The first part of this proposition follows, because symmetric equilibria are Pareto rankable. In a symmetric equilibrium, each payer receives $1/N$ of the total surplus of all the payers. This total surplus, $Ba - C(a)$ is increasing and convex by Condition CR, so it is higher for a_H^* than for a_L^*, since both are smaller than a^{SB} by Proposition 1. The provider is also better off under a_H^* than under a_L^*, because incentive rents, $R(a)$ are increasing in a by Condition CR. The second part of the proposition also follows from the observation that $R(a)$ is increasing in a when Condition CR is satisfied: the lower equilibrium action necessarily makes the provider worse off.■

Accountable Care Organizations

PROPOSITION 4. *Suppose Condition W holds. Then for each S, there is a unique aggregate equilibrium contract $b^*(S)$, which is decreasing in S.*

Proof of Proposition 4. If Condition W holds, then there is a unique equilibrium action $a^*(S)$, which satisfies $B + S = c'(a^*(S)) + Na^*(S)\,c''(a^*(S))$. Moreover, we will also have that $b^*(S) + S = c'(a^*(S))$. Implicitly differentiating both expressions, we have

$$\frac{db^*(S)}{dS} = -N\frac{c''(a^*(S)) + a^*(S)\,c'''(a^*(S))}{(1+N)\,c''(a^*(S)) + Na^*(S)\,c'''(a^*(S))} < 0,$$

establishing that $b^*(S)$ is decreasing in S.■

PROPOSITION 5. *Suppose Condition CR holds, and there is a sticking-point equilibrium. Then there exists a B and an ACO intervention $S > 0$ such that $b_L^*(S) > b_L^*(0)$. Additionally, for any value $\kappa > 0$, there exists a B for which the returns to an ACO intervention are greater than κ in the least equilibrium.*

Proof of Proposition 5. For both parts of the proposition, let $B = \partial^+ C_N(a_L^*(0))$. Since $a_L^*(0) = 0 < a_H^*(0)$, we have that $b_L^*(0) = 0$. Set $S = \varepsilon > 0$ small. Then $a_L^*(\varepsilon) > 0$ and $b_L^*(\varepsilon) + \varepsilon = \partial^- c(a_L^*(\varepsilon))$, so that $b_L^*(\varepsilon) = \partial^- c(a_L^*(\varepsilon)) - \varepsilon > 0$ for sufficiently small ε, which establishes the first claim.

For the second claim, note that there is some $\delta > 0$ such that for all $\varepsilon > 0$, $a_L^*(\varepsilon) \geq a_L^*(0) + \delta$. It follows that there is some $\Delta > 0$ such that for all $\varepsilon > 0$, $W_L(\varepsilon) - W_L(0) \geq \Delta$. $a_L^*(\varepsilon)$ is weakly increasing in ε and is bounded from above by one. We therefore have that for $\varepsilon < \Delta/\kappa$,

$$\frac{W_L(\varepsilon) - W_L(0)}{\varepsilon a_L^*(\varepsilon)} \geq \frac{\Delta}{a_L^*(\varepsilon)}\frac{1}{\varepsilon} \geq \frac{\Delta}{\varepsilon} > \kappa.$$

This establishes the second claim.■

Provider Fragmentation

The first lemma in this section shows that integration and non-integration weakly dominate any other governance structure. In order to establish this claim, we can define all sixteen governance structures by which items are controlled by doctor A. Denote these governance structures as $g_1 = (\pi, a, d_1, d_2)$, $g_2 = (\pi, a, d_1)$, $g_3 = (\pi, a, d_2)$, $g_4 = (\pi, a)$, $g_5 = (\pi, d_1, d_2)$, $g_6 = (\pi, d_1)$, $g_7 = (\pi, d_2)$, $g_8 = (\pi)$, $g_9 = (a, d_1, d_2)$, $g_{10} = (a, d_1)$, $g_{11} = (a, d_2)$, $g_{12} = (a)$, $g_{13} = (d_1, d_2)$, $g_{14} = (d_1)$, $g_{15} = (d_2)$, $g_{16} = \emptyset$. The set of possible governance structures is $G = \{g_1, \ldots, g_{16}\}$. Note that $g_1 = I$ and $g_2 = NI$.

LEMMA 10. *Given any aggregate bonus b, either $g^* = NI$ or $g^* = I$.*

Proof of Lemma 10. First, note that if doctor i possesses π, then total surplus is weakly higher if doctor i also possesses a. This is because if it is ever optimal for the doctors to choose $a > 0$, then the doctor possessing a will only do so if she also possesses π. This step establishes that each of $g_5, \ldots, g_{12}$ is weakly dominated by one other governance structure. Next, note that if doctor A (B) possesses d_2 (d_1), then she should also possess d_1 (d_2). If, say, doctor A possesses d_2, then in any pure-strategy equilibrium, she will always choose $d_2 = d_1$. Any equilibrium choice involving $d_2 = d_1 = 0$ is also an equilibrium choice under the governance structure in which she possesses d_1, and any equilibrium choice involving $d_2 = d_1 = 0$ is also an equilibrium choice under the governance structure in which doctor B possesses both d_1 and d_2. This observation implies that g_3 and g_{14} are weakly dominated. Next, since $\alpha < 1$, governance structure g_4 is strictly dominated by g_1 and governance structure g_{16} is weakly dominated by g_2. Finally, governance structure g_{13} yields the same outcomes as g_1, and governance structure g_{15} yields the same outcomes as g_2. The details for all these claims are straightforward but tedious.■

LEMMA 11. *Given an aggregate contract b, $W^{NI}(b) = \max\{V(b) - 1, 0\}$ and $W^I = V(b) - \alpha$. There exists a $\hat{b}$, which may be 0 or ∞, such that for all $0 \leq b \leq \hat{b}$, non-integration is optimal, and for all $b \geq \hat{b}$, integration is optimal.*

Proof of Lemma 11. Given an aggregate contract b, under non-integration, doctor B will always choose $d_2 = 1$. Doctor A then solves

$$\max_{a, d_1} ba(1 - |d_1 - 1|) - d_1 - c(a).$$

If she chooses $d_1 = 1$, then the problem becomes

$$\max_a ba - c(a) - 1,$$

and by definition, the value of this problem is $V(b) - 1$. If she chooses $d_1 = 0$, then she receives 0. She will therefore coordinate with doctor B if $V(b) - 1 \geq 0$, and she will not otherwise. Doctor B receives 0 no matter what, so total welfare is given by $W^{NI}(b) = \max\{V(b) - 1, 0\}$.

Under integration, doctor A will choose $d_1 = d_2 = 0$ to minimize her private costs, while still coordinating. These choices yield a payoff of $-\alpha$ for doctor B. Further, doctor A will solve

$$\max_a ba - c(a),$$

and will therefore receive $V(b)$. Total welfare under integration is therefore $V(b) - \alpha$.

Since $\alpha < 1$, if $V(b) \leq \alpha$, $W^I(b) \leq 0 = W^{NI}(b)$. If $\alpha \leq V(b) \leq a$, $W^I(b) \geq 0 = W^{NI}(b)$, and if $V(b) \geq \alpha$, $W^I(b) \geq W^{NI}(b)$. By the envelope theorem, $V'(b) = a^*(b) \geq 0$, so $V(b)$ is increasing, which implies the last set of results.

References

[1] Baicker, Katherine and Amitabh Chandra. 2011. Aspirin, Angioplasty, and Proton Beam Therapy: The Economics of Smarter Health Care Spending. In *Jackson Hole Economic Policy Symposium*.

[2] Baker, Laurence, Kate Bundorf, Aileen Devlin, and Daniel Kessler. 2016. Why Don't Commercial Health Plans Use Prospective Payment? NBER Working Paper 22709. *NBER Working Paper Series*, Cambridge, Mass.

[3] Baker, Laurence, Kate Bundorf, and Anne Royalty. 2014. Measuring Physician Practice Competition Using Medicare Data. In *Measuring and Modeling Health Care Costs*, eds. Ana Aizcorbe, Colin Baker, Ernst Berndt, and David Cutler. University of Chicago Press.

[4] Bernheim, B. Douglas and Michael Whinston. 1986a. Menu Auctions, Resource Allocation, and Economic Influence. *Quarterly Journal of Economics*, 101(1): 1-32.

[5] Bernheim, B. Douglas and Michael Whinston. 1986b. Common Agency. *Econometrica*, 54(4): 923-942.

[6] Besley, Timothy and Stephen Coate. 2001. Lobbying and Welfare in a Representative Democracy. *Review of Economic Studies*, 68: 67-82.

[7] Blumenthal, David. 2011. Wiring the Health System Origins and Provisions of a New Federal Program. *New England Journal of Medicine*, 365: 2323-2329.

[8] Burns, Lawton and Mark Pauly. 2002. Integrated Delivery Networks: A Detour on the Road to Integrated Health Care? *Health Affairs*, 21(4): 128-143.

[9] Cebul, Randall, James Rebitzer, Lowell Taylor, and Mark Votruba. 2008. Organizational Fragmentation and Care Quality in the U.S. Healthcare System. *Journal of Economic Perspectives*, 22(4): 93-114.

[10] Centers for Disease Control. 2010. National Ambulatory Care Survey: 2010 Summary Tables.

[11] Crosson, Francis. 2009. Medicare: The Place to Start Delivery System Reform. *Health Affairs*, 28(2): w232-w234.

[12] Cutler, David and Dan Ly. 2011. The (Paper)Work of Medicine: Understanding International Medical Costs. *Journal of Economic Perspectives*, 25(2): 3-25.

[13] Dixit, Avinash, Gene Grossman, and Elhanan Helpman. 1997. Common Agency and Coordination: General Theory and Application to Government Policy Making. *Journal of Political Economy*, 105(4): 752-769.

[14] Glazer, Jacob and Thomas McGuire. 2002. Multiple Payers, Commonality and Free-Riding in Health Care: Medicare and Private Payers. *Journal of Health Economics*, 21(6): 1049-1069.

[15] Hsiao, Chun-Ju and Esther Hing. 2014. Use and Characteristics of Electronic Health Record Systems Among Office-based Physician Practices: United States, 2001–2013. *NCHS Data Brief*, 143.

[16] Hussey, Peter, Eric Schneider, Robert Rudin, Steven Fox, Julie Lai, and Craig Pollack. 2014. Continuity and the Costs of Care for Chronic Disease. *JAMA Internal Medicine*, 174(5): 742-748.

[17] Innes, Robert. 1990. Limited Liability and Incentive Contracting with Ex-ante Action Choices. *Journal of Economic Theory*, 52: 45-67.

[18] Kirchsteiger, Georg and Andrea Prat. 2001. Inefficient Equilibria in Lobbying. *Journal of Public Economics*, 82(3): 349-375.

[19] Kiselman, Christer and Shiva Samieinia. Forthcoming. *Journal of Mathematical Sciences*.

[20] Martimort, David and Lars Stole. 2009. Selecting Equilibria in Common Agency Games. *Journal of Economic Theory*, 144(2): 604-634.

[21] Martimort, David and Lars Stole. 2012. Representing Equilibrium Aggregates in Aggregate Games with Applications to Common Agency. *Games and Economic Behavior*, 76: 753-772.

[22] Milstein, Arnold and Elizabeth Gilbertson. 2009. American Medical Home Runs. *Health Affairs*, 28(5): 1317-1326.

[23] Moses, Hamilton, David Matheson, Ray Dorsey, Benjamin George, David Sadoff, and Satoshi Yoshimura. 2013. *JAMA*, 310(18): 1947-1964.

[24] Rebitzer, James and Mark Votruba. 2011. Organizational Economics and Physician Practices. *Working Paper*.

[25] Robinson, James. 1999. *The Corporate Practice of Medicine: Competition and Innovation in Health Care*. University of California Press.

[26] Romano, Max, Jodi Segal, and Craig Pollack. 2015. The Association Between Continuity of Care and the Overuse of Medical Procedures. *JAMA Internal Medicine*, 175(7): 1148-1154.

[27] Rosenthal, Meredith B., Bruce E. Landon, Sharon-Lise T. Normand, Richard G. Frank, and Arnold M. Epstein. 2006. Pay for Performance in Commercial HMOs. *New England Journal of Medicine*, 355: 1895-1902.

[28] Ross, Joseph. 2002. The Committee on the Costs of Medical Care and the History of Health Insurance in the United States. *Einstein Journal of Biology and Medicine*, 19: 129-134.

[29] Sappington, David. 1983. Limited Liability Contracts between Principal and Agent. *Journal of Economic Theory*, 29: 1-21.

[30] Simon, Steven R., Rainu Kaushal, Paul D. Cleary, Chelsea A. Jenter, Lynn A. Volk, Eric G. Poon, John E. Orav, Helen G. Lo, Deborah H. Williams, and David W. Bates. 2007. Correlates of electronic health record adoption in office practices: a statewide survey. *Journal of the American Medical Informatics Association*, 14(1): 110–117.

[31] Stigler, George. 1958. The Economies of Scale. *Journal of Law and Economics*, 1: 54-71.

[32] Tarski, Alfred. 1955. A Lattice-Theoretical Fixpoint Theorem and its Applications. *Pacific Journal of Mathematics*, 5: 285-309.

[33] Topkis, Donald. 1998. *Supermodularity and Complementarity.* Princeton University Press.