Patient-Level Competitive Bidding and Risk Selection in Health Care Entitlement Programs

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August 29, 2017

Abstract

Health care entitlement programs in the United States support more than 125 million individuals, at a cost of approximately $1.2 Trillion. Sustaining these programs is both an immense fiscal challenge and the subject of heated political debate. In the pursuit of operational efficiencies, program administrators often contract with private managed care organizations (MCOs) to procure insurance for beneficiaries. Unfortunately, this induces MCOs to attract the healthiest beneficiaries and avoid the sickest; a phenomenon known as risk selection. This leaves the sickest patients to seek care in safety net facilities or emergency rooms. This paper investigates whether risk selection can be mitigated with a mechanism where MCOs bid to enroll individual patients. Although procurement auctions to source goods and services have been studied extensively in extant literature, individual-level bidding is rarely discussed or evaluated. We model an entitlement program under three payment mechanisms: uniform payment, bidding, and a mix of payment and bidding. Analytical results show that risk selection always occurs under the optimal uniform payment, but never under either bidding mechanism. The optimal mixed payment achieves the same enrollment as pure bidding, but at a strictly lower cost. Numerical analysis shows bidding dominates uniform payment in 87 percent of simulated parameter sets. Compared to uniform payment, bidding typically enrolls 13 percent more beneficiaries at 31 percent lower cost. Sensitivity analysis reveals the circumstances under which bidding is likely to deliver the greatest positive impact. These results demonstrate that individual-level auctions are a promising mechanism for achieving the dual aim of financially sustainable health care entitlement programs as well as expanded access to care for the most vulnerable.

Keywords: Risk selection; Cream skimming; Procurement auction; Public health insurance; Entitlement programs; Health administration.

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1 Introduction

Federal and state governments in the United States spend over $1.19 Trillion on the two major health care entitlement programs of Medicare and Medicaid (Centers for Medicare & Medicaid Services, 2017). This figure represents a nearly hundredfold increase since 1970. These programs now consume approximately 20% of federal, state, and local budgets, reflecting an increasing financial burden for U.S. taxpayers. In an effort to reduce costs and achieve operational efficiencies, governments have contracted out certain parts of these programs to private managed care organizations in the forms of Medicare Advantage and Medicaid Managed Care (Brown et al., 1993; Howell et al., 2012). Despite these efforts, inefficiencies remain and the costs of running these programs are high. Medicare Advantage has never achieved savings (McGuire et al., 2013) and greater Medicaid-HMO penetration rates have not delivered spending reductions (Herring and Adams, 2011). As the financial burden of these programs continues to rise despite existing privatization efforts, drastic changes, including restriction of coverage or benefits, may be necessary to maintain solvency.

In a climate of uncertainty surrounding the health care system, where existing reform efforts could eliminate coverage for up to 23 million people (Congressional Budget Office, 2017; Hall, 2017), a way to maintain beneficiaries’ access to care without increasing costs would be invaluable to program administrators.

The high and rising costs of health care entitlement programs and the difficulties with privatization stem from the uniquely intricate organization of the U.S. health care industry. Various agents, such as health care providers, payers, patients, employers, managed care organizations (MCOs), public health institutions, and health care administrators, engage in complex interactions with one another. These agents often have diverging objectives and constraints. Such conflicting goals, and the well-known contracting problems due to asymmetric information (Arrow, 1963), can result in suboptimal outcomes for patients, which is of significant concern to health care administrators. Those inefficient outcomes most-covered in the existing literature include supply- and demand-side moral hazard (Manning et al., 1987; Newhouse, 1996), and demand-side adverse selection (Rothschild and Stiglitz, 1976; Glazer and McGuire, 2000).

This paper investigates a different, though immensely consequential and problematic, source of inefficiency: supply-side preferred risk selection by MCOs. This phenomenon has also been labeled “active selection”, “selective enrollment”, and “cream skimming” (Pauly, 1984; Newhouse et al., 1989; van de Ven and van Vliet, 1992), or “creaming, skimming, and dumping” (Ellis, 1998). For the remainder of this paper, we follow other researchers in referring to this phenomenon simply as “risk selection” (Eggleston, 2000).
Brown et al., 2014; Cox et al., 2016). It refers to the operating practices by health plans or providers designed to enroll a group of patients of lower cost or risk than the overall population on which the reimbursement is based. Risk selection occurs when a uniform prospective payment is offered to facilitate the care of individuals comprising a defined group. However, where there is significant within-group heterogeneity in cost or risk, a uniform payment makes some individuals in the group more profitable than others. A conflict is thus created between a payer’s objective to procure high-quality private health insurance for a given population at a reasonable-cost and health plans’ objective to maximize profits by attracting relatively profitable individuals and avoiding unprofitable ones. Where successful, risk selection results in broken pooling arrangements wherein sponsors overpay for those patients accepted or enrolled, and must find alternative, often inferior, arrangements for those rejected (van de Ven et al., 2003).

It is well-established in the literature that risk selection is widespread in health care entitlement programs, despite existing measures by administrators to thwart it. In Medicare, even as regulations are enacted to stop risk selection along one set of patient characteristics, MCOs redirect selection efforts toward unadjusted characteristics (Brown et al., 2014). These efforts include offering supplementary benefits attractive to healthy individuals and unappealing to the disabled (Cooper and Trivedi, 2012), selective advertising to healthy individuals and in healthy areas (Aizawa and Kim, 2015), and increased spending on services used by high-profit patients (Ellis et al., 2013). Such efforts are difficult to verify as intentionally selective, and are thus difficult to regulate. These practices are also a problem in entitlement programs for the poor. For instance, sickness funds in the German Social Health Insurance system selectively engage with patients having profitable unadjusted geographic characteristics (Bauhoff, 2012). Kuziemko et al. (2013) show that MCOs treated profitable and unprofitable patients differently once Medicaid Managed Care was established in Texas, with the latter more often directed to alternate safety-net care. With 15.8 million Medicare Advantage beneficiaries (Kaiser Family Foundation, 2016a) and 43.3 million enrollees in Medicaid Managed Care (Centers for Medicare & Medicaid Services, 2016), risk selection presents a potentially large source of inefficiency in the United States. It is thus critical that health care administrators contemplating significant reforms to these programs account for and address this problem.

The primary existing method for addressing risk selection is risk adjustment, which involves accounting for various patient characteristics, such as age, medical diagnosis, and geographical location, and adjusting payments to MCOs accordingly. While this practice has had some success in pricing heterogeneity across Medicare Advantage plans (McWilliams et al., 2012), the aforementioned evidence of risk selection in enti-
tlement programs all occurred under some form of risk adjustment. Furthermore, crafting risk adjustment so fine as to completely eliminate unpriced heterogeneity may exacerbate other problems, such as incentivizing MCOs to “upcode” patients’ diagnoses in order to increase revenue (Geruso and Layton, 2015). This distorts MCOs’ incentive to treat efficiently by making payments less prospective. Given that existing efforts at comprehensive risk adjustment have preserved incentives to select, or created other distortionary incentives, it is worth studying complementary or alternative mechanisms for achieving this goal.

It is important to note that risk selection occurs because a payer offers a uniformly-priced beneficiary enrollment contract to MCOs, which can respond differently based on each individual beneficiary’s expected profitability. Could the process be structured as an individually-priced procurement auction where the payer “offers” separate contracts for each beneficiary? Auctions can motivate the revelation of private information and result in efficient allocations of resources (Milgrom, 1987). The use of competitive bidding in procurement allows purchasers to minimize expenditure while still ensuring that the winning bidder expects to profit from the contract; a mutually beneficial exchange. Applying the auction mechanism to the problem of risk selection, with payer as the principal, MCOs or health plans as bidders, and patient enrollment as a contract, could potentially bring these advantages to health care entitlement programs and lower costs for resource-constrained government payers.

Procurement auctions have been used in the U.S. public sector for several decades (Lewis and Bajari, 2011; Gupta et al., 2012; Haruvy and Katok, 2013; Kwasnica and Katok, 2007; Tadelis, 2012). Several of these have been conducted specifically in the healthcare sector and investigated by health economists (Christianson and Smith, 1984; Katzman and McGeary, 2008; McCombs and Christianson, 1987; Mechanic and Altman, 2010; Paringer and McCall, 1991; Schlesinger et al., 1986; Waters, 2006). Although the efficacy of these auctions has been debatable, buyers have generally lowered their costs. Concurrently, there is a rich history of procurement auctions in the operations management (OM) literature (Elmaghraby, 2007; Rothkopf and Whinston, 2007; Pinker et al., 2003; Aloysius et al., 2016; Li and Scheller-Wolf, 2011; Chen et al., 2008), and of the application of OM techniques, such as process design, capacity allocation, planning, and appointment scheduling in the delivery of health care to patients (Green and Savin, 2008; Klassen and Yoogalingam, 2009; Salzarulo et al., 2011; Chen and Robinson, 2014; Barz and Rajaram, 2015; Song et al., 2015; Helm et al., 2016; KC and Terwiesch, 2017; Osadchiy and KC, 2017).

The current literature in both OM and health economics, while extensive and insightful, can be extended to consider patient-level heterogeneity in sourcing care. The OM literature examining health-related prob-
lems has predominantly focused on the use of operations research techniques for solving operational and tactical issues. To our knowledge, the use of auctions for solving health care access problems is limited in the OM literature. The health economics literature discusses the use of procurement auctions to source medical supplies and determine group-level reimbursement. Existing auctions, however, do not account for individual-level heterogeneity, which can lead to risk selection. This paper examines an alternative application of competitive bidding: setting separate prospective payments for the enrollment of individual, heterogeneous beneficiaries. Such a mechanism was extreme or impractical in the past due to high transaction costs (Enthoven 1988; Newhouse 1996), but advances in information technology have made patient-level competitive bidding a more plausible option today.

In this paper, we model the interactions between consumers, a payer, and MCOs capable of practicing risk selection in a health care entitlement program. Three different reimbursement mechanisms, incorporating different degrees of competitive bidding, are evaluated. The first is a traditional uniform prospective payment system, where MCOs are offered a fixed fee per beneficiary enrolled. Beneficiaries failing to gain enrollment resort to seeking care in an emergency room or other costly settings. The second is a pure competitive bidding mechanism, offering no prospective payment but instead allocating each individual beneficiary to an MCO based on submitted bids. Finally, a mixed payment mechanism is evaluated, offering an initial prospective payment for enrollment, but then allocating any unenrolled beneficiary by submitted bids. We compare these mechanisms on the share of program beneficiaries securing enrollment and the tax burden of the entitlement program. The results show that, regardless of the magnitude and variation in unpriced enrollment costs, risk selection always occurs under the optimal uniform payment, but never occurs under competitive bidding. Another result shows that the optimal mixed payment system eliminates risk selection at a strictly lower tax burden than does pure bidding. Finally, the paper identifies necessary and sufficient conditions under which the bidding mechanisms achieve a lower tax burden than the uniform mechanism. Numerical analysis shows that these conditions hold over approximately 87% of parameter sets from simulated entitlement programs designed to approximate the real-world conditions of Medicare and Medicaid. Furthermore, relative to uniform payment, competitive bidding results in an additional 13% of the beneficiary population enrolled, on average, and reduces the total cost by 31%. These findings reveal the potential for patient-level competitive bidding mechanisms to both increase access and reduce costs.

See Jiang et al. (2012) for the use of queuing theory and contracting to solve outpatient scheduling problems in the U.K.
This paper bridges the gap between OM and health economic research, and makes three key contributions to the literature. It is the first paper to formally model the impact of individual, patient-level competitive bidding as a mechanism for mitigating risk selection. Second, whereas existing research frames competitive bidding and uniform payment as alternative mechanisms, this paper outlines a single mechanism utilizing both pricing methods. It thus determines whether any complementarities arise from the use of bidding and uniform pricing together. Finally, our results indicate that there is significant potential for patient-level competitive bidding to mitigate risk selection in health care entitlement programs, making even the most costly beneficiaries profitable to private MCOs, without increasing the programs’ burden on taxpayers. These results can be used to craft sustainable policies ensuring health care access to eligible beneficiaries.

2 Background Literature

Competitive bidding arrangements have long been proposed for the procurement of health care and health insurance (Hogan, 1983; Christianson and Smith, 1984; Pauly et al., 1991; Diamond, 1992; Keijser and Kirkman-Liff, 1992; Berwick and Hackbarth, 2012; Feldman et al., 2012). In practice, Medicare has used procurement auctions to source durable medical equipment, prosthetics, laboratory services, orthodontics and supplies (Waters, 2006; Katzman and McGeary, 2008; Mechanic and Altman, 2010). Additionally, health care systems in New York, Massachusetts, California, Wisconsin, and Arizona have used auctions to procure a variety of health services (Christianson and Smith, 1984; McCombs and Christianson, 1987; Paringer and McCall, 1991; Schlesinger et al., 1986). Importantly, Medicare and Medicaid continue to directly or indirectly allocate beneficiaries across private health plans using bidding mechanisms. Medicare uses bidding to set baseline capitation payments to MCOs enrolling Medicare Advantage participants (McGuire et al., 2013; Song et al., 2013). Furthermore, at least 16 U.S. states have allocated Medicaid beneficiaries among MCOs based on a competitive bidding process (Howell et al., 2012).

Where this study fundamentally departs from these existing mechanisms is the level at which private MCOs bid for beneficiaries. Past and proposed mechanisms use bidding to set uniform reimbursement rates for the enrollment of defined groups of patients. This may price group-level characteristics, but leaves any remaining within-group heterogeneity unpriced and can preserve selection incentives. Alternatively, this paper proposes mechanisms with individual- or patient-level bidding. The closest real world example of this patient-level competitive bidding is Medibid.com, where surgeons bid through electronic auctions to serve the needs of individual patients (Ellis, 2014; Young, 2016). Rather than serving an insurance function,
however, Medibid.com facilitates direct transactions between patients and providers for non-emergency surgical procedures. In contrast, the insurance mechanisms proposed here use bidding to secure low-cost enrollment for beneficiaries with managed care plans.

Outside of the health care context, there are few additional examples from the auction literature of models where individuals are the subject of competitive bidding. For instance, the marketing literature investigates various online auctions that take into consideration advertisement format, potential customer profile, and advertiser quality and competition in customizing messages to target specific types of individuals (Agarwal and Mukhopadhyay 2016; Animesh et al. 2011; Zhu and Wilbur 2011). A second stream of literature examines organizations’ use of online freelancing platforms to bid for outside individuals’ skills and expertise (Popiel 2017; Hong and Pavlou 2013). The third stream of the literature comes from the field of human resource accounting. Hekimian and Jones (1967) proposed a mechanism for allocating human resources in a firm by having divisional managers bid on employees, and in doing so, establish a valuation for each employee. Though this mechanism was ultimately not embraced by the rest of the field (Baker 1974; Barta 1975), Hekimian and Jones (1967) raises an interesting point regarding the special concerns inherent with bidding for individuals: some may feel unease with bidding on individuals or worry that it reduces people to a commodity. As mentioned previously, however, health care entitlement programs have already used competitive bidding to allocate groups of patients to managed care plans. We simply investigate whether bidding over individuals, rather than groups, can resolve an important source of market failure at a justifiable cost.

Although not focused on individuals as the unit of examination, the OM literature has examined procurement auctions in significant detail. Driven by the need to lower costs, and facilitated by digital technologies in the last two decades, a large number of organizations have used procurement auctions to source their needs (Bichler and Steinberg 2007; Li and Scheller-Wolf 2011; Mithas and Jones 2007). In fact, competitive sourcing mechanisms are an important means of procurement operations at more than 65 percent of organizations, accounting for 10% of the actual spend, with a further upside potential of 40% (Haruvy and Katok 2013). Procurement auctions have also been used extensively in the public sector, including for highway repair contracts (Lewis and Bajari 2011), and procurement of food products by the U.S. Department of Agriculture (MacDonald et al. 2002). Prior research suggests that the design of these auctions and the information display format have significant implications on the cost savings for buyers (Aloysius et al. 2016; Gupta et al. 2012; Mithas and Jones 2007; Rothkopf and Whinston 2007), but incumbents
still win in a large percentage of auctions (Elmaghraby, 2007). Additionally, participation in these auctions may enable incumbents to assess their capabilities and standing with the buyer in comparison to newcomers. Due to the flexibility of online auction rules and formats and the potential cost savings, policymakers are strongly considering expanding the use of procurement auctions in day-to-day operations (Aloysius et al., 2016; Anandalingam et al., 2005; Pinker et al., 2003).

Gupta et al. (2012) discuss the use of procurement auctions in the health insurance context. They investigate an initiative where several Fortune 500 firms invited MCOs to compete in open electronic auctions to enroll their employees in hopes of reducing health care procurement costs. The auctions generated significant cost savings the first year, but failed to retain bidder participation during subsequent years and were shut down. The issues related to auction winner determination, information feedback, ending rules, and price visibility. The authors suggest that it is important for buyers to sufficiently codify the “product” so it can be easily converted into a commodity, with clearly identified and understood operational parameters. Unlike the individual-level bidding mechanisms explored here, bidding in the procurement auction from Gupta et al. (2012) was conducted at the group-level. While this experience was ultimately unsuccessful, it presents a real-world example of competitive bidding in the procurement of health insurance.

In light of the paucity of theoretical and empirical research using individual-level auctions for the procurement of health insurance, this paper bridges a number of scholarly fields, and proposes an innovative mechanism to eliminate risk selection, contain health care costs and expand access to care for the most vulnerable beneficiaries.

3 The Model

There is a population of consumers of measure 1. A share $D$ of these are “beneficiaries”; those entitled to government-sponsored health insurance. The remaining $(1 - D)$ share, or “taxpayers”, bear the tax burden of the program. All consumers have preferences represented by the strictly concave utility function $U(y, H)$, where $y$ is consumption and $H$ is health status. Beneficiaries are endowed with income $m_1$ and taxpayers are endowed with $m_2$, where $m_2 > m_1$. Health status is binary; beneficiaries enrolled with a health plan enjoy health status $H_1$ and those without enjoy $H_2$, where $H_1 > H_2$. Taxpayers’ health status is fixed at $H_1$. Beneficiaries are heterogenous in ex ante risk type $k$, which is unobservable to consumers. There are $K \in \mathbb{Z}^{++}$ different types and the share of beneficiaries of risk type $k$ is $\alpha_k$, where $\sum_{k=1}^{K} \alpha_k = 1$. Risk type is an important consideration in the cost that a health plan expects to bear upon enrolling a given beneficiary.
Beneficiaries match randomly and sequentially with each of $n \in \mathbb{Z}^{++}$ symmetric managed care organizations, where $n \geq 2$. Each MCO is unaware of its place in the order of these matches. The simplest interpretation of $n$ is the total number of MCOs who have met the payer’s minimum quality requirements and are open to enrolling beneficiaries. Alternatively, even though the steps are not modelled here, $n$ could be the number of MCOs visited before either falling ill or giving up the search. MCOs are risk-neutral profit maximizers. The expected cost to MCO $j$ of taking on beneficiary $i$ of risk type $k$ is $c_{ijk}$. These are independently distributed according to $F_k(c)$, with corresponding probability density function $f_k(c)$ over $[\underline{c}, \bar{c}]$, a support common across all risk types. Assume that each distribution $F_k(c)$ is smooth, continuous, atomless, and has first-order stochastic dominance over the preceding distribution $F_{k-1}(c)$ for all $k \geq 2$. This implies that mean enrollment cost, conditional on risk type, increases in $k$. Assume that risk type is verifiable among MCOs, but $c_{ijk}$ is private information held by MCO $j$. Any MCO is able to engage in risk selection, and can thus reject excessively costly beneficiaries. In the real world, this is accomplished through a variety of indirect risk selection techniques that are difficult for payers to verify (Newhouse, 1996; van de Ven et al., 2003). Assume that rejecting a beneficiary is costless to an MCO.

Beneficiary utility is unaffected by the number of rejections as long as there is an eventual acceptance.

Expected costs of enrollment are modelled here as independent and match-specific. This means that, even if a given beneficiary’s final cost were different from the MCO’s initial expectation, any difference is assumed to be independent of the other MCOs’ expected costs. The model does not investigate the scenario where each beneficiary carries a common enrollment cost, of which each MCO only receives a noisy signal. This is done for three reasons. First, beyond the symmetric MCOs modelled here, real-world health plans differ along many characteristics related to cost. These include profit motive, business model, covered services, cost-sharing arrangements, and provider networks. Both expected and final enrollment costs are thus bound to differ across health plans. Second, even though there may be some common component to enrollment costs, risk-pooling insurers are more reliant on predictive analytics than idiosyncratic signals when making decisions. Finally, the common component most relevant to health insurance results from an individual’s private information regarding their own health status. While this is a well known source of adverse selection in health insurance, the model here focuses on asymmetric information between health plan

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2The assumption of a common support ensures that other players cannot directly infer risk type based on any reports of $c_{ijk}$.

3Costly rejections would predictably reduce the incentive to reject, and thus lessen the importance of risk selection as a problem. The empirical evidence of risk selection in entitlement programs, however, suggests that any rejection costs in these cases are not prohibitive.
and payer rather than health plan and patient. The mechanisms examined here are not designed to mitigate this source of adverse selection, the avoidance of which may require separate or additional measures. The potential impact of common costs are explored further in the discussion section.

There is a government-sponsored payer managing the health care entitlement program, with the objective of maximizing aggregate expected consumer utility. The payer takes in revenue of $\tau$ from each taxpayer and compensates MCOs for enrolling beneficiaries. MCO profits are excluded from the payer’s objective function under the assumption that industry profits are not well-captured by beneficiaries or taxpayers. The payer cannot condition compensation on risk type. This is due to either asymmetric information, where the payer does not observe risk type, or through mandatory community rating regulations requiring the payer (or government) to disregard risk type. Therefore, any prospective payment $w$ at which MCOs are compensated is constant across all risk types. For each beneficiary failing to enroll with an MCO, the payer bears a cost $w_{ER} > c$. This is the cost of the beneficiary’s care if left uncoordinated by an MCO, delivered instead in an emergency department or acute care setting for a preventable illness. Finally, assume for this set of beneficiaries that universal enrollment is first-best optimal for the payer, implying that:

$$\Delta U \geq U\left[m_2 - \left(\frac{D}{1-D}\right) w_{ER}, \ H_1\right] - U\left[m_2 - \left(\frac{D}{1-D}\right) \bar{c}, \ H_1\right]$$

where $\Delta U = U(m_1, H_1) - U(m_1, H_2)$ is the benefit of enrollment. The assumption ensures that the payer would prefer that even the most costly individuals in this set of beneficiaries achieve enrollment rather than leave any unenrolled. This fully defines the payer’s first-best optimal outcome: enrollment for each beneficiary with the plan incurring the lowest enrollment cost on that beneficiary. This would achieve the maximum utility for each beneficiary at the lowest cost to taxpayers. In the case where $w_{ER} \geq \bar{c}$, Condition (1) is implied. On the other hand, where $w_{ER} < \bar{c}$, Condition (1) implies that the extra expense of enrollment to taxpayers is justified by a sufficient boost in aggregate utility to beneficiaries. Both cases are explored in the numerical analysis section.

### 3.1 Equilibrium: Uniform Payment

The first mechanism evaluated is uniform prospective payment $(U)$, where the payer sets a fixed payment $(w_u)$ to MCOs per beneficiary enrolled. Given this payment, and because they can select risks, MCOs take on those beneficiaries they find profitable and reject the rest. MCO $j$’s problem when confronted with a

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4Any consumers for whom Condition (1) does not hold are presumed excluded or enrolled in alternative public programs.
beneficiary with cost of treatment \(c_{ijk}\) is whether to accept or reject. For each acceptance, it would receive \(w_u\) in revenue and bear cost \(c_{ijk}\). In rejecting a beneficiary, the MCO takes in no revenue and bears no cost. Therefore, in this subgame, each MCO \(j\) has a simple optimal strategy: accept if \(w_u \geq c_{ijk}\), and reject otherwise. With its understanding of conditional enrollment cost distributions, the payer knows that the probability of a given beneficiary of risk type \(k\) being unacceptable to an MCO is \(1 - F_k(w_u)\). As these costs are independent across MCOs, the probability that all \(n\) MCOs find this beneficiary unacceptable is \([1 - F_k(w_u)]^n\). Therefore, in maximizing expected consumer utility subject to a balanced budget constraint, the payer’s problem becomes:

\[
\max_{w_u} \left\{ D \left[ U(m_1, H_1) - \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^n \cdot \Delta U \right] + (1 - D) U(m_2 - \tau_u, H_1) \right\}
\]

s.t. \(\tau_u = \frac{D}{1 - D} \left[ w_u + \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^n \cdot (w_{ER} - w_u) \right]\)

Even though a higher uniform payment increases the chance that any beneficiary secures an acceptance, it also increases the amount of overpayment on each beneficiary accepted. The optimal uniform payment \(w_u^*\) recognizes this trade-off, satisfying:

\[
(2) \quad n \left( \frac{\Delta U}{MU_y} + w_{ER} - w_u \right) \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^{n-1} f_k(w_u) = 1 - \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^n
\]

where \(MU_y\) is taxpayers’ marginal utility of consumption. The term on the left is the benefit of a marginal increase in the uniform payment. Specifically, it is the increase in the measure of beneficiaries both forgoing emergency room care (thus costing \(w_u\) instead of \(w_{ER}\)) and also the benefit of enrollment (\(\Delta U\)), the value of which is measured in units of taxpayer consumption once divided by \(MU_y\). The increase in program spending due to the marginally higher uniform payment on the expected measure of enrolled beneficiaries is on the right.

**Proposition 1.** \([1 - F_k(w_u^*)]^n > 0 \forall k\) in any equilibrium under the uniform payment mechanism.

**Proof.** In Appendix. 

Proposition 1 states that, no matter how costly it is to have beneficiaries remain unenrolled, the optimal uniform payment leaves a positive measure of beneficiaries universally rejected. Intuitively, a higher acceptance rate become increasingly costly to achieve as the rate approaches 1. This is because the payment is
uniform; it must increase for all accepted beneficiaries, not just the marginal one. As \( w_u \) approaches \( \bar{c} \) from below, the burden of higher payments on all accepted beneficiaries eventually outweighs the benefit of the marginal beneficiary’s acceptance. The equilibrium uniform payment is therefore below \( \bar{c} \), leaving those beneficiaries with treatment costs only between \( w_u^* \) and \( \bar{c} \) universally rejected. Note that, due to the stochastic dominance assumptions on the expected cost distributions, higher risk types are more likely to incur the highest expected treatment costs. Therefore, even though MCOs in the model cannot directly discriminate by risk type, high risk types suffer indirect discrimination through over-representation in the universally rejected group, and thus benefit the least from the entitlement program \textit{ex ante}.

3.2 Equilibrium: Mixed Payment

The mixed payment mechanism (\( X \)) begins similarly to uniform payment. MCOs are offered a fixed payment (\( w_x \)) for each beneficiary enrolled, beneficiaries and MCOs interact, and MCOs evaluate \( c_{ijk} \) values in taking on those they find profitable. The difference is that under mixed payment, upon rejecting beneficiary \( i \), an MCO must report to the payer an amount (\( b_{ij} \)) at which that beneficiary would be acceptable. These amounts are the MCOs’ “bids”. For those beneficiaries rejected by all \( n \) MCOs, the payer awards the contract to enroll the beneficiary to the MCO submitting the lowest bid, and pays this MCO an amount equal to the second-lowest bid. The payer funds this reimbursement method by charging \( \tau_x \) to each taxpayer. Note that the pure bidding mechanism (\( P \)), where all beneficiaries are allocated by submitted bids, is a special case of the mixed payment mechanism. Setting an extremely low initial payment in the mixed mechanism, \( w_x < \bar{c} \) for example, would make every MCO unwilling to accept any beneficiary at the initial payment, leaving all beneficiaries to be allocated based on bids.

Working backward, an MCO \( j \) that has rejected beneficiary \( i \) must decide on the amount to submit as a bid to enroll beneficiary \( i \). If this beneficiary is subsequently accepted by a different MCO, then MCO \( j \)’s resulting payoff is zero. MCO \( j \)’s payoff is affected by its bid if and only if the beneficiary is rejected by the other \( n - 1 \) MCOs. The process under this universal rejection outcome is equivalent to a second-price reverse or procurement auction. The payer is the principal, all \( n \) rejecting MCOs are bidders, and the enrollment of the universally rejected beneficiary is the contract. It is well established in the literature that bidder \( j \)’s optimal bid in such an auction (\( b_{ij}^* \)) is the opportunity cost of the contract (\( c_{ijk} \)). As this bid weakly dominates all bids in the universal-rejection outcome, and payoff is independent of bid in any other

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5 If MCOs could directly discriminate (for example, by discouraging high risk types from attempting to match at all) then it may be advantageous for them to do so given that high risk types are relatively less profitable in expectation. High risk types under the uniform payment mechanism in the real world may therefore face further access barriers in addition to those modelled here.
outcome, this is also bidder $j$’s optimal strategy \textit{ex ante}.

Before submitting a bid, a given MCO must decide whether to accept or reject this beneficiary. It is assumed, following Kirkman-Liff et al. (1985), that an MCO $j$ can estimate both the probability that a beneficiary $i$ is accepted following a rejection, as well as the probability and expected payment in the event that $c_{ijk}$ is the lowest bid. Given the prospective payment offered by the payer, the value of accepting is the same as in the uniform system $(w_x - c_{ijk})$. For any $w_x < \bar{c}$, the value to the MCO of rejecting is strictly positive because there is a positive probability that the $n-1$ other MCOs also reject and the beneficiary is allocated by submitted bids. In such a case, each rejecting MCO has a non-negative expected payoff. Should MCO $j$’s bid of $c_{ijk}$ be the lowest, then it would receive the lowest of the set of weakly higher bids. To MCO $j$, this second-lowest bid ($\hat{c}_k$) is a random variable, distributed according to the cumulative distribution function $1 - G_k(\hat{c}_k) = 1 - [1 - F_k(\hat{c}_k)]^{n-1}$. Therefore, the expected payment conditional on $c_{ijk}$ being the lowest bid is:

$$E(\hat{c}_k | \hat{c}_k > c_{ijk}) = \int_{c_{ijk}}^{\bar{c}} x \cdot \frac{d[1 - G_k(x)]}{dx} dx = c_{ijk} + \int_{c_{ijk}}^{\bar{c}} \frac{G_k(x)}{G_k(c_{ijk})} dx.$$

Let $h_k$ be the highest expected treatment cost at which it is a best response for an MCO to accept a beneficiary of risk type $k$. This means that any MCO would reject whenever $c_{ijk} > h_k$. Therefore, the expected value of rejecting a beneficiary is the product of the probability that the $n-1$ other MCOs also reject ($G_k(h_k)$), the probability that $c_{ijk}$ represents the lowest bid ($\frac{G_k(c_{ijk})}{G_k(h_k)}$), and the expected payoff conditional on $c_{ijk}$ being the lowest bid ($E(\hat{c}_k | \hat{c}_k > c_{ijk}) - c_{ijk}$). Thus, unlike the uniform payment system, an MCO’s optimal strategy is to accept if:

$$w_x \geq c_{ijk} + G_k(h_k) \cdot \frac{G_k(c_{ijk})}{G_k(h_k)} \cdot \int_{c_{ijk}}^{\bar{c}} \frac{G_k(x)}{G_k(c_{ijk})} dx = c_{ijk} + \int_{c_{ijk}}^{\bar{c}} G_k(x) dx$$

and reject otherwise. Condition (4) defines $h_k$:

$$h_k = h_k(w_x, n) \text{ such that } w_x = h_k + \int_{h_k}^{\bar{c}} G_k(x) dx.$$

---

6 This would be the bid of an MCO with cost $c_{ijk}$ in a first-price reverse auction [Milgrom and Weber 1982; Huh and Roundy 2002], and also the expected payment to a winning MCO bidding $c_{ijk}$ in a second-price reverse auction due to the Revenue Equivalence Theorem [Myerson 1981].

7 At any place in the order of matches, $n-1$ rejections are required either before or after the current match before the beneficiary is allocated by bids. For this reason, an MCO facing a match does not need to consider potential match orders when deciding whether or not to reject.
The right side of (4) is increasing in \( c_{i,j,k} \). Therefore, when facing a beneficiary of type \( k \), a payment \( w_x \), and \( n - 1 \) other providers, MCO \( j \) would accept beneficiary \( i \) if \( c_{i,j,k} < h_k \). Due to \( \int_{h_k}^{c} G_k(x) \, dx \geq 0 \), it is clear that \( h_k(w_x,n) < w_x \) for all \( w_x < c \) and \( h_k(c,n) = c \). Intuitively, facing a given payment to enroll a particular beneficiary, rejecting is more attractive under mixed payment than under uniform payment due to the prospect of realizing a positive payoff in the auction stage. This means that any choice of payment would induce more rejections under mixed payment relative to uniform payment.

Rather than the actual costs taken on by the MCOs, the payment \( (\pi) \) to the winning MCO (ie. the second-lowest bid) is relevant to the payer’s problem. When allocating a beneficiary of type \( k \) according to bids, the probability that the second-lowest bid is less than \( \pi \) is the probability that any two MCOs (of which there are \( n(n - 1) \) combinations) both bid below \( \pi \) while the remaining \( n - 2 \) other MCOs bid higher. For the payer, this means that the payment for a type \( k \) beneficiary is a random variable distributed according to the probability density function:

\[
q_k(\pi \mid h_k) = n(n - 1) \frac{[F_k(\pi) - F_k(h_k)]}{[1 - F_k(h_k)]^n} [1 - F_k(\pi)]^{n-2} f_k(\pi)
\]

and the payer’s expected payment to MCOs per beneficiary of type \( k \) allocated by bids is \( E[\pi_k \mid w_x, n] = \int_{h_k}^{c} \pi q_k(\pi \mid h_k) \, d\pi \). Under the mixed payment system, each beneficiary is either accepted by an MCO during an initial match, or allocated to the lowest bidding MCO in the auction stage. This means that all beneficiaries ultimately become enrolled and enjoy health status \( H_1 \). Beneficiaries enjoy the utility \( U(m_1, H_1) \) and taxpayers the utility \( U(m_2 - \tau_x, H_1) \), and so the payer’s problem becomes the minimization of expected cost per beneficiary:

\[
\min_{w_x} \left\{ w_x + \sum_{k=1}^{K} \alpha_k \left\{ [1 - F_k(h_k)]^n \cdot (E[\pi_k \mid w_x, n] - w_x) \right\} \right\}
\]

with the optimal payment \( (w^*_x) \) characterized by:

\[
\begin{align*}
&n \sum_{k=1}^{K} \alpha_k [1 - F_k(h_k)]^{n-1} f_k(h_k) \frac{\partial h_k}{\partial w_x} (E(\pi_k \mid w_x, n) - w_x) \\
&= 1 - \sum_{k=1}^{K} \alpha_k [1 - F_k(h_k)]^n + \sum_{k=1}^{K} \alpha_k \left\{ [1 - F_k(h_k)]^n \frac{\partial E(\pi_k \mid w_x, n)}{\partial w_x} \right\}.
\end{align*}
\]

(6)
The left side of the equation represents the marginal benefit of increasing the prospective payment in the mixed system. It is the reduction in the measure of beneficiaries expected to be allocated in the auction stage, each of whom costs an additional \((E(\pi_k | w, n) - w_x)\) above the prospective payment. The right side of the equation is the marginal cost, which includes both higher payments on the measure of beneficiaries avoiding the auction stage as well as higher expected payments in the auction stage for those who do not.

**Proposition 2.** \(\sum_{k=1}^{K} \alpha_k [1 - F_k(h_k(w^*_x, n))]^n < 1\) in any equilibrium under the mixed payment system.

**Proof.** In Appendix.

Proposition 2 states that it is never optimal in the mixed system to set the payment so low that every beneficiary is allocated by auction. Define \(w^*_x,k = w^*_x,k(n)\) such that \(h_k(w^*_x,k, n) = c\). This is the highest prospective payment such that MCOs still reject all beneficiaries of type \(k\), regardless of \(c_{ijk}\). Setting a payment in the mixed system at or below \(w^*_x,1\) would result in the pure bidding allocation mechanism, with expected entitlement program costs of \(\tau_p = \tau_x(w^*_x,1)\). By Proposition 2, spending can always be reduced below \(\tau_p\) by raising \(w^*_x\) strictly above \(w^*_x,1\), and thus having at least an infinitesimally small positive measure of type 1 beneficiaries accepted before the auction stage. Intuitively, an MCO with cost \(c_{ijk} = h_k\) is guaranteed to have the lowest bid and win any auction for this beneficiary, and were an auction to happen, can expect to realize a large payoff. When deciding whether or not to accept, such an MCO realizes that this large payoff is not guaranteed; it is contingent on every other MCO also rejecting. By accepting, however, the MCO is assured of revenues equal to the prospective payment. The payer can exploit this tension between potential and guaranteed payoffs by increasing the prospective payment. This induces an acceptance by the marginal MCO at the lower prospective payment rather than paying out a larger payment in an auction to the winning bidder, and thus reduces the expected payment per beneficiary.

**Proposition 3.** For any parameter set,

\[
\frac{\partial (\tau^*_u - \tau^*_x)}{\partial H_2} < 0,
\]

\[
\frac{\partial (\tau^*_u - \tau^*_x)}{\partial m_1} > 0, \quad \text{and}
\]

\[
\frac{\partial (\tau^*_u - \tau^*_x)}{\partial m_2} > 0.
\]
Proof. In Appendix.

where $\tau_u^* = \tau_u(w_u^*)$ and $\tau_x^* = \tau_x(w_x^*)$. This proposition follows from a comparison of the First Order Conditions (2) and (6). In Condition (2), the optimal uniform payment depends on both $\Delta U$ and $MU_y$. These terms are absent in Condition (6). This is because, while consumer preferences are relevant to the payer’s problem under the uniform payment mechanism, they are irrelevant in what amounts to a cost minimization problem under the mixed mechanism. Therefore, the parameters that affect $\Delta U$ and $MU_y$ will in turn affect $\tau_u^*$ but not $\tau_x^*$. An increase in $H_2$ means reduces the negative health consequences of going unenrolled, which reduces the payer’s incentive to get the marginal beneficiary enrolled and leads to a lower optimal uniform payment. The marginal effects of $m_1$ and $m_2$ are due to the concavity of $U(y, H)$. The benefit of enrollment increases in $m_1$, which increases the payer’s incentive to enroll beneficiaries, and thus a higher optimal uniform payment. Finally, an increase in $m_2$ makes the marginal unit of taxpayer income relatively less valuable as consumption rather than program spending, and thus induces the payer to increase taxes and enrollment.

Proposition 4. For a given parameter set,

$$\frac{\partial (\tau_u^* - \tau_x^*)}{\partial w_{ER}} \geq 0$$

if, under the uniform payment mechanism evaluated at $w_u^*$.

$$\left( \frac{\Delta U}{MU_y} \right) \varepsilon_{MU,y,\tau} \leq \frac{(1 - D) \tau_u^*}{D \left( \sum_{k=1}^{K} \alpha_k (1 - F(w_u^*))^n \right)}$$

Proof. In Appendix.
This, in turn, would restrict the payer’s enrollment efforts. As revealed in Condition (7), however, the substitution effect dominates the income effect as long as the universally rejected share of beneficiaries
\[ D \sum_{k=1}^{K} \alpha_k (1 - F(w_k^*))^{n} \] is low relative to total entitlement program spending, \((1 - D) \tau_u^*\). Intuitively, an increase in the cost of such a small share of beneficiaries would have a small impact on both taxes and taxpayer consumption.

Comparison of the three mechanisms examined here requires criteria for the basis of an ordering. The implications of Propositions 1 and 2 allow for at least a partial ordering on the basis of \(\text{ex ante}\) Pareto dominance. That is, if mechanism \(A\) were to achieve at least as much expected utility for one group of consumers (beneficiaries or taxpayers) as mechanism \(B\), while leaving the other group strictly better off in expectation, then mechanism \(A\) would \(\text{ex ante}\) Pareto dominate mechanism \(B\). Let “\(\succeq\)” be a binary relation implying \(\text{ex ante}\) Pareto dominance. Since the mixed \((X)\) and pure \((P)\) bidding mechanisms both eliminate risk selection, while the mixed mechanism results in lower entitlement program spending (and thus lower taxes) by Proposition 2, it follows that \(X \succeq P\) in a strict sense. The ordering can be further extended to include the uniform payment mechanism \((U)\) under the following necessary and sufficient conditions:

\[ \tau_x^* \leq \tau_u^*, \quad \iff \quad X \succeq U. \]
\[ \tau_p^* \leq \tau_u^*, \quad \iff \quad X \succeq P \succeq U. \]

These follow directly from Proposition 1, because beneficiaries’ prospects for enrollment are higher under either competitive bidding mechanism than under uniform payment. With beneficiaries unambiguously better off, a competitive bidding mechanism dominates uniform payment if the entitlement program spending under the former is no greater than under the latter, leaving taxpayers no worse off.

4 Numerical Analysis

This section reports numerical analyses conducted to reveal the circumstances in which Conditions (8) and (9) are most likely to hold, as well as the circumstances delivering the greatest expected improvements between mechanisms in program costs and beneficiary access to care. This is useful for two reasons. First, the model examined above gave no consideration to administrative costs. This is an important consideration if competitive bidding is administratively complex. The mixed bidding system, in particular, may be complex as it essentially runs the other two mechanisms in tandem. Estimates of the savings would therefore illustrate
whether or not differences in administrative costs are justified. Second, from the analytical results alone, it is unclear which distributional characteristics or model parameters are most important in determining the ordering of mechanisms. This knowledge would be useful in distinguishing which situations are most likely to realize program improvements under competitive bidding.

Using MATLAB 9.0, we randomly drew 50,000 parameter sets from a thirteen-dimensional parameter space. Each element of each parameter set was drawn independently from a uniform distribution between the bounds shown in the Table 1 summary statistics. The bounds on these parameters were selected to produce parameter means approximating actual conditions in U.S. health care entitlement programs. There are currently 55.5 million beneficiaries enrolled in Medicare and 74.2 million in Medicaid (Kaiser Family Foundation, 2016b, 2017), meaning the share of beneficiaries \( D \) in the U.S. population is 39.6%. The parameter mean for \( m_1 \) is set at $14,115.60, which is the weighted average of the incomes of all Medicare and Medicaid beneficiaries (Jacobson et al., 2014; Department of Health & Human Services, 2016). In the case of Medicaid, nationwide average enrollee income was unavailable. As a substitute, we used the Affordable Care Act (ACA) minimum income eligibility threshold (138% of federal poverty level). Assuming that the remaining 60.4% of consumers are taxpayers, the U.S. per capita GDP of $55,836.80 (World Bank, 2017) translates into average taxpayer income \( m_2 \) of $83,190.43. We assume \( m_2 > \left( \frac{D}{1-D} \right) \times \left( \max \{ w_{ER}, \bar{c} \} \right) \) to ensure that taxpayer consumption cannot become negative under any mechanism.

Empirical evidence shows that entitlement program beneficiaries with poor access to disease prevention and primary care are often funneled to emergency departments or acute care settings (Kusserow, 1992; Oster and Bindman, 2003; Tang et al., 2010; Kellermann and Weinick, 2012). Furthermore, enrollment with an MCO results in more coordinated care and reductions in avoidable complications (Grossman et al., 1998; Bindman et al., 2005). For this reason, unenrolled beneficiary health status \( H_2 \) is drawn randomly from a uniform distribution bounded between 0 and 5, while that for an enrolled beneficiary \( H_1 \) is between 5 and 10. The mean number of MCOs \( n \) is set at 6 based on typical insurer participation rates in the ACA health insurance exchanges over the past three years (Cox et al., 2016). The parameter \( K \) is set between 1 and 3 to provide equally rich investigation of cases in which there is no variation in risk type as well as those in which patients are one of low, medium, or high risk.

We assume that consumer preferences are represented by a Cobb-Douglas utility function, \( U(y, H) = H^\beta y^{(1-\beta)} \). This choice of functional form provides some guidance as to an appropriate parameter mean for \( \beta \). Under Cobb-Douglas preferences, the solution to a hypothetical consumer optimization problem is to
Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean (Std. deviation)</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ξ</td>
<td>50.02 (28.96)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>¯c</td>
<td>101,250 (14,421)</td>
<td>76,079</td>
<td>126,100</td>
</tr>
<tr>
<td>n</td>
<td>6 (2.59)</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>wER</td>
<td>42,329 (35,754)</td>
<td>1,574</td>
<td>318,000</td>
</tr>
<tr>
<td>m₁</td>
<td>14,110 (6.112)</td>
<td>3,544</td>
<td>24,687</td>
</tr>
<tr>
<td>m₂</td>
<td>84,533 (38,540)</td>
<td>20,137</td>
<td>334,000</td>
</tr>
<tr>
<td>D</td>
<td>0.396 (0.114)</td>
<td>0.198</td>
<td>0.594</td>
</tr>
<tr>
<td>H₁</td>
<td>7.49 (1.44)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>H₂</td>
<td>2.52 (1.44)</td>
<td>4.20e-05</td>
<td>5</td>
</tr>
<tr>
<td>β</td>
<td>0.18 (0.10)</td>
<td>2.04e-06</td>
<td>0.36</td>
</tr>
<tr>
<td>σ</td>
<td>0.0375 (0.0072)</td>
<td>0.025</td>
<td>0.05</td>
</tr>
<tr>
<td>K</td>
<td>1.997 (0.818)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Skew</td>
<td>0.027 (0.05)</td>
<td>0</td>
<td>0.33</td>
</tr>
<tr>
<td>Concentration</td>
<td>0.025 (0.057)</td>
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<td>0.672</td>
</tr>
<tr>
<td>E(cijk)</td>
<td>6,590 (4,068)</td>
<td>1,558</td>
<td>29,972</td>
</tr>
<tr>
<td>α₁</td>
<td>0.899 (0.095)</td>
<td>0.64</td>
<td>1</td>
</tr>
<tr>
<td>Reject_u</td>
<td>0.1134 (0.0826)</td>
<td>0.0031</td>
<td>0.5090</td>
</tr>
<tr>
<td>Reject_x</td>
<td>0.5218 (0.0551)</td>
<td>0.4057</td>
<td>0.6677</td>
</tr>
<tr>
<td>Cond₈</td>
<td>0.870 (0.34)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cond₉₈</td>
<td>0.866 (0.34)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>τₜ_u</td>
<td>6,561 (8,017)</td>
<td>247</td>
<td>102,000</td>
</tr>
<tr>
<td>τₚ</td>
<td>3,847 (3,766)</td>
<td>148</td>
<td>34,620</td>
</tr>
<tr>
<td>τₜ z</td>
<td>3,812 (3,755)</td>
<td>141</td>
<td>34,447</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>50,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
devote share of income $\beta$ to the pursuit of greater health. Given the current percentage of U.S. GDP devoted to health care, the parameter mean for $\beta$ is set at 0.18.

A different set of $F_k(c)$ distributions is drawn for each simulation. These distributions are truncated normal over $[c, \bar{c}]$ with the same standard deviation as a share of the support $\left(\bar{\sigma} = \frac{\sigma}{\bar{c} - c}\right)$. The cost distributions of actual Medicare and Medicaid beneficiaries reveal a lower bound of essentially 0 (we use a mean of $50 to allow for sensitivity analysis in both directions) and a weighted average cost of $101,250 for the top percentile, which is used as a mean upper bound in the simulations (Coughlin et al., 2014; De Nardi et al., 2016). Given such a wide typical support, three additional constraints were placed on these distributions in order to ensure an unconditional mean treatment cost between those of Medicare ($7,720) and Medicaid ($5,790) (Young et al., 2015). First, the standard deviations are set fairly low at 3.75% of the support, on average. Second, the mode of the lowest risk type’s distribution is set at the lower bound $c$ and this type’s share of the beneficiary population ($\alpha_1$) is set, on average, at 90%. Finally, the modes for any other risk types are spread randomly over the lower 75% of the support in each simulation. Altogether, these constraints result in an average unconditional mean treatment cost ($E(c_{ijk})$) of $6,589.90 across all simulated parameter sets.

Two measures were constructed in order to capture the exogenous characteristics of the simulated distributions. From Table 1, let Skew be the mass of the unconditional probability density function distributed over the greater half of the support, $(0.5(c + \bar{c}), \bar{c})$. Let Concentration be the measure of the support containing 50% of the mass, excluding highest and lowest quartiles. These measures allow for investigation into the impact of population distribution characteristics on the equilibrium degree of selection, any cost savings between mechanisms, and the likelihood of ex ante Pareto dominance.

Selecting a parameter mean for $w_{ER}$ is difficult in that we do not observe the counterfactual treatment costs that unenrolled beneficiaries would have incurred in the absence of enrollment. Because of this, we rely on descriptive statistics drawn from the literature to serve as proxies. Coughlin et al. (2014) find that those remaining uninsured for a full year consume approximately half the dollar value in health services as those insured for a full year. Other references for this parameter are obtained through comparisons of charges for primary care services in emergency departments, which are an important source of care for those with poor access, versus those in more appropriate primary care settings. These estimates vary, showing that emergency department charges are between 1.2 and 5.4 times greater (Kusserow, 1992; Blue Cross Blue Shield, 2009). In order to test all of these scenarios, $w_{ER}$ is drawn randomly in each simulation to be between 0.5 and 6 times the mean cost of the upper two quartiles of patients (ie. those most likely to face
rejection). This allows for investigation into alternative scenarios where it is either less or more expensive to have these consumers remain unenrolled.

A final note on the simulations concerns Condition (1). Unlike in the analytical section, this condition is not required to hold over the simulated parameter sets. This is because the numerical section attempts to replicate the conditions of real-world U.S. entitlement programs, and there is no guarantee that enrollment is efficient for all current beneficiaries. Under the assumptions of the model, relaxing Condition (1) could bias the numerical results against the bidding mechanisms because it may create a measure of beneficiaries in some parameter sets for whom enrollment is inefficient for the payer. Despite the inefficiency, they would become enrolled under competitive bidding because these mechanisms are designed to secure enrollment for all beneficiaries. Even so, over all simulated parameter sets, Condition (1) ends up holding for 97.3% of beneficiaries, on average. Therefore, even though the bidding mechanisms ultimately secure enrollment for these “inefficient” beneficiaries, they make up a relatively small share and so any bias against the competitive bidding mechanisms is likely modest.

Given the functional forms, MATLAB’s fsolve function was used to determine the optimal prospective payments under alternative uniform \((w_u^*)\) and mixed \((w_x^*)\) payment mechanisms for each simulated parameter set. Outputs were examined for satisfaction of second-order conditions and for consistency with Propositions 1 and 2. Inconsistencies occurred in 7 out of 50,000 simulations, and in these cases, the evaluated \(\{w_u, w_x\}\) delivering the highest expected utility in their respective mechanisms were recorded as solutions. The optimal payments allow for the derivation of several key outcome variables. Define \(\text{Cond}_8\) and \(\text{Cond}_9\) as dummy variables equal to 1 if Conditions (8) and (9) hold, respectively. Additionally, we used the optimal payments to calculate the equilibrium measures of beneficiaries that would not be accepted (\(\text{Reject}_u\) under uniform payment and \(\text{Reject}_x\) under mixed payment) and the taxpayer burden under each alternative mechanism (\(\tau_u^*, \tau_p, \text{ and } \tau_x^*\)). Summary statistics of these outcome variables appear at the bottom of Table I.

Competitive bidding mechanisms achieved higher expected consumer utility, relative to uniform payment, in 90.6% of simulated parameter sets. One reason for this is that, whereas the entire beneficiary population gains enrollment and enjoys the greater health status under competitive bidding, an average 11.3% of beneficiaries are left unenrolled and with the lower health status under the optimal uniform payment. Due to stochastic dominance assumptions, this group is disproportionately composed of the most risky beneficiary types. Additionally, competitive bidding mechanisms reduce the tax burden by 31% on average compared
To put this into perspective, given the characteristics of the programs described above, this percentage of cost reduction would equate to $133.2 billion in savings on Medicaid and $132.8 billion on Medicare. Regarding ex ante Pareto dominance, Conditions (8) and (9) hold in 87% and 86.6% of cases, respectively. This shows that competitive bidding outperforms uniform payment, for both beneficiaries and taxpayers, over the vast majority of the parameter space.

The simulations show that there are very few cases (220 out of 50,000) in which mixed bidding, but not pure bidding, dominates uniform payment. This is because, even though Proposition 2 proves that mixed bidding is less expensive than pure bidding, the simulations reveal the additional savings to be relatively small. The majority of savings are achieved under pure bidding whereas mixed bidding only saves an average additional 1%. Over all simulations, the maximum additional savings achieved by mixed over pure bidding is 5.7%. Despite the negligible difference in savings, the mean value of Reject_X shows that, on average, 52% of beneficiaries in the mixed system are accepted at the optimal prospective payment. Therefore, even though beneficiary enrollment is identical and spending nearly is, the differences in operation between the mixed- and pure-bidding systems are non-negligible. The relative appropriateness of the two bidding mechanisms would thus likely depend on administrative simplicity.

As competitive bidding dominates uniform payment over many, but not all, simulated parameter sets, it is important to determine the parameter values at which dominance is most likely, as well as the parameters to which dominance is most sensitive. Table 2 shows summary statistics of key parameters, conditional on whether or not the competitive bidding mechanisms dominate uniform payment. The results are consistent with Propositions (3) and (4). The most important differences in the two columns concern the unconditional average enrollment cost $E(c_{ijk})$ and the cost of uncoordinated care for the unenrolled $w_{ER}$. In cases where $E(c_{ijk})$ is low and $w_{ER}$ is high, risk selection is a significant source of inefficiency in the entitlement program. It is very costly to reduce risk selection using uniform payment, but the competitive bidding mechanisms eliminate it completely and tend to do so at lower cost. There is a positive measure of the parameter space, however, where eliminating risk selection is not very important. These are the cases where enrollment is expensive to achieve and where uncoordinated care is relatively inexpensive. In such cases, eliminating risk selection is not worth the cost, and as Table 2 shows, it is better to set a uniform payment so low that nearly 18% of beneficiaries can expect universal rejection. Patient-level competitive bidding thus outperforms uniform payment in jurisdictions where risk selection is a significant problem.

---

8Condition (9) implies Condition (8), so it is impossible for pure (but not mixed) bidding to dominate uniform payment.
Table 2: Conditional Summary Statistics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cond. 8 = 1</th>
<th>Cond. 9 = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \xi )</td>
<td>50.04</td>
<td>49.88</td>
</tr>
<tr>
<td>(28.92)</td>
<td>(29.32)</td>
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<tr>
<td>( \bar{c} )</td>
<td>101,270</td>
<td>101,080</td>
</tr>
<tr>
<td>(14,436)</td>
<td>(14,302)</td>
<td></td>
</tr>
<tr>
<td>( n )</td>
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<td>5.65</td>
</tr>
<tr>
<td>(2.56)</td>
<td>(2.72)</td>
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<tr>
<td>( w_{ER} )</td>
<td>45,910</td>
<td>19,160</td>
</tr>
<tr>
<td>(36,875)</td>
<td>(16,263)</td>
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<td>( m_1 )</td>
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<td>13,997</td>
</tr>
<tr>
<td>(6,110)</td>
<td>(6,128)</td>
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<tr>
<td>( m_2 )</td>
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<td>83,087</td>
</tr>
<tr>
<td>(38,783)</td>
<td>(36,667)</td>
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<tr>
<td>( D )</td>
<td>0.396</td>
<td>0.397</td>
</tr>
<tr>
<td>(0.11)</td>
<td>(0.11)</td>
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<tr>
<td>( H_1 )</td>
<td>7.49</td>
<td>7.51</td>
</tr>
<tr>
<td>(1.44)</td>
<td>(1.45)</td>
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<tr>
<td>( H_2 )</td>
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<td>(1.45)</td>
<td>(1.44)</td>
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<tr>
<td>( \beta )</td>
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<td>( \theta )</td>
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<tr>
<td>(0.007)</td>
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<tr>
<td>( K )</td>
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<tr>
<td>(0.83)</td>
<td>(0.60)</td>
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<tr>
<td>( Skew )</td>
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<td>0.048</td>
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<tr>
<td>(0.049)</td>
<td>(0.059)</td>
<td></td>
</tr>
<tr>
<td>( Concentration )</td>
<td>0.025</td>
<td>0.028</td>
</tr>
<tr>
<td>(0.057)</td>
<td>(0.057)</td>
<td></td>
</tr>
<tr>
<td>( E(c_{ijk}) )</td>
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<td>8.509</td>
</tr>
<tr>
<td>(4,044)</td>
<td>(3,720)</td>
<td></td>
</tr>
<tr>
<td>( \alpha_1 )</td>
<td>0.905</td>
<td>0.860</td>
</tr>
<tr>
<td>(0.096)</td>
<td>(0.076)</td>
<td></td>
</tr>
<tr>
<td>( Reject_u )</td>
<td>0.103</td>
<td>0.179</td>
</tr>
<tr>
<td>(0.080)</td>
<td>(0.066)</td>
<td></td>
</tr>
<tr>
<td>( 1{EU_u(w^+_u) \geq EU_u(w^+_w) } )</td>
<td>1</td>
<td>0.27</td>
</tr>
<tr>
<td>(0)</td>
<td>(0.37)</td>
<td></td>
</tr>
<tr>
<td>( \frac{\tau_{w_a}^u - \tau_{w_a}^l}{\tau_{w_a}^l} )</td>
<td>0.428</td>
<td>-0.375</td>
</tr>
<tr>
<td>(0.162)</td>
<td>(0.331)</td>
<td></td>
</tr>
<tr>
<td>No. of obs.</td>
<td>43,306</td>
<td>6,474</td>
</tr>
</tbody>
</table>
For the types of parameter sets where patient-level competitive bidding does not reduce the tax burden, the average $w_{ER}$ is only 14% greater than the expected enrollment cost of the top two quartiles, a figure which the literature suggests is closer to 200% in real-world health care entitlement programs (Kusserow 1992; Blue Cross Blue Shield 2009). Furthermore, the average enrollment cost in the parameter sets where bidding did not dominate uniform payment was $8,509, which is larger than the per-beneficiary treatment costs of either Medicare or Medicaid. Thus, on both these key parameters, bidding dominates in scenarios that more closely resemble real-world health care entitlement programs, whereas uniform payment dominates bidding in situations that are relatively different. Finally, as shown in Table 2, 27% of scenarios where competitive bidding does not generate savings still result in a higher expected consumer utility $(EU_x(w^*_x) \geq EU_u(w^*_u))$ due to improved health achieved through universal enrollment.

Although Table 2 is useful in describing the typical parameter sets in which competitive bidding or uniform payment dominates, it does not identify the parameters to which dominance is most sensitive. In order to investigate this, we estimate linear probability models by regressing $Cond_8$ and $Cond_9$ on all simulated parameters and distributional characteristics. Table 3 shows the marginal effects and significance levels. Due to the near-perfect correlation of $Cond_8$ and $Cond_9$, the effects of parameter values on the two conditions in Table 3 are nearly identical in significance, sign, and value. Considering the differences in units and bounds across parameters, elasticities best illustrate which parameters are most determinant of the dominance conditions. Analysis of the elasticities shows the importance of some distributional characteristics. For example, the three parameters to which $Cond_9$ has the greatest sensitivity are $\alpha_1$, $E(c_{ijk})$, and $w_{ER}$ with elasticities of -0.63, -0.52 and 0.39, respectively. The importance of the latter two are consistent with Table 2. The relatively large and negative elasticity on $\alpha_1$ indicates that jurisdictions with a significant population of higher risk types (i.e. low $\alpha_1$) are most likely where patient-level competitive bidding would generate significant savings. This is because higher risk types are guaranteed enrollment under the bidding mechanisms but are left disproportionately unenrolled under uniform payment.

The effects of parameter values on the differences in tax burden between payment mechanisms are shown in Table 4. Multiple significant coefficients from Table 4 show that several key parameters have the opposite effects on $\tau^*_u - \tau_p$ compared to $\tau_p - \tau^*_x$. This indicates that, in cases where competitive bidding performs poorly, the mixed payment mechanism can compensate by allocating more beneficiaries by prospective payment. Like $Cond_8$ and $Cond_9$, the reduction in tax burden under competitive bidding relative to uniform payment is most sensitive to $\alpha_1$, $E(c_{ijk})$, and $w_{ER}$ with elasticities of -4.54, -0.83 and 2.10,
Table 3: Marginal Effects of Simulated Parameters on Conditions (8) and (9)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient (Std. Error)</th>
<th>Elasticity</th>
<th>Coefficient (Std. Error)</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c$</td>
<td>5.63e-05 (4.07e-05)</td>
<td>0.0032</td>
<td>5.25e-05 (4.12e-05)</td>
<td>0.0030</td>
</tr>
<tr>
<td>$\bar{c}$</td>
<td>1.66e-06*** (1.02e-07)</td>
<td>0.1932</td>
<td>1.64e-06*** (1.03e-07)</td>
<td>0.1914</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>4.37*** (0.18)</td>
<td>0.1883</td>
<td>4.39*** (0.18)</td>
<td>0.1899</td>
</tr>
<tr>
<td>$Skew$</td>
<td>0.067 (0.044)</td>
<td>0.0021</td>
<td>0.059 (0.045)</td>
<td>0.0018</td>
</tr>
<tr>
<td>$Concentration$</td>
<td>0.646*** (0.025)</td>
<td>0.0188</td>
<td>0.651*** (0.025)</td>
<td>0.0190</td>
</tr>
<tr>
<td>$K$</td>
<td>-0.066*** (-0.003)</td>
<td>-0.1524</td>
<td>-0.069*** (-0.003)</td>
<td>-0.1592</td>
</tr>
<tr>
<td>$n$</td>
<td>0.0075*** (4.58e-04)</td>
<td>0.0515</td>
<td>0.0086*** (4.65e-04)</td>
<td>0.0598</td>
</tr>
<tr>
<td>$w_{ER}$</td>
<td>7.85e-06*** (4.86e-08)</td>
<td>0.3815</td>
<td>7.98e-06*** (4.93e-08)</td>
<td>0.3899</td>
</tr>
<tr>
<td>$m_1$</td>
<td>4.44e-07* (1.93e-07)</td>
<td>0.0072</td>
<td>4.01e-07* (1.95e-07)</td>
<td>0.0065</td>
</tr>
<tr>
<td>$m_2$</td>
<td>-2.15e-07 (2.02e-07)</td>
<td>-0.0208</td>
<td>-2.84e-07 (2.05e-07)</td>
<td>-0.0278</td>
</tr>
<tr>
<td>$D$</td>
<td>-0.0024 (0.0103)</td>
<td>-0.0011</td>
<td>0.0030 (0.0104)</td>
<td>0.0032</td>
</tr>
<tr>
<td>$H_1$</td>
<td>-6.19e-04 (8.17e-04)</td>
<td>-0.0053</td>
<td>-3.6e-04 (8.28e-04)</td>
<td>-0.0032</td>
</tr>
<tr>
<td>$H_2$</td>
<td>-0.0016+ (8.15e-04)</td>
<td>-0.0045</td>
<td>-0.0018+ (8.27e-04)</td>
<td>-0.0052</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.062*** (0.011)</td>
<td>0.0128</td>
<td>0.061*** (0.011)</td>
<td>0.0126</td>
</tr>
<tr>
<td>$E(c_{ijk})$</td>
<td>-6.74e-05*** (9.91e-07)</td>
<td>-0.5104</td>
<td>-6.81e-05*** (1.00e-06)</td>
<td>-0.5185</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>-0.572*** (0.034)</td>
<td>-0.5910</td>
<td>-0.604*** (0.034)</td>
<td>-0.6270</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.385</td>
<td></td>
<td>0.386</td>
<td></td>
</tr>
</tbody>
</table>

Notes: The dependent variables are dummies equal to 1 if the respective condition holds. All specifications are linear probability models. Columns 2 and 4 are the elasticities of the dependent variables with respect to the parameters, evaluated at the means. Significance at the 0.1 level is indicated by +, at the 0.05 level by *, at the 0.01 level by **, and at the 0.001 level by ***.
Table 4: Marginal Effects of Simulated Parameters on Savings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient (Std. Error)</th>
<th>Elasticity</th>
<th>Coefficient (Std. Error)</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c )</td>
<td>-0.44 (0.42)</td>
<td>-0.0081</td>
<td>-0.0061* (0.0024)</td>
<td>-0.0086</td>
</tr>
<tr>
<td>( \bar{c} )</td>
<td>0.0027** (0.0010)</td>
<td>0.1010</td>
<td>3.67e-04*** (6.03e-06)</td>
<td>1.0444</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>19885*** (1820)</td>
<td>0.2748</td>
<td>759.24*** (10.46)</td>
<td>0.7999</td>
</tr>
<tr>
<td>Skew</td>
<td>-7667.30*** (454.97)</td>
<td>-0.0762</td>
<td>5.19* (2.61)</td>
<td>0.0039</td>
</tr>
<tr>
<td>Concentration</td>
<td>18348*** (258.14)</td>
<td>0.1710</td>
<td>11.29*** (1.48)</td>
<td>0.0080</td>
</tr>
<tr>
<td>( K )</td>
<td>-700.06*** (27.76)</td>
<td>-0.5153</td>
<td>0.31† (0.16)</td>
<td>0.0173</td>
</tr>
<tr>
<td>( n )</td>
<td>37.51*** (4.71)</td>
<td>0.0829</td>
<td>-6.01*** (0.03)</td>
<td>-1.0128</td>
</tr>
<tr>
<td>( w_{ER} )</td>
<td>0.135*** (4.99e-04)</td>
<td>2.1036</td>
<td>-1.41e-06 (2.87e-06)</td>
<td>-0.0017</td>
</tr>
<tr>
<td>( m_1 )</td>
<td>1.69e-04 (0.002)</td>
<td>8.78e-04</td>
<td>-7.09e-07 (1.14e-05)</td>
<td>-2.81e-04</td>
</tr>
<tr>
<td>( m_2 )</td>
<td>0.0024 (0.0020)</td>
<td>0.0734</td>
<td>1.30e-05 (1.19e-05)</td>
<td>0.0308</td>
</tr>
<tr>
<td>( D )</td>
<td>11085*** (105.93)</td>
<td>1.6185</td>
<td>144.89*** (0.61)</td>
<td>1.6126</td>
</tr>
<tr>
<td>( H_1 )</td>
<td>6.88 (8.40)</td>
<td>0.0190</td>
<td>-0.049 (0.048)</td>
<td>-0.0103</td>
</tr>
<tr>
<td>( H_2 )</td>
<td>-23.58** (8.38)</td>
<td>-0.0219</td>
<td>0.053 (0.048)</td>
<td>0.0037</td>
</tr>
<tr>
<td>( \beta )</td>
<td>329.75*** (116.35)</td>
<td>0.0219</td>
<td>0.0068 (0.6686)</td>
<td>3.45e-05</td>
</tr>
<tr>
<td>( E(c_{ijk}) )</td>
<td>-0.34*** (0.01)</td>
<td>-0.8341</td>
<td>-1.98e-04*** (5.85e-05)</td>
<td>-0.0366</td>
</tr>
<tr>
<td>( \alpha_1 )</td>
<td>-13693*** (346.97)</td>
<td>-4.5378</td>
<td>38.57*** (1.99)</td>
<td>0.9744</td>
</tr>
</tbody>
</table>

Notes: The dependent variables are the differences in savings between respective payment mechanisms. All regressions are simple OLS. Columns 2 and 4 are the elasticities of the dependent variables with respect to the parameters, evaluated at the means. Significance at the 0.1 level is indicated by +, at the 0.05 level by *, at the 0.01 level by **, and at the 0.001 level by ***.
respectively. Putting these elasticities into perspective: for every percentage point increase above the mean in the high-risk share of its beneficiary population, a jurisdiction adopting patient-level competitive bidding would realize $123.22 in additional savings per beneficiary. These additional savings would be attained even while improving the likelihood that these high-risk beneficiaries secure enrollment in a managed care plan.

Unlike in the previous regressions, Table 4 reveals that the difference in tax burden is significantly impacted by and highly sensitive to the share of consumers that are beneficiaries ($D$), with an elasticity of 1.62. This means that, although $D$ has no significant impact on whether or not bidding dominates, it has a large impact on the magnitude of resulting savings. This is because the cost differences due to risk selection between mechanisms occur at the beneficiary-level. Since beneficiaries are ex ante identical, the expected cost savings or increases from adopting competitive bidding are the same for all beneficiaries. This means that the share of beneficiaries in the consumer population only magnifies the differences in tax burdens rather than determining the sign. In summary, the above estimates suggest that a jurisdiction’s cost savings from patient-level competitive bidding would significantly increase with the number of beneficiaries, the concentration of risky beneficiary types, and the relative cost of having beneficiaries remain unenrolled.

5 Discussion and Conclusion

This paper investigates whether and how patient-level competitive bidding can mitigate the problem of risk selection in health care entitlement programs. It compares three mechanisms for allocating program beneficiaries across private MCOs: uniform prospective payment, pure competitive bidding, and a mix of prospective payment and bidding. Results show that risk selection occurs under the optimal uniform payment; there is always a positive share of beneficiaries rejected by all MCOs, and this share is disproportionately composed of more risky types of beneficiaries. This is because the efficiency gains from raising the uniform payment and inducing MCOs to accept more beneficiaries are eventually outweighed by the cost of higher payments on those beneficiaries already enrolled.

On the contrary, risk selection never occurs under either the pure or mixed competitive bidding mechanisms. This is because, where MCOs follow their optimal bidding strategies, the lowest bidder to enroll a given beneficiary always expects to make a profit and is thus willing to enroll that beneficiary regardless of risk type or expected cost. The analytical results show that the mixed payment mechanism achieves this result at a strictly lower tax burden than the pure bidding mechanism. Numerical analysis of 50,000 simulations approximating the actual conditions of U.S. health care entitlement programs reveals that the com-
petitive bidding mechanisms achieve both greater beneficiary enrollment and lower taxpayer burden over approximately 87% of simulated parameter sets. On average, the bidding mechanisms increased beneficiary enrollment by 13% and reduced program expenses by 31%. In the 13% of parameter sets where bidding did not dominate uniform payment, it is typically because the cost of leaving beneficiaries unenrolled is very low. This indicates that competitive bidding is better than uniform payment for mitigating risk selection in cases where risk selection represents a significant problem. Intuitively, because health plans practice risk selection due to unpriced heterogeneity in enrollment costs across individuals, auction mechanisms that price such individual-level heterogeneity would remove the incentive to select.

5.1 Research Contributions and Implications

The theoretical and numerical analysis presented here makes a significant contribution to the literature. Although previous authors have mentioned a role for bidding in resolving selection problems in health care and health insurance markets (Enthoven, 1988; Newhouse, 1996), this is the first study to formally model and evaluate patient-level competitive bidding mechanisms in health care entitlement programs vulnerable to risk selection. This is particularly important in an era with lowered transaction costs made possible through electronic auctions, as well as the immense challenges in keeping entitlement programs solvent, while still covering all qualified beneficiaries. No theoretical model can capture every nuance of complex real-world health care entitlement programs, however, these findings still reveal the exciting potential for patient-level competitive bidding to accomplish important policy objectives. These include the elimination of incentives for risk selection, expanded enrollment with private MCOs for even the most costly beneficiaries, and a significantly reduced burden on taxpayers. Implementation problems and costs accompanying a transition to patient-level competitive bidding do exist, but with the magnitude of the health and financial benefits uncovered here, further efforts to investigate and pursue these mechanisms may be justified.

A number of implications emerge from our theoretical model and numerical analysis. First, competitive bidding allows an uninformed payer to eliminate risk selection while keeping reimbursement fully prospective, and thus preserves MCO incentives to contain costs. This may prove useful to researchers investigating mechanisms that manage tradeoffs between various sources of inefficiency in health care and health insurance markets. Second, competitive bidding eliminates risk selection regardless of both the degree of group-level unpriced heterogeneity as well as whether the heterogeneity is \textit{ex ante} (i.e., many risk types) or \textit{ex post} (i.e., large variation in match-specific treatment costs). This suggests that competitive bidding mechanisms
would be particularly effective in cases where it is difficult for traditional risk adjustment schemes to verify payment groups or otherwise price heterogeneity. This provides researchers and health care administrators with the tools to price heterogeneity in a wider set of circumstances. A third implication emerges from the analytical dominance of the mixed payment mechanism over pure bidding, which suggests that complementarities can be achieved when utilizing prospective payment and competitive bidding in combination rather than mutually exclusive options. This somewhat surprising result may yield further advancements utilizing more elaborate combinations of competitive bidding with traditional payment methods in the pursuit of even better outcomes.

An interesting extension of our model would assume that, rather than match-specific costs, MCOs receive signals of an underlying common enrollment cost. On the surface, it is not clear how this alternative assumption would affect the ordering of mechanisms. In a common value auction, rational bidders would adjust their bids above the cost indicated by their signal, and would thus avoid a winner’s curse in equilibrium (Cox and Isaac, 1984; Thaler, 1988) with the expected payment to the winning bidder approaching the true common cost as competition increases (Wilson, 1977). On the other hand, under uniform payment, MCOs would be more likely to reject where costs are common rather than match-specific. This is because each MCO must consider the possibility that a matched beneficiary has already been rejected by other MCOs whose signals indicated that enrollment was unprofitable. The results of such an investigation could determine whether competitive bidding, possibly along with additional components, could mitigate other selection problems in health insurance.

5.2 Implications for Practice

Our results have significant implications for state and federal policy makers and health care administrators. First, the numerical results reveal that patient-level competitive bidding tends to dominate uniform payment in a variety of circumstances. This shows that competitive bidding at least deserves consideration in most jurisdictions. Further, the sensitivity analysis provides guidance to administrators as to the appropriateness of competitive bidding in their respective jurisdictions. Patient-level competitive bidding is most effective in those jurisdictions where a large share of the population is of a higher risk type, or where coordination of care by MCOs achieves substantial cost savings over disjointed or unmanaged care. The finding that savings from competitive bidding increase with and are sensitive to the eligible share of consumers shows that this mechanism is scalable, which should appeal to program managers in jurisdictions with large beneficiary
populations. The competitive bidding mechanisms proposed here rely on competition to a greater degree than uniform payment. Therefore, patient-level bidding would be most effective in urban and suburban areas with large populations capable of sustaining multiple competing health plans. The analytical results showed that high consumer income and improved health outcomes from care coordination also increase the amount of savings, although the numerical results revealed these considerations to be of likely secondary importance. Entitlement program administrators should assess all these characteristics in determining whether or not their jurisdictions are suitable candidates for the implementation of competitive bidding.

Barring extraordinary interventions, administrators may find it difficult or even impossible to change the number of beneficiaries, the distribution of risk types, or total consumer income. They may, however, have more leverage to promote competition among MCOs and to facilitate the coordination of care among providers. If an otherwise “attractive” jurisdiction lacks competition among plans, then it may be worthwhile to incentivize entry. Furthermore, administrators could consider the establishment of accountable care organizations, patient-centered medical homes, health information exchangers, or other initiatives that improve coordination among care providers. Such policies improve the likelihood of competitive bidding mechanisms achieving their desired outcomes.

Health care administrators contemplating the transition to patient-level bidding must proceed carefully. The technology to conduct large numbers of auctions at low transaction costs exists, but it is necessary to choose an auction platform that protects patient privacy. Additionally, taxpayers, care providers, politicians and others may have misgivings with the idea of auctions being conducted over individual patients. There may also be sustained inertia in the system, which may create resistance to change and discourage innovation. These types of concerns are not captured by the model or incorporated into the numerical analysis, and so administrators must decide if the predicted enrollment expansion and cost savings are worth the cost and uncertainties of implementation. Information dissemination campaigns, staged roll outs, and periodic assessments are all potential ways to mitigate these concerns.

5.3 Limitations of the Research

This study has several limitations, which provide opportunities for further extension of the research model we developed. The first limitation concerns the prospect of collusion among MCOs, which the model assumes away. Like any mechanism based on competition among suppliers, collusion would drive up payments and make either of the two competitive bidding mechanisms more expensive. Notwithstanding the
relative success of existing bidding arrangements in health care, there are features of patient-level bidding that naturally mitigate the threat of collusion. Due to expectations of privacy, there is no need to publicly announce the winning bidder, thus removing one avenue for bidders to monitor and enforce collusive behavior. Patient-level bidding involves many auctions for relatively small contracts, meaning there is both little payoff to colluding in individual auctions and greater opportunity for payers to discover correlated bidding between auctions. Finally, real concerns over collusion could be addressed by utilizing collusion-proof auction designs (Che and Kim, 2006, 2009; Pavlov, 2008). Our goal in this paper was to establish the potential of individual patient level bidding to improve health care entitlement programs; future research can examine the use of more involved collusion proof mechanisms in this context.

With a primary focus on the supply-side, our model does not allow for beneficiary preferences across MCOs, which is a second limitation. This is a strong assumption given the likely differences in network providers and covered services. Even though real-world health care entitlement programs commonly place limits on beneficiaries’ choice of plan in the interest of cost savings, such preferences would mean that enrollment with the lowest bidder is not necessarily an efficient beneficiary-provider match. Possible ways to address this problem include allowing beneficiary input into which MCOs may bid for their specific contract or some distribution of shared savings between beneficiaries and taxpayers. Future researchers can consider these two factors in designing allocation rules, accounting for low bids and beneficiary preferences.

We were unable to obtain real individual patient-level auctions data for analysis. Due to excessively high transaction costs, such auctions were practically impossible to conduct in the non-digital environment. With the widespread availability of high throughput online auction platforms, and given our promising results, this is an opportune time for health care administrators and researchers to discuss the merits of patient-level competitive bidding and the potential ways in which it could be implemented. In the absence of real-world data, the numerical simulation and sensitivity analysis serve as useful guides rather than concrete estimates.

5.4 Conclusion

This study was motivated by the observation that, despite significant efforts by state and federal health care administrators to curtail it, risk selection remains a pervasive and costly fixture of U.S. health care entitlement programs. As discussed, the conditions for risk selection arise when payment mechanisms leave individual-level heterogeneity in treatment cost unpriced. We suggested that having MCOs bid to enroll individual patients in a procurement auction may explicitly account for this heterogeneity, and thus mitigate
the incentives for risk selection. We investigated the impact of this patient-level competitive bidding on entitlement program enrollment and cost using a mix of theoretical and numerical approaches. Our theoretical results indicate that a hybrid mechanism, using both prospective payment and competitive bidding, achieves universal beneficiary enrollment at a lower cost than pure bidding. Either of these bidding mechanisms achieves greater beneficiary enrollment than an optimally-set uniform prospective payment. Additionally, our numerical analysis predicts that, relative to uniform payment, competitive bidding enrolls an additional 13 percent of beneficiaries at 31 percent lower cost. To the best of our knowledge, this research represents the first effort to formally model patient-level competitive bidding and its impact on health care entitlement programs. It strongly suggests that competitive bidding can be of use in achieving the dual aim of lower costs and expanded access. We caution health care administrators against hasty implementation, however the expected improvements in beneficiary enrollment and program solvency represent an intriguing prospect. We hope this study stimulates additional research and demonstration projects to fully explore the potential for patient-level bidding to improve the health outcomes of beneficiaries in a financially sustainable manner for taxpayers.

References


McWilliams, J. M., J. Hsu, and J. P. Newhouse (2012). New risk-adjustment system was associated with reduced favorable selection in Medicare Advantage. *Health Affairs* 31(12), 2630–2640.


Appendix

Proof of Proposition 1

Proposition 1. \( [1 - F_k(w_u^* n)]^n > 0 \forall k \) in any equilibrium under the uniform payment mechanism.

Proof. By Condition (1) and the concavity of \( U(y, H) \), the left side of Condition (2) remains positive as \( w_u \) approaches \( c \) from above, while the right side approaches zero. As \( w_u \) approaches \( \bar{c} \) from below, the left side is driven to zero while the right side approaches 1. Due to the continuity in \( w \) of both sides of Condition (2), by the Intermediate Value Theorem, there exists \( w_u \in (c, \bar{c}) \) such that Condition (2) holds. Because \( w_u^* < \bar{c} \) and the expected cost of treating beneficiaries of any risk type is distributed over the common support \( [c, \bar{c}] \), then \( [1 - F_k(w_u^* n)]^n > 0 \forall k \). \( \square \)

Proof of Proposition 2

Proposition 2. \( \sum_{k=1}^{K} \alpha_k [1 - F_k(h_k(w_x^*, n))]^n < 1 \) in any equilibrium under the mixed payment system.

Proof. Define \( w_{x,k} = w_{x,k}(n) \) such that \( h_k(w_{x,k}, n) = \bar{c} \). This is the highest prospective payment such that MCOs still reject all beneficiaries of type \( k \), regardless of \( c_{ijk} \). The value of \( w_{x,k} \) increases in \( k \).

Obtaining the first derivatives of \( h_k(w_x) \) and \( E(\pi_k | w_x, n) \):

\[
\frac{\partial h_k}{\partial w_x} = \frac{1}{1 - G_k(h_k)} \quad \quad \frac{\partial E(\pi_k | w_x, n)}{\partial w_x} = \frac{n f_k(h_k)}{1 - F_k(h_k)} \frac{\partial h_k}{\partial w_x} \left\{ E(\pi_k | w_x, n) - E(\hat{\pi}_k | \hat{c}_k > h_k) \right\}
\]

if \( w_x \geq w_{x,k} \). Both derivatives equal 0 otherwise. and using (3) and (5) allows Condition (6) to be rearranged into:

\[
\sum_{k=1}^{K} \alpha_k n f_k(h_k) \int_{h_k}^{\bar{c}} G_k(\pi) \, d\pi = 1 - \sum_{k=1}^{K} \alpha_k [1 - F_k(h_k)]^n.
\]

As \( w_x \) approaches \( w_{x,1} \) from above, the right side of the equation approaches 0 while the left side approaches a value greater than 0. Therefore, costs could be lowered by setting \( w_x \) strictly above \( w_{x,1} \). Because \( w_x^* > w_{x,1} \Rightarrow [1 - F_1(h_1(w_x^*, n))]^n \) is less than 1, therefore \( \sum_{k=1}^{K} \alpha_k [1 - F_k(h_k(w_x^*, n))]^n < 1 \). \( \square \)
Proof of Proposition 3

Proposition 3. For any parameter set,

\[
\frac{\partial (\tau_u^* - \tau_x^*)}{\partial H_2} < 0,
\]

\[
\frac{\partial (\tau_u^* - \tau_x^*)}{\partial m_1} > 0, \text{ and}
\]

\[
\frac{\partial (\tau_u^* - \tau_x^*)}{\partial m_2} > 0.
\]

Proof. First Order Condition (2) can be rewritten as:

(10) \( A(\Delta U, MU_y, w_{ER}) \cdot B(w_u) - C(w_u) = 0 \)

where,

\[
A(\Delta U, MU_y, w_{ER}) = n \left( \frac{\Delta U}{MU_y} + w_{ER} - w_u \right),
\]

\[
B(w_u) = \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^{n-1} f_k(w_u),
\]

\[
C(w_u) = 1 - \sum_{k=1}^{K} \alpha_k [1 - F_k(w_u)]^n.
\]

The total derivative of Condition (10) yields:

\[
\frac{d w_u}{d H_2} = \frac{\partial A}{\partial H_2} \cdot B
\]

where SOC is the first derivative of Condition (10) and also the second order condition with respect to \( w_u \) from the payer’s problem under the uniform payment mechanism. Since, in equilibrium, SOC must be negative and \( B(.) \) must be positive, the sign of \( \frac{d w_u}{d H_2} \) will be determined by \( \frac{\partial A}{\partial H_2} \). Since, due to the quasi-concavity of \( U(y, H) \),

\[
\frac{\partial A}{\partial H_2} = \frac{\partial \Delta U}{\partial H_2} \left( \frac{n}{MU_y} \right) < 0,
\]

therefore, \( \frac{d w_u}{d H_2} < 0 \). Since,
\[
\frac{\partial \tau_u^*}{\partial H_2} = \frac{\partial \tau_u^*}{\partial H_2},
\]

and \(\frac{\partial \tau_u^*}{\partial w_2}\) must be positive in equilibrium, therefore \(\frac{\partial \tau_u^*}{\partial H_2} < 0\). Since Condition (6) is independent of \(H_2\), therefore \(\frac{\partial (\tau_u^* - \tau_x^*)}{\partial H_2} < 0\). The total derivative of Condition (10) also yields:

\[
\frac{d w_u}{d m_1} = -\frac{\partial A}{\partial m_1} \cdot B
\]

Since, due to the quasi-concavity of \(U(y, H)\),

\[
\frac{\partial A}{\partial m_1} = \frac{\partial U}{\partial m_1} \cdot \frac{MU_y}{MU_y} > 0,
\]

then, following the same process above, \(\frac{\partial (\tau_u^* - \tau_x^*)}{\partial m_1} > 0\). Finally, the total derivative of Condition (10) also yields:

\[
\frac{d w_u}{d m_2} = -\frac{\partial A}{\partial m_2} \cdot B
\]

Since, due to the quasi-concavity of \(U(y, H)\),

\[
\frac{\partial A}{\partial m_2} = \frac{\partial MU_y}{\partial m_2} \left( -\frac{\Delta U}{(MU_y)^2} \right) > 0,
\]

then, following the same process above, \(\frac{\partial (\tau_u^* - \tau_x^*)}{\partial m_2} > 0\).

\[
\Box
\]

**Proof of Proposition 4**

Proposition 4. For a given parameter set,

\[
\frac{\partial (\tau_u^* - \tau_x^*)}{\partial w_{ER}} \geq 0
\]

if, under the uniform payment mechanism evaluated at \(w_u^*\).
\[
\left( \frac{\Delta U}{MU_y} \right) \varepsilon_{MU_y, \tau} \leq \frac{(1 - D) \tau_u^*}{D \left[ \sum_{k=1}^{K} \alpha_k (1 - F(w_u^*))^n \right]}
\]

**Proof.** The total derivative of Condition (10) yields:

\[
\frac{dw_u}{dw_{ER}} = - \frac{\partial A}{\partial w_{ER}} \cdot B
\]

Since, as in Proposition 3, \( B \) must be positive and \( SOC \) must be negative in equilibrium, therefore

\[
\frac{dw_u}{dw_{ER}} \geq 0 \text{ if and only if } \frac{\partial A}{\partial w_{ER}} \geq 0.
\]

Since,

\[
\frac{\partial A}{\partial w_{ER}} = 1 - \left( \frac{\Delta U}{(MU_y)^2} \right) \left( \frac{\partial MU_y}{\partial \tau} \right) \left( \frac{\partial \tau}{\partial w_{ER}} \right)
\]

and

\[
\frac{\partial \tau}{\partial w_{ER}} = \left( \frac{D}{1 - D} \right) \sum_{k=1}^{K} \alpha_k [1 - F(w_u)]^n,
\]

therefore \( \frac{\partial A}{\partial w_{ER}} \geq 0 \) can be rearranged into the condition:

\[
\left( \frac{\Delta U}{MU_y} \right) \varepsilon_{MU_y, \tau} \leq \frac{(1 - D) \tau_u^*}{D \left[ \sum_{k=1}^{K} \alpha_k (1 - F(w_u^*))^n \right]},
\]

which is Condition (7). Since \( \frac{\partial \tau_u^*}{\partial w_{ER}} = \left. \left( \frac{\partial \tau_u^*}{\partial w_{ER}} \right) \right|_{w_u^*} > 0 \) and \( \frac{\partial \tau_u^*}{\partial w_{u}} > 0 \) in equilibirum, therefore Condition (7) is sufficient for \( \frac{\partial \tau_u^*}{\partial w_{ER}} \geq 0 \). Since \( \tau_x(w_u^*) \) is independent of \( w_{ER} \), therefore Condition (7) is also sufficient for \( \frac{\partial (\tau_u^* - \tau_x^*)}{\partial w_{ER}} > 0 \).