The Welfare Effects of Supply-Side Regulations in Medicare Part D

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Abstract

We study the regulatory mechanisms through which the government currently administers subsidies in Medicare Part D, a large prescription drug program for US seniors. Using the data from the first six years of the program, we estimate an econometric model of supply and demand that incorporates the regulatory pricing distortions in the insurers' objective functions. We have four primary results: consumers have a relatively low willingness-to-pay for prescription drug plans when compared to drug coverage within comprehensive private Medicare HMO plans; competition among insurers is fairly effective in lowering prices towards marginal cost; the primary driver of welfare in the program is the trade-off between relative subsidies and the relative willingness to pay for different parts of Medicare Part D program; and the current mechanism achieves a level of total welfare close to that obtained under an optimal voucher scheme, but is far from the social planner's first-best solution.

JEL: I11, I18, L22, D44, H57

Keywords: Medicare; Prescription Drugs; Health Insurance; Subsidies; Regulation; Auctions

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1 Introduction

The past decade has seen an unparalleled increase in the scope and magnitude of the private provision of government-subsidized social programs. The motivation for private provision is that the combination of supply-side competition and consumer choice would maximize consumer utility and keep costs low. Medicare Part D, an elective program providing prescription drug insurance coverage to eligible populations, is one such program, with 37 million enrolles and total governmental expenditures totalling more than $76 billion in 2014. Part D has generated a tremendous amount of policy interest and academic research since its inception in 2006, with the majority of the literature focused on demand-side questions. In this paper, we focus on the supply side of the market in order to gauge the efficacy of the current regulatory mechanism used to set subsidies and thus determine market outcomes. This mechanism is particularly complex in stand-alone Prescription Drug Plan (PDP) component of Part D, with equilibrium subsidies reflecting a combination of producers' exercise of market power, the rules by which subsidies for enrollees are set on the basis of producer behavior, and distortions generated by strategic gaming by firms for rents arising from a part of the program providing subsidies to low-income enrollees. The goal of this paper is to disentangle these forces, assess the efficiency of the current mechanism, and provide guidance about market outcomes under alternative subsidy mechanisms.

Our research strategy starts with the estimation of demand for prescription drug plans. In each market, firms offer a list of insurance plans which vary across several dimensions such as the size of the deductible, the set of drugs that are covered, whether the plan has a "donut-hole," which is a region of expenditures for which the plan reverts to 100 percent co-insurance, and the plan's premium. Demand in Part D is slightly more complicated than the typical setting due to the presence of two groups of consumers: so-called regular enrollees and low-income (LIS) enrollees. Regular enrollees make unrestricted choices from all plans offered in their region and pay a partially-subsidized premium. In contrast, low-income enrollees, who constitute 35 percent of all enrollees, are randomly assigned to eligible plans by the Centers for Medicare and Medicaid Services (CMS) and pay nothing. However, low income enrollees can opt out of the random assignment process and freely choose any plan at additional cost. As of 2011, about one-third of LIS enrollees had opted out of the random assignment system. Using six years of data on the characteristics and enrollments of all Part D PDP plans across all 34 Medicare regions, we estimate demand for both regular and LIS enrollees using the random coefficients discrete choice framework pioneered by Berry, Levinsohn, and Pakes (1995).

Given demand estimates for plans, we then turn our attention to modeling the behavior of firms. A critical piece of this puzzle is the rule for how a firm's pricing decision, hereafter referred to as its bid, are turned into premiums that regular enrollees and LIS choosers face. Essentially, CMS takes the sum of all bids for all firms in the US, averages them using enrollment weights from the previous year, and takes a fraction of the resulting number to obtain the base subsidy. The premium of a given plan is then determined by taking the maximum of zero and the firm's bid minus this base subsidy. This pricing mechanism has three effects on market outcomes. First, consumers face premiums which are strictly lower than firm bids, which increases demand. Second, the relative premiums of plans are distorted by this mechanism; this is important since it distorts the choices behavior of consumers across plans. Third, the same bids determine both the subsidy levels for the low-income enrollees and the plans' eligibility to enroll the randomly-assigned LIS enrollees. Only plans with a bid below the average bid are eligible for random assignment of LIS enrollees. Consequently, there is key linkage between the two groups: the bidding process by which plans qualify to be eligible for low-income assignments also influences premiums for regular enrollees. Thus, these incentives distort both the public payments for low-income enrollees and the prices and choices of regular enrollees.

Modeling this mechanism in its entirety is complicated by the fact there is a discontinuous incentive in pricing due to the eligibility threshold for the random assignment of LIS enrollees.[1] This invalidates the typical practice of taking consumer demand and inverting firms' pricing first-order conditions under an assumption of Bertrand-Nash pricing to obtain marginal costs. To circumvent this problem, we focus on estimating marginal costs only on firms that we posit are not strategically distorting prices to obtain eligibility for LIS enrollees. We then project these marginal costs onto a set of plan characteristics and use this to predict marginal costs for the LIS-seeking plans.

With demand and supply cost estimates in hand, we then characterize the welfare effects of the current subsidy mechanism. Our welfare estimates depend on the estimated consumer surplus, producer profits, and the social cost of government spending. We assume that the deadweight loss of taxation is given by 30 cents per dollar of revenue raised. We also make two critical assumptions in computing welfare. First, we assume that the rest of the world does not change as we modify the subsidy mechanism in Part D PDP. As such, all of our counterfactual results are subject to the usual partial-equilibrium critiques. Second, all of our estimates, demand, marginal cost, and government spending, are measured relative to their opportunity cost. Consumers in this market are not left without coverage if the Part D PDP market were to shut down; one can readily see this as the inside share of consumers in Part D PDP is only 37.5 percent in 2012. The remaining 62.5 percent are primarily

[1] There is also a dynamic pricing incentive involving the LIS enrollees; see Decarolis (2014) for details.

covered by private insurance or a similar insurance program offered under Medicare Advantage (MA-PD). Producers face a direct marginal cost of providing the good here, but also the opportunity cost of potentially serving the same consumer in the MA-PD market. The government spending opportunity cost is particularly salient, as we assume that consumers would substitute from Part D PDP plans exclusively to MA-PD plans. Our thinking is that these consumers do not have the outside option of private insurance, and have already revealed that they are willing consumers of some kind of publicly-subsidized drug insurance. This implies that all of our estimates—demand, marginal cost, government spending, and, thus, social welfare—are relative to the outside option.

We first calculate welfare estimates from the observed prices and allocations. Our findings suggest that relative to the existing outside option, the current levels of subsidies in the stand-alone Prescription Drug Plans are generating negative nominal welfare with a return of only 33 cents of surplus for every dollar of government spending. However, once the foregone costs of providing similar services in MA-PD are considered, the program generates substantial surplus, with a return of \$2.22 per dollar of opportunity cost. This is one of our primary findings; the positive welfare effect of Part D PDP is driven exclusively by opportunity costs. On its own merits, the total cost of providing subsidized goods exceeds their benefits; expenditures of \$9.4 billion generated \$4.0 billion of consumer surplus and \$529 million of producer profit. However, we estimate that foregone costs of providing similar coverage in MA-PD is \$8.3 billion. Considering the opportunity cost and the deadweight loss of taxation to raise government funds, we estimate that the program in its current form generates \$3.12 billion in surplus.

Recognizing potential problems arising from mixing together the regular enrollees and the LIS enrollees, several policy initiatives have proposed removing the LIS enrollees to their own market. In this counterfactual, we re-simulate the current subsidy mechanism without the influence of LIS enrollees.[2] We find that consumer surplus and producer profit increase relative to the observed mechanism, but overall surplus declines as the net surplus generated by the marginal consumers is exceeded by the social cost of subsidizing the program. As we are unable to compute counterfactual equilibria for mechanisms that have the LIS enrollees as part of the market, we consider this our baseline counterfactual.

To assess the competitiveness of the market, we perform two counterfactuals where we change the ownership structure. In the first, we assume that each plan is its own firm; in the second, we assume that every plan in each market belongs to one firm. Compared to the baseline counterfactual, we find the expected pattern that profits increase greatly and

[2]This simulation also removes the enrollment weights from the MA-PD market in determining the base subsidy; details are provided below.

consumer surplus declines under the monopolistic regime, with the opposite pattern under atomistic competition. Interestingly, total surplus declines in both situations. Under a monopoly, the loss is driven by decline in product market surplus, dominating the increase in producer profits. Under atomistic competition, the changes are less dramatic, but still result in negative welfare as the marginal benefits of serving additional consumers are exceeded by the social costs of providing the goods.

This highlights a general tension in this setting: the social planner must balance the benefits of additional consumer surplus and producer profits against the social cost of subsidizing the provision of those goods. To formalize this, we perform several counterfactuals where the government sets prices directly. In the first, prices are set at private marginal cost. In the second, prices are equal to social marginal costs. In the last, the government acts as the social planner, maximizing total welfare.

Under marginal cost pricing, consumer surplus is half of the current mechanism, driven by a more than doubling of consumer premiums and a corresponding large decline in the amount of consumers choosing to buy a Part D PDP plan. This is not a completely unexpected result; on the one hand, prescription drug coverage in general is certainly a valuable product for seniors. For example, Town and Liu (2003) conclude in their estimates of welfare effects from the introduction of Medicare Advantage program that the prescription drug insurance part of the program was extremely valuable for the Medicare population. At the same time, Engelhardt and Gruber (2011) find evidence of substantial crowd-out, where Part D insurance was used merely as a substitute for other prescription drug coverage sources. Given the outside option, we may have expected to see a large substitution to the outside good if consumers faced private marginal costs. The situation becomes even more extreme under social marginal costs, which incorporate the fact that the government has expenditures on plans that are unrelated to the subsidy directly. In this case, enrollment decline to only five percent of the market.

Interestingly, the social marginal cost counterfactual has lower welfare than the private marginal cost mechanism. The reason is that both mechanisms are ignoring an important component of welfare, which is the opportunity cost of government spending. To assess that situation, we compute the social planner's problem. As expected, the social planner has high total surplus of $5.3 billion. This is approximately 70 percent higher than the current mechanism. Enrollment in Part D PDP under the social planner is nearly 50 percent of the market. Consumer surplus is nearly identical to the observed mechanism, but the distribution of equilibrium prices is completely different. Average prices are lower than all other mechanisms that we consider; the social planner prices where straight producer profits are negative.

With these benchmarks in mind, we then proceed to investigate a menu of counterfactual subsidy-setting policies that CMS could implement in lieu of the current bid averaging process. The simplest scenario would be to provide fixed vouchers that could be used to buy a plan in the Part D market. We find that the current system operates like a voucher, in that the average bid mechanism is set by bids of all plans, and any individual firm has little influence on that average. Unsurprisingly, we can replicate the observed surplus very closely using a fixed voucher. Bridging the gap between a uniform voucher at the national level and the social planner's plan-specific prices, we also evaluate the welfare gains of instituting vouchers which vary at the regional level, but find that the welfare increase is very minor.

A second option would be to use a uniform proportional discount on all plans' bids. Proportional subsidies are, in general, a disastrous idea as firms simply scale their bids in proportion to the subsidy. Consumers face increasingly low premiums, firms are paid increasing large bids, and government expenditures explode. That combination results in large negative welfare losses.

Our paper is related to a large theoretical literature that has examined the role and motivation for in-kind subsidies in different sectors of the economy; surprisingly, however, the empirical analysis of the motivation and effects of such government policies is much less explored (Currie and Gahvari, 2008). In health insurance, the literature has focused on the effects of tax subsidies to employer-provided health insurance (Gruber and Washington, 2005). At the same time, the recent expansion of federal health insurance programs into private markets has brought a large public policy interest to how the federal budget subsidizes these programs—from privatized Medicare and Medicaid plans to the ACA health insurance exchanges. This paper is also related to the growing literature that analyzes the Medicare Part D program as a prominent example of a health insurance program with consumer choice. This literature has so far mostly focused on demand questions. Several papers have explored the rationality of individual choices (Heiss et al., 2010, 2013; Abaluck and Gruber, 2011, 2013; Ketcham et al., 2012; Kesternich et al., 2013; Kling et al., 2012). Einav et al. (2013) explore the effect of non-linear contract structure on the drug consumption decisions in Part D. Ericson (2013); Miller and Yeo (2012); Abaluck and Gruber (2013); Polyakova (2013) explore the presence and role of inertia in the individual choices of Part D contracts.

Further, this paper is related to a substantial theoretical and empirical literature on the supply-side effects of government regulation. Laffont and Tirole (1993) gives a classic reference on the multitude of theoretical issues. Our research question is related to the issues of government procurement in health care (e.g. Duggan (2004); Duggan and Scott Morton (2006)). The literature on the supply side of Part D is still rather small. Ericson (2013) raises the questions of insurer strategies in Part D, arguing that insurers are exploiting individual inertia in their pricing decisions. Ho et al. (2013) expand on this theme, presenting a model of strategic supply-side pricing in response to consumer inertia. Duggan et al. (2008); Duggan and Scott Morton (2010) estimate the effect of Part D on drug prices, and Yin and Lakdawalla (2010) analyzes how Part D enrollment affects private insurance markets. Decarolis (2014) focuses entirely on the supply-side, documenting that insurers are pricing strategically to take advantage of low-income-subsidy policies in Part D.

The remainder of the paper is organized as follows: Section 2 discusses the key economic concepts. Section 3 describes the institutional details of the Medicare Part D market and our sources of data. Section 4 introduces the theoretical model underpinning our analysis, while Section 5 describes our empirical application of that model to the data and our results. Section 6 discusses our counterfactual pricing mechanisms and presents our results. Section 7 concludes.

2 Conceptual framework

In imperfectly competitive markets, such as Medicare Part D, subsidy policies may affect both consumer and producer behavior. In this section we describe the key economic forces that we consider in the paper separately for demand and supply sides.

Consider first the demand perspective. Suppose first that individuals face a simplified decision of how much health insurance to buy and they face a market where any amount of health insurance can be purchased. The fact that the government covers part of consumer's premium for a health insurance plan introduces a kink in the budget constraint. As in Peltzman (1973), the distortion of the budget constraint is even larger if the government only subsidies certain kinds of health insurance, rather than any health insurance chosen by the individual. The kink in the budget constraint shifts out the constraint and improves welfare for those consumers who would have purchased more than the subsidy-worth amount of health insurance without the subsidy. However, it pushes other individuals to purchase at the kink, while they would have preferred to buy less than subsidy-worth amount of insurance and get the difference in cash. Consequently, depending on the exact level of subsidies, the policy of paying for some amount of health insurance premium may, in a neo-classical framework with rational consumers, result in excessive consumption of insurance. Thus, we would expect that changes in subsidy levels would be followed by the reallocation of individuals along the extensive margin of purchasing and not purchasing insurance.

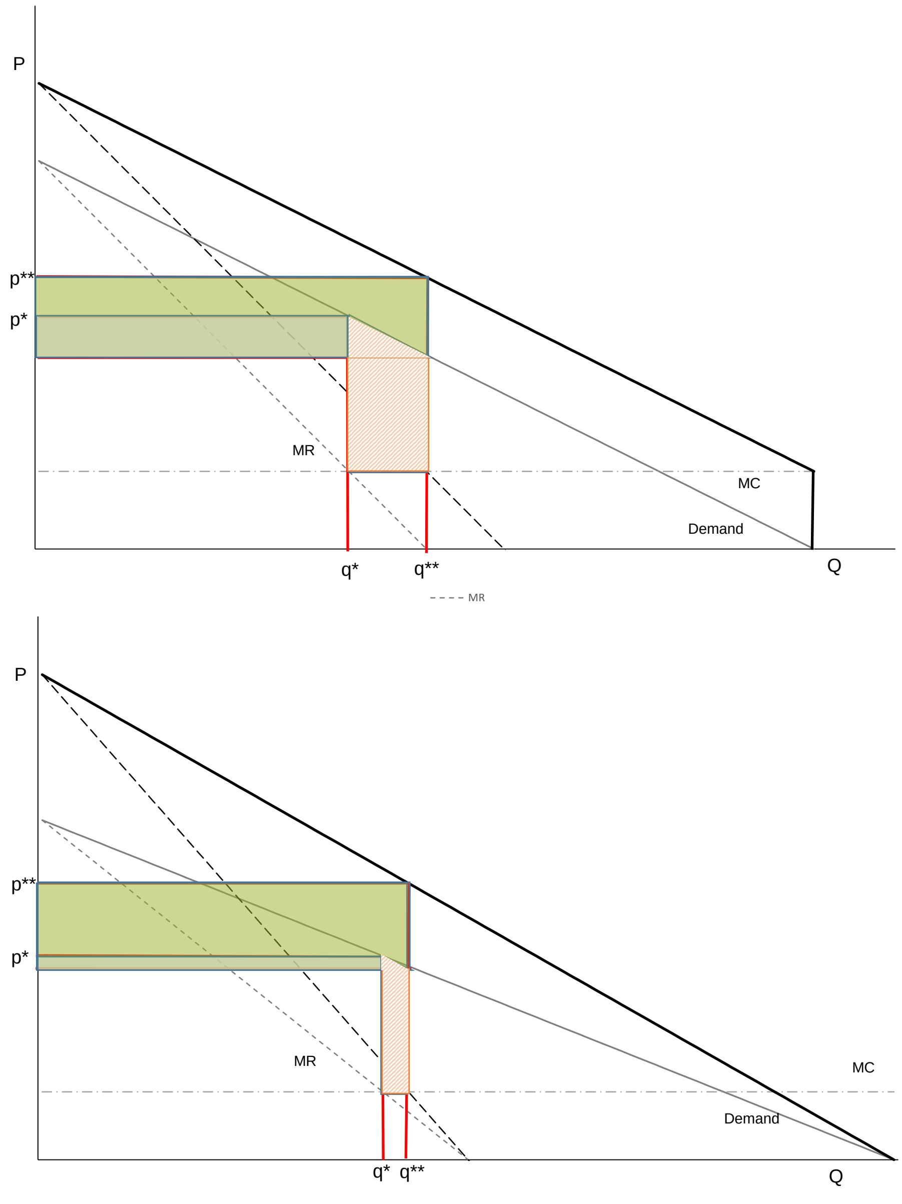
A similar, but more nuanced, distortionary effect of a subsidy is possible on the intensive margin in an environment of differentiated product markets. Consider a situation where the individual is now choosing between two insurance contracts A and B, where A offers more coverage and is more expensive, while B offers less coverage and is cheaper. Suppose at market prices, the individual would prefer to buy the cheaper contract B. If now we introduce a subsidy that is the same for both contracts and higher than the market price of contract B, the relative price of the two contracts falls. It is then possible that the individual will decide to consume contract A instead of B as for sufficiently high levels of subsidy, the individual will achieve higher net utility from contract A at lower relative prices. Thus, a flat subsidy may lead to distortions in which insurance contracts individuals choose. These aspects of the subsidy's effects on demand for health insurance suggest that which level of subsidy the government chooses to set for which plans may have important implications for the allocative efficiency of the programs.

We next move away from the partial equilibrium demand perspective and consider how different ways of providing subsidies may impact insurers' pricing behavior. Subsidies would have no impact on the supply-side of the market if insurers were competing perfectly a la Bertrand and setting their premiums at marginal cost. In that case subsidies would affect individual demand, but not insurers' pricing decisions. The presence of subsidies, however, changes insurers pricing decisions if there is any degree of market power in the market. To illustrate this idea consider the simplest case of a textbook monopolist.

Consider a monopolist insurer with a constant marginal cost c and linear demand $q = 1 - p$.[3] The monopolist sets premiums p to maximize profits $\pi = (p - c)(1 - p)$. The equilibrium premium in this setting is $p = \frac{1+c}{2}$ with the profit equal to $\pi^{\text{no}\sigma} = (\frac{1-c}{2})^2$. Now suppose that the government introduces a subsidy for the monopolist's insurance plan. Let the subsidy σ be a flat dollar amount that is set by the government independently of the monopolist actual prices, and is known to the enrollees and to the monopolist ex ante. Assume the subsidy is low enough relative to the monopolist's marginal cost, that it does not create corner solutions in the profit function. Then, for any premium set by the monopolist, p^M, the individual faces the price $p^M - s$ and demand is thus $1 - p^M + s$. Taking this into account, the monopolist will increase its equilibrium prices, but not by the full subsidy amount. In particular, profit-maximizing price is going to be $p = \frac{1+c+\sigma}{2}$ and the profit becomes $\pi^{\sigma} = (\frac{1-c+\sigma}{2})^2$. The extra profit which equals $\frac{2(1-c)s+s^2}{4}$ is positive for parameter values where the monopolist's problem is well defined and is increasing in the level of subsidy. Figure 1 illustrates the set-up graphically.

[3] We abstract from the possibility of non-constant marginal costs due to selection in the current discussion, although considering this aspect may add additional insights to the problem. We discuss in Section 4.2 how we treat the selection concern in our empirical supply-side model.

Figure 1: Welfare effects of flat (Plot A) and proportional subsidies (Plot B) in textbook monopoly case



Net welfare change (in this case gain) is shaded in light pink. Government spending is shaded in green. Note that while government spending is the same in both cases, the net welfare gain and additional consumer surplus is substantially smaller under proportional subsidy.

As a result of this very simple subsidy mechanism, individuals will face lower premiums, but not lower by the whole subsidy amount. The potential consumer surplus from the subsidy will be partially dissipated to higher monopoly profits. The pass-through of subsidies to insurers' profits will depend on the elasticity of demand, on the level of subsidy relative to equilibrium prices, as well as on whether the subsidy is set as an exogenous amount or is endogenous to monopoly's pricing decisions. In an oligopoly case, which is going to be a closer description of our empirical setting, the effect of subsidies on efficiency will lie in between the zero effect in a perfectly competitive market and the level of rent dissipation that would have characterized a pure monopoly. In our counterfactual simulations in Section 6, we will be assessing the degree of market power in Medicare Part D as well as which combinations of decentralized subsidy mechanisms and subsidy levels could improve the efficiency of the program.

3 Institutional Environment

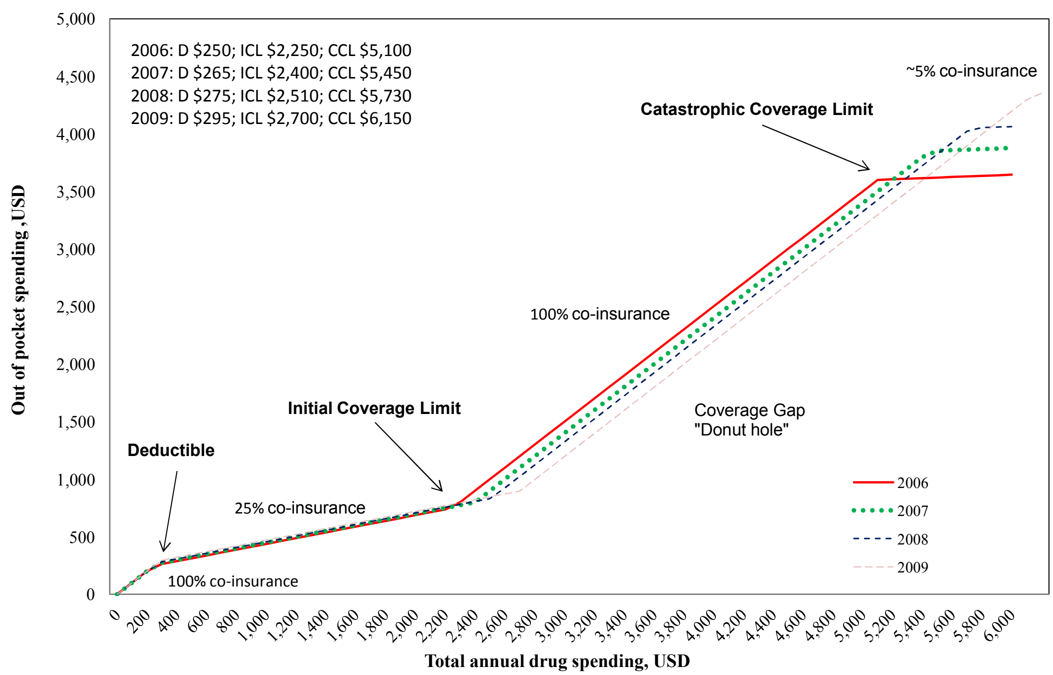
Medicare is a public health insurance program for the elderly and disabled in the United States that covers over 50 million beneficiaries. Signed into law in 1965, the program aims to provide health insurance for a population which is generally characterized by high health expenses and low economic resources, and which historically had trouble finding and affording private health insurance coverage. Medicare costs the government about $500 billion annually and constitutes a large (14 percent in 2013) and growing share of the federal budget.

The Medicare program is administered by the Centers for Medicare and Medicaid Services (CMS), and consists of several pieces. Parts A and B cover hospital and outpatient services, respectively, under a fee-for-service model. Part C or Medicare Advantage, introduced in 1997, allows consumers to switch from fee-for-service to managed care plans administered by private insurers, but highly subsidized by the government. In 2006, Congress expanded Medicare program to include prescription drug coverage via Medicare Part D as part of the Medicare Modernization Act of 2003. In 2014, approximately 37 million individuals benefited from Medicare Part D program and the Congressional Budget Office estimates that the government currently spends over $76 billion on Part D annually. This new part of the Medicare program is the institutional setting of our study.

Medicare Part D coverage is voluntary and enrollment is not automatic for the so-called "regular" beneficiaries, who are Medicare enrollees without eligibility for extra low-income support. Beneficiaries eligible for low-income subsidies are instead automatically assigned to plans by CMS; these individuals can subsequently change their random assignment by making an active choice. The latter group is known as "LIS choosers". In general, beneficiaries face a choice of more than 30 stand-alone Rx contracts offered in their state of residence. Alternatively, if beneficiaries choose to enroll in private Medicare Advantage plans rather than traditional fee-for-service Medicare, their Part D coverage will be provided within the MA plans, known as MA-PD. Once enrolled, regular beneficiaries pay premiums on the order of $400-$500 a year, as well as deductibles, co-payments or co-insurance. LIS-eligible enrollees receive additional support to cover premiums and cost-sharing.

The exact structure of cost-sharing varies from contract to contract. Insurers, are required to provide coverage that has at least the same actuarial value as the annually set Standard Defined Benefit. The latter has a non-linear structure illustrated in Figure 2; it includes a deductible, a 25% co-insurance rate and the infamous donut hole, which is a gap in coverage at higher spending levels. As long as actuarial minimum is satisfied, insurers are allowed to adjust and/or top up the SDB contract design, which generates empirical variation in contract characteristics. Some of the differentiation from the minimum requirement is purely financial - contracts can change cost-sharing thresholds, co-pay and co-insurance levels, and may offer coverage in the "donut" hole. Other differentiating features are related to the quality of insurer's pharmacy networks, formulary coverage and other non-pecuniary quality measures.

Figure 2: Minimum coverage requirements in Part D



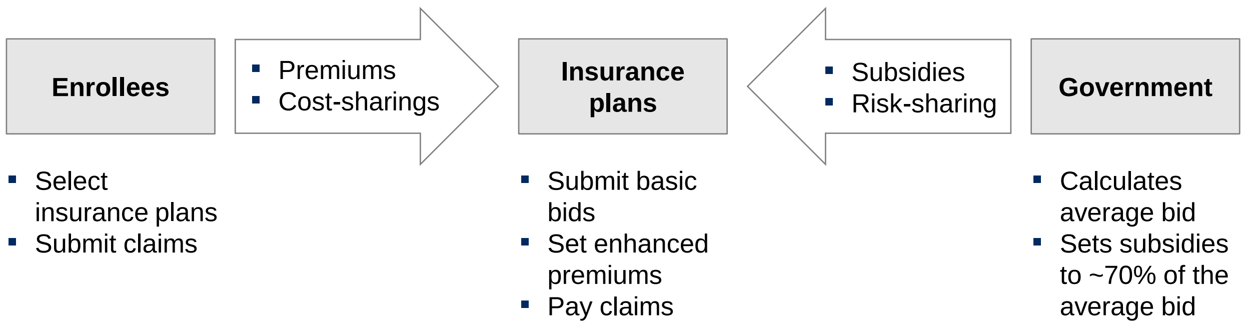
The supply-side of the Part D program has a unique, and controversial, design. Unlike the rest of Medicare, the drug insurance benefit is administered exclusively by private insurance companies. At the same time, the setting differs from more conventional private insurance markets in two key ways. First, the participating insurance companies are highly regulated, and continuously audited by Medicare. Second, consumers bear only a fraction of the cost in the program, as more than 75 percent of insurer revenues come from government's per capita subsidies. For individuals eligible for low-income-subsidies, these subsidies go up to 100 percent. The intricate policies governing the program's subsidy system are the focus of our paper. We briefly outline the details of the two subsidy mechanisms - for regular and LIS enrollees - in what follows.

First, to decide upon the division of the total per enrollee revenue between the consumer premium and the subsidy component for regular enrollees, the government administers an annual "auction" mechanism. According to this mechanism, all insurers wanting to participate in the program in a given year submit bids for each plan they will be offering. Part D program is divided into 34 geographic markets and insurers are allowed to submit separate bids for the same plan in different regions. By statue, the bids are supposed to reflect how much revenue the insurer "needs" (including a profit margin and fixed cost allowances) to be able to offer the plan to an average risk beneficiary.[4]

Medicare takes the bids submitted by insurers for each of their plans and channels them through a function that outputs which part of the bid is paid by consumers in premiums and which part is paid by Medicare as a subsidy. This function takes the bids of all plans nationwide, weights them by enrollment shares of the plans and takes the average. Roughly 75 percent of this average is the Medicare's subsidy portion. The remaining 25 percent of the national bid average together with the difference between the plan's bid and the national average is set as consumer's premium. The per capita subsidy payment from Medicare is further adjusted by the risk score of each enrollee, while the consumer premium may also include an additional payment for enhanced benefits if the plan offers them. Figure 3 summarizes payment flows in the program. In our counterfactual analyses we explore welfare properties of this part of subsidy regulations, asking whether simple adjustments to the mechanism could improve the efficiency of the program.

[4]There are several nuances buried in the set-up of the bidding procedure that are important for insurers' incentives and will enter the insurers' profit function in our empirical model. First, Medicare sets a minimum required actuarial benefit level that plans have to offer. Plans are allowed to offer more coverage ("enhance" the coverage), but that enhanced portion is not subsidized. Thus, when submitting their bids plans are supposed to only include the costs they expect to incur for the baseline actuarial portion of their benefit. The incremental premium for the enhanced coverage in the plans has to be directly passed on to the consumers.

Figure 3: Summary of who pays what



The second feature of the subsidy policies that we consider, concerns the role of low income beneficiaries (LIS) in the Part D program. Medicare utilizes the bids of the mechanism outlined above, to also determine the level of subsidies provided to the low income (LIS) population. For each geographic market, Medicare calculates the average consumer premium (without the enhanced coverage add-ons); the average is weighted by the lagged LIS enrollment in the plans. This average constitutes the subsidy amount that low-income beneficiaries receive, known as LIS benchmark or LIPSA. Most LIS beneficiaries do not in fact choose plans, but rather are randomly assigned by Medicare to qualifying plans in their regions. Qualifying plans are those that have premiums below the LIS benchmark and thus by definition zero premium for the LIS enrollees. Decarolis (2014) demonstrates that the way the LIS subsidy and enrollment are designed significantly distorts insurers' incentives and encourages gaming. In this paper we will be able to evaluate aggregate welfare effects of the LIS market for the efficiency of the market for regular enrollees.

4 Model

We propose an empirical model of demand and supply of insurance contracts in Medicare Part D that will help us evaluate the efficiency of the regulatory design and market structure in the program. The model takes into account the key policies governing the multiple sources of subsidies in the system. We start with a model of demand for insurance contracts that follows the approach of Berry (1994) and Berry, Levinsohn, and Pakes (1995) (hereafter referred to as BLP). We then move to a supply-side model that allows us to estimate the marginal costs of the insurers. As we discuss below in more detail, we adjust the standard supply-side approach to take into account the regulatory distortions generated by the random assignment of low-income beneficiaries to plans.

4.1 Demand

We utilize the random utility model of discrete choice to estimate demand. We consider two separate demand systems. First, we estimate demand of regular enrollees, who choose their plans, pay full enrollee premiums, and also pay full cost-sharing - deductibles, co-insurance and co-pays. Second, we estimate a separate demand system for enrollees that are eligible for low income subsidies and thus face different premiums and plan characteristics. Since most LIS individuals are randomly assigned towards plans, our estimation of preferences for this segment of demand largely relies on the decisions of so-called LIS choosers, as we describe below in more detail.

We start with the enrollment decisions of regular enrollees. To formulate a parsimonious model of demand for these individuals, we make the following modeling choices. We define the potential market as all Medicare beneficiaries that are not eligible for low income subsidies and did not receive their Part D coverage through their employer or through special groups like Veteran Affairs. This leaves us with non-LIS Medicare beneficiaries that chose to enroll into a stand-alone prescription drug plan (PDP), or a Medicare Advantage Prescription Drug plan (MA-PD), or did not have any Part D coverage. We let the choice of not enrolling into any part of the Part D program or enrolling through a Medicare Advantage plan comprise the outside option. Within the inside option, individuals are choosing among 30-40 stand-alone Prescription Drug Plans (PDPs) that are available in their state of residence.

We posit that individuals select insurance contracts among PDP plans by choosing a combination of pecuniary and non-pecuniary plan characteristics that maximizes their indirect utility. We take the characteristics-space approach and project all plans into the same set of characteristics. This approach allows us to make fewer assumptions about how individuals perceive the financial characteristics of plans, but also implies that we remain agnostic about the objective actuarial efficiency of choices and also do not recover deeper structural parameters such as risk aversion. Despite the fact that we are estimating demand for insurance and thus preferences may depend on risk aversion, we argue that our model of linear index utility with unobserved heterogeneity is suitable for our goals. The risk protection quality of an insurance plan is represented by its financial characteristics other than premiums. We can think about the linear utility index as a reduced form way of capturing revealed valuation of different financial characteristics of plans that are generated by underlying concave utility functions over the distributions of expected spending. In the simulations of the model in Section 6, we will be interested in capturing the demand response to changes in premiums, while keeping the plans' actuarial properties and thus their revealed valuations fixed.

With these modeling choices in mind, we let the utility consist of a deterministic component and a random shock. The deterministic indirect utility function of a regular enrollee i

who chooses plan j in market t is given by:

$$v_{ijt} = -\alpha_i p_{jt} + \beta x_{jt} + \xi_{jt}, \tag{1}$$

where p_{jt} is the plan's enrollee premium. Note that unlike in standard product markets, the premium that enrollees pay in Part D is not equivalent to the per capita revenue that firms receive, since there is a large part paid in federal subsidies to insurers. Allowing for the possibility that the government subsidy, σ, can be larger than a particular plan's desired per capita revenue, the premium is then equal to $p_{jt} = \max\{0, b_{jt} - \sigma_{jt}\}$. b_{jt} denotes the supply-side price or the per capita revenue that is the insurers' choice variable. Medicare regulator refers to b_{jt} as a bid, and we adopt this terminology to distinguish between supply and demand-side prices.[5] x_{jt} contains observable characteristics of plan j in market t, ξ_{jt} is a plan-specific fixed effect that captures unobserved plan quality. Each choice is also subjected to a random shock, ϵ_{ijt}, distributed as a Type I Extreme Value. The resulting utility is:

$$u_{ijt} = v_{ijt} + \epsilon_{ijt}. \tag{2}$$

We define the market to be one of the 34 statutory Part D geographic regions in years 2007 to 2010, for a total of 136 well-defined markets. The observable characteristics of plans j in market t, x_{jt}, includes the annual deductible, a flag for whether the plan has coverage in the donut hole, whether the plan is enhanced, several generosity measures of drug formularies, and vintage of plans that accounts for consumer inertia. We also include fixed effects for parent organizations that capture individuals' preferences for brand names of large insurance companies and insurer-level quality characteristics of plans, such as pharmacy networks.

Unobserved consumer heterogeneity enters the model through random coefficients on the premium. The unobserved heterogeneity may capture differences in income, as well as individuals' differences in risk and risk aversion. As theory suggests a negative coefficient on price, we choose a log-normal distribution for random coefficients that is only defined on the positive quadrant. The coefficients are specified as:

$$\ln \alpha_i = \alpha + \sigma_\alpha \nu_i \tag{3}$$

$$\text{where } \nu \sim \mathcal{N}(0,1) \tag{4}$$

where α and σ are parameters of interest that guide the distribution of taste heterogeneity.

[5] Note that strictly speaking, in CMS terminology bids include only insurers' prices for the minimum required Part D coverage. Additional coverage if offered has to be priced separately - this price is known as an enhanced premium. In the set up of the model, we refer to the bid as the aggregate of these two parts and we discuss how we deal with enhanced premiums in more detail in the estimation section.

We complete the utility model for regular enrollees by specifying the outside good of not choosing to enroll in a stand-alone Prescription Drug Plan. This utility is normalized to zero. As described above, we define the market share of the outside option as the fraction of enrollees who chose MA-PD plans or did not acquire any Part D coverage.

We next proceed to formulating a preferences model for the low income subsidy -eligible population. The institutional design of this part of the program posits substantial challenges for estimation. Typically, individuals eligible to receive low-income subsidies are automatically assigned to plans by the government rather than choose their plans. At the same time, however, individuals are eligible to change their assignment to a plan of their own choice after the random assignment took place. As the number of the so-called "LIS choosers" is substantial, competition for this part of the market potentially plays an important role in the pricing decisions of the insurers. In order to include this part of the market into the supply side part of the model, we need to estimate the elasticity of LIS demand.

We use observations on the choices of the "LIS choosers" as well as a set of assumptions about the structure of the outside option to recover the elasticity of demand in this part of the market. We posit that the demand of low-income beneficiaries can be described by a random utility very similar to the one we use for the regular enrollees. The key difference is that low-income beneficiaries face different characteristics of plans, as their cost-sharing is largely covered by the government. We do not include a distribution of unobserved heterogeneity in this part of demand system. Let the deterministic indirect utility function of a low-income subsidy enrollee i who chooses plan j in market t be given by:

$$v_{ijt} = -\alpha^{LIS} p_{jt}^{LIS} + x_{jt}^{LIS} \beta^{LIS} + \xi_{jt}^{LIS}, \tag{5}$$

where p_{jt}^{LIS} is the plan's premium for the low-income population. This premium is computed as the remainder of the difference between the insurers' bid and the federal LIS subsidy, which is higher than the subsidy for regular enrollees. x_{jt}^{LIS} contains observable characteristics of plan j in market t as faced by the low-income population. The difference in the plan characteristics that regular and LIS enrollees face lies primarily in cost-sharing: to the first order, the LIS population does not face a deductible or coverage in the gap, as this cost-sharing part is picked up by the government.

To close the demand model for the LIS enrollees, we assume the following about the outside option. The potential market for the LIS population is defined as all LIS individuals enrolled in stand-alone PDP plans. Since many LIS enrollees are assigned to plans rather than choose plans, it would be unreasonable to assume that these "choices" represent individual preferences.

Therefore, we say that all LIS-eligible individuals that are enrolled in plans that are eligible for Medicare's automated LIS assignment are choosing the outside option. We thus estimate preferences of the LIS-eligible population from the choices of LIS "choosers" that enrolled in plans not eligible for random assignment. Then, individuals that were randomly assigned by Medicare and did not change their plan are treated as having chosen the outside option by choosing to stay in their assigned plan. Unfortunately, we cannot observe in the data if someone voluntarily changes their randomly assigned plan to another plan that is also eligible for random assignment. These individuals are thus also treated as having chosen the outside option in our model.

4.2 Supply

Modeling the supply side in Medicare Part D market presents a considerable challenge, as the decision-making of the insurers is affected by a complex set of regulatory provisions. We start with a description of the key regulatory distortions and set-up a general profit function that can incorporate these distortions. We then discuss our strategy of arriving at an empirically tractable version of the supply-side model. We view our strategy of simplifying the problem as a contribution to the growing literature on the estimating of supply-side models in insurance.

We begin with a description of the revenue channels and costs for a single stand-alone prescription drug plan (PDP) in Medicare Part D. Consider one insurance plan j offered by a one-plan-insurer in one market. We assume that all characteristics of plan j are pre-determined and the only decision variable for this insurer is which bid b_j to submit to Medicare for plan j.[6] For each individual that plan j enrolls, the insurer collects an enrollee premium, p_j. The premium is a function of the bid b_j that the plan submits to Medicare, as well as function of the enrollment-weighted average of all other bids in the whole country, $\bar{b}$. Recall the latter arises, since premiums are determined as a residual between the insurer's bid and the baseline subsidy, which is determined as a fraction of the average bid $\bar{b}$.

The subsidy payment σ_i from the government is different for each enrollee, as it is adjusted for individual risk profiles. For example, an individual with average risk level will only receive baseline subsidy, while an individual with costly chronic conditions may generate twice the amount of the baseline subsidy in insurers' revenues. The level of the baseline subsidy depends on the average bid, $\bar{b}$. In other words, we can write the subsidy a function of the average bid and individual-specific health risk: $\sigma_i(\bar{b}, r_i)$.

[6] Recall that in practice insurers that offer enhanced Part D coverage decide on both the bid to CMS and the "enhanced" premium. We take this aspect into account in the estimation, but abstract from it in the description of the model.

On the cost side, the ex-post costs of a plan differ for each enrollee and depend on individual drug expenditures. Some of the costs are mitigated by the government through catastrophic reinsurance provisions, according to which the government directly pays about 80 percent of individual's drug spending for particularly high spenders. For an individual with a given total annual drug expenditure amount, the costs of the plan will also depend on the cost-sharing characteristics of the plan, denoted by ϕ. These include characteristics such as the deductible level, co-pays and co-insurance, as well as coverage in the donut hole if any. We let individual-level ex-post costs be the function of these cost-sharing characteristics of a plan as well as the individual's measure of health risk, r_i; that is we let the cost be $c_{ij}(r_i, \phi_j)$.

The final piece of a plan's ex-post profit are risk corridor transfers between insurers and the federal government that happen at the end of the year at the parent organization level. These symmetric risk corridors restrict the amount of realized profits and losses that the insurers are allowed to collect in Medicare Part D. We denote the function which adjusts a insurer's ex-post profit with Γ.

The ex-post profit for one representative plan j as a function of its bid b_j is then:

$$\pi_j(b_j) = \Gamma\left[\sum_{i\in j}\left(p_j(\bar{b}, b_j) + \sigma_i(\bar{b}, r_i) - c_{ij}(r_i, \phi_j)\right)\right]. \tag{6}$$

For each individual, the subsidy and the cost can be expressed as an individual-specific deviation from the baseline subsidy and an average plan-specific cost of coverage: $\sigma_i = \sigma + \tilde{\sigma}_i$ and $c_{ij} = c_j + \tilde{c_{ij}}$. Denote the individual-specific difference in the subsidy and cost as $\eta_{ij} = \tilde{c_{ij}} - \tilde{\sigma}_i$. This function allows us to capture adverse or advantageous selection from the point of view of the insurance plan. Given the empirical evidence in Polyakova (2013) on the selection patterns in Medicare Part D, η_{ij} mostly depends on whether or not a plan offers coverage in the gap. We thus let this individual-specific component be a function of plan characteristics: $\eta_{ij}(\phi_j)$. Using this new notation, we can then re-write the profit function above as:

$$\pi_j(b) = \Gamma\left[N(\mathbf{p})(p_j(\bar{b}, b_j) + \sigma(\bar{b}) - c_j(\bar{r}, \phi_j)) + \left(\sum_i \eta_{ij}(\phi_j)\right)\right]. \tag{7}$$

Denoting $\eta_{ij}(\phi_j)$ with $H_j(\phi)$, we obtain a profit function that does not have individual-specific terms and can be written using the market share notation that is useful for the empirical analysis.

Note that the premium that insurers collect together with the baseline level of the subsidy is by construction equal to the bid submitted by insurer to Medicare, i.e. $p_j(\bar{b}, b_j) + \sigma(\bar{b}) = b_j$.

We can then re-write the pre-risk corridor profit of plan j as:

$$\pi_j(b_j) = (b_j - c_j)s_j(p_j, p_{-j})M - H_j(\phi), \tag{8}$$

where, as highlighted above, premiums are functions of insurers' bids: $p_j(\bar{b}, b_j)$ and $p_{-j}(\bar{b}, b_{-j})$.

We now expand this expression to allow for multi-plan insurance organizations as well as to allow for different prices, marginal costs, and demand elasticity for the Low-Income-Subsidy segment market. The structure of profit from LIS enrollment is specified as entirely symmetrical to the regular enrollees. We denote quantities related to regular enrollees with superscript R, and quantities related to the LIS part of the market with superscript LIS. The profit function for insurer J offering a portfolio of $j \in J_t$ plans across markets $t \in T$ is:

$$\pi_J(\mathbf{b}) = \sum_{t\in T} \Gamma \left(\sum_{j \in J_t} M_t^R s_{jt}^R(b)(b_{jt} - c_{jt}^R) - H_{jt}^R(\phi) + \sum_{j\in J_t} M_t^{LIS} s_{jt}^{LIS}(b)(b_{jt} - c_{jt}^{LIS}) - H_{jt}^{LIS}(\phi) \right), \tag{9}$$

where (ignoring type superscripts) M_t is the population in the market (defined as region-year), $s_{jt}(p_{jt}(\bar{b}_t, b_{jt}), p_{-jt}(\bar{b}_t, b_{-jt}))$ is the share of plan j given the vector of all bids and the bid-averaging rule that translates bids into premiums, b_{jt} is the firm's bid for plan j in market t, and c_{jt} is the marginal cost. Firms maximize profits by choosing bid b for each insurance plan in each market.

While similar, Equation 9 is more complex than a standard profit function in a differentiated products market. The key difference lies in how the share equation $s_{jt}(b)$, is constructed. For regular enrollees, the share depends on the plan's premium, which is not set directly by insures, but rather depends on the bids of other insurers in the following non-linear fashion:

$$p_{jt}^R = \max\left\{0, b_{jt} - \gamma \bar{b_t}\right\}, \tag{10}$$

where $\bar{b_t}$ is the enrollment-weighted average bid of all plans in the entire US and γ is the share of the average bid covered by the federal subsidy. γ is set every year by the Centers of Medicare and Medicaid and is governed by fiscal considerations and the Part D statutes. The share equation for the low-income segment of the market is substantially more complex. It can be thought about a piece-wise function with two components: random assignment of low-income enrollees by CMS for those plans that are eligible for random assignment, and enrollment choices by LIS choosers. For the latter group, the share again depends on premiums that are non-linear functions of bids and subsidies. Decarolis (2014) discusses the piece-wise structure of the share function and the incentives generated by the

LIS random assignment mechanism in much greater detail. Section 5.3 discusses how we deal with the piece-wise structure in the estimation. Here, we derive the first-order conditions for an insurer that it is not eligible for random assignment, but rather can only enroll LIS "choosers". In this case the share function for the LIS population is differentiable.

Then, for a contract j offered by firm J, the first order condition for setting bid b_j is as follows (omitting market subscripts):

$$\frac{\partial \pi_J}{\partial b_j} = M^R s_j^R(b) + (b_j - c_j^R) M^R \frac{\partial s_j^R(b)}{\partial b_j} + \sum_{k \neq j \in J} (b_k - c_k^R) M^R \frac{\partial s_k^R(b)}{\partial b_j} \tag{11}$$

$$+ M^{LIS} s_j^{LIS}(b) + (b_j - c_j^{LIS}) M^{LIS} \frac{\partial s_j^{LIS}(b)}{\partial b_j} + \sum_{k \neq j \in J} (b_k - c_k^{LIS}) M^{LIS} \frac{\partial s_k^{LIS}(b)}{\partial b_j} \tag{12}$$

This expression differs from the more familiar first order condition in the differentiated product literature in that the market size now plays an important role for the firm's decision-making. The market size affects the relative effects on profit from enrolling regular beneficiaries versus LIS choosers. As we now have one equation in two unknowns - marginal costs for regular and LIS enrollees c_j^R and c_j^{LIS}, we need to make an additional assumption to close the model. As Medicare specifically increases its risk-adjustment payments to plans for each LIS enrollee, we will assume that those payments make the marginal cost of these two groups the same from the point of view of the insurer. In other words, we assume that $c^R = c^{LIS}$. Imposing this assumption and collecting terms in vector notation, we arrive at:

$$c = b(p) - \Omega^{-1}(M^R s^R(p^R(b)) + M^{LIS} s^{LIS}(p^{LIS}(b)). \tag{13}$$

where

$$\Omega_{kj} = \begin{cases} -M^R \frac{\partial s_k^R(p)}{\partial p_r} - M^{LIS} \frac{\partial s_j^{LIS}(p)}{\partial p_k} & \text{if } \{j,k\} \in J \\ 0 & \text{else} \end{cases} \tag{14}$$

Note again the role of the relative market size for regular and LIS enrollees in the pricing decision.

4.3 Welfare Metrics

In our counterfactual exercises, we will focus on measuring welfare levels and changes for regular enrollees only, excluding the LIS market. Thus, here we formulate a welfare metric for regular enrollees only. For these enrollees, total welfare in the Medicare Part D PDP market is comprised of three pieces: consumer surplus (CS), insurer profits (Π), and the deadweight loss associated with taxation used to fund government subsidies (G):

$$W = CS + \Pi - \lambda G, \tag{15}$$

where λ is the social cost of raising revenues to cover government expenditures, G.

Since utility is ordinal, we need to impose a normalization that would allow us to measure surplus levels in dollars. A natural normalization is to consider all three pieces of the welfare function as being defined relative to the outside option. For consumer surplus CS the normalization to the outside option follows directly from the utility model. In Section 4.1 we had defined utility from enrolling in stand-alone Part D prescription drug plans as being relative to the choice of an MA-PD plan or to the choice of not purchasing any Part D coverage. For producer surplus, or profits Π, the insurer pricing decision as formulated in Section 4.2 implicitly takes into account the opportunity cost of "serving" the outside option. In other words, the marginal cost as recovered from the inversion of the first-order conditions incorporates the opportunity costs of potentially serving each consumer in the MA-PD market or not serving the consumer at all. Consequently, the profit function is defined relative to profits that could have been made in the MA-PD program or elsewhere. Finally, since the government subsidizes both PDP and MA-PD parts of the market, we have to only consider the extra government spending in PDP as compared to what it would have spent in subsidizing the same individual in an MA-PD. We conservatively assume that the outside option for the government is subsidizing MA-PD, excluding the possibility that some individuals could leave subsidized insurance altogether. With this interpretation of surplus in mind, we specify each of the welfare metrics as follows.

Following Williams (1977) and Small and Rosen (1981), surplus for consumer i with marginal utilities θ_i from plan characteristics, including the premium, takes the following form:

$$CS(\theta_i) = \frac{1}{\alpha_i}\left[\gamma + \ln\left[1 + \sum_{j=1}^{J} \exp(v_{ij}(\theta_i))\right]\right], \tag{16}$$

where γ is Euler's constant, and v_{ij} is the deterministic component of utility for person i from contract j as given in Equation 1.[7] We integrate out over the unobserved taste heterogeneity

[7]Euler's constant is the mean value of the Type I Extreme Value idiosyncratic shock under the standard normalizations in the logit model, and is approximately equal to 0.577.

to obtain consumer surplus:[8]

$$CS = \int CS(\theta)dF(\theta). \tag{17}$$

The second piece of the welfare calculation is producer surplus that we approximate using the pre-risk-corridor and pre-selection-adjustments version of the profit in Equation 9. For each plan j, we thus measure the profit as follows and then add up the profits of all plans in each market.

$$\pi_{jt}(b) = (b_{jt} - c_{jt})s_{jt}(b_{jt}, b_{-jt}, \bar{b}_t)M_t^R. \tag{18}$$

The last piece of net welfare calculations is the deadweight loss associated with raising revenue to cover government transfers to insurance firms and regular Part D beneficiaries enrolled in stand-alone prescription drug plans. In our welfare calculations, we weigh the government spending with the shadow cost of public funds, $\lambda = 1.3$. Similarly to the outside option reasoning in the case of consumer and producer surplus, we consider how much extra government spending the PDP part of the Part D program (G^{PDP}) generates relative to the outside option of subsidizing the beneficiaries in Medicare Advantage prescription drug plans (G^{MAPD}).

Adding the three parts of the welfare function back together, we have the following measure of average total surplus per capita:

$$W = \overbrace{\int \frac{1}{\alpha}\left(\gamma + \ln\left[1 + \sum_{j=1}^{J} \exp(v_j(\theta))\right]\right) dF(\theta)}^{\text{Consumer Surplus (CS)}} + \overbrace{\sum_{j=1}^{J}(b_j - c_j)s_j(p)}^{\text{Producer Profit }(\Pi)}$$
$$- \lambda \overbrace{\left(\sum_{j=1}^{J}(G_j^{PDP} - G^{MAPD})s_j(p)\right)}^{\text{Social Cost of Government Spending (G)}}. \tag{19}$$

While this welfare function describes the surplus for the private market, where the firms administer the insurance contracts, it does not correspond to the welfare function that a social planner would maximize. If we had the government setting prices for insurance contracts and in effect hypothetically administering these contracts, we would need to take into account the cost of public funds for doing that in the social planner's problem. Another way of thinking about is problem is to imagine that the government dictates prices to private insurers that

[8]Note that the addition of unobserved heterogeneity on price in the demand model increases the level of surplus. Since surplus is proportional to the inverse of the marginal utility of income, individuals with very low marginal utility on income are calculated to have very high surplus. Due to the non-linearity of the problem, these low α_i draws do not symmetrically cancel out with high draws of the marginal utility of income, resulting in overall higher surplus.

administer the plans, but then taxpayers cover any shortfall in insurers' profits. Algebraically, both of these interpretations imply that surplus or loss generated in the product market should be weighted with the deadweight loss of taxation. Adding the product market profit under the λ-weighted term, we get the following welfare function for the social planner optimal pricing. Note that since the distinction between bid and price is not meaningful in the social planner's case, we replace the per-plan profit notation to include prices directly:

$$W^{SP}(p) = \overbrace{\int \frac{1}{\alpha}\left(\gamma + \ln\left[1 + \sum_{j=1}^{J} \exp(v_j(\theta), p_j)\right]\right) dF(\theta)}^{\text{Consumer Surplus (CS)}} + \lambda\left[\overbrace{\sum_{j=1}^{J}(p_j - c_j)s_j(p)}^{\text{Product Market Surplus}} - \overbrace{\left(\sum_{j=1}^{J}(G_j^{PDP} - G^{MAPD})s_j(p)\right)}^{\text{Cost of Subsisidies (G)}}\right]. \quad (20)$$

and

$$p^{SocialPlanner} = \text{arg max } W^{SP}(p) \quad (21)$$

The social planner's solution is defined by the set of first order conditions obtained by differentiating $W^{SP}(p)$ with respect to prices. The derivative of consumer surplus with respect to p_j has a conveniently simple form after some simplifications:

$$\frac{\partial CS(p)}{\partial p_j} = \int \frac{1}{\alpha}\left[\frac{-\alpha \exp(v_j(\theta))}{1 + \sum_{k=1}^{J} \exp(v_k(\theta))}\right] dF(\theta) = -s_j(p). \quad (22)$$

The derivative of product market profit with respect to p_j is:

$$\frac{\partial \Pi(p)}{\partial p_j} = \lambda s_j(p) + \lambda \sum_k (p_k - c_k)\frac{\partial s_k(p)}{\partial p_j}. \quad (23)$$

The derivative of the government spending with respect to p_j is:

$$\frac{\partial GS(p)}{\partial p_j} = -\lambda\left[\sum_k (G_k^{PDP} - G^{MAPD})\frac{\partial s_k(p)}{\partial p_j}\right], \quad (24)$$

$$= -\lambda\left[\sum_k \Delta G_k \frac{\partial s_k(p)}{\partial p_j}\right]. \quad (25)$$

Summing these terms, we obtain:

$$\frac{\partial W(p)}{\partial p_j} = (\lambda - 1)s_j + \lambda \sum_k (p_k - c_k)\frac{\partial s_k(p)}{\partial p_j} - \lambda \left[\sum_k \Delta G_k \frac{\partial s_k(p)}{\partial p_j}\right], \tag{26}$$

$$= (\lambda - 1)s_j + \lambda \sum_k (p_k - c_k - \Delta G_k)\frac{\partial s_k(p)}{\partial p_j}. \tag{27}$$

Note that a decrease in consumer surplus in response to an increased price ($-s_j(p)$) is offset, up to the cost of transferring public funds, by an increase in profit in the product market ($\lambda s_j(p)$).

The first order conditions can be expressed in a particularly simple formula in vector notation; the set of equations defining the social planner's solution is:

$$(\lambda - 1)s(p) + \lambda\Omega(p)(p - c - \Delta G) = 0, \tag{28}$$

where $\Omega(p)$ is a matrix of partial derivatives such that the element in the i-th row and j-th column is:

$$\Omega_{ij}(p) = \frac{\partial s_j(p)}{\partial p_i}. \tag{29}$$

The solution to Equation 28 is uniquely given by:

$$p^{SocialPlanner} = c + \Delta G + \Omega(p)^{-1}\frac{(1-\lambda)}{\lambda}s(p). \tag{30}$$

Price is set to marginal cost plus an additional term which adjusts for the opportunity cost of government spending across the inside and the outside option. The final term represents the trade-off between lost consumer surplus and additional product market surplus, which is captured by the social planner and recycled into government revenues (if positive). We use this analytic expression for optimal prices to report the benchmark welfare for the social planner's case. Note that this benchmark does not impose a non-negativity constraint on insurers' profits, as we are implicitly assuming that the social planner can force the insurers to set any (even negative) prices.

5 Data and Estimation

5.1 Data and Descriptive Facts

Our primary data set combines a variety of aggregate plan-level statistics released annually by the Centers of Medicare and Medicaid Services (CMS).[9] Table 1 provides basic summary statistics for the subset of Part D plans that we use in our empirical analysis as well as some key enrollment statistics. In 2010, which is the last year of our data, about 47 million individuals in the US were eligible to purchase Medicare Part D coverage. Out of these individuals, 13 million obtained coverage through their employer or through other sources such as Veteran Affairs. Out of the remaining 34 million, about 6 million did not purchase any Part D coverage and about 10 million chose to buy Rx plans bundled with Medicare Advantage. We consider the latter two groups as choosing the outside option. Figure 5 illustrates the fraction of the outside option separately for the regular and LIS-eligible enrollees across each market. The outside option for the regular enrollees lies around 60%, and it is around 80% for the LIS beneficiaries. Recall that in the latter case, we define all randomly assigned LIS beneficiaries as choosing the outside option.

In our empirical analysis we consider only stand-alone-prescription drug plans, which excludes prescription coverage that is bundled with Medicare Advantage health policies. In years 2007-2010, we observe 1,500 to 1,800 stand-alone prescription drug plans in each year.[10] This corresponds to about 50 plans on average per market that individuals are choosing from. As Table 1 demonstrates, the supply-side is more concentrated than the raw counts of plans may suggest. We observe a total of around 50 insurer parent organizations operating in Part D in these years, with on average 17-19 separate organizations competing in each market. Figure 5 further shows that there is large heterogeneity in market shares attained by single plans both within and across markets. While many plans have market share close to zero, some plans cover as many as 20% of eligible beneficiaries within a market.

We see in Table 1 that the average plan premiums for regular enrollees increased quite substantially in the time frame we are considering. The unweighted average premium went up from \$439 per year in 2007 to \$559 in 2010. This growth in premiums was accompanied with increased dispersion in plan premiums and in particular with a higher number of very expensive plans. Panel 2 in Figure 4 demonstrates that plans that offered coverage in the donut hole were consistently more expensive, up to three times more expensive, than plans with only the minimally required coverage. We also see that the dispersion in premiums was

[9]All of the data is publicly available at http://www.cms.gov/Research-Statistics-Data-and-Systems.

[10]These numbers are slightly lower than the official counts of PDP plans available in the program, as we had to drop several plans due to missing observations on some characteristics.

relatively similar across different markets in the 2010 cross-section.

The growth in premiums between 2007 and 2010, however, differed dramatically across regions. The increase in the non-weighted average premium over the four years ranges from 13 percent in New Mexico to 61 percent in the California market. Part of the explanation for the different development of premiums could be the differences in market power exercised by insurers in different markets. Figure 4 documents a stark downward slope between the level of premiums and the number of competing parent organizations in a market, which is consistent with the variation in market power across regions. A different part of the explanation could be the differential effect of policy-design distortions across markets. Using our model of the program developed in Section 4, we will be able to explore the potentially heterogeneous effects of market power and the of uniform subsidy rules across different geographic regions. To summarize the development of subsidy levels, we note in Table 1 that baseline subsidy levels grew slower than consumer premiums. Thus, CMS was paying \$637 a year as a baseline subsidy for an average risk beneficiary in 2007, and this amount went up to \$677 in 2010, which is an increase of 6% as compared to an increase of 10% in insurers' bids and the 27% in unweighted average premiums. The low-income beneficiaries were eligible for an additional subsidy of on average \$388 (in 2010), with the slight variation in this subsidy across geographic markets illustrate in Panel 2 of Figure 4.

5.2 Demand Parameters

We discuss several specifications of demand estimates leading to our preferred baseline. We first consider two sets of estimates without random coefficients for the demand of regular enrollees. The first specification is the logit model estimated using the transformation as in Berry (1994). The linearity of this model allows us to easily test our instrumental variables in a 2SLS version of Berry logit - the instrumental variable results comprise our second set of estimates. Moreover, despite the general limitation of the logit model in producing reasonable substitution patterns, it gives us a simple way to establish that plan characteristics included into the utility specification are able to rationalize individuals' choices to a large extent.

The results of Berry OLS and Berry 2SLS are reported in Table 2. For all demand estimates we use market-level data on all stand-alone prescription drug plans PDPs that were offered in years 2007-2010 and for which the data on pharmacy networks and drugs were available. The latter restriction excludes a very small fraction of plans. We focus on the stand-alone PDP plans only, as prescription drug plans that are part of the Medicare Advantage package are bundled with inpatient and outpatient insurance and thus do not exist as separate Rx insurance products. We exclude the observations from year 2006, which was the first year of the program - in this year, the CMS did not have plan weights to calculate subsidies and all plans were weighted equally, thus changing the regulatory environment on which we focus. We stop our analysis at 2010 for similar reasons.

In the OLS version of the specification, we estimate a negative coefficient on plan premiums and the deductible.[11] We also estimate positive coefficients on the generosity features of the plans. Beneficiaries appear to like plans that offer coverage in the gap, cover more of common drugs and include more pharmacies in their networks. We also note an economically and statistically significant positive coefficient on the vintage of plans, suggesting that plans that entered earlier in the program were able to capture a larger beneficiary pool.

In the second column of Table 2 we report 2SLS estimates of the model without random coefficients. This model address the concern that premiums, which directly depend on the bids submitted by insurers, may be correlated with unobserved quality of plans that we fail to capture with the observed characteristics. While we include a rich set of observed plan features, we may not be fully capturing insurer-plan specific customer service or advertising efforts, as well as issues such as drug prices on the plan's formularies that largely depend on the unobserved bargaining power of the insurers. Some of the variation in the latter features will be insurer-specific rather than plan specific and so will likely be captured by insurer fixed-effects; some of the insurer-market-plan specific quality may still remain correlated with prices. We use four instrumental variables in the estimation. Three of these are common BLP-style instruments, measuring the number of PDP or MA-PD contracts that the same insurer offers in the same or different regions. The second instrument, which we believe is important and particularly suitable for our setting is a version of the Hausman instrument. The Hausman instrument measure prices charged for the "same" plan in other geographic markets.[12] The instrument picks up common cost-shocks for a set of plans offered by the same insurer, which may, for example, have especially favorable discount agreements with some pharmaceutical companies. The idea of the Hausman instrument is very appealing in the current setting due to the regulatory structure of the market, where market are separated by the regulator. Instrumenting the price in one region with the prices of the same contract in other regions, allows us to isolate the variation in prices that is common across these contract due to, e.g., particular agreements of a given insurer with pharmaceutical producers, and is thus not correlated with market-specific unobserved quality due to, for example, local marketing.

Table 4 reports the first stage for the 2SLS estimates. One of the BLP instruments

[11] Note that all non-indicator variables in the specification are scaled by a factor of 1,000.

[12] Specifically, we construct the instrument by including the lagged enrollment-weighted average of prices of plans offered in other regions in the same macro region and in the other macro-regions by the same company, where macro-regions are defined as three large geographic areas in the US.

and the Hausman instrument are strongly correlated with plans' premiums. The Hausman instrument is positively correlated, suggesting that plans that cost more in other regions are likely to be priced higher in a given region, as we would expect if the Hausman instrument is able to pick up common cost components. The first stage is jointly statistically significant with an F-statistic of 246. Instrumenting has a large effect on the price coefficient. The price coefficient increases in absolute value by about five-fold (from -2.741 to -10.44). The estimates of the marginal utilities from other features also adjust, retaining the intuitive signs in the cases where we can estimate the coefficients with enough statistical precision.

While we instrument for plan premiums, we assume that other characteristics of the contracts are exogenous in the short run. We motivate this assumption by observing that insurers appear to offer a very stable portfolio of contract types over time (see Polyakova (2013)). For example, if an insurer offers a contract with some coverage in the gap at the start of the Part D market, this insurers is likely to continue offering a contract with some coverage in the gap. The amount of coverage may change, but the dummy-measure that we are using of whether there is any coverage in the gap does not appear to respond to short-term demand shocks or be related to anything else about the insurer and its plans. Similarly, for the deductible, the insurers tend to either follow the standard deductible set by Medicare every year, or offer zero deductible contracts. We thus consider it appropriate to assume that short-run demand volatility and unobserved characteristics of the plans conditional on insurer fixed effects, such as advertising, primarily generate the endogeneity concerns for premiums, but not for the other features of the plans.

We next proceed to the full BLP model of regular enrollees' demand that introduces unobserved heterogeneity in the individuals' marginal utility of income. The output of the BLP model as specified in Section 4.1 is reported in Columnn (3) of Table 2. The BLP version of the model uses the same set of instruments as Berry Logit IV. We find greater average sensitivity to price in the specification that allows for unobserved heterogeneity (the mean of the log-normally distributed coefficient is estimated at -25.9, but we also find substantial dispersion in the sensitivity to price. The parameters governing the variance of the log-normal distribution are estimated to be $\ln N(3.06, 0.62)$. BLP estimation also produces some adjustments in the magnitude of the coefficients for the other contract features. While all the signs remain the same and intuitive, we now find greater sensitivity to deductible levels, number of covered common drugs and greater impact of plan's vintage.

Finally, Table 3 reports the Berry Logit estimates for the demand of the LIS part of the market. We again report both the OLS and the 2SLS version of the model. We utilize the same instruments as in the estimation of the regular enrolees' demand. The first stage for the LIS market is reported in the second Column of Table 5 and looks very similar across the two markets. To estimate the LIS demand, we shut down the deductible and gap coverage characteristics of plans, as individuals eligible for low-income subsidies received additional support from the government that helps cover these out of pocket expenditures. We also adjusts premiums to reflect the additional premium support for the LIS enrollees. As described in Section 4.1, we have to make several additional assumptions to formulate a meaningful demand system for the LIS market. The key assumption is that all individuals that we observe being enrolled in plans that are eligible for LIS random assignment are considered as choosing the outside option. The results of the OLS and IV specifications for this part of the market are quite similar to the demand of regular enrollees. Individuals prefer plans with more generous formularies and larger pharmacy networks. Plans that have existed on the market for longer time are also more likely to attract beneficiaries. The price coefficient in the OLS specification is almost identical to the one for regular enrollees. In the IV specification, it is slightly lower at -7.6, suggesting lower price sensitivity to prices that, recall, are about $400 lower per year for the LIS enrollees.

5.3 Marginal Cost Estimates

The key step in the supply-side estimation is the recovery of plan-level marginal costs that will enable us to simulate counterfactual prices under different regulatory scenarios of subsidy mechanisms. Unlike the standard differentiated product settings, our environment presents several challenges in way of profit function inversions. First, in general, insurance plans will not have constant marginal costs. Moreover, marginal costs will be a function of premiums and other characteristics of the plans, as these characteristics screen individuals of different expected risks. Second, the presence of subsidies that are determined through the mechanism that averages bids from all plans, potentially implies additional deviations from the standard Bertrand-Nash competition concepts. Finally, the presence of the low income subsidy market with its random assignment of individuals only to qualifying plans implies a discontinuity in the profit function (Decarolis, 2014).

Therefore, in order to proceed with the estimation of marginal costs, we make several important assumptions. First, we assume that the multitude of risk-adjustment and reinsurance mechanisms implemented in Medicare Part D imply that insurers de facto face constant expected marginal costs. Second, given the large number of plans in the country and the small influence of smaller plans on the bid averaging mechanism that is weighted by enrollment, we assume that the mechanism does not distort pricing decisions for smaller plans. Third, and similarly in spirit, we select a subset of plans that were plausibly not distorted by LIS gaming.

In essence, the idea is to select a group of plans for which we find the Bertrand-Nash assumption acceptable for describing the pricing behavior of the insurer. We construct a group of such plans by selecting all contracts of those insurers that within a given market (year-region) were not eligible to enroll randomly assigned LIS individuals into any of their plans. Even if the assumption that this group of plans is "non-manipulating" appears reasonable, we may be still be worried that these plans are not comparable to plans qualifying for low-income enrollees. Empirically, this does not seem to be the case. There has been substantial variation in the low-income subsidy across regions and there are many insurers who never qualified for low-income enrollees in at least one region. This variation is mostly due to the different penetration of Medicare Advantage: where in 2006 enrollment in Medicare C was high, MA-PD received a high weight in the calculation of the low-income subsidy and, since their premium is typically close to zero, they induced a small low-income subsidy (Decarolis, 2014).[13] Consequently, we proceed with the inversion of the first-order conditions for these "non-distorted" plans. Since the plans offered by the same insurer across different regions are remarkably similar, the marginal cost estimates of the "non-distorted" plans through the inversion of the first-order condition, can be used to predict the cost of similar plans in other regions for which we could not directly apply the inversion approach.

In the first step we thus recover the marginal costs for "non-distorted" plans using Equation 13. We do the inversion only for plans offered in 2010, as our counterfactuals will focus on this year only. The right hand side of this expression contains quantities that are either observed in the data, such as prices, or quantities that we recovered from the demand estimation, such as the marginal change in share of a plan in response to a marginal change in price. Plugging these into Equation 13, we estimate the marginal cost for our group of non-manipulating plans, which consists of 756 plans that were offered in 2010.

Using these estimates, we proceed to the next step of relating the estimated marginal costs to the observed characteristics of non-manipulating plans. In practice, we estimate the following hedonic-style linear regression:

$$mc_{jt} = X_{jt}\beta + \delta_t + \gamma_j + \epsilon_{jt}, \tag{31}$$

where X_{jt} includes the same non-premium characteristics of plans that we had included in the utility function. We also add the unobserved quality estimate for each plan as an additional explanatory variable in X. We condition the regression on firm and market fixed effects to account for inherent differences in marginal costs across insurers and geographic regions.

[13] The variation in the total weight assigned to MA-PD in 2006 is substantial ranging from almost 60 percent in Arizona and Nevada to less than 4 percent in Mississippi and Maine.

Table 5 reports the coefficients for the hedonic regression. We note that the most important determinants of marginal costs for the insurance plans are, as expected, the plans' coverage limits, as well as the generosity of its drug formularies. For example, we estimate that offering coverage in the gap increases a plan's marginal cost by \$405 a year, which is a large increase relative to the average marginal cost estimate of about $\$1,000$ from the inversion procedure. This estimate of the additional marginal cost from coverage in the gap also roughly corresponds to the premium add-ons that are charged by insurers that offer coverage in the gap.

We use the estimates of how plan characteristics translate into marginal costs to predict marginal costs for all plans that we did not include in the inversion procedure. This exercise hinges on the assumption that all plans have a similar "production function." In other words, we assume that the plans that manipulate the LIS threshold manipulate the premiums, but do not have different marginal costs conditional on a set of non-price characteristics. This appears reasonable, as the main source of costs in the insurance market is determined by individual risk spending; therefore, it is conceivable to assume that plans with the same financial characteristics and formulary generosity will have similar marginal costs.

Figure 6 plots the distribution of predicted marginal costs and compares it to the estimated distribution via the inversion procedure. We estimate substantial heterogeneity in the marginal costs across plans. We are able to capture this heterogeneity both through the inversion procedure and in the hedonic projection exercise. This is important, as it indicates that our hedonic-style regression captures the key drivers for the differences in marginal costs. Across the two sets of marginal costs calculations, the distributions appear remarkably similar. The manipulating plans are estimated to have slightly lower marginal costs on average, which is intuitive if we believe that cheaper plans are the ones that would try to compete for LIS enrollment.

5.4 Welfare Estimates

Using the demand and supply estimates, we compute consumer surplus, producer profits, government transfers, and total surplus for the observed market allocation, using the welfare function in Equation 19. We restrict our calculations to regular enrollees that are not eligible for the low-income subsidy. The calculations are reported in the first column of Table 6.

We estimate that at the observed consumer premiums, the total annual consumer surplus is about \$4 billion. This consumer surplus is estimated relative to the outside option, as the utility model is inherently ordinal. By construction, it reflects the surplus for those regular beneficiaries that enrolled in PDP plans and also for those non LIS-eligible beneficiaries that chose the outside option of MA-PD or no Part D coverage. Insurer profit that we estimate without the multitude of re-insurance transfers from the government, is estimated to be around 0.6 billion USD.

On the cost side, we calculate that the government spends about $6 billion on premium subsidies for regular enrollees - equal to about $680 a year for each individual. Moreover, using CMS data on average non-premium level of subsidies, we calculate that the total amount of this subsidy is on the order of $3.5 billion. To take into account that the government would still have to pay subsidies if individuals were to leave PDP and switch to MA-PD, we also estimate how much the government would have spent on the same individuals were they to enroll in MA-PD.[14] The difference between the total PDP subsidies and what these would have been in MAPD, allows us to calculate the "net" government spending on PDPs, which is the value we need to calculate total surplus as outlined in Equation 19.

Multiplying the net government subsidy by 1.3 to account for a 30 cents a dollar cost of public funds, and subtracting it from consumer and producer surplus, we arrive at the total surplus calculation for the regular Part D PDP market to be about $3 billion. In relative terms, we estimate that a dollar of public funds generates only 33 cents of surplus per dollar directly spent in the PDP program if we do not take into account the government's opportunity cost of paying MA-PD subsidies. If we do take the government's payments for the outside option into account, we arrive at a more positive calculation of 222 cents per opportunity-cost-dollar spent by the government.

In the next section of the paper, we will conduct several simulations of counterfactual market structure and regulatory regimes. We will evaluate these counterfactuals using the same approach as we just outlined for calculating welfare in the non-counterfactual data. Since evaluating welfare in the counterfactual settings will require several additional assumptions, we outline additional details of how we calculate each piece of the welfare function in what follows.

The amount of consumer surplus is calculated as the sum across markets of average consumer surplus in each market multiplied by the market size of each market. Note that the consumer surplus amount reported relies solely on the demand model for regular enrollees and does not depend on any assumptions or specification of the supply side. To estimate insurer profits from regular enrollees in the counterfactuals we take the difference in estimated marginal cost and counterfactual per capita revenue for each plan, [15] and multiply it by the

[14]We utilize public data realized annually by CMS on the average levels of subsidies for different Part D plans to calculate these estimates.

[15]Specifically, we let the per capita revenue from regular enrollees be equal to the bid of the plan as simulated in the counterfactual plus the enhanced component of the premium as observed in the data if the plan is enhanced. We thus assume that the enhanced component of the premium does not change across

counterfactual share of each plan in each market scaled by the market size of the regular enrollees' market.[16]

Throughout the counterfactuals, we rely on several data points to account for government spending on regular enrollees. In each counterfactual, we calculate government spending on premium subsidy on stand-alone prescription drug plans as the sum of per capita simulated subsidies multiplied by counterfactual enrollment predicted by the demand model. We assume that average non-premium subsidy for each plan does not change across counterfactuals. Thus, the total non-premium subsidies only change across counterfactuals due to enrollment changes. We use CMS annual reporting on average reinsurance payment for each Part D plan as the data point for the non-premium subsidy.[17] In 2010, for example, the unweighted mean per capita reinsurance payment among PDP plans was \$503 per plan with a standard deviation of \$297. In addition to calculating the premium and non-premium subsidies on stand-alone prescription drug plans, we also estimate the government's opportunity cost of having individuals enroll in PDP plans. We assume that if individuals switch from the inside option of PDP plans to the outside option, they are likely to switch to the MA-PD program rather than leave drug insurance altogether. Thus, the government is still likely to incur subsidy spending for these individuals through the MA-PD program.

To account for the MA-PD spending, we use CMS data to calculate average observed level of government spending on premium and non-premium (re-insurance) subsidies in the MA-PD program. We observe that the average per capita premium subsidy in the MA-PD program is \$ 686, while the average non-premium subsidy is \$260. This amounts to a total of \$946 government spending per capita on individuals enrolled in the MA-PD program. We use this average spending together with enrollment predictions for inside and outside option in each counterfactual to calculate the total opportunity cost for the government of having individuals enroll in PDP rather than MA-PD program. It is crucial to emphasize that we assume this number does not change across our counterfactuals, as we are focusing on the mechanisms of determining subsidy levels within the PDP part of the program. This implies that while at the PDP subsidy levels observed in the data, the per capita government spending is higher on the PDP plans rather than MA-PD plans, this relationship can reverse in counterfactuals where we increase the PDP premium subsidy.

We further report the measures of total surplus per dollar spent. The latter calculation

counterfactual mechanisms and does not enter bidding

[16]Relative to the profit function formulation in Equation 9 we are not explicitly calculating the effects of risk-corridors that may alter profits at the end of the fiscal year. We are further not explicitly calculating the selection component of the profit function $H(\phi)$.

[17]For raw CMS data see http://www.cms.gov/Medicare/Medicare-Advantage/Plan-Payment/Plan-Payment-Data.html.

takes two forms in order to emphasize the role of government opportunity cost for our conclusions. We first report the total surplus per dollar spent within the PDP program, without taking into account the potential government expenditures in case beneficiaries were to switch to the outside option. We then report the total surplus per "opportunity-cost-dollar", which takes into account only the extra government spending on PDPs relative to the outside option of subsidizing MA-PD.

6 Simulation Results

6.1 Market Forces under the Current Regulatory Regime

Dependence of regular PDP premiums on other parts of the program We start by calculating prices and allocations that our model would predict for the currently used subsidy mechanism for regular enrollees in PDP plans if we removed the interconnections with other parts of the market. We proceed in two steps. First, we remove only the LIS pricing incentive, but keep fixed the presence of MA-PD bids in the weighted average that CMS uses as a baseline for the subsidy calculation:[18] In other words, we set prices to be:

$$p_{jt} = b_{jt} - 0.68 * (Average(b_{PDP}, b_{MAPD})). \tag{32}$$

In the next counterfactual, we remove the presence of MA-PD bids in the weighted average:

$$p_{jt} = b_{jt} - 0.68 * (Average(b_{PDP})). \tag{33}$$

The results of these two counterfactuals, reported in Columns (2) and (3) of Table 6 allow us to assess the impact of the LIS and MA-PD distortions on PDP prices for regular beneficiaries. Moreover, the second counterfactual generates a benchmark to which we can compare other subsidy mechanisms, keeping the LIS random assignment and MA-PD bids separate across different counterfactual subsidy mechanisms for regular beneficiaries.

Relative to the allocation observed in the data, removing the LIS pricing incentives from the mechanism results in slightly lower enrollment-weighted average premiums ($436 vs $502 in the data), but also higher consumer surplus. Removing LIS incentives of submitting lower

[18] In practice, we do not observe and cannot deduct MA-PD bids directly, as MA-PD premiums contain not only subsidies whose levels are known, but also unobserved Medicare Advantage - specific additional possibilities to further reduce premiums (Part C rebates). Thus, we back out the contributions of MA-PD to bid average by calculating averages that would have resulted from PDP bids only and the CMS data on realized bids.

bids, lead to slightly higher average bid and on net higher subsidies for regular enrollees. Therefore, even though consumer surplus increases once we detach the LIS part of the market, insurer profits and government expenditures also go up, resulting in a lower total surplus of $2.7 billion. Next, we also remove the MA-PD portion of the average bid that is currently used by CMS to calculate subsidies. As the MA-PD bids are quite low and thus typically drive down the average bid, removing their bids increases the average bid both mechanically and due to PDPs' strategic response. Consequently the subsidy, which is set at 68% of the average bid also increases. In net, removing MA-PD part of the mechanism results in lower premiums for regular enrollees, with the average premium going down to $ 423. The change in premiums increases enrollment by 13 percentage points to 51%. Higher subsidies, however, also imply higher government spending, and thus the net result on total surplus is just slightly negative relative to the counterfactual with MA-PD but without LIS. Given the increase in government spending, the per dollar ratios go down to about 20 cents on a dollar and 81 cents on an opportunity cost dollar.

We use the results of the current mechanism's simulation without LIS and MA-PD pricing incentives as a benchmark for other counterfactuals.

Market power Before proceeding to counterfactuals that change subsidy mechanisms, we first evaluate the market power in the stand-alone prescription drug plans part of the Part D program. For that, we simulate the allocations that would result under the current CMS mechanism without LIS market and MA-PD pricing link if we changed the ownership structure on the supply side. The results of these counterfactuals are reported in Table 7. To assess the competitiveness of the market, we perform two counterfactuals where we change the ownership structure. In the first, we assume that each plan is its own firm; in the second, we assume that every plan in each market belongs to one firm. Compared to the baseline counterfactual, we find the expected pattern that profits increase greatly and consumer surplus declines under the monopolistic regime (consumer surplus goes down to $3.4 billion and profits go up to $2.3 billion) , with the opposite pattern under atomistic competition (consumer surplus at $5 billion and insurer profits at $1 billion). Interestingly, total surplus declines in both situations. Under a monopoly, the loss is driven by decline in product market surplus, dominating the increase in producer profits. Under atomistic competition, the changes are less dramatic, but still result in negative welfare as the marginal benefits of serving additional consumers are exceeded by the social costs of providing the goods.

6.2 Social Planner's Solution

In addition to calculating the welfare effects of changing the current subsidy mechanism, we estimate several second-best optimal mechanisms. We start with a mechanism that imposes the private marginal cost of the insurance plans as consumer premium. In this mechanism, the government keeps subsidizing the non-premium part of insurers' expenditures, but does not provide premium subsidies in the PDP part of the market. We then completely remove government subsidies in PDP, forcing individuals to pay the full social marginal cost of the stand-alone prescription drug insurance. In this case, the premiums are set to equal the plans' marginal costs together with the amount of government's re-insurance subsidy. Finally, we calculate insurance premiums and corresponding surplus levels that maximize the social welfare function.

Marginal Cost and Social Marginal Cost Pricing We start by setting the premiums to equal the estimated marginal costs for each insurance plan. The results are reported in Table 8.

$$p_{jt} = MC_{jt}. \tag{34}$$

Facing premiums as high as marginal costs, consumers leave the PDP program in favor of the outside option with enrollment dropping to 10%. The level of total surplus is nevertheless high, since only consumers with the highest willingness to pay enroll in the program, while the government is paying relatively little as it provides only non-premium subsidies. We expand the counterfactual above to let the consumers face the full social marginal cost rather than only the marginal cost of insurers estimated subject to the existing non-premium government subsidies. To calculate the premiums, we add average observed re-insurance subsidies (RIS_{jt}) for each plan to the estimated marginal costs.

$$p_{jt} = MC_{jt} + RIS_{jt}, \tag{35}$$

The outcome is similar, albeit starker, than in the counterfactual where premiums included only the estimated private marginal cost. In this case, enrollment and total surplus fall even more, with only about 5% of the market choosing the inside option of PDP plans.

Finally, we consider the social planner's problem. As expected, the social planner's problem generates the highest total surplus of 5.3 billion USD. This surplus comes at the cost of large subsidies. We calculate that the optimal prices in PDP plans are on average lower than in the benchmark case, at \$373. In addition to premium "subsidies", the government carries the full cost of the program, including the coverage of insurer "losses" at 10 billion

USD. As the algebraic expression for social planer's prices in Equation 28 suggests, the social planner sets prices for each plans as a function of this plan's social marginal cost and a fiscal adjustment term. The latter takes into account how much the enrollment in a given plan would cost the government. The social planner's solution demonstrates the idea that at flat subsidy rates that are unrelated to the efficiency of individual plans, subsidies distort the allocation of individuals across plans within a given market. Figure 7 demonstrates this point graphically on the example of California's market in 2010. Relative to observed prices, the social planner's solution is to increase premiums in plans with higher social marginal costs. This results in re-allocation of individuals across plans - market shares of plans with lower social marginal cost increase, while the market shares of plans with higher social marginal costs decrease. Note, however, that the effects are not monotonic. For example, for some plans with coverage in the gap, which have high social marginal cost, the prices increase substantially, but the market share almost doesn't change, as there is still enough willingness to pay for at least some plans with generous coverage in the market.

6.3 Simulation of Counterfactual Regulatory Environments in a Decentralized Market

In the next set of counterfactuals we consider deviations from the current subsidy-setting mechanism. The goal of these counterfactuals is to explore what happens if we keep the ownership structure on the market fixed and assume that the government cannot dictate prices directly, but can provide subsidies. We ask whether simple deviations in the subsidy mechanism form the averaging rule currently used to flat or proportional subsidies could get the market closer to the social planner's levels of surplus.

We start with a flat voucher mechanism. In this counterfactual we experiment with several different levels of vouchers that are applied to insurers' bids. We assume that insurers and consumers know the levels of the flat subsidy in advance and adjust their behavior accordingly. In calculating the new equilibrium bids, we check corner solutions, where the insurers may decide to bid exactly at the subsidy level. The premiums are set to equal to:

$$p_{jt} = b_{jt} - F. \tag{36}$$

In Table 9, we report results for three flat subsidy levels: \$ 676 a year, which is effectively the level of premium subsidies observed in the data, a somewhat higher \$ 721 per year and then twice of that for $F = \$1340$ a year.

In interpreting the first of these counterfactuals, it is important to emphasize that even though the subsidy level is nominally the same, the mechanism and insurer incentives are very different. While in the observed mechanism, the subsidy is determined after the bidding process as a fraction of the average bid, here we set the subsidy ex ante and it does not depend on the submitted bids. We find that the mechanism matters, as consumer surplus, producer surplus and allocations change relative to our benchmark. First, we find that prices that consumers face increase by about $ 100. This leads to a drop in enrollment to 35% and accompanying decrease in total consumer surplus. Government spending patterns, however, change starkly in response to decreased enrollment and thus eventually, the total surplus generated in the program is higher under the ex ante set voucher than in the benchmark case ($3.3 billion vs. $2.5 billion in the benchmark). Importantly, although the level of surplus slightly decreases, the efficiency per dollar, and especially per opportunity-cost dollar spend jumps dramatically, from 81 cents per opportunity-cost dollar to 241 cents. Increasing the voucher slightly to 721 USD leads to broadly similar results.

A more extreme counterfactual is reported in column (3) of Table 9, where we increase the flat subsidy to 1,340 USD a year, which is double of the observed levels. This increase is sufficient to push the enrollment into the PDP part of the program to 100%. In other words, with this level of subsidy, PDP plans are substantially more attractive than any outside option. This is not surprising, as the average premium with this level of subsidy drops to about $34 a year. The insures utilize the increase in subsidy and thus consumers' sensitivity to prices and increase their bids, but not dramatically, as the consumers still face higher prices for more expensive plans. Consumer surplus increases almost three-fold to more than 13 billion USD. Producer profit increases substantially as well. At the same time, government spending increases much more dramatically, driving the welfare levels down to *negative* $6.3 billion compared to the benchmark level of positive $2.5 billion.

We repeat the calculation of total welfare at a range of vouchers from $0 to $1400, in order to identify the optimal uniform voucher. The first Panel in Figure 8 summarizes the outcome of these calculations graphically. We find that the total welfare is the highest at the subsidy of $600. Setting higher vouchers significantly reduces welfare. So do lower vouchers, but the welfare gradient and thus the cost of deviation from the optimum is lower. Thus, setting the PDP voucher at zero, or in other words, not subsidizing at all, still leads to total welfare of $2.7 billion. This is $900 million less in total surplus than at the optimal voucher. Setting the voucher at $600 above the optimum, on the other hand, results in the welfare *loss* of about -$4 billion.

In looking at welfare outcomes at different voucher levels, we held constant the assumption that subsidy levels are the same in each market across the country. At the same time, we document substantial heterogeneity in demand, supply, and prices across 34 geographic markets. Thus, the next dimension of regulatory intervention we explore is allowing the government to set geographically differentiated subsidies across regions. We focus on the flat voucher mechanism, as regionally differentiated vouchers would be the simplest policy change to implement. To implement this counterfactual, we compute welfare at different levels of possible vouchers (form $0 to $1400 at $100 steps) within each region and then for each market, select the voucher that results in the highest welfare within that region. The results of this exercise are reported in Panel 2 of Figure 8 and Table 10. We find that in 19 out of 34 markets, it is optimal to set the same voucher subsidy that would have been the uniform optimum - at $600. In other regions, however, it would be welfare-maximizing to deviate from this subsidy. We find that in two markets, it would be optimal to offer higher subsidies of $700 and $800, while in the remaining markets it would be welfare-increase to lower subsidies by $100-$200. Figure 8 illustrates welfare gains per market that could be achieved through these adjustments to vouchers. Table 10 reports that the total welfare gain relative to the uniform optimal voucher would amount to about $35 million, which is not a large change. Changes in government spending are more pronounced, however, saving around $800 million in subsidy outlays.

The next set of counterfactuals, reported in Table 11 set subsidies to directly be a fraction of individual bids submitted by insurers. Proportional subsidies have two effects relative to the observed mechanism. First, there is a price level effect, by which, for example, a very generous subsidy would decrease the overall level of prices. Second, there is a significant change in relative prices that makes the more generous plans relatively more attractive. These counterfactuals illustrate a strong impact of subsidy structure on insurer behavior. In cases where consumers do not face 100% of the extra premium in more expensive plans, competitive forces are significantly muted and the insurers pass through substantially higher expenditures to the (by construction) inelastic federal budget.

We report the results of three proportional subsidy mechanisms in Table 11. We set the premium to be equal to 5%, 32% , or 95% of the bids:

$$p_{jt} = x * b_{jt}. \tag{37}$$

The idea of the 5% counterfactual is to test how insurers would respond if the government almost entirely bore consumer premiums. This counterfactual removes most of consumer price sensitivity, as the government is not price sensitive in the model and consumers bear only 5% of the premiums. This counterfactual has the intuitive effect according to which the insurers dramatically increase their bids. We estimate an increase in bids on he order of 200%. Consequently, even though the individuals now pay only 5% of the bids, the premiums are still relatively high - at 132 USD a year on average. This drop in premiums, however, is sufficient to increase enrollment to 99% in the PDP plans from 51% in baseline. Consumer surplus increases to 13 billion. The change in insurers' profits is, as expected, very large. Given the dramatic increase in bids, government spending increases dramatically. The result is a stark drop in welfare levels to negative 26 billion USD. The per-dollar efficiency measures are small and negative. In this counterfactual, we essentially generate a large transfer from the taxpayers to the insurers with a less than one-to-one pass-through to consumers.

In a counterfactual where we decrease the premium subsidies to be only 5% of the price, we observe that prices are about three-fold of the baseline level. At this level of prices, very few individuals (8%) are willing to purchase PDP plans and switch to the outside option. Despite the drop in enrollment, the program generates almost the same amount of total surplus as in the benchmark and a very high surplus per dollar spent if we do not take into account government' spending on the outside option. Such high per dollar surplus is not surprising, as the government is now paying little and only the beneficiaries with the highest willingness to pay participate in the program.

7 Conclusion

In this paper we have analyzed the welfare effects of supply-side regulations, and in particular subsidy mechanisms, in Medicare Part D. We draw several conclusions. First, we find that the current program as it is, for the market of regular enrollees in stand-alone prescription drug plans, generates less than one dollar value for one dollar of government spending. In levels, we find that the stand-alone prescription drug insurance plans generate around $4 billion of consumer surplus and $529 million in insurers' economic profits for enrollees without low income subsidies. While these appear substantial, the government nominally spends about $9 billion to generate these returns for consumers and insurers. Taking into account the fact that the government would have likely subsidized the outside option for the currently enrolled beneficiaries and thus considering only the net extra spending on stand-alone prescription drug plans, the PDP part of the program generates $3.12 billion of surplus, or 2.22 dollars of surplus per opportunity cost dollar spent.

Further, we find that the current structure of the program, where prices for distinct parts of the program, such as Medicare Advantage Prescription Drug coverage, Low Income Subsidies, and market premiums for regular beneficiaries, are tied together into one mechanism decreases the efficiency of allocations in a large part of the market for regular enrollees in stand-alone prescription drug plans. To be specific, we find that removing the tie to Medicare Advantage PD plans and separating the low-income subsidy pricing incentives from stand-alone prescription drug market would increase consumer surplus in the regular PDP market by $500 million, but would result in a total welfare decrease of $600 million USD due to the cost of providing the subsidized plans.

Finally, we find that the efficiency of the Part D PDP market for regular enrollees could be increased even further by changing the mechanism through which the government determines subsidy levels for regular enrollees. The simplest mechanism of providing flat vouchers that are optimally chosen set ex ante could increase the total surplus in levels and relative to federal dollars spent. In addition, this mechanism could dramatically reduce the cost of administering the program, an effect that we do not include in our calculations.

While our institutional setting focused on the Medicare Part D program, our findings have broader implications for market design of privately provided and publicly subsidized social insurance programs. The motivation of subsidizing these programs is typically redistribution—the government attempts to ensure the affordability of insurance. Inevitably, such subsidy policies will have efficiency costs for the market. One source of such inefficiencies is market power. Subsidies create incentives for imperfectly competitive insurers for raise markups and pass them through to the price inelastic government. For example, in some counterfactual exercises we have demonstrated that the higher is the subsidy, the higher is the incentive for the insurers to increase their bids in the Medicare Part D program. We show in this paper, however, that conditional on the decision to subsidize social insurance programs, there are large welfare differences across specific mechanisms that are feasibly at the policy maker's disposal. Depending on whether the policy is guided by the considerations of consumer surplus, or total welfare, or government spending, different policies deliver drastically different results across these three measures of surplus. Overall, we argue that contrary to the focus of the literature on consumer choices in social insurance markets, the much less studied supply-side behavior in the presence of regulatory intervention plays the key role in determining the efficiency outcomes of social insurance programs.

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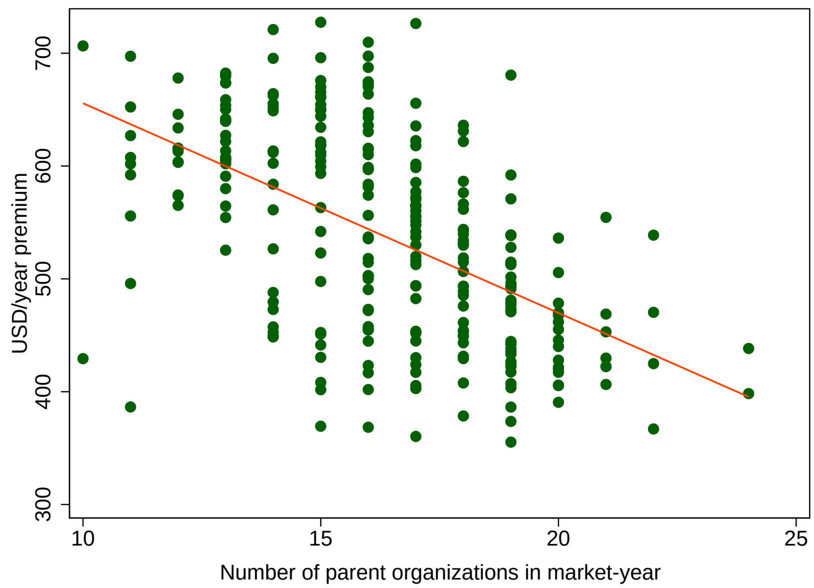
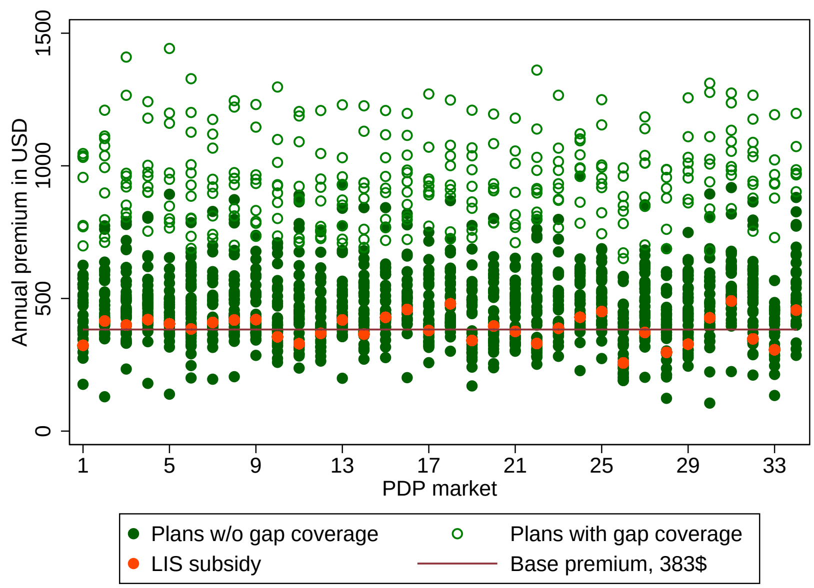
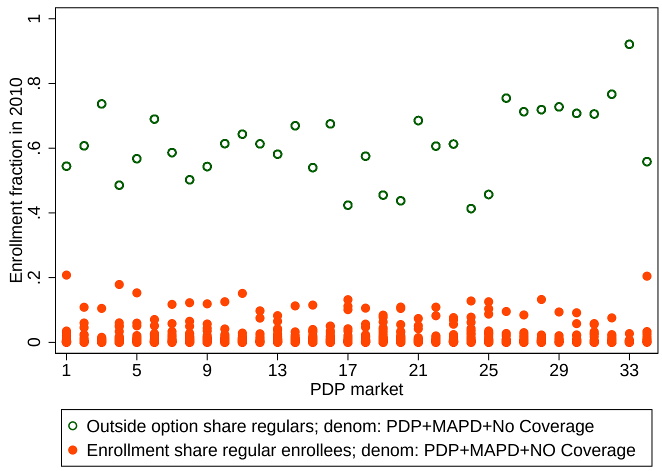
Figure 4: Contract prices and market structure

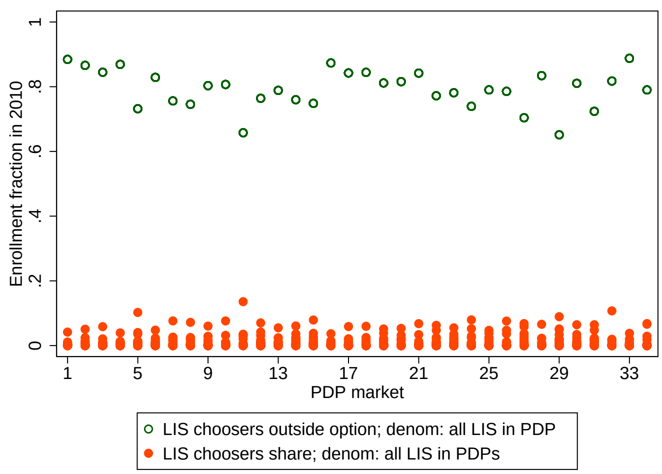




Panel 1. Data shows a negative correlation between the number of competing insurers and average premiums in the market. The premiums are not enrollment-weighted. The data includes years 2006-2010. Panel 2. The data for 2010 only depicts the cross-sectional variation in premiums, the levels of low income subsidies and "base premiums". Base premiums are based on a regulatory bidding mechanism that includes typically very low MA-PD bids. Plans with premiums below LIPSA are eligible for the random assignment of LIS beneficiaries.

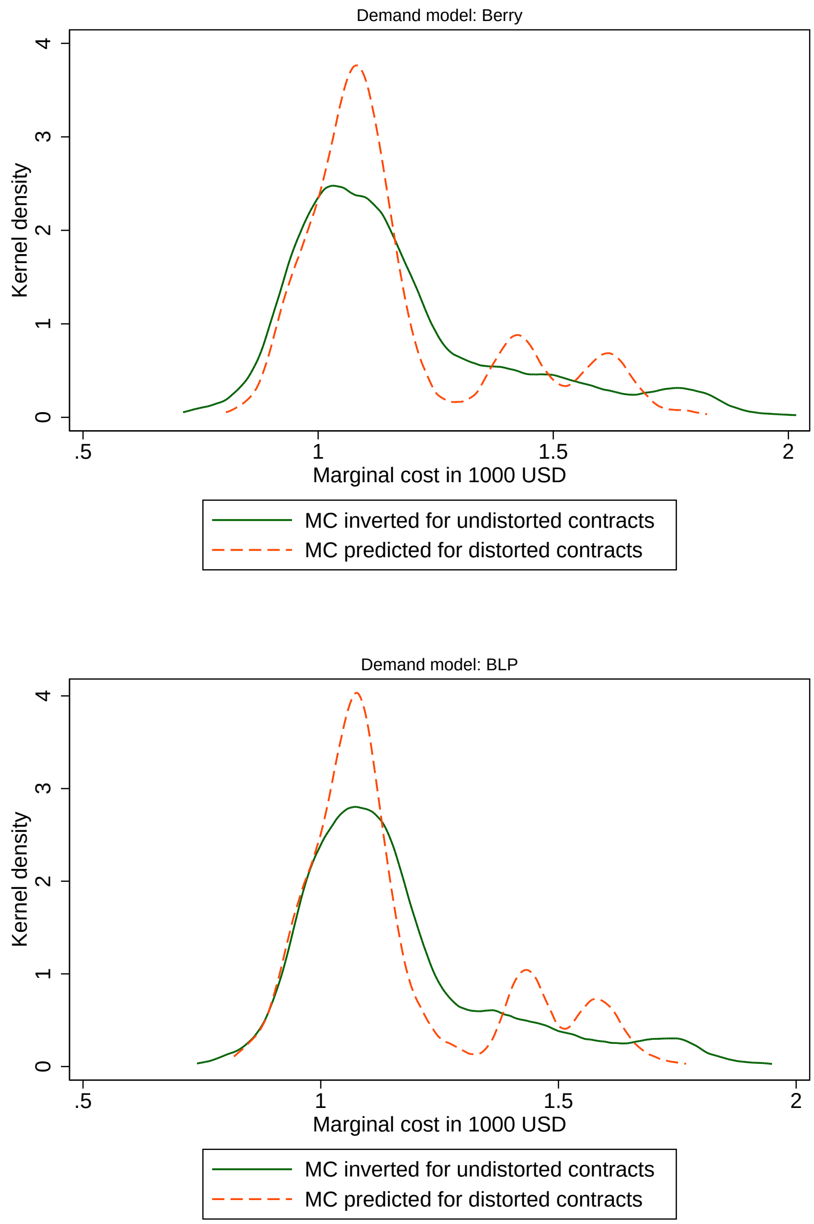
Figure 5: Cross-sectional variation in market shares of plans and of the outside option for regular and LIS (chooser) enrollees, 2010





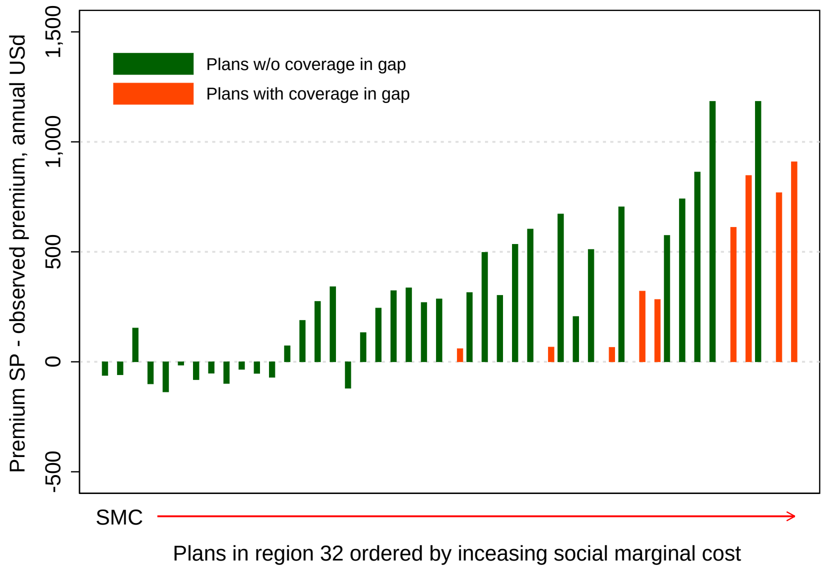
The distribution of market shares of the outside and inside options across 34 Medicare Part D regions, separately for regular and LIS-eligible enrollees. According to CMS, in 2010, almost 47 million individuals in the US were eligible for Medicare Part D coverage. This includes beneficiaries of all incomes that were eligible both due to old age and disability (9 million). CMS estimates that out of 47, about 42 million had a coverage that satisfied minimum requirements. Out of the 42 million with creditable coverage, 18 million were enrolled in stand-alone PDPs, 10 million were enrolled in MA-PDs, about 6 million through their employer and about 8 million had other coverage, such as federal employee or military insurance. In the current graphs, we restrict the definition of the market to include PDP options, MA-PDs and no coverage choices. The latter two comprise the outside option. We exclude employer-based plans and other sources of coverage. We include both individuals that are eligible for Medicare because of old age and disability.

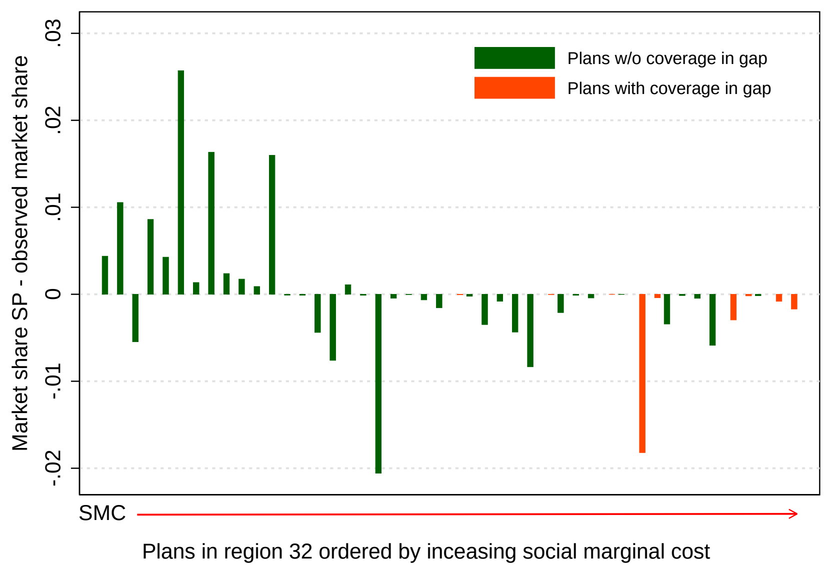
Figure 6: Marginal cost estimates



Marginal cost estimates from inversion (for undistorted contracts) and from hedonic projection (for distorted contracts). Plan characteristics used in the hedonic projection include deductible, coverage in the gap and enhanced plan indicators, measures of formulary generosity, pharmacy networks, vintage, as well as estimated unobserved plan quality, and region and insurer fixed effects.

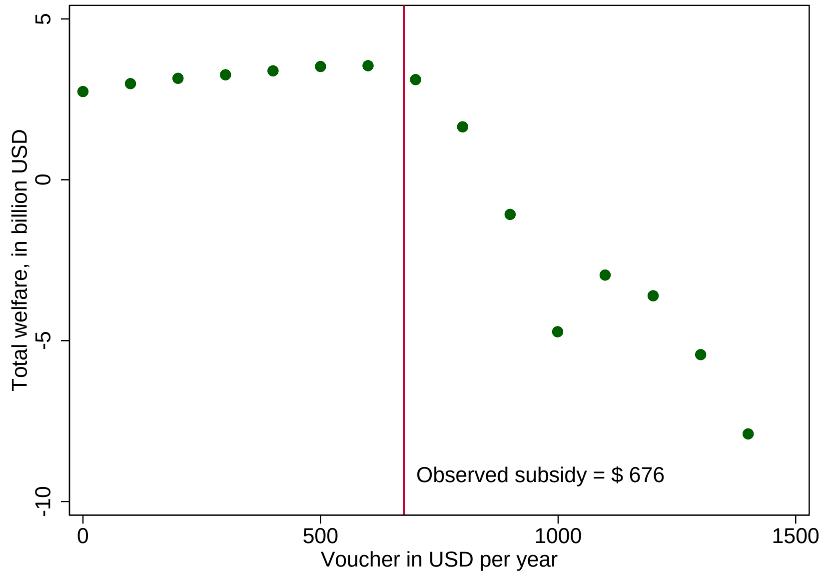
Figure 7: Social planner solution: reallocation across contracts within the inside option

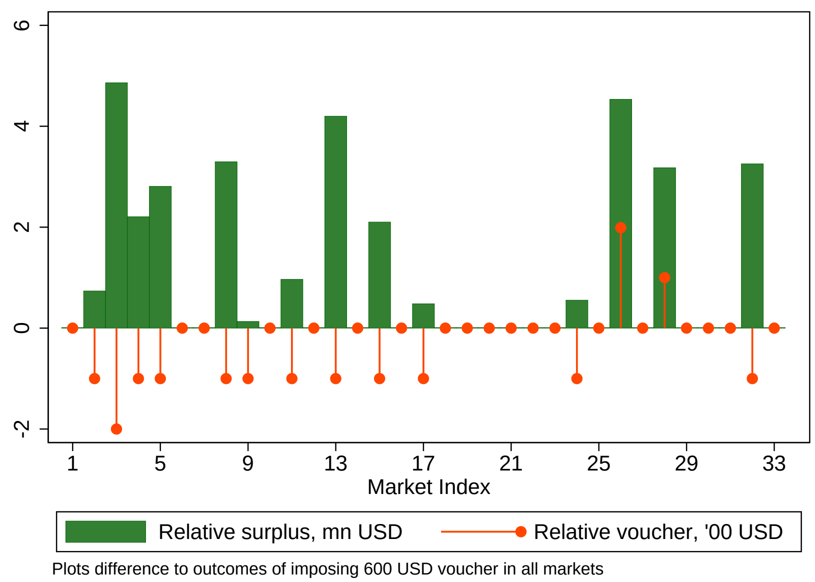




Example market: California in 2010. Panel 1. Plots the difference between premiums set by social planner and observed premiums. Panel 2. Plots the difference between shares in the social planner counterfactual and observed shares. Note that the social planner increases prices in contracts with higher social marginal cost, which shifts enrollment out of these contracts to plans with lower social marginal cost.

Figure 8: Welfare with flat subsidies: uniform and market-specific optimal vouchers





Panel 1. Plots estimated total welfare in full equilibrium counterfactuals at different levels of voucher-like subsidies. Panel 2. From Panel 1 it follows that optimal uniform voucher lies at $ 600. In Panel 2 we calculate optimal vouchers for each market and plot the difference between the market-specific optimal voucher and optimal uniform voucher. We also record the extra welfare that would be gained in each region by implementing the market-specific optimal voucher rather than the uniform voucher.

Table 1: Summary Statistics

Year	2007	2008	2009	2010
Plans				
Total number of PDP plans	1,742	1,791	1,674	1,565
Average number of PDP plans per market	51	53	49	46
Firms				
Total number of PDP parent organizations	56	56	50	50
Average number of PDP parent organizations per market	19	19	17	17
Premiums				
Unweighted average annual PDP consumer premium	$439	$477	$545	$559
Subsidies				
CMS national average bid (annual)	$965	$966	$1,012	$1,060
CMS base consumer premium (annual)	$328	$335	$364	$383
CMS subsidy for average risk beneficiary	$637	$631	$648	$677
Low income (LIS) benchmark threshold	$341	$333	$353	$388
Enrollment				
All Part D Eligible (in millions)	43.3	44.4	45.5	46.6
PDP enrollment, non LIS (in millions)	8.3	8.6	8.9	9.4
PDP enrollment, LIS (in millions)	8.2	8.2	8.2	8.4
Total MAPD enrollment (in millions)	7.5	8.6	9.4	9.8
Employer sponsored coverage RDS (in millions)	7.0	6.6	6.5	6.7
Other coverage sources (in millions)	5.7	5.9	6.0	6.1
No creditable coverage (in millions)	6.6	6.5	6.4	6.2

Table 2: Parameter Estimates for the Demand System of Regular Enrollees

	(1) OLS Logit	(2) IV Logit	(3) Random Coefficients
Annual consumer premium in USD	-2.741***	-10.44***	$\alpha = 3.06^{***}$ (0.58)
	(0.146)	(1.090)	$\sigma_\alpha = 0.62$ (0.57)
			mean = -25.9
Annual deductible in USD	-3.253***	-6.721***	-8.125***
	(0.206)	(0.556)	(1.819)
Has coverage in the gap (1/0)	0.182**	2.928***	2.735*
	(0.0651)	(0.402)	(1.093)
No. of top drugs covered	0.238	31.58***	25.785*
	(4.356)	(7.298)	(13.131)
Pharmacy network measure	0.308***	0.289***	0.347***
	(0.0426)	(0.0614)	(0.031)
Number of years the plan is on the market	606.2***	880.2***	950.6***
	(24.34)	(45.26)	(128.7)
Observations	6675	6675	6675

Standard errors in parentheses. All non-indicator variables in 1,000s. Includes firm, market, and year fixed effects.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The table compares the point estimates of the OLS Logit demand specification, Logit with instrumental variables, as well as the demand specification with random coefficients. Each estimation uses data on Medicare Part D stand-alone prescription drug plans in years 2007 to 2010. In addition to the displayed coefficients and fixed effects, all models also include a constant and the following plan characteristics: a dummy for an enhanced plan; number of APIs in formulary; number of drugs placed in Tiers 1-2 of the formulary (i.e. having low cost-sharing). Berry IV and Random Coefficients specifications use a collection of traditional BLP-style and Hausman-style instruments, see the text for more details. Computed mean is reported for the distribution of the price parameter in the random coefficients specification. The mean is computed as $exp(\mu + \frac{1}{2}\sigma^2)$, where μ is estimated at 3.06 and σ is estimated to be 0.62.

Table 3: Comparison of Demand Estimates for Regular and LIS-eligible Enrollees

	(1) Regular OLS	(2) Regular IV	(3) LIS OLS	(4) LIS IV
Annual consumer premium in USD	-2.741***	-10.44***	-2.075***	-7.577***
	(0.146)	(1.090)	(0.0906)	(1.266)
Annual deductible in USD	-3.253***	-6.721***	0	0
	(0.206)	(0.556)	(.)	(.)
Has coverage in the gap (1/0)	0.182**	2.928***	0	0
	(0.0651)	(0.402)	(.)	(.)
No. of top drugs covered	0.238	31.58***	-3.048	10.63
	(4.356)	(7.298)	(4.620)	(7.151)
Pharmacy network measure	0.308***	0.289***	0.227***	0.220**
	(0.0426)	(0.0614)	(0.0492)	(0.0830)
Number of years the plan is on the market	606.2***	880.2***	775.4***	875.5***
	(24.34)	(45.26)	(28.75)	(39.29)
Observations	6675	6675	4561	4561

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The table shows four sets of demand estimates. Each estimation uses data on Medicare Part D stand-alone prescription drug plans in years 2007 to 2010. In addition to the displayed coefficients and fixed effects, all regressions also include a constant and the following plan characteristics: a dummy for an enhanced plan; number of APIs in formulary; number of drugs placed in Tiers 1-2 of the formulary (i.e. having low cost-sharing). 2SLS specifications of the Berry Logit use a collection of traditional BLP-style and Hausman-style instruments, see the text for more details. The first two columns report the output of the demand regression for regular beneficiaries only. The last two columns estimate PDP demand for the LIS market. In the latter regressions, we assume that LIS choosers and randomly assigned LIS beneficiaries choose the "outside option" if they are enrolled in plans that are eligible for LIS random assignment.

Table 4: First stage - BLP and Hausman instruments for plan premiums

	(1) Regular FS	(2) LIS FS
No. of PDP plans in a region-year by same PO	-9.631***	-3.318
	(2.375)	(4.352)
No. of MA plans in a region-year by same PO	-0.184	0.0285
	(0.242)	(0.474)
Deductible of MA plans in the same region-year	-0.147	0.0294
	(0.173)	(0.344)
Hausman IV	0.371***	0.275***
	(0.0326)	(0.0551)
Observations	6675	4561

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The table reports the first stage for a collection of variables that are used as instruments for premiums. Each regression uses data on Medicare Part D stand-alone prescription drug plans in years 2007 to 2010. The first column reports the first stage for the regular premiums, while the second column reports the first stage for low-income-subsidy adjusted premiums. See the text for more details on the construction of the instruments. PO stands for Parent Organization. MA stands for Medicare Advantage. The regressions also include all plan characteristics that are used in demand estimation, including a constant, fixed effects for geographic markets, parent organizations, and years.

Table 5: Marginal cost projection

	(1) Berry logit MC inversion	(2) BLP MC inversion
Annual deductible	-0.365***	-0.322***
	(0.0440)	(0.0419)
No. of common APIs	0.142	0.196
	(0.130)	(0.124)
Has coverage in the gap (1/0)	0.422***	0.405***
	(0.0105)	(0.00990)
Enhanced plan (1/0)	-0.0352**	-0.0221*
	(0.0118)	(0.0112)
No. of top drugs in Tier 1 and 2	-0.569	-0.391
	(0.380)	(0.362)
No. of top drugs covered	-8.696***	-8.913***
	(2.476)	(2.354)
Pharmacy network measure	-0.188***	-0.198***
	(0.0509)	(0.0484)
Number of years the plan is on the market	46.09***	39.22***
	(3.170)	(3.010)
Observations	756	756

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We select a subset of "undistorted" insurance plans in 2010. These are defined as plans offered by insurance companies that had not qualified for LIS random assignment with any of their plans in a given market. For example, if Humana had qualified to enroll LIS beneficiaries in California, we would exclude all plans offered by Humana in California in 2010, calling them "distorted" plans. We next take the sample of undistorted plans and project the MC estimates obtained through the inversion of the first-order conditions (Equation 13) onto characteristics of plans. The result of this regression is reported in this table separately for the Berry IV and BLP demand models. Note that in for the model marked with BLP, we use the Berry IV specification for the LIS part of the market in the inversion procedure. The MC projection regression has exactly the same characteristics as the utility function. Fixed effects for markets and insurers are included in the regression but not reported.

Table 6: Welfare Estimates: Data and Simulations of current Medicare Mechanisms

	Data	CMS Mechanism no LIS	CMS Mechanism no LIS, no MA-PD
Consumer Surplus	3,996,398,181	4,576,988,315	4,692,408,257
Insurer Profit	529,076,841	965,679,936	995,316,843
Premium subsidy	5,935,960,582	8,428,673,863	8,916,874,542
Non-premium subsidy	3,443,904,881	4,570,509,744	4,778,676,591
Inside option, enrollment	8,772,183	11,406,542	11,920,955
Inside option , %	38	49	51
Average weighted premium	502	436	423
Average weighted bid	1,123	1,125	1,122
Premium subsidy if MAPD	6,017,717,533	7,824,887,495	8,177,775,357
Non-premium subsidy if MAPD	2,280,767,578	2,965,700,800	3,099,448,386
Total surplus	3,119,680,563	2,671,494,343	2,543,899,492
Surplus per dollar spent on PDP subsidies	0.33	0.21	0.19
Surplus per opportunity cost dollar	2.22	0.93	0.81

Table 7: Counterfactual Welfare Estimates: CMS Mechanism without LIS and MA-PD weights with altered market power

	Each plan independent	One insurer owns all plans
Consumer Surplus	5,089,571,018	3,433,381,351
Insurer Profit	1,006,614,093	2,289,832,376
Premium subsidy	10,429,132,627	7,846,106,853
Non-premium subsidy	5,593,306,195	4,211,544,933
Inside option, enrollment	13,532,612	9,355,453
Inside option , %	58	40
Average weighted premium	383	431
Average weighted bid	1,108	1,233
Premium subsidy if MAPD	9,283,371,535	6,417,840,962
Non-premium subsidy if MAPD	3,518,479,007	2,432,417,857
Total surplus	1,909,420,347	1,553,602,868
Surplus per dollar spent on PDP subsidies	0.12	0.13
Surplus per opportunity cost dollar	0.46	0.37

Table 8: Counterfactual Welfare Estimates: Marginal Cost Pricing

	p=MC	p=Social MC	Social Planner
Consumer Surplus	1,615,869,829	1,088,909,571	4,330,903,887
Insurer Profit	-	-	(10,330,128,870)
Premium subsidy	-	-	-
Non-premium subsidy	967,642,993	-	-
Inside option, enrollment	2,332,240	1,126,756	11,693,333
Inside option , %	10	5	50
Average weighted premium	1,266	1,459	373
Average weighted bid	1,266	1,459	373
Premium subsidy if MAPD	1,599,916,805	772,954,641	8,021,626,367
Non-premium subsidy if MAPD	606,382,462	292,956,570	3,040,266,553
Total surplus	3,226,122,985	2,474,594,145	5,282,197,152
Surplus per dollar spent on PDP subsidies	3.33	-	0.39
Surplus per opportunity cost dollar	(2.00)	(1.79)	(5.55)

Table 9: Counterfactual Welfare Estimates: Vouchers

	Voucher 676USD	Voucher 721USD	Voucher 1340USD
Consumer Surplus	3,877,628,741	4,359,199,340	13,028,237,462
Insurer Profit	789,095,421	909,158,474	4,658,972,171
Premium subsidy	5,458,970,411	7,494,350,681	31,290,170,716
Non-premium subsidy	3,232,421,136	4,162,975,313	9,235,692,894
Inside option, enrollment	8,075,400	10,394,384	23,350,874
Inside option , %	35	44	100
Average weighted premium	536	463	34
Average weighted bid	1,212	1,184	1,374
Premium subsidy if MAPD	5,539,724,407	7,130,547,173	16,018,699,549
Non-premium subsidy if MAPD	2,099,604,003	2,702,539,745	6,071,227,234
Total surplus	3,299,042,083	2,896,847,016	(6,279,508,243)
Surplus per dollar spent on PDP subsidies	0.38	0.25	(0.15)
Surplus per opportunity cost dollar	2.41	1.22	(0.26)

Table 10: Optimal uniform voucher vs. market-specific voucher vs. social planner

	Social Planner	Optimal uniform voucher	Optimal market specific voucher
Consumer Surplus	4,330,903,887	3,261,166,188	2,996,573,024
Insurer Profit	(10,330,128,870)	674,512,364	634,683,523
Premium subsidy	-	3,353,494,720	2,815,291,154
Non-premium subsidy	-	2,233,856,028	1,961,858,855
Inside option, enrollment	11,693,333	5,589,158	5,008,116
Inside option , %	50	24	21
Average weighted premium	373	672	726
Average weighted bid	373	1,272	1,288
Premium subsidy if MAPD	8,021,626,367	3,834,162,263	3,435,567,245
Non-premium subsidy if MAPD	3,040,266,553	1,453,181,033	1,302,110,035
Total surplus	5,282,197,152	3,545,668,863	3,579,941,999
Surplus per dollar spent on PDP subsidies	0.39	0.63	0.7
Surplus per opportunity cost dollar	(5.55)	9.09	69.8

Table 11: Counterfactual Welfare Estimates: Proportional subsidies

	p=5% bid	p=32% bid	p=95% bid
Consumer Surplus	13,201,940,745	5,600,609,044	1,385,423,657
Insurer Profit	26,054,526,123	3,157,777,811	349,114,095
Premium subsidy	58,068,310,802	12,982,594,700	142,907,896
Non-premium subsidy	13,801,072,519	5,557,184,964	827,153,873
Inside option, enrollment	23,130,311	11,928,259	1,952,794
Inside option , %	99	51	8
Average weighted premium	132	512	1,390
Average weighted bid	2,643	1,601	1,464
Premium subsidy if MAPD	15,867,393,373	8,182,785,332	1,339,616,978
Non-premium subsidy if MAPD	6,013,880,870	3,101,347,210	507,726,551
Total surplus	(25,728,074,934)	(673,954,402)	2,875,004,039
Surplus per dollar spent on PDP subsidies	(0.36)	(0.04)	2.96
Surplus per opportunity cost dollar	(0.40)	(0.07)	(2.52)