Adverse Selection, Plan Diversity, and Welfare: Evidence from Medicare Advantage

By Jaemin So

I develop an oligopoly model of Medicare Advantage (MA) to investigate the impact of adverse selection on the equilibrium set of insurance plans in the context of risk-adjustment gradually implemented from 2003 to 2007. Demand and cost estimates verify the correlation between enrollees' risks and willingness-to-pay for the generosity of the insurance plan, implying that an increase in the benefit generosity of the insurance plan causes an increase in average cost of the MA plan. Furthermore, I estimate the fixed cost of adding insurance plans from inequality constraints generated by the best responses of MA insurers' profit-maximizing problem as illustrated in Pakes et al. (2015). The counterfactual analysis suggests heterogeneous welfare effects of risk-adjustment (1) on consumers with different risks and (2) under different levels of competition. Under the low level of competition, risk-adjustment decreases the consumer surplus, especially for healthy consumers, since an increase in the premium outweighs the quality improvement for most consumers and the low-premium plan is eliminated. With more insurers in the market, however, risk-adjustment increases the diversity of insurance plans and consumer surplus, especially for sick patients.

[This draft is preliminary and incomplete]

I. Introduction

In this paper, I develop and estimate a model of the health insurance markets where quantity and quality of insurance plans, as well as market participants, are endogenously chosen. These choices are associated with market failure from adverse selection in the health insurance markets. Specifically, equilibrium pricing under adverse selection would induce inefficiently low the enrollment (Einav and Finkelstein (2011)) or market unraveling where no one is willing to pay the pooled cost of insurance (Akerlof (1970)). On the other hand, market failure arises also from underinsurance problems where the coverage level of insurance plan is inefficiently low (Rothschild and Stiglitz (1978), Veiga and Weyl (2016)). Furthermore, if the entire set of insurance plans, including the number of plans, are endogenously determined by insurers, the impact of adverse selection on welfare is associated with both the intensive and the extensive margins in more complex ways (Azevedo and Gottlieb (2017), Hendren (2013)).

With a growing literature on the theory of adverse selection in the insurance market, empirical papers of adverse selection have tested adverse selection in insurance markets (Chiappori and Salanie (2000), Einav and Finkelstein (2011)) and measured welfare loss from selection (Glazer et al. (2014),Saltzman (2018)). However, empirical studies about adverse selection and the policy remedies for selection problems have imposed the strong assumption that insurers respond to adverse selection only by pricing for their insurance plans Ellis et al. (2013). While this assumption holds in some managed care markets in the U.S. such as ACA marketplaces, this does not hold in other markets such as Medicare Advantage, where insurers determine the non-price features of insurance plans, including copays, deductibles, or maximum out-of-pocket cost, as well as premium. In Medicare Advantage, the fixed contract assumption would limit the channels and the level of the impact of adverse selection on welfare, leading to inaccurate policy implications.

This paper empirically investigates the impact of adverse selection on the provision of insurance plans and on welfare in the health insurance market where insurers compete with price and quality of their sets of insurance plans. In most health insurance markets regulated by the government, though consumers differ in their expected cost or risk, insurers are not allowed to discriminate against consumers[1]. Therefore, insurers have incentives for risk-selection that is to attract healthy consumers who are cheaper to serve than risky consumers with chronic diseases. This paper empirically verifies whether insurers respond to the selection incentives through an endogenous set of insurance plans with different level of benefit generosity and measures the welfare consequences.

I answer this question in the context of Medicare Advantage, which is a privatized health insurance plans alternative to the traditional Medicare for elderly people in the U.S. This market has historically suffered from risk-selection, where relatively healthy consumers have been enrolled in Medicare Advantage, privatized insurance plans, and relatively sick patients have remained in the traditional Medicare, public insurance plan. (McGuire et al. (2011), Brown et al. (2014), McWilliams et al. (2012)). Risk-adjustment was gradually implemented in Medicare Advantage since 2003 to resolve the selection problem. The basic concept of risk-adjustment is to compensate private insurers according to their enrollees' health status. If it works successfully, then the perceived cost of serving sick patients would be similar to that of serving healthy consumers and the impact of adverse selection would be ameliorated. This paper draws questions regarding the risk-adjustment effect as follows; How could changes in the impact of adverse selection affect a set of insurance plans and consumer welfare? Specifically, would diverse insurance plans become available for all types of consumers including sick patients in the market and would consumer welfare be enhanced?

In the market where consumers differ in values of product characteristics, firms usually provide diversified products in terms of their characteristics in order to

[1] The regulation such as community rating prohibits insurers from pricing differently across consumers for the same insurance plan in the market.

match the diverse tastes. Theoretically, the product segmentation could be optimal for vertically differentiated products (Mussa and Rosen (1978), Moorthy (1984)). In this line of thought, firms often provide high-end products in addition to the regular (or low-end) products such as premium gasoline, business class seats in aircraft, or flagship smartphones, for the consumers who highly value the product quality. Secondly, price competition among firms leads to more differentiated products. This is because the firms can avoid fierce price competition by providing products further away from each other (Shaked and Sutton (1982)).

Adverse selection could dampen these diversifying forces. Specifically, if certain types of products attract consumers with high risks and firms cannot charge them differently, firms would not serve those products. In the health insurance market, therefore, high-generosity insurance plans would not be served if they attract risky consumers more than healthy consumers and only the low-quality-low-premium plans could be provided. This is why insurance plans with higher quality can be made available by insurers when risk-adjustment successfully reduces the perceived cost of serving high-risk beneficiaries.

Although this argument predicts that the high-quality plan could be provided by risk-adjustment, its implication for welfare is ambiguous due to the following factors.

1) Adverse sorting[2]

2) Fixed cost of adding plans

3) Competition

First, the provision of high-quality plans after risk-adjustment can be predicted under adverse sorting where high-quality plans attract high-risk beneficiaries more than low-risk beneficiaries in the market. Secondly, if it is too costly to serve additional plans in the market, the risk-adjustment effect on the number of plans and diversity would be small. Specifically, while the high-quality insurance plans become available, the low-quality-low-premium plans would not be served after risk-adjustment. Finally, competition affects the impact of risk-adjustment on both the diversity of products and the price. Specifically, an increase in diversity by risk-adjustment would be larger in the market with many insurers because products could be further away from each other to avoid price competition(Shaked and Sutton (1982)). Furthermore, insurers under oligopoly could extract the increased consumer surplus from the high-quality plan by charging higher premiums and this effect could be smaller under competition than under monopoly. This paper estimates the demand and the supply of Medicare Advantage which recovers (1) and (2) and investigate the heterogeneous effects of risk-adjustment across market structures in the counterfactual analyses.

[2]Veiga and Weyl (2016) introduced and defined "adverse sorting" as the positive correlation between consumers' marginal willingness-to-pay for the quality of products and a firm's cost of serving them.

I first estimate adverse selection on the insurance plan. Using a discrete choice model which describes consumer's plan choice, I estimate demand parameters using both micro and macro data as in Petrin (2002) and Berry et al. (2004). Specifically, information about the plan-level average risk and distribution of individual risk in the dataset is the key variation needed to identify consumers' heterogeneous preferences over insurance plans across different risks. These parameters determine the selection pattern of insurance plans with different characteristics, suggesting which characteristics attract riskier or healthier consumers into insurance plans. Specifically, a positive coefficient for the interaction terms of individual risk-score and quality of insurance plan would imply adverse selection on quality.

Then, I estimate the insurer's cost of serving beneficiaries with different risks which determine the impact of adverse selection on the quality level, given the demand estimates. In the supply model, insurance premiums and the subsidy[3] from CMS determines the insurers' revenue. Moreover, the implementation of risk-adjustment over time provides variation in the profitability of serving each level of risk. This variation, combined with the quality and premium of insurance plans, helps identification of the cost of serving different risks. I estimate the insurer's cost function by using optimality conditions for the premium and the quality choices, which are similar to Crawford et al. (2015) and Lustig (2010).

These estimates verify adverse sorting on the quality of insurance plans and insurers' risk-selection incentives in Medicare Advantage. Specifically, I show that high-risk-scored consumers value insurance coverage more than low-risk-scored consumers. Furthermore, I find that the insurer's cost is increasing in enrollees' risk-score. These results imply that an increase in quality of insurance plans causes higher cost from attracting more costly consumers and I find that this effect accounts for 67% of the total changes in cost.

To evaluate the impact of adverse selection on the diversity of insurance plans, I also estimate how much it costs for insurers to provide multiple insurance plans. I apply moment inequality in Pakes et al. (2015) to estimate the fixed cost of adding an insurance plan. Specifically, the lower and the upper bound of the fixed cost is identified by the inequality constraints arising from the best responses for the number of insurance plans. The estimates suggest that the fixed cost of adding insurance plans for MA insurers is considerably large and heterogeneous across markets with different Medicare population.

In the counterfactual analyses, I first evaluate the overall impact of risk-adjustment in Medicare Advantage. The most significant changes are increases in price and generosity of insurance plans by 115% and 109%, respectively. Accordingly, the average risk-score of Medicare Advantage plans increases by 7%, since unhealthy consumers value the quality more than healthy consumers. This could be explained by the fact that risk-adjustment reduces the cost of serving high-risk-

[3]Even without risk-adjustment, Center for Medicare/Medicaid Services (CMS) reimburses Medicare Advantage insurers with capitation payments

scored enrollees. Furthermore, the number and the diversity of insurance plans increase by risk-adjustment. The diversity of insurance plans in this paper is measured by the reciprocal of Herfindahl index[4] and an increase in the index implies that risk-adjustment induces insurance plans to be located in a more diverse level of quality[5].

The impact of risk-adjustment on consumer welfare is vastly heterogeneous (1) across markets with a different number of insurers and (2) across consumer's risk-score. First, I find that overall consumer surplus increases by 17% in the market with 5 insurers while it decreases by 10% under monopoly. This is because competition between insurers leads to less increase in price and more increase in diversity than under competition. Secondly, changes in the set of insurance plans by risk-adjustment are more advantageous for high-risk beneficiaries than for low-risk beneficiaries under competition between insurers. Moreover, high-risk beneficiaries lose less from risk-adjustment than low-risk beneficiaries under monopoly. This is because high-risk beneficiaries who highly value the quality of insurance plans could benefit from the enhanced level of quality, however, the consumers who do not prioritize the level of quality and are sensitive to price would be negatively affected.

Finally, I find that the impact of risk-adjustment on welfare could be inaccurately estimated without allowing for an endogenous set of insurance plans in the market. When insurers are only allowed to adjust their premiums in a response to the risk-adjustment, the changes in price itself barely affect the pool of enrollees in Medicare Advantage and the consumer surplus. This result implies that the fixed cost assumption can underestimate the positive effects of risk-adjustment under competition and the negative effects of risk-adjustment without competition. Therefore, the changes in the provision of insurance plans are the key channels for correctly evaluating the risk-adjustment.

A. Literature

The main contribution of this paper is to illustrate the impact of adverse selection on the endogenous set of insurance plans under oligopolistic competition. Prior studies in adverse selection theory focus on both inefficient pricing under fixed contract framework (Akerlof (1970), Einav and Finkelstein (2011)) and distortion in contract design (Rothschild and Stiglitz (1978)). Recently this literature extends to address which types of insurance plans, or set of plans, are served in equilibrium and allocation inefficiency under perfect competition (Azevedo and Gottlieb (2017)). This paper is theoretically parallel to Azevedo and Gottlieb

[4]Herfindahl index measures both the number of categories and the relative density of each category, representing richness and evenness of observations in each category. Herfindahl index is at maximum (equal to one) when only one group is represented and at a minimum (equal to 1/(number of categories)) when all the observations are distributed evenly. (Kelly (1981), Haughton and Mukerjee (1995))

[5]This the result could be recalculated with different sampling for counterfactual analysis, by linking the insurers to markets. Current results are from the independent sampling of insurers and markets for the purpose of calculating heterogenous effects across different market structure

(2017) but considers the impact of adverse selection on product provision associated with oligopolistic competition.

This paper also contributes to the growing empirical works related to the supply-side selection in the health insurance market. Frank et al. (2017) and Ellis and McGuire (2007) show that insurance services in managed competition with capitation are vulnerable to be distorted. In addition, different types of insurer-side selection are discussed; benefit generosity and premium in part C (Decarolis and Guglielmo (2017)), drug formularies in part D and ACA marketplaces for selection of profitable disease (Carey (2017), Geruso et al. (2016)) or access to prenatal care for selection of low cost infants (Kuziemko et al. (2013)). However, not many papers have addressed the equilibrium implications of risk selection considering both a consumer's and an insurer's problem. Recently, Aizawa and Kim (2018) show that advertisement in Medicare advantage can attract healthy consumers and Shepard (2016) finds evidence that the network of hospitals can disenroll unprofitable consumers who are expensive to serve. Risk selection of this paper is achieved by insurer's profit-maximizing menu contracts, with different premiums and coverage levels, based on demand structure. While Aizawa and Kim (2018) and Shepard (2016) consider either dropping unhealthy, dumping, or attracting healthy, cream-skimming, risk-selection in this paper is a simultaneous allocation of continuum types of consumers through insurers' menu contracts considering both dumping and cream-skimming.

This paper also augments the literature of risk-adjustment both theoretically and empirically. Mahoney and Weyl (2017) find risk-adjustment possibly reduces welfare by under-enrollment of high-coverage plans under fixed contract design. I provide different welfare implication of risk-adjustment considering flexible contract design. While empirical papers have focused on how risk-adjustment equalizes insurer's risk and on changes in the sorting of beneficiaries (McWilliams et al. (2012), Brown et al. (2014), Geruso and McGuire (2016)), little is known about the impact of risk-adjustment on characteristics of insurance plans and welfare. Recently, Glazer et al. (2014) and Saltzman (2018) discuss the welfare consequences of risk-adjustment through equilibrium pricing. This paper builds on this literature by considering the changes in product provision, including the number and characteristics of tiered plans.

Moreover, this paper builds on the literate of the equilibrium analysis of Medicare Advantage, following the seminal work of Town and Liu (2003). Most of the papers in this strand evaluated MA by recovering private insurer's cost of serving Medicare services in comparison with one in Traditional Medicare (Curto et al. (2014), Miller (2014), and Guglielmo (2016))[6]. However, not many papers study inefficiency from MA insurer's risk selection and the effect of risk-adjustment. The most closely related paper to mine is Lustig (2010) which measures welfare loss

[6]Miller (2014) and Guglielmo (2016) allow insurers to choose both premium and generosity benefit in their analyses. Miller (2014) allows switching cost and Guglielmo (2016) studies environments with bidding system

from adverse selection through endogenously chosen price and generosity. This paper additionally allows the entry of insurance plans in this context by considering both the flexible number of plans for each insurer and the entry of insurers. Furthermore, I take advantage of the newly available information through full implementation of risk-adjustment, including individual-, plan-, and market-level risk-score, which identifies policy-relevant selection in MA and welfare effects of current risk-adjustment.

Finally, this paper augments a growing literature of welfare effects of introduction of new products. Starting from papers emphasizing the valuation on new products for revising consumer price index (Hausman (1996), Hausman (1999), Bresnahan and Gordon (2008)), many papers have measured consumer benefits from new products in a diverse range of markets (Petrin (2002), Sweeting (2007), Draganska et al. (2009), Fan and Yang (2016), Wollmann (2018)). This paper contributes to this literature by investigating the welfare implications of changes in the available set of insurance plans arising from adverse selection. The main driver of entry of new products is consumer's taste for product characteristics in previous studies, however, this paper considers changes in the impact of adverse selection, that is a firm's perceived cost of serving consumers with different risks, as an important factor which brings changes in product provision and diversity.

II. Industry and Data

A. Medicare Advantage

Medicare is a public insurance program in the United States. Every elderly American over 65 years old are eligible and are automatically enrolled in Medicare. Medicare benefits are composed of Part A, B, and D which reimburse the costs of the hospital (inpatient), medical (outpatient), and drug services, respectively[7]. Medicare Advantage is one option for Medicare beneficiaries, alternative to traditional Medicare, which is provided by private insurers. Medicare Advantage also covers part A and B services and optionally part D benefits[8]. Medicare Advantage insurers are required to submit the contracts to the Center for Medicare/Medicare Services (CMS) illustrating what types of insurance coverage they offer every year. If CMS approves the MA insurers' contracts, then they can provide MA insurance plans to Medicare beneficiaries in each market.

There are several pros and cons of joining MA plans instead of traditional Medicare. First Medicare Advantage provides other benefits which traditional Medicare does not cover, such as vision, hearing, and dental insurance with additional premiums. Furthermore, MA plans often provides more comprehensive coverage. However, MA plans usually have restricted regions and networks of facilities and doctors. Therefore, it could be more costly for beneficiaries to visit

[7]Before the introduction of part D, traditional Medicare covers only part A and B services.

[8]However, MA insurers are required to provide at least one MA-PD plan which also covers part D to serve insurance plans in each market

out-of-network doctors and hospitals than in traditional Medicare. Moreover, enrollees in HMO, one organization type of MA plans[9], need to get a referral to see a specialist, while enrollees in traditional Medicare have fewer restrictions on choosing doctors and hospitals and do not need to get a referral to receive health care from specialists.

B. Outside Option

Outside option in the analysis of this paper includes being enrolled in traditional Medicare or being enrolled in both traditional Medicare and Part D, which can also be combined with Medigap. Medicare eligibilities basically benefit from Part A and B and have the option to add part D (drug) services to their Medicare services. However, unlike other private health insurances, there is no maximum out-of-pocket amount on what enrollees should pay in Medicare. To try to avoid extremely high copay for the medical services or out-of-pocket expenses for drugs, Medicare enrollees also have options to buy supplemental coverages called Medigap, which could lower out-of-pocket expenses with an additional premium.

Medigap is also served by private insurers but different from Medicare Advantage in several ways. Medigap benefits could bring lower out-of-pocket expenses with a higher premium, while Medicare Advantage could cover diverse services, such as vision, hearing, and dental insurance, with a lower premium than Medigap. Furthermore, Medigap covers the same network of doctors and hospitals as Traditional Medicare, while Medicare Advantage provides a more restricted set of hospitals and doctors who are contracted with MA insurers.

C. Risk-adjustment

Medicare Advantage plans are reimbursed by CMS for their cost of serving enrollees per-month-per-member basis[10], which accounts for the majority of the revenue. Before 2004, when risk-adjustment is not implemented, the capitation payment to MA insurers are as follows.

$$payment_{im}^{noRA} = B_{jm}$$

Without risk-adjustment, the payment to insurers is determined by baseline payments which consider only the insurer-market level differences. These baseline payments are benchmark before 2006 and the bid under bidding system after 2006. I discuss the bidding system in the next subsection.

The risk adjustment is a payment process that takes into account heterogeneity in enrollees' risks in each insurance plan. This is introduced in Medicare Advan-

[9]There are different types of Medicare Advantage plans including HMO, PPO, and PFFS. Each of them has different rules to receive health services in Medicare Advantage plans, which includes referrals and out-of-network coverage

[10]A payment arrangement for each enrolled person assigned to insurers is also called capitation payment

tage for the accurate payment to insurers considering how costly each enrollee is predicted to be relative to others. CMS constructs a formula for a risk score[11] to measure individual risk. The risk score is calculated based on various factors which determine the predicted cost to maintain the enrollee's health. These factors include demographic information, such as gender and age, and diagnosis of chronic disease.

Under risk-adjustment, beneficiaries in the same insurance plan have a different rate of payment as follows.

$$payment_{im}^{RA} = riskscore_i * B_{ijm}$$

The payment under risk-adjustment is equal to the baseline payment multiplied by risk-score. This payment considers the difference in predicted cost not only across insurers and markets but also across enrollees.

Risk-adjustment is gradually implemented in Medicare Advantage. The payment to MA insurers in 2003 to 2007 is as follows.

$$Payment_{imt} = \lambda_t * (payment_{ijm}^{RA}) + (1 - \lambda_t) * payment_{jm}^{noRA}$$

where $\lambda_t \in \{0, 0.3, 0.5, 0.7, 1\}$, $t \in \{2003, 2004, 2005, 2006, 2007\}$. The payment was increasingly risk-adjusted by the risk-adjustment parameter, λ_t, through 2003-2007. The payment is equal to the $payment^{noRA}$, where $\lambda_t = 0$, before 2003 and equal to $payment^{RA}$, where $\lambda_t = 1$, after 2007. However, the payment is a linear combination of $payment^{noRA}$ and $payment^{RA}$ in 2004, 2005 and 2006.

D. Bidding System

In addition to risk-adjustment, Medicare Advantage also experienced an introduction of a bidding system for the payments to insurers throughout the data period of this paper, 2003-2008. Since 2006, Medicare has paid MA plans under a bidding process and insurers submit "bids" based on estimated costs per enrollee for services covered under Medicare Parts A and B; all bids that meet the necessary requirements are accepted. Therefore, the baseline payment in equation [risk-adjusted payment] to which risk-score is multiplied is each insurer's bid under the bidding system, while the baseline payment is just the benchmark before 2006.

$$B_{jm} = \begin{cases} benchmark_m, & if\ t < 2006 \\ bid_{jm}, & otherwise \end{cases}$$

The actual payments to insurers and premiums are determined also by these bids. First, the bids are compared to benchmark amounts that are set by a formula established in statute and vary by county. The benchmarks are the maximum

[11] The mean risk-score is equal to 1.

amount Medicare will pay a plan in a given area. If a plan's bid is higher than the benchmark, enrollees pay the difference between the benchmark and the bid in the form of a monthly MA premium, in addition to Part B premium, and Part D premium, if it is MA-PD[12]. If the bid is lower than the benchmark, the plan and Medicare split the difference between the bid and the benchmark; the MA plan's share is known as a "rebate," which must be used to provide supplemental benefits to enrollees or to lower the premium. Therefore, the payment and the MA and MA-PD premium under both bidding system and risk-adjustment are as follows.

$$payment_{jm} = \begin{cases} bid \cdot rs_i - (bid - benchmark), & if\ bid > benchmark \\ bid \cdot rs_i, & otherwise \end{cases}$$

$$premium^{MA}_{jm} = \begin{cases} p^C + (bid - benchmark), & if\ bid > benchmark \\ p^C, & otherwise \end{cases}$$

$$premium^{MA-PD}_{jm} = \begin{cases} p^C + p^D + (bid - benchmark), & if\ bid > benchmark \\ p^C + p^D, & otherwise \end{cases}$$

When the standardized bid is greater than the benchmark, the payment of CMS to the plan is the risk-adjusted bid minus the gap between the bid and the benchmark which is covered by the enrollee's premium. The payment to MA insurers is just the risk-adjusted bid in the case where the bid is smaller than the benchmark.

E. Data

I have combined datasets mostly from CMS for the periods 2003-2008 in this paper. The main reason for this period selection is because data should be through implementation periods of the policy of interest, Risk-adjustment, and not many significant policies are intervened. Risk-adjustment with HCC system has been gradually implemented from 2004 to 2007 and payment system has gone through structural changes after 2009, including changes in the benchmark, the rate of rebates and star rating system for MA plans, prior to Affordable Care Act (ACA). I drop 2006 due to the lack of Out-of-pocket Cost (OOPC) data on which a measure of insurance generosity in this paper is based. Medicare Current Beneficiary Survey (MCBS) provides me the demographic information of Medicare eligibles which helps me constructing risk-score and income distribution of them for each market. I also use a publicly available dataset from CMS. This includes the plan's

[12]MA-PD is Medicare Advantage plans which also provide Part D (drug) coverages as well as Part A and B

premium, different types of Out-of-pocket Cost (OOPC) and other characteristics of Medicare Advantage plans. Market share data is also provided by CMS State-County-plan (SCP) for 2003-2005 periods and Contract-Plan-State-County (CPSC) for 2007-2008 periods. This paper uses insurer's payment data in Medicare Advantage such as bids, rebates and importantly the average risk-score in a plan-level for the periods 2007-2008 from CMS. Finally, Medicare Geographic Variation provides me the information regarding market level average demographics of Medicare population and the cost of serving enrollees in Traditional Medicare.

MCBS

MCBS is a survey of a nationally representative sample of the Medicare population in the United States. Around 15000 participants are surveyed and tracked up to 4 years. The information this paper mainly uses in MCBS is demographics, medical claims, and health status of Medicare population samples both in Traditional Medicare and Medicare Advantage. Demographic information includes age, gender, income, and the address the enrollees live. Health status information contains the history of chronic disease, the level of difficulty in daily life, and self-evaluation of various health conditions. Furthermore, we can differentiate whether each participant is enrolled in Traditional Medicare or Medicare Advantage and contract number is provided for MA enrollees.

The main purpose of this data is to recover the distribution of individual risk-score for structural estimation. Heterogeneity in individuals' tastes is represented by risk score, rs, which is a measure for individual risk calculated by CMS. The code for calculating risk-score is based on demographic information, such as gender and age, and diagnosis of chronic disease. CMS uses HCC codes for the risk-score to reimburse Medicare Advantage plans for the predicted cost of patients by adjusting those payments according to risk-score. I recover the risk-score from my dataset in the same way that CMS adopts using HCC codes. The data I used to assign HCC codes is the diagnosis information pulled from claims data in MCBS.

I can reformulate the risk score for the enrollees in Traditional Medicare (TM) using claims data in MCBS. As in Brown et al. (2014), I followed a formula of constructing a risk-score provided by CMS. However, we do not observe individual risk-score who are enrolled in Medicare Advantage (MA). I use the survey regarding health conditions and history of diseases in MCBS to generate proxy of risk-score for them. I first needed to regress various factors in this survey on the risk-score of Traditional Medicare enrollees. Then I used the estimate to predict the Medicare Advantage enrollee's risk score. This survey includes various disease factors for both history and previous year's experience, self-estimated health conditions, and various difficulties of activities in daily life.

Insurer-plan level and market level data

I use several insurer-level and plan-level datasets which are publicly available from CMS. First, I use out of pocket cost (OOPC) for the periods 2003-2005 and 2007-2008. A projected OOPC is one measure of benefits generosity for each plan, capturing how much out of pocket cost for medical care of the enrollees in each plan is predicted per month. This plan-level OOPC is calculated by combining benefit structure of plans, including cost sharing and categories of services, and information about how enrollees in Traditional Medicare utilize the Medicare services from MCBS. This is accessible to consumers who search for MA plans to join from the CMS official websites. OOPC is calculated for different types of services of medical care and for different health conditions in a dollar unit for both Medicare Advantage and Traditional Medicare. In addition, I use the Plan Benefit Package (PBP) for 2003-2008 periods. This includes information about types of organization, plan premiums and different types of benefits of the plan such as maximum out-of-pocket limits, deductible, coinsurance rates, copayments, and drug benefits[13].

CPSC dataset includes information about enrollment in Contract-Plan-State-County level for the years 2006-2008 and SCP dataset is for enrollment of the period before 2006, however, this does not include plan-level market share but only the insurer-level one. Therefore, demand estimation is based on post-2006 periods enrollment data from CPSC and SCP (2003-2005) dataset is used only for recovering insurer-level variables such as unobserved characteristics by using a variation of contract-level market share given the demand estimates. I drop the plans where the number of enrollees is less than 10. In addition, Plan-area files include the information about each plan's service area, counties, where insurers offer Medicare Advantage plans. Furthermore, Medicare Advantage plan's payment information from CMS is used for the supply-side estimation. This includes average PMPM (per member per month) payment from CMS, rebate, and an average risk score of enrollees in each plan. In addition, data on benchmark which is the standard rate for the reimbursement to the MA plans in each county comes from the MA Ratebooks.

Lastly, I use the public use file of Medicare geographic variation which includes information regarding demographics and medical costs across all counties in U.S for the years 2007-2008[14]. The key information I use is average risk score for all Medicare beneficiaries and government calculated standardized cost and actual cost to serve enrollees in TM for each county. Average risk score in a plan level helps identification of heterogeneous utility function with respect to individual risk-score. Standardized cost is an adjustment for different payment rates for the same service across counties, accounting for local wages or input prices, and

[13]Types of the organization are mostly one of HMO, HMOPOS, PPO, and PFFS

[14]Data Source : CMS Chronic Conditions Data Warehouse (see http://ccwdata.org/index.php) which contains 100 percent of Medicare claims for beneficiaries who are enrolled in the fee-for-service (FFS) program as well as enrollment and eligibility data

other payments from Medicare[15]. I use these types of heterogeneity in average cost across markets as market-level cost shifter in the estimation of the structural model.

Generosity

The out of pocket cost (OOPC) is a predicted expenditure for the medical cost when you are enrolled in each plan, which is calculated by the government. This OOPC is calculated for different types of services of medical care in a dollar amount. Since this is a dollar unit, we can just add up the OOPC across different coverages to calculate a measure of total generosity [16]. This OOPC is also calculated for five types of self-reported health status. I take OOPC for the enrollee's with "poor" health, the lowest health status. Lastly, outside option in this market is traditional Medicare (TM) and OOPC for TM can be also calculated in the same manner. I take a gap of OOPC between MA and TM for the measure of the generosity. Therefore, generosity in this paper is the OOPC for poor health relative to TM as follows.

$$g = OOPC^{TM}_{poor} - OOPC^{MA}_{poor}$$

III. Demand

Since MA insurers contract with Center for Medicare Medicaid for each county m in each year t, the market is defined by county-year, mt. Every eligible in each market has the option to choose one of Medicare Advantage plans, denoted by $k > 0$, or to remain in Traditional Medicare, denoted by $k = 0$. The number of insurers and plans in each market is denoted by J_{mt} and by K_{mt}, respectively. I assume that individual, i, gets indirect utility from MA plan, k, in the market, mt, is as follows.

$$\begin{aligned} u_{ikmt} &= X_{kmt}\beta_i + \xi_{kmt} + \tilde{\epsilon}_{ikmt} \\ u_{i0} &= \epsilon_{i0} \end{aligned}$$

where, X_{kmt} and ξ_{kmt} are plan-level observable and unobservable characteristics, respectively. Observable characteristics include generosity, premium, and a type of organization.

$$X = \{1, g, p, d^{HMO}\}$$

[15]For example, Medicare compensates certain hospitals for the cost of training doctors. (CMS County All Reports: State and County Level Demographic, Cost, Utilization, and Quality Data)

[16]Lustig (2010) considers generosity as a sum of utility from different types of insurance coverage with estimated weight from a demand-side model.

where, constant, 1, is for preference over MA itself and generosity, g_{kmt}, captures how much the plan covers for the a measure of generosity which is discussed in the previous section. A premium p_{kmt} includes Part C and Part D. A dummy variable, d_{kmt}^{HMO}, takes 1 if the plan is HMO and 0 otherwise.[17] Unobserved characteristics, ξ_{kmt}, are unmeasured aspects of insurance plans. In addition, product $j = 0$ is an outside option, which is Traditional Medicare in this market and u_{i0} is utility from remaining in Traditional Medicare.

The coefficients, β_i, capture consumers' heterogeneous tastes for plan characteristics and Medicare Advantage itself.

$$\beta_i = \{\beta_i^{MA}, \beta_i^{g}, \beta_i^{p}, \beta_i^{HMO}\}$$

Consumers are defined by observable characteristics, e_i, which include individual health risk, rs_i, income, inc_i.

$$\beta_i^l = \bar{\beta}^l + e_i' \cdot \beta_e^l$$
$$e_i = \{rs_i, \sqrt{inc_i}\}$$

where, $l \in \{MA, g, p, HMO\}$

Individual characteristics, e_i, are assumed to follow log normal distribution with different mean and variance across markets. I assume the non-linear impact of income interacting with plan characteristics on demand by taking a square root for inc_i.

$$rs_i \sim F_m^{rs} = LN(\mu_m^{rs}, \sigma_m^{rs})$$
$$inc_i \sim F_m^{inc} = LN(\mu_m^{inc}, \sigma_m^{inc})$$
$$v_i \sim N(0, 1)$$

I assume that ξ_{kmt} is decomposed into insurer-time specific fixed effect and a market level deviation from the mean. Insurer ,j, serving plan, k, is indexed by $j(k)$ and $j(\cdot)$ is known.

$$\xi_{kmt} = \xi_{j(k)t} + \Delta\xi_{j(k)mt}$$

This insurer-time fixed effect, $\xi_{j(k)t}$, captures insurer-specific factors which can affect demand of insurance plans, such as the network of hospitals and physicians, reputation or advertisement. A market-level deviation from them, $\Delta\xi_{jmt}$, is assumed to be *iid* across markets. However, $\Delta\xi_{jmt}$ could be correlated with insurer's choice variables, adjusted premium and generosity, p and g, because I assume it is observed prior to decision of the number of plans and their contract

[17]The plan can be either HMO, PPO, HMOPOS, or PFFS, and HMO has a distinct rules of providing insurance services. It usually limits coverage to care from doctors who contract with the insurer and may require enrollees to live or work in its service area to be eligible for coverage.

design, p and g.

The unobserved individual preferences for products are correlated within inside options and within an outside option, MA plans and TM. In the resulting random coefficient nested logit model or RCNL, we can decompose the idiosyncratic valuation as follows.

$$\tilde{\epsilon}_{ikmt} = \psi_{igmt} + (1-\rho)\epsilon_{ikmt}$$

where the "nesting parameter" $\rho \in [0,1]$ and ϵ is distributed i.i.d. multivariate type I extreme value, and the distribution of ψ_{igmt} is such that $\tilde{\epsilon}_{ikmt}$ is also distributed extreme value.

Demand parameters in this paper are identified by various types of micro and macro data. To see this, I rewrite the utility function which are decomposed into plan-level mean utility, δ, individually heterogeneous utility, μ, and idiosyncratic shock, ϵ, as follows.

$$\begin{aligned} (1) \quad u_{ikmt} &= \delta_{kmt} + \mu_{ikmt} \\ &= \delta_{kmt} + \sum_{l \in \{1,g,p,x\}} (\beta^l_{rs} rs_i + \beta^l_{inc} inc_i + \beta^l_v v^l_i) X^l_{kmt} + \epsilon_{ikmt} \end{aligned}$$

where, $\delta_{kmt} = X'_{kmt}\bar{\beta} + \xi_{kmt}$.

First, given non-linear parameters, $\beta_{rs}, \beta_{inc}, \beta_v$ and ρ, δ can be recovered, which matches the market share to the predicted share by model. Equation (1) is a traditional random coefficient model with plan-market-specific term, δ, which is not varying across individuals. Under distributional assumptions on $w = (rs, inc, v, \epsilon)$, we can solve for δ for each parameter set, β_{rs}, by equating observed and predicted market share.

$$(2) \qquad s_{kmt} = s(\delta, \beta_{rs}, \beta_{inc}, \beta_v; X, F_w)$$

where,

$$s(\delta, \beta_{rs}, \beta_{inc}, \beta_v; X, F) = \int_{A_{kmt}(\delta, \beta_{rs}, \beta_{inc}, \beta_v; X)} F_w(dw)$$

and

$$A_{kmt}(\delta, \beta_{rs}, \beta_{inc}, \beta_v; X) = \{w : max_{r=0,1,\ldots,K}[u_{irmt}(w; \delta, \beta_{rs}, \beta_{inc}, \beta_v, X)] = u_{ikmt}\}$$

Then, without assumption about $\{X, \Delta\xi\}$, individual health risk and plan-level average risk information combined with plan characteristics identify $\beta_{rs} = \{\beta^{MA}_{rs}, \beta^g_{rs}, \beta^p_{rs}, \beta^x_{rs}\}$. I match the observed average risk-score in a plan level to the corresponding conditional expectation of risk-score on individuals who chose each plan.

$$\bar{rs}_{kmt} = E[rs \mid \mathbf{1}_{mt}(choice = k) = 1]$$
$$= \frac{\int_{A_{kmt}(\delta,\beta_{rs},\beta_{inc},\beta_v;X)} rs\ F_w(dw)}{\int_{A_{kmt}(\delta,\beta_{rs},\beta_{inc},\beta_v;X)} F_w(dw)}$$

Furthermore, variation in plan-level risk-score interacted with plan characteristics identifies $\beta^g_{rs}, \beta^p_{rs}, \beta^{HMO}_{rs}$ and β^{MA}_{rs}. I match observed correlation of plan characteristics and enrollee's risk-score of each plan with model's prediction.

$$corr(X_{kmt}, \bar{rs}_{kmt}) = E[X_{kmt} \cdot E[rs \mid \mathbf{1}_{mt}(choice = k) = 1]]$$

Furthermore, various market and plan level data, including instruments for p and g, identifies the rest of parameters, both non-linear and linear parameters, such as $\beta_{inc} = \{\beta^{MA}_{inc}, \beta^g_{inc}, \beta^p_{inc}, \beta^x_{inc}\}$, $\beta_v = \{\beta^{MA}_v, \beta^g_v, \beta^p_v, \beta^x_v\}$ and $\bar{\beta} = \{\bar{\beta}^g, \bar{\beta}^p, \bar{\beta}^x\}$ as in Berry et al. (1995). Given δ from (2), I can solve for plan-market deviation from the insurer-year level unobservable characteristics, $\Delta\xi$ as follows.

$$\Delta\xi_{kmt} = \delta_{kmt} - [\bar{\beta}^g g_{kmt} + \bar{\beta}^p p_{kmt} + \bar{\beta}^x x_{kmt} + \xi_{jt}]$$

Since insurers choose the generosity and the premium for their insurance plans after observing the demand and the cost shocks, $\Delta\xi$ could be possibly correlated with g and p. I consider three sets of IVs for identification of these parameters as follows.

$$Z = \{Z_1, Z_2, Z_3\}$$

First, I use competitor's plan characteristics, one of "BLP" instruments. I assume organization type of each insurance plan is exogenously determined but it affects competitor's price and generosity choices, thus I use a proportion of competitor's plan types (HMO, PPO, HMOPOS) in the market as instruments. The second type of IVs are characteristics and prices of same insurer's other plans and number of plans in other market. These resemble "Hausman" instruments, but are different in a sense that I use price and generosity of different product's in different markets instead of the same products. This is because the price and generosity of the same plans across markets are the same in MA. Plans' characteristics and prices in other markets but belonging to the same insurer are correlated since underlying cost is shared by within insurer plans. However, these are not correlated to other market's $\Delta\xi$, by the assumption that $\Delta\xi$ are independent across markets. The last set of instruments are market level variation of insurers' revenue and cost shifters, which include benchmark and actual and standardized cost of serving Traditional Medicare enrollees. Finally, I construct additional instruments β_{inc} by interacting market-level average income z with these three sets of IVs, $Z_{kmt} \cdot inc_m$.

A. Demand Estimation

Demand estimation in this paper uses a generalized method of moments which resembles Berry et al. (1995), Berry et al. (2004) and Petrin (2002). I recover both linear and non-linear parameters in my model through macro and micro moments.

$$\begin{aligned}\theta^{NL} &= \{\beta_{rs}, \beta_{inc}, \beta_v, \rho\}\\ &= \{\beta_{rs}^{MA}, \beta_{rs}^{g}, \beta_{rs}^{p}, \beta_{rs}^{x}, \beta_{inc}^{MA}, \beta_{inc}^{g}, \beta_{inc}^{p}, \beta_{inc}^{x}, \beta_{v}^{MA}, \beta_{v}^{g}, \beta_{v}^{p}, \beta_{v}^{x}, \rho\}\\ \theta^{L} &= \{\bar{\beta}, \xi_{jt}\}\\ &= \{\bar{\beta}^g, \bar{\beta}^p, \bar{\beta}^x, \xi_{jt}\}\end{aligned}$$

Estimation Procedure

The estimation procedure basically separates out non-linear and linear parameters to search. First, given any non-linear parameters $\beta_{rs}, \beta_{inc}, \beta_v$, I match market share data to the predicted share to back out plan-level mean utility δ from contraction mapping as in BLP.

$$\delta^{n+1} = \delta^n + (1-\rho)[ln(s_{kmt}) - ln(\hat{s}_{kmt}(\delta^n)]$$

where,

Then, I recover plan-market deviation, $\Delta\xi_{kmt}$ through regression of δ on plan characteristics and insurer-time fixed effects.

$$\Delta\xi_{kmt} = \delta_{kmt} - \bar{\beta}^g g_{kmt} + \bar{\beta}^p p_{kmt} + \bar{\beta}^x x_{kmt} + \xi_{jt}$$

Under assumptions regarding instruments for price and characteristics of insurance plans and $\Delta\xi_{kmt}$, I construct macro moments as follows.

$$\begin{aligned}E[\Delta\xi_{kmt} \mid Z] &= 0\\ E[\Delta\xi_{kmt} \mid Z \cdot inc_m] &= 0\end{aligned}$$

This allows one to search only for β_{inc}, β_v and ρ. Furthermore, given δ, I construct micro-moments for identifying β_{rs} which are generated by matching predicted average risk-score for each plan to the data. The distance between predicted risk-score of each plan and observed plan-level average risk-score is defined as follows.

$$\epsilon_{kmt} = \bar{rs}_k - E[rs \mid \mathbf{1}(choice = k) = 1]$$

I assume ϵ_{kmt} is independent on plan characteristics. Therefore micro moments are given by

$$E[X \cdot \epsilon_{kmt}] = 0$$
$$Where,\ X = [1, g, p, x]$$

Distribution of individual characteristics

I recover the distribution of individual characteristics, risk-score and income, by assuming log normal distribution and estimating mean and variance of them for each market. I use county-year-level mean of risk-score of Medicare population and individual characteristics of MCBS sample from 2003 to 2008. Since I do not directly observe the mean income of Medicare population for each county, I use mean income of overall population for each county for approximation of it. I assume a linear relationship between mean income of Medicare and overall population and estimate the linear parameter as follows.

$$\bar{inc}_m^{Medicare} = \mu \cdot \bar{inc}_m^{overall}$$

The main goal of estimation for distribution parameters is to back out variance of risk-score in each market. I assume the variance of log normal distribution of individual characteristics as a linear function of their market mean. Then, the mean and the variance of log normal distribution of individual characteristics, μ, σ, is as follows.

$$e = \{rs, inc\}$$
$$\sigma(\bar{e}) = \sigma_0 + \sigma_1 * \bar{e}$$
$$\mu(\bar{e}) = log(\bar{e}) - \frac{1}{2}\sigma(\bar{e})^2$$

where, $\bar{e}$ is mean of individual characteristics. Based on these parameters of log normal distribution, which are function of county mean of individual characteristics, $\bar{e}$, I estimate variance function parameters, σ_0 and σ_1, by maximizing a likelihood function as follows.

$$e_i \sim LN(\mu(\bar{e}_m), \sigma(\bar{e}_m)^2)$$
$$L = \sum_{i \in I} ln\ f_e(e_i; \mu_m, \sigma_m)$$

where, f_e is a probability density function of log normal distribution of individual characteristics, e.

B. Results - Demand

First, I recover distribution of individual characteristics, risk-score, and income, which are used to calculate model-predicted plan- and market-level values for estimation and counterfactual analysis, including market share, average risk-score of insurance plan, and the insurer's expected profit. Table [Distribution Parameters] displays the estimates of variance parameter in lognormal distribution as a function of the market mean of risk-score and income. The estimates for σ_1^{rs} and σ_1^{income} shows a positive correlation between mean and variance for both risk-score and income distribution. The market with a higher mean of risk-score (income) is likely to have more heterogeneous individuals in terms of risk-score (income). Furthermore, the last row of the table [Distribution Parameters] shows that the mean income of the Medicare population is half of the mean of the overall population. Since Medicare-eligible population is over 65, their income should not be as high as income of the overall population.

Distribution Parameters	
σ_0^{rs}	0.479***
	(0.004)
σ_1^{rs}	0.161***
	(0.018)
σ_0^{inc}	0.538***
	(0.002)
σ_1^{inc}	0.373***
	(0.003)
μ^{inc}	0.543***
	(0.003)

standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table [Demand Estimates] displays the estimates in the demand model. The overall effects of generosity, premium, or HMO on demand are a sum of heterogeneous effects, β_{rs}, β_{inc}, and common effects, $\bar{\beta}$. The generosity has a positive effect on demand for most of the consumers considering a distribution of income and risk-score, though the common effect, which is the effect with zero risk-score and income, is negative. In a similar way, I check the overall effect of a premium on the demand for MA plans is negative for most of the consumers.

For the purpose of this paper, the parameters of interest lie on the heterogeneous effects of generosity and premium on demand. The estimate for a parameter, β_{rs}^{g}, interacted with $G * rs$, is positive. This suggests high risk-scored consumers value the insurance coverage more than low risk-scored consumers. Without direct information about insurer's cost, these results imply adverse sorting in the MA plan, where an increase in the generosity of MA plan induces higher average cost since risk-score measures predicted spending of Medicare enrollees.

The estimates for β^p_{rs} and β^p_{inc} suggests that consumers with higher income and higher risk-score are less sensitive to the premium. Furthermore, negative signs for estimates, β^{MA}_{rs} and β^{MA}_{inc}, risky consumers are more likely to stay in Traditional Medicare instead of choosing one of Medicare Advantage plans. This could be because sick patients value the flexibility of a network of hospital and physicians in Traditional Medicare. The last row of the Table [Demand Estimates] is an estimate for a nesting parameter, ρ, which implies unobserved individual preference shocks of within-insurer plans are highly correlated.

Demand Estimates			
	HCC risk-score	$\sqrt{Income}$	Common Effects
G	0.077^{*}	1.814	-0.714^{***}
	(0.044)	(3.149)	(0.074)
P	0.034	0.829	-2.884^{***}
	(0.101)	(4.88)	(0.104)
HMO	0.231^{***}	4.931^{**}	-4.076^{***}
	(0.034)	(2.144)	(0.143)
MA	-0.303^{**}	-1.249	
	(0.127)	(10.29)	
nesting parameter (ρ)	0.862^{***}		
	(0.301)		
FE		Insurer*year	

Elasticity			
	Mean	Median	Standard error
Price Semi-elasticity (mean)	2.411	2.435	0.094
Generosity Elasticity (mean)	0.706	0.652	0.416

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table [Adverse Sorting in Benefit Generosity] provides more interpretable results. The second and the third column of the table display the marginal willingness to pay for an increase in generosity and the change in willingness to pay for the replacement of insurance plan with low (5%) generosity with the one with high (95%) generosity. A marginal ($100 per month) increase in generosity is associated with $8 per month for healthy enrollees and $22 per month for sick patients. Furthermore, the difference of WTP to substitute generous MA plan for less generous one is $55 between sick patients (99%) and healthy enrollees (1%).

Adverse Sorting in Benefit Generosity		
Risk-score	MWTP	Δ WTP (5% $\rightarrow$ 95%)
1%	\$8.18	\$25.91
25%	\$8.87	\$28.09
50%	\$9.78	\$30.96
75%	\$11.30	\$35.78
99%	\$21.96	\$69.55
From the data		
Generosity	95%	5%
Poor	\$371.16	\$118.72
Excellent	\$54.43	\$17.52

IV. Supply

Insurers simultaneously choose their number of plans to offer in each market and the contract design, premium and generosity, of the plans.

A. *Decision on Premiums and Generosity*

Insurers choose the number of plans and the contract design for each plan they provide after observing the set of demand shocks (ξ_{jmt}) and cost shocks (ω_{jmt}). Individual demographic information is denoted as $e = \{rs, inc\}$ and insurers are also informed about the distribution of them F_e.

$$
\begin{aligned}
Max_{K_j} Max_{g,p}\ \Pi =& N \sum_{k}^{K} \int_e [(p_k + S(rs, B) - c(g_k, rs, Z, \omega, \omega^g)) \cdot prob(G, P, \Xi, e)] dF(e) - FC(K_j) \\
s.t\ \ & g = \phi_1^g * rebate + \phi_2^g * p, \quad if \quad t > 2006 \\
where,\ \ & g = oopc_{TM}^{poor} - oopc^{poor}
\end{aligned}
$$

The generosity of the insurance plan, or a relative OOPC for poor health, is denoted by g and the premium is denoted by p.

I specify a direct subsidy which is a function of benchmark and risk-score under pre-bidding system before 2006 as follows.

$$S_{imk} = S(\lambda, B, rs) = (1 - \lambda_t) \cdot B_m + \lambda_t \cdot rs_i \cdot B_m$$

Since risk-adjustment is gradually implemented in MA, a risk-adjustment parameter, λ_t, takes a value from 0 to 1 as follows

$$\begin{aligned}\lambda_{2003} &= 0\\ \lambda_{2004} &= 0.3\\ \lambda_{2005} &= 0.5\\ \lambda_{2006} &= 0.7\\ \lambda_t &= 1, \quad t \geq 2007\end{aligned}$$

In 2006, Medicare Advantage introduced a competitive bidding system for payments to insurers. A baseline subsidy is a county-level benchmark before the bidding system and a bid each insurer submits under the bidding system. Before the bidding system, every plan in the same market has the same subsidy if their enrollees have the same average risk score. However, after a bidding system, even with the same level of risk score of enrollees in the same market, subsidy differs according to the plan's bid.

I specify the subsidy structure under a bidding system after 2006, which is a function of bids, benchmark and risk-score.

$$\begin{aligned}S_{imk} = S(b, B, rs) &= rs_i * b + rebate \ , \ if \quad b < B\\ &= rs_i * benchmark \ , \ otherwise\\ rebate &= 0.75 * (B - b)\end{aligned}$$

If the MA plan's bid is less than the benchmark, 75% of that difference is "rebate" that must be used to offer mandatory supplemental benefits or premium reductions. The other 25% is retained by the Trust Funds as savings. When the standardized bid is greater than the benchmark, the payment of CMS to the plan for each enrollee i of the plan is $b \cdot r_i - (b - B)$, while it is $b \cdot r_i$ in the case where the bid is smaller than the benchmark. Then, the revenue of the plan for serving beneficiary, i, which is adjusted for the enrollees' risk profiles, is as follows. Note that this is not depending on whether the bid is greater than the benchmark.

A marginal cost or a per-enrollee cost of each individual who is enrolled in this plan is a function of individual risk-score, rs, generosity, g, and a market-level cost shifter, Z_m. A cost shifter includes an index for heterogeneity in the cost of serving the same services across markets, estimates of unobserved characteristics of the insurers in each market, ξ, an indicator variable for HMO types of insurers, x. An index for market-level cost shifter is the average cost of serving enrollees in TM divided by the standardized cost which CMS calculated. The standardization accounts for local wages or input prices, and extra payments that Medicare makes to advance other program goals, thus this index captures the relative costliness of each market arising from these factors.

$$c(g, rs, Z_m, \omega, \omega^g) = \gamma_0 + \eta_0 \cdot rs + \mu_0 * Z_m + (\gamma_1 + \eta_1 \cdot rs_i + \mu_1 * Z_m + \omega^g) \cdot g + exp(g) + \omega$$

where, ω^g and ω, are per-enrollee cost shocks; ω^g affects marginal cost of increasing generosity and ω does not.

Since a bidding system and Part D are introduced in Medicare Advantage after 2006, premiums are determined in a different way across payment regimes. Regardless of pre- or post-bidding system, I consider the amount which consumer should pay for the entire services of each insurance plan except Part B premium as a premium for MA. Before 2006, the premium is a single payment from consumers for Medicare Advantage services.

$$p = p^{MA}$$

After 2006, a premium includes part C and part D premium as well as the gap between bid and the benchmark, if a bid is larger than the benchmark, which covers part A and B coverages.

$$\begin{aligned} p = premium &= p^C + p^D \ , \ if \quad b < B \\ &= p^C + p^D + (b - B), otherwise \end{aligned}$$

Part C premium is for the supplemental mandatory benefits of MA, while part D premium is for the drug coverages. After bidding system comes in, this premium is also affected by the insurer's bid and the benchmark

A constraint implies a financial restriction of MA plans. CMS imposes two rules regarding allocation of rebates and how to finance the cost of additional benefits. Extending an idea of reduction in choice variables discussed in Stockley et al. (2014) and Guglielmo (2016), I impose a identity, $g = \phi_1^g * rebate + \phi_2^g * p$, where additional reduction in OOPC for consumers in poor health should be financed by the rebate and the premium from consumers. I allow the financing rule to be different across time and types of insurers, which are estimated separately before estimating the cost function.

B. Necessary Equilibrium Conditions

To estimate a variable cost function, I back out structural cost shocks from necessary conditions for profit maximization based on demand estimates as in Crawford (2012) and Crawford et al. (2015). However, a per-enrollee variable cost in this paper, which is a function of individual-level risk-score, cannot be obtained directly by inverting out a system of the first-order conditions. Instead, I solve for cost shocks from the first-order conditions themselves as in Lustig (2010). I now derive the optimality conditions for pairs of price and generosity for each plan the insurers offer. Given the number of plans the insurers have chosen, the profit function in [the equation number] yeilds a system of $2 * K_{jm}$ first order conditions in each insurer and $2 * K_m$ in each market :

(3)
$$\frac{d\pi}{dp} = \sum_{k \in K_{jm}} \sum_{i \in I_m} [\frac{\partial pr_{ik}}{\partial p}[p_k + S(b_k, B_m, rs_i) - c(g_k, rs_i, Z_m)] + \sum_{i \in I_m} [(1 + \frac{\partial S_{ik}}{\partial p}) \cdot prob_i] = 0$$

(4)
$$\frac{d\pi}{dg} = \sum_{m \in M} \sum_{i \in I_m} [\frac{\partial pr_i}{\partial g}[p_k + S(b_k, B_m, rs_i) - c(g_k, rs_i, Z_m)] - \sum_{i \in I_m} [(\frac{\partial S_{ik}}{\partial g} + \frac{\partial c_{ik}}{\partial g}) \cdot prob_i] = 0$$

The choice probability is heterogeneous in individual risk-score coming from demand system in the previous subsection, thus the derivative of them with respect to the adjusted premium and the generosity is also heterogeneous. This brings an insurer's tool for sorting consumers in terms of their risk-score, for example, by increasing (decreasing) generosity, the plan can attract higher (lower) risk-scored consumers in a probabilistic way. Since the subsidy and cost are also functions of individual risk-score, we can evaluate the marginal effect of premium and generosity on the profitability of sorting. If the sum of the two terms, $\frac{\partial pr_{ik}}{\partial x} S_{ik}$ and $\frac{\partial pr_{ik}}{\partial x} c_{ik}$, where $x = \{\tilde{p}, G\}$, are positive, then higher x brings the better sorting, that is, marginal consumer who joins the plan due to this changes in x is expected to bring high subsidy-cost margin.

The later summation yields the direct effect of premium and generosity on the per-enrollee profit. The premium would increase per-enrollee revenue directly as well as through the rebates and bids, which is according to financial constraints described in the previous subsection of the supply model. Generosity also affects subsidy through the rebate and the bid. Furthermore, an increase in generosity has a direct effect on cost, since per-enrollee cost is a function of generosity and its interaction with individual risk score and market cost shifter as follows.

$$\frac{\partial c_{ik}}{\partial g} = \gamma_1 + \eta_1 \cdot rs_i + \mu_1 * Z_m + \omega^g_{jmt}$$

From the constraints and estimates in the previous step, we have the value for the following derivatives.

$$\begin{aligned} \frac{\partial S_{ik}}{\partial g} &= rs_i \cdot \phi^b_g + \phi^{reb}_g, \quad if \quad rebate > 0 \\ &= 0, \qquad\qquad\qquad\quad otherwise \\ \frac{\partial S_{ik}}{\partial \tilde{p}} &= rs_i \cdot \phi^b_p + \phi^{reb}_p, \quad if \quad rebate > 0 \\ &= 0, \qquad\qquad\qquad\quad otherwise \end{aligned}$$

To understand the identification of the cost function parameters, we can rewrite these by equating marginal revenue and marginal cost with respect to premium and generosity, where cost parameters belongs only to marginal cost part as follows.

$$MR = MC$$

$$(5)\quad \sum_{k\in K_{jm}}\sum_{i\in I_m}[\frac{\partial pr_{ik}}{\partial p}[p_k + S(b_k, B_m, rs_i)] + \sum_{i\in I_m}[(1+\frac{\partial S_{ik}}{\partial \tilde{p}})\cdot prob_i] = \sum_{k\in K_{jm}}\sum_{i\in I_m}\frac{\partial pr_{ik}}{\partial p}[c(g_k, rs_i, Z_m, \omega^g) + \omega_{kmt}]$$

$$(6)\quad \sum_{k\in K_{jm}}\sum_{i\in I_m}[\frac{\partial pr_{ik}}{\partial g}[p_k + S(b_k, B_m, rs_i)] + \sum_{i\in I_m}[(\frac{\partial S_{ik}}{\partial g})\cdot prob_i] = \sum_{k\in K_{jm}}\sum_{i\in I_m}\frac{\partial pr_{ik}}{\partial g}[c(g_k, rs_i, Z_m, \omega^g) + \omega_{kmt}] + \sum_{i\in I_m}[(\frac{\partial c_{ik}}{\partial g})\cdot prob_i]$$

For each period, per-enrollee cost is realized as follows.

$$c(g_{kmt}, rs_{imt}, Z_{jmt}, \omega^g_{jmt}, \omega_{jmt}; \theta_{cost}) = \gamma_0 + \eta_0\cdot rs_{imt} + \mu_0 * Z_{jmt} + \omega_{jmt} + (\gamma_1 + \eta_1\cdot rs_{imt} + \mu_1 * Z_{jmt} + \omega^g_{jmt})\cdot g_{kmt} + \gamma 2exp(g_{kmt})$$

The first adverse selection parameter, η_0, can be identified from variation of marginal effect of generosity and price on the pool of enrollees, that is, how much the average risk score of the plan changes by the marginal changes of generosity and price. If both η_0 and β_1^{rs} from demand are positive, then, a marginal increase of generosity induces a pool of enrollees with higher risk-score and an increase in cost. This term varies across plans, since marginal effect of generosity on choice probability is also a function of generosity and price interacted with risk-score from a demand model. Furthermore, variation comes from markets due to the different distribution of risks-core across markets.

Adverse selection parameter interacted with generosity, η_1, is identified by changes in a direct and an indirect selection-related cost factors. A change in a direct factor is the variation of current pool of enrollees, $\sum rs_i prob_i$, and an indirect one is the marginal effect of generosity and premium on the pool of enrollees interacted with generosity, $(\sum_i rs_i * prob_{gi}) * g$ and $(\sum_i rs_i * prob_{pi}) * g$. If both η_1 and β_1^{rs} from demand are positive, it is more costly to increase generosity when a current pool is riskier (direct effect) and when the enrollee's risk pool sensitively respond to the changes in generosity with higher generosity level. Both terms are varying across plans since insurers offer a different level of generosity which attracts consumers differently across types, and also across markets due to the different distribution of risk-score cross counties.

Importantly, a left-hand-side variable, a marginal revenue with respect to generosity, is a function of generosity and risk-score. A risk score and generosity affects the choice probability, and risk-score itself affects per enrollee revenue through risk-adjusted subsidy after Risk-adjustment is implemented. The payment to the insurer is risk-score multiplied by the baseline payment, which is a benchmark in the pre-RA period and a bid for an insurer who bids lower than benchmark after 2006, varying across plans and markets. We also have time variation which represents the percentage of risk-adjustment implementation. This can also help to identify how marginal revenues are affected by the interaction of generosity and risk-score. I allow a fixed effect on a cost shock to be estimated

$$\omega_{jmt} = \omega_{jt} + \Delta\omega_{jmt}$$

Since all covariates in relation with cost parameters are functions of choice probability or the first order derivative of it, including endogenous choice variables, g, p, and N. Those choice variables are determined by insurers after they observe the cost shocks, $\Delta\omega_{jmt}$ and ω^g_{jmt}, thus they are correlated with the covariates of the parameters in the cost function. I estimate the cost function with 2 step GMM with the control function approach.

$$\Delta\omega = \tilde{\Delta\omega} + \phi_1 * u$$
$$\omega^g = \tilde{\omega^g} + \phi_2 * u$$

$$X = f(Z) + u,$$

where $X = \{g, p, N\}$, Z is instruments for endogenous variabes, X, which are uncorrelated with ωs. Then, the estimation procedure is as follows.

1) Solve for ω_{jmt} and ω^g_{jmt} from equation (3) and (4)
2) Considering a fixed effect on ω, construct within variables and back out $\Delta\omega$
3) Regress X on Z and estimate residuals, $\hat{u}$
4) Include estimated residuals, $\hat{u}$, into the equation for ω^g from step 1 and for $\Delta\omega$ from step 2
5) Construct moments with all covariates of parameters and exogenous parts of cost shocks $\tilde{\Delta\omega}$ and $\tilde{\omega^g}$

Instruments used for estimation of cost function are (1)Competitor's exogenous characteristics : proportion of opponent's plan types (2) Characteristics and prices of other plans and number of plans in other market, but which belongs to that insurer (3) Competitor's insurer-time level and market-level demand shocks, ξ and $\Delta\xi$.

Starting from (5) and (6), I now show how to derive moment conditions by backing out cost shocks from FOCs. I define the matrix Δ^p_{ilk} and Δ^g_{ilk} whose (l,k) element is given by

$$\begin{aligned}\Delta^p_{ilk} &= \frac{\partial pr_{ik}}{\partial \tilde{p}_l} \quad if \quad insurer(l) = insurer(k)\\ &= 0, \qquad otherwise\\ \Delta^g_{ilk} &= \frac{\partial pr_{ik}}{\partial g_l} \quad if \quad insurer(l) = insurer(k)\\ &= 0, \qquad otherwise\end{aligned}$$

I also define the matrix Δ^p_{lk} and Δ^g_{lk} whose (l,k) element is given by

$$\begin{aligned}\Delta^p_{lk} &= \sum_i^{I_m} \Delta^p_{ilk}\\ \Delta^g_{lk} &= \sum_i^{I_m} \Delta^g_{ilk}\end{aligned}$$

Applying these to (5) and (6), we can back out a cost shock which is not interacted with generosity level.

$$\begin{aligned}(\Delta^p_{lk})^{-1}\vec{MR}_p &= (\Delta^p_{lk})^{-1}\sum_{i\in I_m}\Delta^p_{ilk}\vec{c}(\vec{g}_j, rs_i, Z_m; \theta_{cost}) + \vec{\omega}_{jm}\\ (\Delta^g_{lk})^{-1}\vec{MR}_g &= (\Delta^g_{lk})^{-1}[\sum_{i\in I_m}\Delta^g_{ilk}\vec{c}(\vec{g}_j, rs_i, Z_m; \theta_{cost}) + \sum_{i\in I_m}\frac{\partial c_{ik}}{\partial g}\cdot prob_i] + \vec{\omega}_{jm}\end{aligned}$$

Finally, I remove $\vec{\omega}_{jm}$ to solve for the remaining cost shock interacted with generosity in a similar way. Then we can construct moment conditions using recovered cost shocks, $\vec{\omega}_{jm}$ and $\vec{\omega^g}_{jm}$, and instruments.

C. Results - Supply

From the estimation result of a cost function in table [Cost Parameters], adverse sorting is precisely verified by η. Demand estimates in the previous section show that consumers with the higher risk-score value the benefit generosity more. Cost estimates confirm that it is more costly for insurers to serve higher risk-scored consumers who more values the generosity. Specifically, the estimate for η_0 implies that one unit increase in risk-score causes \$524.2 higher per-enrollee-per-month cost. The estimate for η_1, which is interacted with generosity and risk-score, suggests that one unit increase in risk-score induces \$77 higher marginal cost of the generosity of MA plan. I also find a little non-linear effect of generosity on the per-enrollee cost of MA insurers.

The estimates of the other cost shifters in table [Cost Parameters] also explain heterogeneity in MA insurers cost across insurers, plans, and markets. An index for a market-level cost shifter, $\frac{total\ cost}{standardized\ cost}$, which captures the difference in wages, input prices and other culture in medical services, is positively associated with both the marginal cost of generosity and the per-enrollee fixed cost. Since I control insurer-year fixed effects, the estimates for ξ captures the effect of insurer's unobserved characteristics, or a demand shock, in each market-year on the market-level deviation of each insurer's fixed and marginal cost, which are negative and positive, respectively. In addition, HMO plans have lower fixed per-enrollee cost and the higher marginal cost of generosity. The last four columns in table [Cost Parameters] display how MA insurers finance extra benefits of their plans in addition to basic TM level coverage by their premiums and rebates. The estimates in brackets show the minimum and the maximum of estimates across different types of MA plans. These are higher than the estimates in Guglielmo (2016) because the measure of generosity in this paper is the relative OOPC for poor health status while it is the mean OOPC in his paper.

Table [MA insurer's cost and payment] displays MA insurer's (HMO) cost and payment by CMS in the market with median cost shifters and benchmark based on cost estimates in table [Cost Parameters]. First three columns show the MA plan's cost of serving consumers with different risk-score percentiles providing a different level of generosity. While relatively healthy (1% - 50%) consumers cost similarly across different benefit generosity, sick patients bring different costs to insurers depending on generosity. Specifically, for 99% risk-score, cost of MA plans with the top (95%) generosity is almost $900 higher per month than MA plans with bottom (5%) generosity.

The fourth and fifth columns in table [MA insurer's cost and payment] are payments to MA insurers by CMS under a pre-bidding system with no risk-adjustment and 50% risk-adjustment, respectively, where the baseline payment is the median benchmark, $732. The last three columns display payments under a bidding system with full (100%) risk-adjustment after 2007 and with different level of bids from MA insurers from the data. Cost estimates combined payment data suggests that consumers with risk-score above 50 percentile are unprofitable before risk-adjustment is fully implemented. For example, a consumer with 90 percentile risk-score incurs $1380 per month with median generosity, but the payments are $732 and $1093 under 0% and 50% of risk-adjustment, respectively. Furthermore, the cost of serving high risk-scored consumers is closely compensated by the risk-adjusted payments after 2007, especially if insurers' bids are positively correlated their choice of generosity.

	Cost Parameters	
	Per-enrollee fixed cost	Per-enrollee marginal cost
Generosity (γ_1)		-0.949^{***}
		(0.0288)
exp(Generosity) (γ_2)	0.002^{***}	
	(0.0002)	
Risk-score (η)	5.242^{***}	0.772^{***}
	(0.1117)	(0.0092)
Cost Shifters (μ)		
$\frac{total\ cost}{standardized\ cost}$	1.5^{***}	0.175^{***}
	(0.0987)	(0.0044)
ξ_{jmt}	-0.793^{***}	0.153^{***}
	(0.0133)	(0.0276)
HMO	-0.055^{***}	0.124^{***}
	(0.0029)	(0.0076)
Fixed Effects	Insurer·Year	
	Constraint Parameters	
$\phi^g_{1,2007}$	[1.266, 1.578]	
$\phi^g_{2,2007}$	[1.522, 2.045]	
$\phi^g_{1,2008}$	[2.144, 2.956]	
$\phi^g_{2,2008}$	[1.971, 2.285]	

MA insurer's cost and payment across different risk-scores								
	Per-enrollee Cost			Pre-bidding Payment		Payment with bids		
	Generosity Level			Partial RA		Full (100%) RA		
Risk-score (%)	5% G	50% G	95% G	0%	50%	5% bid	50% bid	95% bid
1%	2.911	2.346	1.731	7.320	4.755	1.893	2.672	3.905
5%	3.075	2.543	1.966	7.320	4.861	2.070	2.869	4.135
10%	3.302	2.814	2.290	7.320	5.007	2.314	3.140	4.454
25%	4.145	3.826	3.498	7.320	5.553	3.221	4.151	5.639
50%	5.765	5.768	5.817	7.320	6.599	4.964	6.090	7.914
75%	8.450	8.987	9.661	7.320	8.335	7.853	9.306	11.686
90%	12.464	13.799	15.407	7.320	10.929	12.171	14.112	17.324
95%	16.173	18.246	20.717	7.320	13.327	16.161	18.554	22.534
99%	26.326	30.419	35.253	7.320	19.890	27.084	30.712	36.795

Based on both demand and cost estimates, I quantify the impact of adverse sorting with respect to generosity on insurer's cost. In table [A Cost of Increasing Generosity of MA plans], I decompose the total cost of increasing generosity by $100 into a direct and an indirect effect. A direct effect explains changes in cost given the pool of enrollees fixed and an indirect effect explains changes in cost due to changes in the pool of enrollees.

The result suggests that a direct effect and an indirect effect account for 33% and 66%, respectively. This also implies an insurer's incentive to lower the generosity level without any risk-adjustment. Since risk-adjustment compensates the insurers who attract high risk-scored consumers and consumers become equally costly, the indirect cost is going to be reduced.

Cost of Increasing Generosity of MA plans		
Decomposition :	The effects of Δg by \$100 on expected per-enrollee cost $E(c) = \sum_i prob(g, rs)c(g, rs) \ / \sum prob$	
Total	Direct	Indirect - Changes in sorting
\$ 51	\$17	\$34
%	33%	67%

V. Fixed Cost

I specify the fixed cost of serving a different number of plans where ϕ denotes the cost of adding one more plan in the market as follows.

$$FC(K_{jmt}) = \phi_{jmt} \cdot K_{jmt}$$

I allow heterogeneous fixed costs across markets with different Medicare population or the market size. Specifically, I categorize markets by the percentile of the market size and the parameters for fixed cost are given for these different categories as follows.

$$\phi_{jmt} = \begin{cases} \phi_1, & if \quad 0 \leq F_N(N_{mt}) < 0.40 \\ \phi_2, & if \quad 0.40 \leq F_N(N_{mt}) < 0.70 \\ \phi_3, & if \quad 0.70 \leq F_N(N_{mt}) < 0.90 \\ \phi_4, & if \quad 0.90 \leq F_N(N_{mt}) < 0.95 \\ \phi_5, & if \quad 0.95 \leq F_N(N_{mt}) < 1 \end{cases}$$

where F_N is the empirical CDF for the market size across markets and N_{mt} denotes the market size of the market mt.

A. *Empirical strategy for the fixed cost of adding a plan*

I apply Pakes et al. (2015) to the identification of Φ. I assume that the numbers of plans observed in data, K^*, is any Nash equilibrium and the necessary condition implies that the number of plan chosen by each insurer is the best response to the other insurers' numbers of plans in data. Therefore, K^* maximizes the insurer's profit, and the alternative numbers of plans should give less profit than the profit by serving K^* number of plans. These constraints construct inequalities which identify the parameter of interest, ϕ.

First, I simplify the notation of the total profit, Π, as follows.

$$\Pi(K) = N \cdot \pi(K) - \phi_n \cdot K$$

where, N denotes the insurer's predicted number of Medicare population in each market and $\pi(K)$ denotes the expected per-enrollee profit of serving K number of plans. Furthermore, ϕ_n denotes heterogeneous fixed cost across market sizes, where $n \in \{1, 2, 3, 4, 5\}$ as described in the previous subsection. Therefore, the total expected profit is the total variable profit, $N \cdot \pi(K)$, minus the total fixed cost, $\phi_n \cdot K$.

Note that the total profit is just a function of the number of plans, not a function of quality and price. This is because I consider the expected per-enrollee profit given the optimal price and quality for each K which are solutions for the problem illustrated in [Insurer's Problem]. I re-write the expected per-enrollee profit as a function of K as follows.

$$\begin{aligned}\pi(K) &= \pi(K, \{g_k(K), p_k(K)\}_{k=1}^{K} \mid \{K'^*, \{G'^*, P'^*\}\}, X, \Xi, \Omega) \\ &= \sum_{k}^{K} \int_e [(p_k(K) + S(rs, B) - c(g_k(K), rs, Z, \omega, \omega^g)) \cdot prob_k(G, P, \Xi, e)] dF(e)\end{aligned}$$

where, $g_k(\cdot)$ and $p_k(\cdot)$ are the optimal choice function of quality and price for the k the plan, where $k \in \{1, \cdots, K\}$. In addition, K'^* and $\{G'^*, P'^*\}$ denote the vectors of other insurers' number of plans and quality and price of their insurance plans, respectively. An asterisk $(*)$ for K'^* and $\{G'^*, P'^*\}$ represents the fact that the choice variables of other insurers are given by those in equilibrium (data). Furthermore, X denotes the market-level variables, including average risk-score and income, cost shifters, and benchmark. Lastly, $\{\Xi, \Omega\}$ are vectors of demand and cost shocks for all insurers in the market.

ASSUMPTION 1 (Best response condition): $\Pi(K) \leq \Pi(K^*)$, *where* $K \neq K^*$ *and* K^* *is the number of plans in equilibrium*

By this assumption, I impose inequalities arising from necessary conditions of Nash equilibrium, or best response conditions. Specifically, the total profit of serving the number of plans, K^*, is greater than or equal to the total profit of serving the other number of plans where the quality and the price of insurance plans are chosen optimally for a given number of plans.

I consider two deviations for each insurer: one more plan, $K^* + 1$, and one less plan, $K^* - 1$, than the observed number of plans in data[18]. By assumption 1, the changes in the expected profit when insurer deviates from the N^* should be negative. I rewrite the inequality imposed by assumption 1 which are decomposed into two parts; changes in the variable profit and changes in the fixed cost as follows.

$$\begin{aligned}\Pi(K^* + 1) - \Pi(K^*) &= N(\pi(K^* + 1) - \pi(K^*)) - \phi < 0 \\ \Pi(K^* - 1) - \Pi(K^*) &= N(\pi(K^* - 1) - \pi(K^*)) + \phi < 0\end{aligned}$$

Note that the fixed cost is a linear function of the number of plans and changes in the

[18]I consider the case where the most profitable deviation is $N^* \pm 1$ and where the inequalities in assumption 1 holds for the number of plans $K^* \pm n$, *where* $n > 1$, whenever those for $K^* \pm 1$ hold.

fixed cost is ϕ as follows. [Best response inequality]

$$FC(K^*+1) - FC(K^*) = (\phi(K^*+1) - \phi K^*) = \phi$$
$$FC(K^*-1) - FC(K^*) = (\phi(K^*-1) - \phi K^*) = -\phi$$

I allow that the number of Medicare population which insurers predict, N, could be different from the true Medicare population, N^*, which is observed in data. I specify the number of plans that I, as an econometrician, observe in data as follows.

$$N^* = N + \epsilon$$

where ϵ denotes the measurement error arising from the difference between the number of plans which insurers actually expect and that I observe in data.

ASSUMPTION 2: *(i) A measurement error, ϵ, is identically and independently distributed and (ii) $E[\epsilon \mid N, K^*, I] = 0$, where K^* and I denote the number of plans that each insurer chooses and the number of insurers in each market, respectively.*

By this assumption, I impose the mean independence of the measurement error on the number of insurers in the market and each insurer's number of plans as well as the insurers' predicted market size. I rewrite inequalities from [Best response inequality] substituting N^* for N as follows.

$$N^*(\pi(K^*+1) - \pi(K^*)) - \epsilon(\pi(K^*+1) - \pi(K^*)) - \phi < 0$$
$$N^*(\pi(K^*-1) - \pi(K^*)) - \epsilon(\pi(K^*-1) - \pi(K^*)) + \phi < 0$$

I first obtain the unconditional moment for the upper and lower bound of the fixed cost by simply taking expectation as follows.

$$\underline{\phi} = E[N^*(\pi(K^*+1) - \pi(K^*))] < \phi$$
$$\bar{\phi} = E[N^*(\pi(K^*) - \pi(K^*-1))] > \phi$$

Note that the expectation of the error term associated with these moments, $\epsilon(\pi(K^*+1) - \pi(K^*))$ and $\epsilon(\pi(K^*-1) - \pi(K^*))$, are zero. It is straightforward after applying the law of iterated expectation and assumption 2 to these terms as follows.

$$\begin{aligned} E[\epsilon(\pi(K^*+1) - \pi(K^*))] =& E[E[\epsilon(\pi(K^*+1) - \pi(K^*)) \mid K^*]] \\ =& E[E[\epsilon \mid K^*](\pi(K^*+1) - \pi(K^*))] \\ =& 0 \end{aligned}$$

ASSUMPTION 3: *Estimates in demand and variable cost function satisfy*

$$\pi(\cdot) = \hat{\pi}(\cdot)$$

where, $\Delta\hat{\pi}(\cdot)$ denotes $\Delta\pi(\cdot)$ evaluated at $\hat{\Theta}, \hat{F}$, where $\hat{\Theta}$ and $\hat{F}$ denote the demand and *the per-enrollee cost parameters and the estimated distribution of individual risk-score and income, respectively.*

Under assumption 3, the per-enrollee profit is measured without an error by the per-enrollee profit evaluated by the estimates derived from the previous section. This assumption is common in the literature.

Therefore, the lower bound of fixed cost, $\underline{\phi}$, and the upper bound of fixed cost, $\bar{\phi}$, are estimated by the average gap between the total variable profit with K^* and K^*+1 and between K^* and K^*-1, respectively, as follows. [Estimator for the fixed cost]

$$\hat{\underline{\phi}} = \frac{1}{JMT}\sum_{jmt}[N^*(\hat{\pi}(K^*+1) - \hat{\pi}(K^*))]$$
$$\hat{\bar{\phi}} = \frac{1}{JMT}\sum_{jmt}[N^*(\hat{\pi}(K^*) - \hat{\pi}(K^*-1))]$$

where JMT denotes the total number of insurer-market-time level observation.

I also consider conditional moments for the bounds of the fixed costs. The conditioning variables are the number of plans they choose, K^*, in equilibrium and the number of insurers, I, in the market. After taking expectation conditional on K^* and I, the conditional moments are given by,

$$E[N^*(\pi(K^*+1) - \pi(K^*)) \mid K^*, I] < \phi$$
$$E[N^*(\pi(K^*) - \pi(K^*-1)) \mid K^*, I] > \phi$$

In the estimation, I find the parameter set which minimizes the violation of the sample analogs of the conditional moments and the unconditional moments.

B. Results - Fixed Cost

Table [Fixed Cost Estimates] displays the lower and the upper bound for the fixed cost of adding plans per year. The estimates in the first and the second column are calculated by imposing unconditional moments and exactly corresponds to the estimator described in [Estimators for the fixed cost]. The third and the fourth column displays the lower and the upper bound estimates which minimize the violation of both conditional and unconditional moment inequalities. By imposing more restriction of conditional moments, the estimates of bounds are more tightened than those only from unconditional moments.

The estimates in different rows are fixed cost of adding insurance plans in the market with different sizes of Medicare population. The results suggest that the fixed cost is increasing in the market size, from \$33K to \$2M. The last column is for the per-plan-per-year variable profit. I find that the fixed cost of adding a plan accounts for from 12% in the smallest market to 40% in the largest market of the variable profit.

	Fixed Cost and Variable Profit (plan-year-level)				
	(1) Unconditional Moments		(2) Conditional Moments		(3) Variable Profit
	$\underline{\phi}^N$ (LB)	$\bar{\phi}^N$ (UB)	$\underline{\phi}^N$ (LB)	$\bar{\phi}^N$ (UB)	π
$\phi^N_{0-40\%}$	\$18,371	\$65,345	\$21,122	\$33,653	\$87,307
$\phi^N_{40-70\%}$	\$38,515	\$86,428	\$62,327	\$63,437	\$216,904
$\phi^N_{70-90\%}$	\$112,645	\$247,878	\$112,645	\$122,538	\$756,423
$\phi^N_{90-95\%}$	\$569,481	\$866,575	\$634,716	\$719,086	\$2,777,854
$\phi^N_{95-100\%}$	\$1,992,176	\$2,175,620	\$1,992,176	\$2,175,620	\$16,407,551

Note : The number of Medicare population in the five categories of markets is as follows.
$[0, 4936]$, $[4935, 11794]$, $[11795, 36923]$, $[36924, 69704]$, $[69705, 1087002]$

VI. Counterfactual Analysis

In this section, I do a counterfactual analysis for evaluating the impact of risk-adjustment. Risk-adjustment is implemented in Medicare Advantage and the payment to insurers has been adjusted for enrollee's risk since 2004. Even though the dataset of this paper covers both pre- and post-risk-adjustment periods (2003-2008), the counterfactual analysis is required to answer the research questions of this paper for several reasons. First, there are confounding factors to evaluate risk-adjustment in this period including the introduction of the bidding system and Part D, changes in the benchmark, or the other changes due to the Medicare Modernization Act. Therefore, separating out the risk-adjustment effect on Medicare Advantage from other effects could not be successful with a simple pre/post analysis. Secondly, as discussed in previous sections, the welfare impact of risk-adjustment could be ambiguous and different across market structures. I experiment risk-adjustment under a different number of insurers in the market given other factors fixed. Furthermore, I decompose the risk-adjustment effect on consumer welfare into the price and non-price effects. Specifically, I experiment with the risk-adjustment under the fixed contract assumption that insurers respond to risk-adjustment only by pricing given the number of plans and quality fixed. Then I compare the results to the risk-adjustment effect under flexible contract where insurers choose the quality and the number of plans as well as price. Finally, I search for the optimal risk-adjustment in Medicare Advantage in the counterfactual analysis.

A. Evaluation of the Current Risk-adjustment

Risk-adjustment is implemented and the payment to insurers is risk-adjusted by increasing the risk-adjustment parameter, λ, in the model of this paper. To evaluate current risk-adjustment system, I compare two cases; no risk-adjustment, $\lambda = 0$, and full risk-adjustment, $\lambda = 1$. The former and the latter cases correspond to risk-adjustment in Medicare Advantage before 2003 and after 2007, respectively.

To control the confounding effects varying across time mainly from changes in the regulation and the payment system, I fix the insurers, the markets, and the payment system in 2008. Specifically, I draw insurers fixed effects of demand-side unobserved characteristics and cost shocks and market-level variables including the number of Medicare beneficiaries, average income, average risk-score, or cost shifters in 2008. I also impose the bidding system which rollout began in 2006 to this experiment to evaluate risk-adjustment under the recent payment system.

I first consider the overall effects of risk-adjustment on equilibrium, such as price, generosity, a number of plans, enrollment, average risk-score of MA, profit, consumer surplus and diversity of insurance plans. I measure the diversity of insurance plans by the inverse of H index which measures how many different types of insurance plans are provided in the market in a different level of quality. I divide the quality level into 6 categories and calculate the number of insurance plans in each category and calculate the Herfindahl index as follows.

$$Diversity = 1/H, \quad where \quad H = \sum_{c=1}^{C} \frac{n_c^2}{N^2}$$

Furthermore, I consider different market structures from the monopoly to the markets with 5 insurers to compare the impact of risk-adjustment on plan diversity and welfare under the different level of competition. I also study the heterogeneous effects of risk-adjustment on consumer surplus across different risks of enrollees. This is to answer who benefits and loses from risk-adjustment, which is based on their heterogeneous preference over characteristics of insurance plans.

Overall Effects of Risk-adjustment

I first evaluate the overall impact of risk-adjustment in Medicare Advantage. The most significant changes are increases in price and generosity of insurance plans by 115% and 109%, respectively. This is explained by changes in insurers' incentives regarding the cost of serving risky consumers due to risk-adjustment. The risky consumers become more profitable by the increase in subsidy level and high-quality plan can be generated to attract risky consumers who value the quality more than healthy consumers. Accordingly, the average risk-score of Medicare Advantage plans increases by 7%, implying riskier consumers are more sorted into Medicare Advantage than before. The fact that MA average risk-score is below 1 (0.97) without risk-adjustment and above 1 (1.03) with risk-adjustment implies that insurers have cream-skimmed Medicare eligibles before risk-adjustment but it is resolved after risk-adjustment. However, insurers are seeking high-risk-scored consumers than healthy consumers after risk-adjustment, which potentially incur a loss of healthy consumers.

Furthermore, the number and the diversity of insurance plans increase by 12% and 8%, respectively. The diversity of insurance plans is measured by the reciprocal of Herfindahl index[19] and an increase in the index suggests that risk-adjustment induces insurance plans to be located in a more diverse level of quality, even given the same number of plans.[20]. This can be explained by the reduction in unprofitable consumers by risk-adjustment and the fact that diverse products could be possibly provided to the consumer with the diverse tastes of products without an impact of adverse selection.

Finally, the consumer surplus slightly decreases. This could be because there are only high-quality-high-premium plans without the low premium insurance plans. I investigate more detail about changes in consumer surplus in the following subsections by comparing the effects of risk-adjustment on consumer surplus under different market structures and across different risks.

[19] Herfindahl index measures both the number of categories and the relative density of each category, representing richness and evenness of observations in each category. Herfindahl index is at maximum (equal to one) when only one group is represented and at a minimum (equal to 1/(number of categories)) when all the observations are distributed evenly. (Kelly (1981), Haughton and Mukerjee (1995))

[20] This the result could be recalculated with different sampling for counterfactual analysis, by linking the insurers to markets. Current results are from the independent sampling of insurers and markets for the purpose of calculating heterogenous effects across different market structure

Overall Effects of Risk-adjustment			
	No RA	RA	Changes (%)
Generosity ($)	200.57	419.08	118.39
Price ($)	57.14	117.43	110.43
Profit ($K)	1008.93	1106.72	4.16
Consumer surplus ($)	191.31	186.23	-4.81
MA average risk-score	0.97	1.03	6.98
MA market share	0.09	0.09	2.81
Number of plans (market)	2.50	2.79	11.84
Number of plans (insurer)	1.25	1.40	11.84
Diversity (1/H)	1.50	1.63	8.37
Number of Simulation		550	

Note : Overall effects are calculated by weighted average of mean effects across markets. with different number of insurers. The weight is given by the number of markets with each number of insurers in data.

Risk-adjustment Effects across Markets with Different Number of Firms

The impact of risk-adjustment on consumer welfare is vastly heterogeneous across markets with a different number of insurers. I find that risk-adjustment enhances consumer welfare only under competition between Medicare Advantage insurers in Table [RA with the small number of insurers] and Table [RA with a large number of insurers]. Specifically, the overall consumer surplus increases by 9.5% and 17% in the market with 4 insurers and 5 insurers, respectively, while it decreases by 10.1%, 4.9%, and 5.2% under monopoly, duopoly, and triopoly, respectively.

This can be explained by the difference of changes in price relative to generosity and diversity between the cases with a different number of insurers. First, changes in the price (102%) is larger than changes in the generosity (86%) under monopoly, while the generosity increases (178%) more than the price (144%) under 5 insurers from Table [RA with the small number of insurers] and Table [RA with the large number of insurers]. This is because insurers competitively lower the price for attracting more consumers, leading to less increase in price relative to an increase in quality. Furthermore, an increase in generosity is greater in the market with more insurers, since they compete for attracting healthy (riskier) consumers by decreasing (increasing) the quality of insurance plans before (after) risk-adjustment.

Furthermore, changes in the available set of insurance plans are also different across markets with a different number of insurers. Specifically, insurance plans with a low premium could become unavailable after risk-adjustment, while high-quality insurance plans are newly provided. In table [The number of zero-premium plans (should be added)], the number of markets without zero-premium MA plans increases after risk-adjustment more under monopoly than under 5 insurers. Therefore, consumers who are sensitive to price but do not value the quality much could possibly lose from risk-adjustment more severely under monopoly than under 5 insurers. This argument is also supported by a large increase in MA risk-score and a small increase in MA share under monopoly, implying that the low-risk consumers are dropped out from MA plans while sick patients are sorted into MA.

Similarly, I find that an increase in the diversity of insurance plans with competition is larger with competition than without competition. The last rows in Table [RA with the small number of insurers] and Table [RA with a large number of insurers] suggests that insurance plans become located in diverse quality levels after risk-adjustment with competition, but this effect is small under monopoly. Under monopoly, the low-quality-low-premium plans are simply replaced by the high-quality-high-premium plans by risk-adjustment. This is consistent with the theory that products could be more further away from each other under price competition in the case where there is no adverse selection (Shaked and Sutton (1982)). To conclude, the sign and the level of the risk-adjustment effects on consumer welfare depend on the level of competition through the relative changes in price to quality and diversity effects.

Risk-adjustment Effects across Market Structure

	1 Insurers			5 Insurers		
	No RA	RA	Changes (%)	No RA	RA	Changes (%)
Generosity ($ / month)	241.79	450.49	86.31	152.94	425.46	178.19
Price ($/ month)	75.23	152.01	102.07	29.87	73.03	144.51
Profit ($K / month)	1593.39	1811.98	13.72	521.73	411.92	-21.05
Consumer surplus ($)	126.39	113.52	-10.19	312.07	365.17	17.02
MA average risk-score	0.95	1.05	10.97	1.02	1.04	2.31
MA market share	0.06	0.06	1.70	0.17	0.18	4.16
Number of plans (market)	1.37	1.53	12.20	5.58	6.35	13.73
Number of plans (insurer)	1.37	1.53	12.20	1.12	1.27	13.73
Diversity (1/H)	1.16	1.22	5.14	2.16	2.67	23.42
Number of Simulation		120			80	

Risk-adjustment Effects across Consumers with Different Risk-score

The changes in the set of insurance plans by risk-adjustment have different impacts on consumers if the preference over the insurance plans is different across consumers. From demand estimates, I find that riskier consumers value the quality of insurance plans more and less sensitive to the price. Table [Risk-adjustment effects] shows changes in consumer surplus across different level of risk-score for the markets with a different number of insurers. The result suggests that healthy consumers benefit more than sick patients under monopoly. Consumer surplus decreases by 5% and 14% for the riskiest and the healthiest type, respectively. This is because healthy consumers lose more by the excessive increase in price and by the absence of the low premium insurance plans. In the 5 insurers case, where the overall consumer surplus increases, sick patients more better off than the low-risk consumers. Specifically, the consumer surplus of the riskiest type and the healthiest type increases by 21% and 13%, respectively. This is mainly because riskier consumers more value the newly generated plans with high quality than healthy consumers. However, even healthy consumers better off by risk-adjustment since price does not go up extremely and there are still insurance plans with the low premiums in the market with a large number of insurers.

Risk-adjustment Effects with the Small Number of Insurers

	1 Insurers			2 Insurers			3 Insurers		
	No RA	RA	Changes (%)	No RA	RA	Changes (%)	No RA	RA	Changes (%)
Generosity ($ / month)	241.79	450.49	86.31	192.04	415.38	116.30	172.93	361.95	109.30
Price ($ / month)	75.23	152.01	102.07	52.33	103.30	97.38	42.79	85.88	100.68
Profit ($K / month)	1593.39	1811.98	13.72	717.74	797.18	11.07	485.10	463.90	-4.37
Consumer surplus ($ / month)	126.39	113.52	-10.19	197.70	188.02	-4.90	257.87	244.53	-5.17
MA average risk-score	0.95	1.05	10.97	0.98	1.03	5.12	0.96	0.99	2.94
MA market share	0.06	0.06	1.70	0.09	0.09	3.23	0.11	0.11	3.53
Number of plans (market)	1.37	1.53	12.20	2.44	2.82	15.68	3.43	3.61	5.21
Number of plans (insurer)	1.37	1.53	12.20	1.22	1.41	15.68	1.14	1.20	5.21
Diversity (1/H)	1.16	1.22	5.14	1.57	1.67	6.33	1.89	1.95	3.48
Number of Simulation	120			150			100		

Risk-adjustment Effects with the Large Number of Insurers

	4 Insurers			5 Insurers		
	No RA	RA	Changes (%)	No RA	RA	Changes (%)
Generosity ($ / month)	100.87	369.51	266.32	152.94	425.46	178.19
Price ($/ month)	26.76	77.32	189.71	29.87	73.03	144.51
Profit ($K / month)	258.13	176.36	-31.68	521.73	411.92	-21.05
Consumer surplus ($)	279.26	305.86	9.52	312.07	365.17	17.02
MA average risk-score	0.99	1.03	3.50	1.02	1.04	2.31
MA market share	0.10	0.11	5.23	0.17	0.18	4.16
Number of plans (market)	4.41	4.80	9.01	5.58	6.35	13.73
Number of plans (insurer)	1.10	1.20	9.01	1.12	1.27	13.73
Diversity (1/H)	1.71	2.21	29.47	2.16	2.67	23.42
Number of Simulation		80			80	

Risk-adjustment Effects on Consumer Surplus across Risk-score					
Risk-score (%)	1	2	3	4	5
1	-14.25	-7.32	-7.81	7.21	12.96
25	-13.94	-7.06	-7.54	7.49	13.20
50	-13.53	-6.74	-7.21	7.86	13.51
75	-12.78	-6.13	-6.60	8.53	14.08
95	-4.75	0.92	0.41	15.61	21.21
Number of Simulation			550		

Total Welfare

[To be added]

B. Risk-adjustment Effects on Consumer Surplus under the fixed contract and the flexible contract

Finally, I find that the impact of risk-adjustment on welfare could be inaccurately estimated without allowing an endogenous set of insurance plans in the market. I do the same counterfactual analysis of risk-adjustment under fixed contract assumption, where insurers adjust their premium in a response to the risk-adjustment given the number of plans and quality of insurance plans fixed. [21] (Table [price effects under the fixed contract] should be added) In table [], the price of a high-quality plan decreases and the price of the low-quality plan increases because the consumers in a high-quality plan become less costly and those in the low-quality plan becomes more costly by risk-adjustment. Table [Decomposition] illustrates changes in price, average MA risk-score, and consumer surplus by risk-adjustment under two different assumptions. The changes in price by risk-adjustment barely affect the consumer surplus in Medicare Advantage. The results under the fixed contract assumption underestimate the negative effects of risk-adjustment under monopoly and also underestimates the positive effects of risk-adjustment from an increase in quality and diversity of insurance plans under competition. Therefore, the endogenous provision of insurance plans should be considered as the key channel for correctly evaluating the risk-adjustment.

Decomposition : Overall Consumer Surplus						
	Fixed Contract			Flexible Contract		
Number of Insurers	No RA	RA	Changes (%)	No RA	RA	Changes (%)
1	126	125	-0.93	126	114	-10.19
2	198	196	-0.70	198	188	-4.90
3	258	254	-1.46	258	245	-5.17
4	286	284	-0.87	286	305	6.63
5	312	310	-0.81	312	365	17.02
Number of Simulation		550			550	

[21] I fixed the number and the quality of insurance plans to the level in the case without risk-adjustment.

C. Optimal Risk-adjustment

[To be added]

VII. Conclusion

This paper empirically measures the impact of adverse selection on welfare in Medicare Advantage. I first develop and estimate an oligopoly model of Medicare Advantage. The estimates verify that insurers have incentives not to serve the high-quality insurance plan because it attracts relatively sick patients more than healthy beneficiaries. Furthermore, MA insurers could cream-skim the beneficiaries from the traditional Medicare (extensive margins) as well as from each other within MA (intensive margins), because traditional Medicare is more attractive to high-risk-scored consumers than Medicare Advantage.

Using these estimates, I assess the impact of risk-adjustment on welfare in the counterfactual analyses. I first find that the risk-adjustment barely affects consumer welfare through pricing given the fixed contract design. However, changes in the quality and the number of insurance plans turns out to be the main factors driving the impact of risk-adjustment on consumer welfare. Furthermore, the impact of risk-adjustment on consumer welfare differs across beneficiaries' risks and across markets with a different number of firms. Specifically, risk-adjustment decreases consumer surplus under monopoly since an increase in the premium outweighs quality improvement for most consumers, especially for healthy consumers. Under the higher level of competition, however, risk-adjustment increases the diversity of insurance plans and consumer surplus, especially for sick patients.

In conclusion, it is crucial to promote competition in health insurance markets with risk-adjustment. This is because risk-adjustment could simply substitute the high-quality-high-premium plans for the low-quality-low-premium plans, not leading to more diverse plans without competition. The future work includes the possible options for better risk-adjustment such as implementing a different level of risk-adjustment across markets with a different number of insurers. For example, the subsidy could be less risk-adjusted in the market with a small number of insurers or under monopoly. Moreover, a mandate of zero-premium plans for MA insurers could be another option. This is because the welfare loss by risk-adjustment is partly due to a decrease in the number of low-premium insurance plans in Medicare Advantage.

REFERENCES

Aizawa, Naoki and You Suk Kim, "Advertising and risk selection in health insurance markets," *American Economic Review*, 2018, *108* (3), 828–67.

Akerlof, George A, "QUALITY UNCERTAINTY AND THE," *The quarterly journal of economics*, 1970, *84* (3), 488–500.

Azevedo, Eduardo M and Daniel Gottlieb, "Perfect competition in markets with adverse selection," *Econometrica*, 2017, *85* (1), 67–105.

Berry, Steven, James Levinsohn, and Ariel Pakes, "Automobile prices in market equilibrium," *Econometrica: Journal of the Econometric Society*, 1995, pp. 841–890.

_ , _ , and _ , "Differentiated products demand systems from a combination of micro and macro data: The new car market," *Journal of political Economy*, 2004, *112* (1), 68–105.

Bresnahan, Timothy F and Robert J Gordon, *The economics of new goods*, Vol. 58, University of Chicago Press, 2008.

Brown, Jason, Mark Duggan, Ilyana Kuziemko, and William Woolston, "How does risk selection respond to risk adjustment? New evidence from the Medicare Advantage Program," *American Economic Review*, 2014, *104* (10), 3335–64.

Carey, Colleen, "Technological change and risk adjustment: benefit design incentives in medicare Part D," *American Economic Journal: Economic Policy*, 2017, *9* (1), 38–73.

Chiappori, Pierre-André and Bernard Salanie, "Testing for asymmetric information in insurance markets," *Journal of political Economy*, 2000, *108* (1), 56–78.

Crawford, Gregory S, "Endogenous product choice: A progress report," *International Journal of Industrial Organization*, 2012, *30* (3), 315–320.

_ , Oleksandr Shcherbakov, and Matthew Shum, "The welfare effects of endogenous quality choice in cable television markets," 2015.

Curto, Vilsa, Liran Einav, Jonathan Levin, and Jay Bhattacharya, "Can health insurance competition work? Evidence from medicare advantage," Technical Report, National Bureau of Economic Research 2014.

Decarolis, Francesco and Andrea Guglielmo, "Insurers' response to selection risk: Evidence from Medicare enrollment reforms," *Journal of health economics*, 2017, *56*, 383–396.

Draganska, Michaela, Michael Mazzeo, and Katja Seim, "Beyond plain vanilla: Modeling joint product assortment and pricing decisions," *QME*, 2009, *7* (2), 105–146.

Einav, Liran and Amy Finkelstein, "Selection in insurance markets: Theory and empirics in pictures," *Journal of Economic Perspectives*, 2011, *25* (1), 115–38.

Ellis, Randall P and Thomas G McGuire, "Predictability and predictiveness in health care spending," *Journal of health economics*, 2007, *26* (1), 25–48.

_ , Timothy Layton et al., "Risk selection and risk adjustment," *Encyclopedia of Health Economics, forthcoming*, 2013.

Fan, Ying and Chenyu Yang, "Competition, product proliferation and welfare: A study of the us smartphone market," 2016.

Frank, Richard G, Jacob Glazer, and Thomas G McGuire, "Measuring adverse selection in managed health care," in "Models of Health Plan Payment and Quality Reporting," World Scientific, 2017, pp. 29–57.

Geruso, Michael and Thomas G McGuire, "Tradeoffs in the design of health plan payment systems: Fit, power and balance," *Journal of health economics*, 2016, *47*, 1–19.

—, Timothy J Layton, and Daniel Prinz, "Screening in contract design: evidence from the Aca health insurance exchanges," Technical Report, National Bureau of Economic Research 2016.

Glazer, Jacob, Thomas McGuire, and Julie Shi, "Risk Adjustment of Health Plan Payments to Correct Inefficient Plan Choice from Adverse Selection," Technical Report, National Bureau of Economic Research 2014.

Guglielmo, Andrea, "Competition and costs in medicare advantage," Technical Report, mimeo 2016.

Haughton, Dominique MA and Swati Mukerjee, "The economic measurement and determinants of diversity," *Social Indicators Research*, 1995, *36* (3), 201–225.

Hausman, Jerry, "Cellular telephone, new products, and the CPI," *Journal of business & economic statistics*, 1999, *17* (2), 188–194.

Hausman, Jerry A, "Valuation of new goods under perfect and imperfect competition," in "The economics of new goods," University of Chicago Press, 1996, pp. 207–248.

Hendren, Nathaniel, "Private information and insurance rejections," *Econometrica*, 2013, *81* (5), 1713–1762.

Kelly, William A, "A generalized interpretation of the Herfindahl index," *Southern Economic Journal*, 1981, pp. 50–57.

Kuziemko, Ilyana, Katherine Meckel, and Maya Rossin-Slater, "Do insurers risk-select against each other? evidence from medicaid and implications for health reform," Technical Report, National Bureau of Economic Research 2013.

Lustig, Josh, "Measuring welfare losses from adverse selection and imperfect competition in privatized medicare," *Manuscript. Boston University Department of Economics*, 2010.

Mahoney, Neale and E Glen Weyl, "Imperfect competition in selection markets," *Review of Economics and Statistics*, 2017, *99* (4), 637–651.

McGuire, Thomas G, Joseph P Newhouse, and Anna D Sinaiko, "An economic history of Medicare Part C," *The Milbank Quarterly*, 2011, *89* (2), 289–332.

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

Miller, Keaton, "Do private medicare firms have lower costs," *University of Oregon Unpublished Mimeo*, 2014.

Moorthy, K Sridhar, "Market segmentation, self-selection, and product line design," *Marketing Science*, 1984, *3* (4), 288–307.

Mussa, Michael and Sherwin Rosen, "Monopoly and product quality," *Journal of Economic theory*, 1978, *18* (2), 301–317.

Pakes, Ariel, Jack Porter, Kate Ho, and Joy Ishii, "Moment inequalities and their application," *Econometrica*, 2015, *83* (1), 315–334.

Petrin, Amil, "Quantifying the benefits of new products: The case of the minivan," *Journal of political Economy*, 2002, *110* (4), 705–729.

Rothschild, Michael and Joseph Stiglitz, "Equilibrium in competitive insurance markets: An essay on the economics of imperfect information," in "Uncertainty in economics," Elsevier, 1978, pp. 257–280.

Saltzman, Evan, "Managing Adverse Selection in Health Insurance Markets: Underinsurance vs. Underenrollment," *Underenrollment (September 27, 2018)*, 2018.

Shaked, Avner and John Sutton, "Relaxing price competition through product differentiation," *The review of economic studies*, 1982, pp. 3–13.

Shepard, Mark, "Hospital network competition and adverse selection: Evidence from the Massachusetts health insurance exchange," Technical Report, National Bureau of Economic Research 2016.

Stockley, Karen, Thomas McGuire, Christopher Afendulis, and Michael E Chernew, "Premium Transparency in the Medicare Advantage Market: Implications for Premiums, Benefits, and Efficiency," Technical Report, National Bureau of Economic Research 2014.

Sweeting, Andrew, "Dynamic product repositioning in differentiated product markets: The case of format switching in the commercial radio industry," Technical Report, National Bureau of Economic Research 2007.

Town, Robert and Su Liu, "The welfare impact of Medicare HMOs," *RAND Journal of Economics*, 2003, pp. 719–736.

Veiga, André and E Glen Weyl, "Product design in selection markets," *The Quarterly Journal of Economics*, 2016, *131* (2), 1007–1056.

Wollmann, Thomas G, "Trucks without bailouts: Equilibrium product characteristics for commercial vehicles," *American Economic Review*, 2018, *108* (6), 1364–1406.

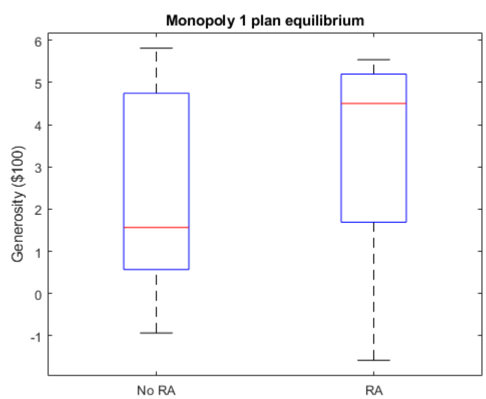
VIII. Appendix

A. *The impact of risk-adjustment on plan diversity under monopoly and duopoly*

In the counterfactual simulation, each insurer frequently provides a single plan both with and without risk-adjustment. Therefore, I focus on the single-plan equilibrium where one plan is provided under monopoly and two plans are provided under duopoly and risk-adjustment does not increase the number of insurance plans. By this experiment, the effect of risk-adjustment on plan quality given the number of plans fixed. The result suggests the impact of risk-adjustment on plan diversity are different. Under monopoly, though risk-adjustment increase generosity of insurance plan, the low-premium plan for low-cost consumers becomes unavailable. However, under duopoly, risk-adjustment increases plan diversity by preserving the L plans and generating H plans.

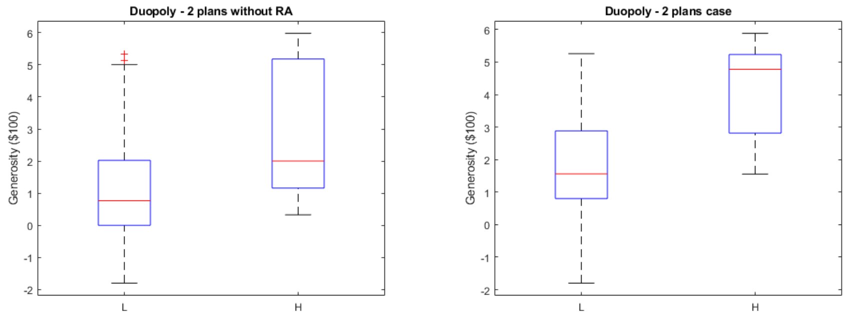
The risk-adjustment effect on a single plan equilibrium under monopoly

Figure [The Risk-adjustment Effect on A Single Plan Equilibrium under Monopoly] displays an insurance plan with the high generosity and the high premium frequently is replaced by the plan with the low generosity and the low premium under monopoly.



The risk-adjustment effect on a single plan equilibrium under duopoly

Figure [The Risk-adjustment Effect on A Single Plan Equilibrium under Duopoly] displays the case where one of two insurers stay in the relatively low generosity and low premium and the other chooses to increase generosity and premium much higher after risk-adjustment.



The risk-adjustment effect on a single plan equilibrium under triopoly