Partial Rating Area Offering in the ACA Marketplaces: Facts, Theory and Evidence *

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Abstract

In the health insurance marketplaces established by the Affordable Care Act (ACA), each state is divided into a set number of geographic "rating areas." The ACA mandates that an insurer price its health insurance plan *uniformly* in all counties within the same rating area, conditional on insurees' age and smoking status. However, the ACA does *not* require that an insurer sell its plan in all counties in a rating area. Using the federal marketplace data, we quantify the prevalence of a phenomenon, which we refer to as *partial rating area offering*, where insurers enter some but not all of the counties in a rating area. To understand why insurers selectively enter a subset of the counties in a rating area, we develop a simple model of insurer competition. The model implies that if common county characteristics, such as the county's risk distribution, market size and provider availability, are the primary drivers for the partial rating area offering phenomenon, then there would be a positive correlation among insurers' entry decisions. In contrast, if the partial rating area offering phenomenon is driven by market segmentation, then there would be a negative correlation. We develop a novel nonparametric correlation test and apply it to the federal marketplace data. We find strong evidence for a positive correlation of insurers' entry decisions, suggesting that common cost factors are the main driver for the partial rating area offering phenomenon. To the extent that it is a concern that many counties now have few insurers, our result suggests that it is important to offer insurers subsidies that are tied to county characteristics.

Keywords: Affordable Care Act; Health Insurance Marketplace; Rating Area; Service Area

JEL Classification Codes: I11, I13, L1

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1 Introduction

The Patient Protection and Affordable Care Act (ACA) established state-by-state health insurance marketplaces which came into full operation in October 2013. The ACA heavily regulates factors that insurers can use for pricing insurance plans. To limit insurers' ability to vary premiums by geographic region, each state is divided into a set number of geographic "rating areas" which were approved by the federal government before the opening of the marketplaces. The division of the rating areas was primarily based on differences in health care provider prices, and in most states, a rating area is composed of several counties. One of the most notable ACA regulations is the requirement that an insurer price its health insurance plan *uniformly* in all counties within the same rating area, conditional on insurees' age and smoking status. However, the ACA does *not* require that a plan be sold in *all* counties within the rating area.

In this paper, we investigate (1) whether insurers sell plans that cover only a strict subset of counties of a rating area – a phenomenon which we refer to as *"partial rating area offering"* – and if so, (2) what the underlying driving forces are. Note that if insurers in the marketplaces issue plans that are sold in some but not all counties of a rating area, then the geographic risk adjustments are effectively based on counties, and not rating areas. Furthermore, different insurer motives for the partial rating area offering phenomenon may call for different policy remedies. For example, if insurers are using partial rating area offering to divide up a rating area with their competitors and avoid head-on competition, then a direct regulation on insurers' *service area* could be called for.[1] On the other hand, if insurers are not offering plans in high-cost counties where it is almost impossible to avoid a loss, then mandating all plans be offered in all counties of a rating area might instead trigger insurer exits. In this case, a different policy intervention should be considered such as providing subsidies that are tied to the risk scores of counties.

We first assess the prevalence of the partial rating area offering phenomenon in the health insurance marketplaces. Our main data come from the 2016 Marketplace Public Use Files collected by the Centers for Medicare and Medicaid Services. The dataset has the universe of individual health insurance plans sold in the 38 states that receive support from the Department of Health and Human Services for their marketplace operations. Based on various statistics developed in this paper, we find that partial rating area offering is quite common in the marketplaces: about 30% of

[1] A service area of a marketplace health insurance plan is the set of counties where the plan is sold. Note that marketplace plans that partially cover a county are almost never approved by the federal government.

the insurance companies exclude at least one county from their service area while selling plans to other counties in the same rating area.

We then present empirical facts that suggest that insurers avoid entering counties with unfavorable market conditions. Using county data from the Area Health Resources Files and the County Health Rankings, we find that counties with relatively fewer potential marketplace enrollees and a higher share of unhealthy consumers have lower insurer participation rates. As the division of rating areas was not strictly based on differences in health risks, counties belonging to the same rating area may have heterogeneous expected medical care spending distributions which could strengthen insurers' risk screening motives. Using the Medicare Advantage service area data, we also find that insurers' entry probability is lower in counties where they did not sell Medicare Advantage plans prior to the ACA. This descriptive pattern suggests that insurers may be less likely to enter counties where they face a large fixed cost of building a provider network.

Motivated by these facts, we develop a simple model of insurer competition within a rating area. Counties in the rating area are differentiated by their market size and their medical care spending distribution. In addition, each insurer faces a fixed cost of entry that varies by county. Insurers simultaneously decide which counties to enter and how to price their plans. An insurer's total fixed cost increases in the number of plans it offers in the rating area. If an insurer sells the same plan to multiple counties, then its price has to be the same for all of the serviced counties, as required by the ACA. Insurer competition in a county takes a form of Bertrand competition with a spurious product differentiation. In the Nash equilibrium, each insurer's entry and pricing decisions are best responses to those of its competitors.

We parameterize the model and numerically compute the equilibrium for a wide range of parameter values. The model implies that when partial rating area entry is driven by insurers' avoidance of counties with unfavorable market conditions (e.g., adverse risk distribution, low demand or high fixed cost of entry), insurers' county-level entry decisions are positively correlated within the rating area. For example, insurers would pool to not servicing the high cost counties. On the other hand, when partial rating area entry is driven by market segmentation, insurers' county entry decisions are negatively correlated as they avoid entering counties where competitors are present.

To test the relative importance of common market characteristics and market segmentation effect, we develop a novel nonparametric correlation test. Our measure of correlation quantifies the average alignment of insurers' county-level entry decisions in a given rating area. We construct a test statistic based on this correlation measure, and test the null hypothesis of independent and random entry against the alternative hypotheses of positively or negatively correlated entry. We reject the null in favor of positively correlated entry at a very small significance level. We therefore find that county characteristics have a larger impact on insurers' entry decisions than the market segmentation effect.

We also use regression analysis to examine which county characteristics are the primary drivers of the positive correlation in the insurers' entry patterns. When we control for heterogeneity in county health risks, market size, and provider costs, the positive correlation disappears, suggesting that these county characteristics are the primary factors driving the positive correlation. In particular, insurers avoid counties with worse health measures, which implies that, to encourage entry, geographic risk adjustments need to be effectively based on counties instead of rating areas.

The findings presented in this paper have several policy implications. First, rating area regulation only delivers an imperfect government control over insurers' ability to vary premiums by geographic region. As documented in this paper, residents of the same rating area can face *de facto* different premiums for the same plan depending on which counties they live. Second, the current risk adjustment program, which transfers funds from plans with lower risk enrollees to plans with higher risk enrollees, is not very effective in eliminating insurers' risk screening incentive. Counties with a higher share of unhealthy consumers are still more likely to be excluded from insurers' service area in the marketplaces. Third, providing insurers with subsidies that are tied to their service area could increase insurer participation, especially in counties that have traditionally had a difficult time attracting insurers.

Our paper is related to the literature on the design of the health insurance exchanges. Many papers in this literature use data from the Massachusetts health insurance exchange, which was established in 2006 and have regulation settings similar to the ACA marketplaces, such as age-based pricing (Ericson and Starc, 2015), individual mandate (Hackmann et al., 2015), and subsidies (Finkelstein et al., 2017; Jaffe and Shepard, 2017). Recent work by Dafny et al. (2017) and Polsky et al. (2016) use ACA marketplace data to examine the prevalence of narrow provider networks and their potentials for lowering premiums.[2] We contribute to this literature by documenting, for the first time to the best of our knowledge, the prevalence of the partial rating area offering

[2]Studies that use estimates based on non-individual health insurance markets, and use simulations to study ACA-like settings include Handel et al. (2015), Aizawa and Fang (2015), and Azevedo and Gottlieb (2017).

phenomenon, and studying insurers' entry/exit responses to the community rating requirement based on geographic rating areas using a novel nonparametric correlation test.

The remainder of the paper is structured as follows. In Section 2, we describe our data. In Section 3, we demonstrate the prevalence of partial rating area offering and provide descriptive patterns. In Section 4, we present our model of insurer competition. In Section 5, we develop and implement a nonparametric correlation test. In Section 6, we conduct a regression analysis. Finally, in Section 7, we conclude.

2 Data

2.1 Brief Background on ACA Marketplaces and Rating Areas

Before the ACA, individual health insurance sold in most states was medically underwritten; insurers could deny coverage or charge a higher premium based on many factors including health status and medical history.[3] The ACA aims to limit such underwriting practices, and mandates that in each state marketplace, premiums be adjusted only for an individual's age, tobacco use and geographic location. Each state has a set number of geographic rating areas that all insurers participating in the state's marketplace must uniformly use in their price setting. The default geographic rating areas for each state was the Metropolitan Statistical Areas (MSAs) plus the remainder of the state that is not included in a MSA. However, states were given a chance to seek approval from the Department of Health and Human Services (HHS) for a different division method, provided that the division method was based on counties, three-digit zip codes, or MSAs/non–MSAs. Furthermore, states had to demonstrate how the new division method would (1) reflect significant differences in health care costs by rating area, (2) lead to stability in rates over time, (3) apply uniformly to all insurers in a market, and (4) not be unfairly discriminatory.[4]

If a state already had an existing rule to divide the state into rating areas, the state frequently kept the division rule to minimize shocks to insurers (Giovannelli et al., 2014). States without such legacy used differences in provider costs to divide the state. In doing so, some states explicitly ruled out morbidity and health risk differences as the ACA prohibits price discrimination based on health.

[3]Source: Kaiser Family Foundation.
[4]Source: Centers for Medicare and Medicaid Services.

Table A1 in Appendix A provides information about each state's method for dividing the state into rating areas. The geographic scope of implemented rating areas varies greatly by state. Seven states (Alabama, New Mexico, North Dakota, Oklahoma, Texas, Virginia, and Wyoming) have the federal default MSAs+1. Six states (Delaware, Hawaii, New Hampshire, New Jersey, Rhode Island, and Vermont) and District of Columbia have a single rating area, meaning that there is no premium adjustment for geographic location within the state. On the other extreme, states like Florida and South Carolina have single-county rating areas, implying that premiums vary by county within the state.

2.2 Data

Marketplace Public Use Files. Our main data come from the 2016 Marketplace Public Use Files (PUF) provided by the Centers for Medicare and Medicaid Services (CMS). The data cover 38 states participating in federally-facilitated marketplaces; the last column in Table A1 indicates whether a state has a federally-facilitated marketplace.[5] From the data, we can obtain information on plan characteristics including benefits, copayments, premiums, and the set of counties where a plan is sold, which is referred to as the plan's *service area*. In Section 3, we use this service area information to assess how prevalently insurers enter a strict subset of counties in a rating area.

There are 4,125 individual health plans offered in 38 federally-facilitated marketplaces in year 2016. We impose the following set of restrictions on the data. First, we exclude two states, Alaska and Nebraska, that use zip codes, rather than counties, to define rating areas. This is because our unit of analysis is at the county level.[6] Imposing this restriction leaves us with 4,059 plans offered by 235 insurers in 36 states and 405 rating areas. Second, we only keep plan-rating area combinations for which we have both service area and premium information. This restriction reduces the number of plan-rating area combinations from 20,569 to 19,991. Table 1 summarizes our sample after imposing this restriction. Lastly, we exclude rating areas that consist of a single county because in such rating areas, there can be no partial rating area offering by definition. Out of the 405 rating areas, 146 have just one county and we exclude them from the sample. Imposing this restriction

[5]The degree to which states rely on the HHS varies; 27 states have marketplaces that are entirely operated by the HHS, 7 states perform in-person consumer assistance while delegating all other functions to the HHS, and 4 states are responsible for performing their own marketplace functions, except that they rely on the federal IT platform. In this paper, we refer to the 38 states that rely on the HHS for any support as having federally-facilitated marketplaces.

[6]We focus on insurers' entry decisions at the county level because the federal government almost never approves plans that are not sold to all residents of a county.

Plans	Insurers	Networks	States	RAs	Non Single County RAs	Counties	Plan-RA
4,059	235	471	36	405	259	2,481	19,991

Table 1: 2016 Marketplace PUF Sample Before Excluding Single County RAs
Notes: Only individual health plans offered in federally-facilitated marketplaces are considered. Alaska and Nebraska are excluded as they use zip codes to define rating areas.

Plans	Insurers	Networks	States	RAs	Counties	Plan-RA
3,442	214	423	34	259	2,335	13,029

Table 2: 2016 Marketplace PUF Sample After Excluding Single County RAs
Notes: Only individual health plans offered in federally-facilitated marketplaces are considered. Rating areas that have only one county are excluded. Alaska and Nebraska are excluded as they use zip codes to define rating areas. Florida and South Carolina are excluded as their rating areas always consist of one county.

excludes all plans from Florida and South Carolina as their rating areas always consist of a single county.

Table 2 reports the summary statistics of the final Marketplace PUF sample. We have 3,442 individual health plans offered by 214 insurers in 34 states. The number of non single county rating areas is 259, and we have a total of 2,335 counties and 13,029 plan-rating area combinations.

Table 3 reports the average characteristics of the plans in our final Marketplace PUF sample by their metal class. Metal classes are determined by the actuarial value of a plan, and it increases from Catastrophic, Bronze, Silver, Gold, to Platinum. Most of the plans are either Silver or Bronze, followed by Gold plans. Catastrophic plans have the highest maximum out of pocket expenditures and deductibles, followed by Bronze, Silver, Gold and Platinum plans. The average premium is the lowest for Catastrophic plans, and rises with metal levels. For a given plan, the average premium increases with enrollees' age.

Table 4 shows the share of each plan type in the sample. Different types of plans put different restrictions on consumers' provider choice outside the plans' networks. Exclusive Provider Organization (EPO) and Health Maintenance Organization (HMO) plans do not cover providers outside their networks, while Point of Service (POS) and Preferred Provider Organization (PPO) plans cover out-of-network providers for an additional cost.[7] HMOs have the largest share (52%), followed by PPO (31%), POS (10%), and EPO (8%).

Table 5 provides summary statistics of insurer participation in the 2016 marketplaces. On average,

[7]The main difference between EPOs and HMOs is that HMOs require primary care physicians while EPOs do not. The main difference PPO and POS is that while POSs usually require primary care physicians and their referrals to see a specialist, PPOs do not have such requirements.

Metal	Plans	Premium 21	Premium 45	Premium 64	OOP Max	Deductible
Catastrophic	230	170	246	509	6,850	6,850
Bronze	1,061	211	306	634	4,913	4,326
Silver	1,282	261	378	782	3,656	1,848
Gold	767	313	455	940	3,429	928
Platinum	102	373	541	1,120	1,613	209

Table 3: Average Plan Characteristics of the 2016 Marketplace PUF Sample
Notes: Premium 21, 45, and 64 represent the average monthly rate for a non-smoking 21-year-old, 45-year-old, and 65-year-old, respectively. OOP Max represents the annual out-of-pocket maximum. For the sample restriction, see Table 2 and the text.

Plan Type	Plans	Share
EPO	263	0.08
HMO	1,778	0.52
POS	350	0.10
PPO	1,051	0.31
Observations	3,442	

Table 4: Plan Types of the 2016 Marketplace PUF Sample
Notes: EPO stands for Exclusive Provider Organization, HMO for Health Maintenance Organization, POS for Point of Service, and PPO for Preferred Provider Organization.

	Mean	Std.	Min	Max	Obs
# of Active Insurers in a County	3.51	1.79	1	13	2,335
# of Active Insurers in a RA	4.77	2.69	1	13	259
# of Active Insurers in a State	6.29	4.65	1	17	34

Table 5: Insurer Participation in the 2016 Marketplace PUF Sample
Notes: The table reports the summary statistics of insurer participation.

there were about 3.5 insurers in a county, and every county had at least one marketplace insurer. The average number of insurers in a rating area was about 4.8, and the average number of insurers in a state was about 6.3.

Later in the paper, we also use the 2017 Marketplace PUF to present some of the meaningful changes that took place from 2016 to 2017. In Appendix F, we provide summary statistics of the 2017 Marketplace PUF data.

Medicare Advantage Service Area Data. To proxy insurers' county-level entry costs into the marketplace, we use information about their Medicare Advantage (MA) service area obtained from the data provided by the CMS. The idea is that, if a marketplace insurer had sold managed MA plans in a county before the ACA, then the insurer probably faced a low entry cost in that county as it could use the legacy from its MA provider networks. The sample period of the MA data is from

August 2012 to July 2013, which covers 12 months prior to the first-ever deadline for insurers to submit marketplace plan information to the government. We further restrict the data to *managed* MA plans (which are the majority) because other plan types such as fee-for-service do not have a well defined network at the county level, and therefore would be an uninformative proxy for insurer-county level entry costs. Using this dataset, we know for each marketplace insurer and each county, the number of managed MA plans (HMO or Local PPO) that the insurer had sold in the county during one year prior to the opening of the marketplaces.

County Data. To obtain additional information about the counties, we use the Area Health Resources Files (AHRF) provided by the HHS as well as the County Health Rankings by the Robert Wood Johnson Foundation (CHR). The AHRF and CHR provide county level data on various health and socioeconomic characteristics.

3 Prevalence of Partial Rating Area Offering

In this section, we assess how prevalently insurers selectively enter counties within a rating area. To this end, we develop various measures based on insurers' service area. We also develop analogous measures using plans' service area, and the results are reported in Appendix B.

3.1 Prevalence of Partial Rating Area Offering

We index health insurance plans by $p = 1, ..., P$; rating areas by $r = 1, ..., R$; counties by $c = 1, ..., C$; and insurers by $i = 1, ..., I$. For each plan p, $\mathbb{I}_P(p) \in \{1, ..., I\}$ denotes the insurer who offers plan p. $\mathcal{C}(r)$ denotes the set of counties in rating area r. Using the Marketplace PUF data, we can construct the following indicator of whether a plan is sold in a county:

$$O(p, c) = \begin{cases} 1 & \text{if plan } p \text{ is sold in county } c, \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

Using these notations, we can construct several auxiliary objects reported in Table 6 which will be helpful for notational clarity throughout the rest of the paper. As described in Table 6, we say an insurer is active in a county if it sells at least one plan in the county. We say an insurer is active in a rating area if it is active in at least one of the counties that belong to the rating area.

Notations	Descriptions
Set of Plans	
$\mathcal{P}_I(i) = \{p : \mathbb{I}_P(p) = i\}$	Set of plans offered by insurer i.
$\mathcal{P}_C(c) = \{p : O(p,c) = 1\}$	Set of plans offered in county c.
$\mathcal{P}_R(r) = \cup_{c\in\mathcal{C}(r)}\mathcal{P}_C(c)$	Set of plans offered in rating area r.
Set of Insurers	
$\mathcal{I}_C(c) = \{i : i = \mathbb{I}_P(p) \text{ for } p \in \mathcal{P}_C(c)\}$	Set of active insurers in county c.
$\mathcal{I}_R(r) = \cup_{c\in\mathcal{C}(r)}\mathcal{I}_C(c) = \{i : i = \mathbb{I}_P(p) \text{ for } p \in \mathcal{P}_R(r)\}$	Set of active insurers in rating area r.
Set of Counties	
$\mathcal{C}_I(i) = \{c : \mathcal{P}_I(i) \cap \mathcal{P}_C(c) \neq \emptyset\}$	Set of counties in which insurer i is active.
$\mathcal{C}_P(p) = \{c : O(p,c) = 1\}$	Set of counties in which plan p is offered.
Set of Rating Areas	
$\mathcal{R}_I(i) = \{r : \mathcal{C}(r) \cap \mathcal{C}_I(i) \neq \emptyset\}$	Set of rating areas in which insurer i is active.
$\mathcal{R}_P(p) = \{r : \mathcal{C}(r) \cap \mathcal{C}_P(p) \neq \emptyset\}$	Set of rating areas in which plan p is offered.

Table 6: Notations and Definitions

Notes: The table defines and describes various sets for notational clarity. $\mathbb{I}_P(p) \in \{1,...,I\}$ denotes the insurer who sells plan p, $\mathcal{C}(r)$ denotes the set of counties in rating area r, and $O(p,c)$ is the indicator for whether plan p is sold in county c.

We develop three statistics to evaluate how prevalently insurers selectively enter counties within a rating area. First, we develop an insurer-rating area level measure to assess how comprehensively an insurer serves a rating area. For every insurer i and for every rating area r where the insurer is active, we compute the share of counties where the insurer offers at least one plan:

$$B_1^I(i,r) = \frac{|\mathcal{C}_I(i) \cap \mathcal{C}(r)|}{|\mathcal{C}(r)|}. \tag{2}$$

The denominator is the number of counties in rating area r and the numerator is the number of counties in rating area r in which insurer i offers at least one plan (see Table 6 for the definition of the set $\mathcal{C}_I(i)$). For example, if insurer i offers at least one plan in every county in rating area r, then $B_1^I(i,r) = 1$. In contrast, if insurer i only offers plans in one of the three counties, then $B_1^I(i,r) = \frac{1}{3}$.

Second, we develop a county level measure to evaluate how completely a county is serviced by insurers active in its rating area. For every county c, we compute the fraction of active insurers in

Measure	Unit	Obs.	Share of Obs. < 1	Mean	Std
$B_1^I(i,r)$	Insurer-RA	1,236	0.29	0.85	0.28
$B_2^I(c)$	County	2,335	0.41	0.83	0.26
$B_3^I(r)$	RA	259	0.52	0.89	0.14

Table 7: Insurer Coverage Measures
Notes: The table reports summary statistics on the three measures of marketing breadth using insurer coverage.

its rating area that sell at least one plan in the county:

$$B_2^I(c) = \frac{|\mathcal{I}_C(c)|}{|\mathcal{I}_R(r) : c \in \mathcal{C}(r)|} \tag{3}$$

where the denominator is the number of active insurers in rating area r to which county c belongs, and the numerator is the number of active insurers in county c.[8]

Third, we develop a rating area level measure to quantify how comprehensively insurers serve counties in a rating area. To do this, we compute the average of the first measure, $B_1^I(i,r)$, or the second measure, $B_2^I(c)$, both of which yield the same result:

$$\begin{aligned} B_3^I(r) &= \frac{1}{|\mathcal{I}_R(r)|} \sum_{i \in \mathcal{I}_R(r)} B_1^I(i,r) \\ &= \frac{1}{|\mathcal{C}(r)|} \sum_{c \in \mathcal{C}(r)} B_2^I(c). \end{aligned} \tag{4}$$

Table 7 reports the summary statistics of the three measures. Using the first measure $B_1^I(i,r)$, we find that in 29% of the 1,236 instances where an insurer is active in a rating area, the insurer enters some, but not all of the counties in a rating area, resulting in $B_1^I(i,r) < 1$. On average, an insurer offers plans in 85% of the counties in a rating area where it is active. Indeed, we find that out of the 214 insurers in our sample, 116 insurers (about 54%) engage in partial rating area offering by not selling any plans in at least one county that belongs to a rating area where they are active. From the second measure $B_2^I(c)$, we find that 41% of the 2,335 counties in our sample are excluded by at least one insurer who is active in their rating areas. On average, a county is excluded by 17% of active insurers in its rating area. Finally, using the third measure $B_3^I(r)$, we find that 52% of the 259 rating areas with multiple counties have some active insurers who do not operate in all of their counties. On average, a rating area has an insurer participation rate of 89%.

[8] The definitions for sets $\mathcal{I}_C(c)$ and $\mathcal{I}_R(r)$ are provided in Table 6.

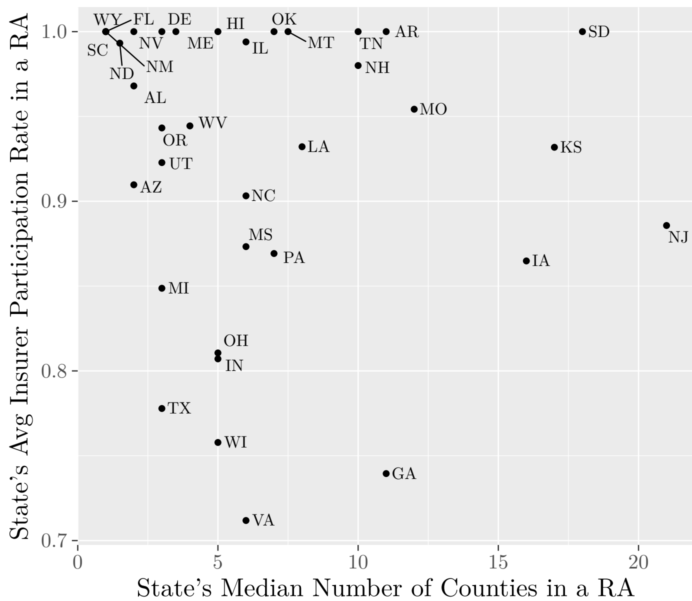

Figure 1: Partial Rating Area Offering by State
Notes: The sample consists of the 2016 Marketplace PUF data including single county rating areas (as summarized in Table 1). For each state, we compute the number of counties in each of its rating areas. The x-axis represents the state's median number of counties in its rating areas. For example, if a state has three rating areas, and each rating area consists of 5 counties, the state's x-axis value is 5. The y-axis represents for each state, the mean value of $B_3^I(r)$ among rating areas that belong to the state.

To sum, partial rating area entry does happen in the marketplaces, and it is not uncommon to observe insurers selectively entering counties within a rating area.

3.2 Descriptive Patterns

To understand why insurers selectively enter counties within a rating area, we examine descriptive patterns between insurers' county entry decisions and various factors such as county characteristics and fixed costs of entry.

We first examine the prevalence of partial rating area offering by state. In particular, we ask if partial rating area offering is driven by the geographic scope of a rating area. For instance, it may be harder for insurers to be active in the entire rating area when the rating area consists of many counties. If this were true, then we would observe more prevalent partial rating area entry in states with large rating areas. Figure 1 shows that this is not always true. For example, South Dakota is divided into large rating areas that consist of 18 counties on average. However, all insurers in the state's marketplace are active in each and every county, implying that there is no partial entry in

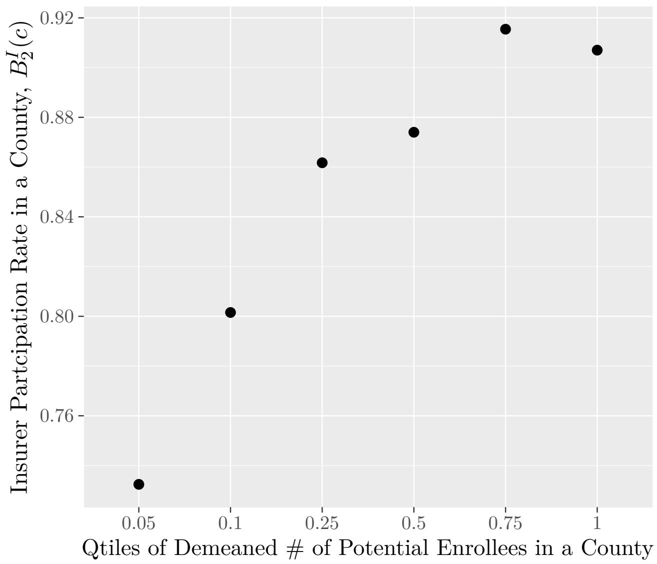

Figure 2: County Market Size and Insurer Participation Rate
Notes: The sample consists of the final 2016 Marketplace PUF data (as summarized in Table 2). For each county c, we measure the number of potential marketplace enrollees as individuals aged below 65 years old whose incomes are less than 400% FPL. Call this variable x_c. Then, for each rating area r, we compute the average value of x_c using counties that belong to the rating area. Call this variable $\overline{x}_r$. To compute the demeaned number of potential enrollees in a county, we do $x_c - \overline{x}_r$ (assuming county c belong to rating area r). The x-axis represents the quantiles of $x_c - \overline{x}_r$. The y-axis represents the mean of $B_2^I(c)$ (insurer participation rate in a county) for each quantile.

any of the state's rating areas. Also, partial rating area entry is very common in Wisconsin and Virginia, but these states have moderately-sized rating areas consisting of 5 or 6 counties. Figure 1 therefore suggests that the geographic scope of a rating area is not a primary factor explaining insurers' partial entry decisions.

Second, we examine how insurers' county-level entry decisions within a rating area are correlated with the county market size. It may be the case that insurers are avoiding counties with relatively fewer potential marketplace enrollees as they may not be able to recover the fixed costs of entry. For each county, we measure the number of potential marketplace enrollees as individuals aged less than 65 years old whose incomes fall below the 400% FPL. This is because premium subsidies are only available for individuals with incomes below the 400% FPL. Since we are interested in examining insurers' county entry decisions *within* a rating area, what matters is how small a county's market size is relative to other counties in the same rating area. We therefore demean each county's market size by their respective rating area average. Figure 2 shows the relationship between a county's demeaned demand size and the insurer participation rate in the county, i.e., $B_2^I(c)$ as defined in

Equation (3). The insurer participation rate falls quite substantially at the bottom quantiles, suggesting that the partial entry phenomenon may be explained in part by insurers' desire to avoid low demand counties.

Third, we ask if insurers are avoiding relatively high risk counties in a given rating area. As argued by Hendren (2013), insurers have an incentive to reject observably high risk individuals (rather than charging them a high price) because they are likely to have greater amounts of private information which would aggravate adverse selection. Since the division of rating areas was primarily based on the differences in health care provider prices, counties within a rating area may have heterogeneous health risk distributions, which could strengthen insurers' risk screening motives.

We use various county health measures from the CHR data, including self-reported physically and mentally unhealthy days per month and the share of heavy drinkers, to study the relationship between the insurer participation rate in a county, $B_2^I(c)$, and county health risks. Again, we demean county health measures by their respective rating area average to examine how risky a county is relative to other counties in the same rating area. Figure 3 reports the results. The insurer participation rate drops substantially at the top quantile which represents the highest risk counties. Such descriptive patterns provide suggestive evidence for risk screening.

Finally, we consider how the fixed costs of setting up a provider network are correlated with insurers' county entry decisions. For instance, insurers may be reluctant to sell marketplace plans in counties where they do not already have established provider networks. To examine if this were true, for each marketplace insurer and each rating area where the insurer is active, we classify a county in the rating area as an MA county if the insurer had sold MA plans in the county before the ACA, and as a non-MA county otherwise. We then compute the share of MA counties and the share of non-MA counties where the insurer sells marketplace plans. The former can be thought of as the insurer's marketplace entry probability in its MA counties, and the latter as the insurer's marketplace entry probability in its non-MA counties. Table 8 summarizes the results. On average, a marketplace insurer enters 91% of counties in a rating area where it sold managed MA plans before the ACA. In contrast, the insurer enters only about 79% of counties where it did not have any MA plans. This pattern suggests that insurers may be avoiding counties in a rating area where they face relatively larger fixed costs of building a provider network.

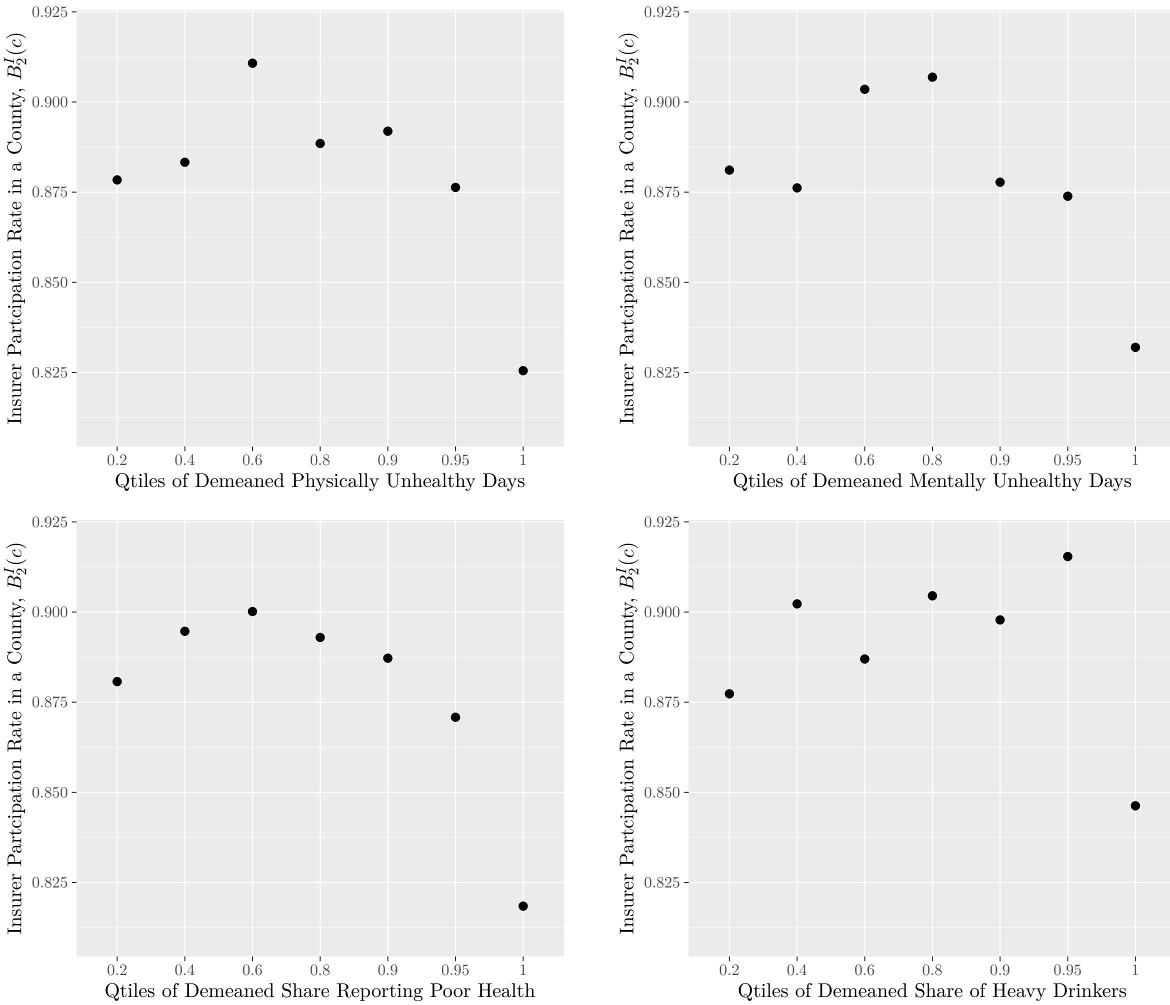

Figure 3: County Health Risks and Insurer Participation Rate
Notes: The sample consists of the final 2016 Marketplace PUF data (as summarized in Table 2). Let x_c represent a county health measure that is either (1) the average number of physically unhealthy days per month, (2) the average number of mentally unhealthy days per month, (3) the share of the county population reporting poor health, or (4) the share of the county population that are heavy drinkers. For each rating area r, we compute the average value of x_c using counties that belong to the rating area, denoted by $\overline{x}_r$. We compute the demeaned county health measure as $x_c - \overline{x}_r$ (assuming county c belong to rating area r). The x-axis represents the quantiles of $x_c - \overline{x}_r$. The y-axis represents the mean of $B_2^I(c)$ (insurer participation rate in a county) for each quantile.

	Mean	1st quartile	3rd quartile
Marketplace entry probability in MA counties	0.91	1	1
Marketplace entry probability in non-MA counties	0.79	0.6	1
Observations (insurer-rating area combinations)	1,236		

Table 8: Marketplace Entry Probability in MA vs. non-MA counties
Notes: The table reports the summary statistics of marketplace insurers' county entry probabilities in counties (1) where they had sold managed Medicare Advantage plans before the ACA, and (2) where they had not sold any managed Medicare Advantage plans. See the text for more details.

3.3 Possible Explanations

The descriptive patterns presented in this section imply that common county characteristics such as the market size and the risk distribution may be important in understanding insurers' county-level entry decisions in a rating area. In particular, given that the division of rating areas was not strictly based on the differences in health risks, insurers may have a strong risk screening incentive as suggested in Figure 3. In such a scenario, we suspect that insurers' entry decisions would be positively correlated because county characteristics such as the market size and the risk distribution affect insurers' profits in a similar manner.

In contrast, considering that the average number of insurers in a county is only 3.5, the desire to avoid competition may also explain insurers' partial entry in a rating area.[9] In such a scenario, we suspect that insurers' county entry decisions would be negatively correlated. For instance, insurers would be less likely to enter counties where competitors are present.

Finally, we speculate that the fixed costs of entry could contribute to either a positive or negative correlation among insurers' entry decisions. For example, if insurers have very similar fixed costs of entry, then all else equal, insurers' entry decisions will be alike. In contrast, if insurers face very heterogeneous fixed costs of entry, then their entry decisions will be very different. In the next section, we develop a model of insurer competition in a rating area to formalize the above channels and derive testable implications.

[9] The degree of insurer competition is higher in other health insurance markets; for example, according to the Kaiser Family Foundation, the average person on Medicare in 2017 had 6 Medicare Advantage insurers to choose from.

4 Model

4.1 Model Description

Market Environment. Consider a rating area that consists of two counties indexed by $c \in \{A, B\}$. The distribution of health expenditure θ in county c is given by CDF $H_c(\theta)$. The willingness to pay for insurance of a type-θ consumer is given by $v(\theta)$. We assume that $v(\theta) > \theta$. The population size of county c is given by $\lambda_c > 0$.

There are two insurance companies indexed by $i \in \{1, 2\}$. Each insurer can sell at most one plan in each county. Let p_i^c denote the price of a health plan sold to county c by insurer i. Each insurer chooses a vector of prices, $p_i = (p_i^A, p_i^B) \geq 0$, to maximize its profit given its competitor's vector of prices, $p_{i'} = (p_{i'}^A, p_{i'}^B)$. If insurer i's price in county c is infinite, i.e., $p_i^c = +\infty$, it implies that insurer i is inactive in county c. A finite price, on the other hand, implies that insurer i is active in county c. If an insurer were to offer an identical plan in both county A and county B, the ACA regulation requires that the prices be the same, i.e., $p_i^A = p_i^B$.

Let C_i^c represent insurer i's fixed cost of entering county c which includes the cost of building a provider network and other administrative costs. The total fixed cost function for insurer i is given as below:

$$TFC_i(p_i) = \begin{cases} C_i^c & \text{if } i \text{ is active in county } c \text{ only, i.e., } p_i^c < \infty \text{ and } p_i^{c'} = \infty, \\ C_i^A + C_i^B & \text{if } i \text{ offers two county-specific plans, i.e., } p_i^A \neq p_i^B,\ p_i^A < \infty \text{ and } p_i^B < \infty, \\ C_i^A + C_i^B - D & \text{if } i \text{ offers the same plan to both counties, i.e., } p_i^A = p_i^B < \infty. \end{cases} \tag{5}$$

That is, if an insurer enters only one county, the total fixed cost is C_i^c which represents the cost of building a provider network in that county and other administrative costs. If the insurer enters both counties and sells two separate plans (one for each county), then the total fixed cost is simply the sum of the insurer's county-specific entry costs. If the insurer sells the same plan to both counties at the same price (as required by the ACA), then compared to the case of selling two county-specific plans, there is a reduction in the administrative costs, $D \geq 0$.[10]

[10] Under the ACA, each and every health plan must be certified by the government before they can be sold at marketplaces. As this process can be lengthy and costly, we assume there is a reduction in the administrative costs when an insurer manages fewer plans.

Imperfect Competition. Following Fang and Wu (2018), we model the competition between the two insurers in a county as a form of modified Bertrand competition. Different from the standard Bertrand competition in which the insurer with the lowest price gets the entire market, we assume that consumers cannot compare prices perfectly. Instead, a consumer receives a noisy signal about which of the two insurers has a lower price. The consumer inspects the actual price of the insurer indicated by the noisy signal, and decides whether to buy from the insurer. The noisy signal creates spurious product differentiation and induces imperfect competition.[11]

Specifically, given the vector of prices posted by the two insurers in county c, (p_1^c, p_2^c), the noisy signal, s, is determined by:

$$s = \begin{cases} 1 & \text{if } p_1^c - p_2^c + \epsilon \leq 0, \\ 2 & \text{otherwise,} \end{cases} \tag{6}$$

where $\epsilon \sim \mathcal{N}(0, \sigma_s^2)$. It is clear that a consumer always follows the signal: if $s = i$, the consumer will find out the actual price p_i^c and decide between purchasing insurance at price p_i^c and staying uninsured. Hence, conditional on price vector (p_1^c, p_2^c), the probability that a consumer considers purchasing from insurer i is $\Phi\left(\frac{p_{i'}^c - p_i^c}{\sigma_s}\right)$, where Φ is the normal CDF. Conditional on observing insurer i's price p_i^c, the purchase decision of type-θ consumer is very simple: purchase at price p_i^c if and only if $v(\theta) \geq p_i^c$.

Game Between the Insurers. We denote an insurer's monopoly profit function in county c as $\Pi_M^c(p)$ where p is the insurer's monopoly price. The monopoly profit function in county c is given by:

$$\Pi_M^c(p) = \lambda_c \int_{v(\theta) \geq p} (p - \theta)\, dH_c(\theta). \tag{7}$$

Insurer i's net profit as a function of its own price vector p_i and its opponent's price vector $p_{i'}$ is given by

$$\Pi_i(p_i, p_{i'}) = \Phi\left(\frac{p_{i'}^A - p_i^A}{\sigma_s}\right)\Pi_M^A(p_i^A) + \Phi\left(\frac{p_{i'}^B - p_i^B}{\sigma_s}\right)\Pi_M^B(p_i^B) - TFC_i(p_i) \tag{8}$$

where $\Phi\left(\frac{p_{i'}^c - p_i^c}{\sigma_s}\right)$ represents the probability that consumers in county c receive a noisy signal indicating that insurer i has the lower premium. So insurer i's net profit function is the sum of any

[11] This is a modeling device to introduce imperfect competition in a tractable way, and not to be taken literally.

profits from county A and county B minus the total fixed cost. Note that if insurer i is inactive in county c, then it is equivalent to charging an infinite price, which would result in zero profit from county c.

Equilibrium. A strategy profile (p_1^*, p_2^*) is a Nash equilibrium of the model described above if, for $i \neq i'$,

$$\Pi_i(p_i^*, p_{i'}^*) \geq \Pi_i(p_i, p_{i'}^*) \quad \text{for all } p_i \geq 0 \text{ and } i = 1, 2. \tag{9}$$

Despite its simplicity, the model cannot be analytically solved. We instead present numerical results below.

4.2 Parameterization

To numerically solve the model, we make several parametric assumptions. We parameterize the health expenditure distribution in county c as a log-normal distribution with location parameter μ_c and scale parameter σ_c. We parameterize type-θ's willingness to pay for a health plan as $v(\theta) = (1+\rho)\theta$ where ρ can be interpreted as the degree of risk aversion. The parameters of the model are therefore $(\{\mu_c, \sigma_c, \lambda_c\}_{c=A,B}, \sigma_s, \rho, \{C_i^c\}_{i=1,2,c=A,B}, D)$.

4.3 Equilibrium Analysis

It is useful to categorize an insurer's pricing decision, $p_i = (p_i^A, p_i^B)$, into five broad categories: (1) charge different and finite prices to county A and county B ("2 plans", one for each county); (2) charge the same finite price to both county A and county B ("RA plan" offered to both counties); (3) charge a finite price to county A only ("A plan"); (4) charge a finite price to county B only ("B plan"); and (5) charge an infinite price to both counties ("Exit"). The reason why we categorize insurers' pricing decisions in this manner is because it would be easier to present equilibria of the game in terms of these market structures, rather than in terms of equilibrium prices.

Figures 4 to 7 present how various factors affect the equilibrium market structures of the game. Details of the simulation are reported in the footnotes of each figure. Figure 4 shows that both insurers are likely to offer two separate plans, one for each county, when there is a large risk heterogeneity between the counties, and the savings from managing fewer plans are negligible. On the other hand, both insurers are likely to offer a single rating area plan to all counties when the

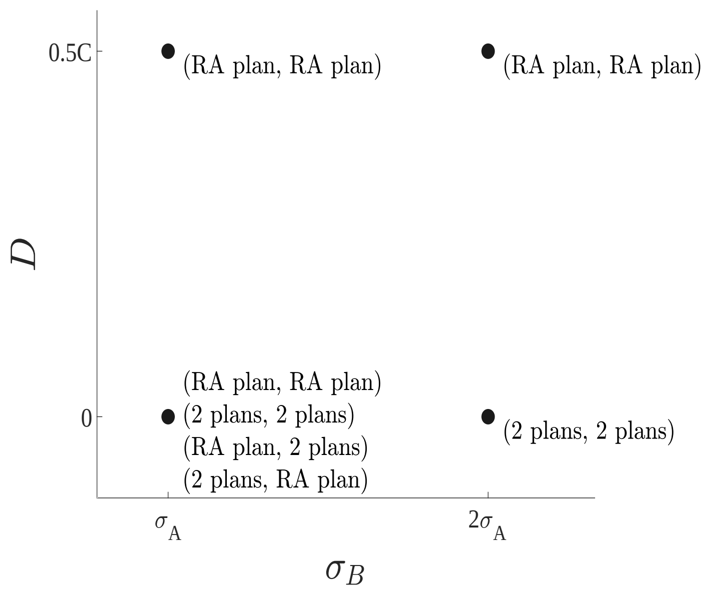

Figure 4: Risk Heterogeneity, Administrative Costs and Nash Equilibrium
Notes: The figure reports the Nash equilibrium market structures for different values of σ_B and D. The x-axis represents σ_B, the scale parameter of the log-normal health expenditure in county B. In the figure, σ_B is equal to either σ_A (no risk heterogeneity) or $2\sigma_A$ (large risk heterogeneity). The y-axis represents D, the reduction in administrative costs from offering a single rating area plan instead of two county-specific plans. In the figure, D is equal to either 0 (no benefit from offering a rating area plan) or $0.5C$ (large benefit from offering a rating area plan). The figure holds constant the rest of the parameters as the following: (1) the log-normal health expenditure in county A has μ_A =5.67 and σ_A =0.25 implying the mean expenditure of \$300 and the standard deviation of \$75, (2) the log-normal health expenditure in county B has the location parameter set at $\mu_B = \mu_A$, (3) the county population size is $\lambda_A = \lambda_B = 1$, (4) the fixed cost of entering a county is the same for all insurers and counties with $C_i^c = C = 20$ for $i = 1, 2$ and $c = A, B$, (5) the standard deviation of the noisy price signal is σ_s =150 and the risk aversion parameter is ρ =1.

counties in the rating area do not differ too much in their risk distributions and there is a substantial reduction in the administrative costs from managing fewer plans. The model therefore sheds light on why there is a substantial number of rating areas in which all plans are sold to all counties of the rating area, despite the presence of county heterogeneity.[12]

Figure 5 shows that counties with very small market size are avoided by insurers in equilibrium. The model can therefore rationalize the empirical pattern that counties with a small number of potential marketplace enrollees have lower insurer participation rates.

Figure 6 presents the equilibrium market structures when for a given county, both insurers face the same fixed costs of entry, i.e., $C_1^c = C_2^c$ for $c = A, B$. For example, if the two insurers had sold

[12]Using the 2016 Marketplace PUF sample, we find that 37% of the rating areas fall into this category (see Table B1 of Appendix B).

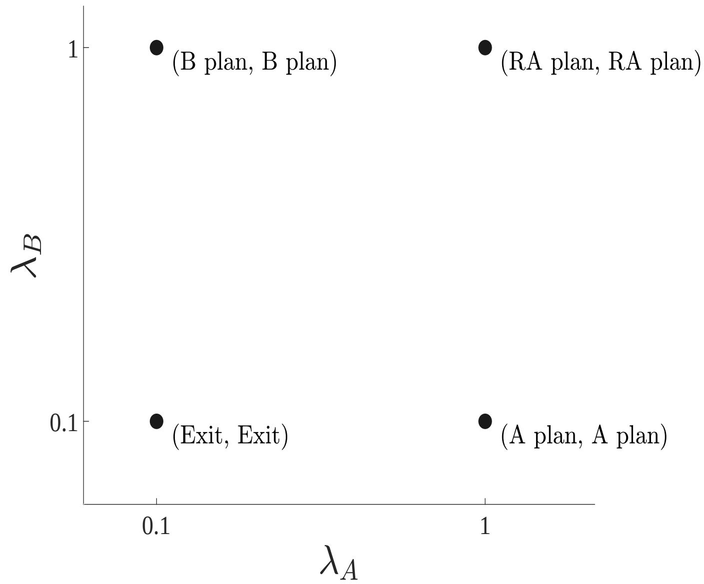

Figure 5: County Market Size and Nash Equilibrium
Notes: The figure reports the Nash equilibrium market structures for different values of county market size. The x-axis represents λ_A, the marketplace market size in county A and the y-axis represents λ_B, the marketplace market size in county B. In the figure, for $c = A, B$, λ_c is equal to either 0.1 (very small demand size) or 1 (large demand size). The rest of the parameters are set such that when $\lambda_c = 0.1$, no insurer can earn a positive profit in county c regardless of the market structure. Specifically, the figure holds constant the rest of the parameters as the following: (1) county A and county B have the same log-normal health expenditure distribution with $\mu_A = \mu_B$ =5.67 and $\sigma_A = \sigma_B$ =0.25 implying the mean expenditure of $300 and the standard deviation of $75, (2) the fixed cost of entering a county is the same for all insurers and counties with $C_i^c = C = 20$ for $i = 1, 2$ and $c = A, B$, (3) $D = 0.05C$, i.e., there is a small reduction in administrative costs when insurers offer a single rating area plan instead of two county-specific plans, (4) the standard deviation of the noisy price signal is σ_s =150 and the risk aversion parameter is ρ =1.

MA plans in the same set of counties before the ACA, then for a given county, they probably faced very similar entry costs in the marketplaces. The figure shows that insurers do not enter counties with a large entry cost in equilibrium. The figure confirms our conjecture that under symmetric fixed costs of entry, insurers' entry decisions would be positively correlated.

Finally, Figure 7 presents the equilibrium market structures when insurers have asymmetric entry costs in the sense that $C_i^c = C_{i'}^{c'}$ for $i \neq i'$ and $c \neq c'$. The figure shows that market segmentation is achieved in equilibrium when insurers face large entry costs in different counties. This would be the case, for example, if the two insurers had operated in completely different sets of counties before the ACA. Note that competitive pressure also helps to sustain market segmentation as an equilibrium outcome. In the figure, when insurer 1 faces a small entry cost in county A and a large entry cost in county B, insurer 1 enters county A only. However, if there were no insurer

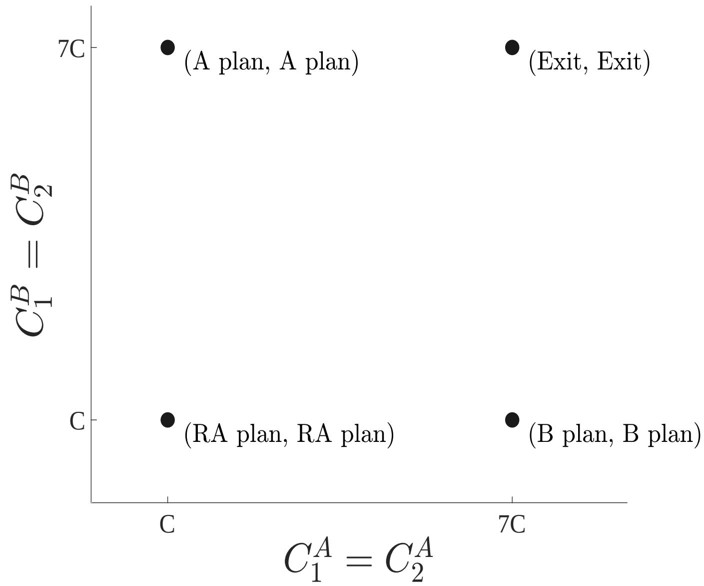

Figure 6: Symmetric Fixed Costs and Nash Equilibrium

Notes: The figure reports the Nash equilibrium market structures when for a given county, insurers face the same fixed costs of entry, i.e., $C_1^c = C_2^c$ for $c = A, B$. The x-axis represents insurers' symmetric fixed costs of entry in county A, and the y-axis represents insurers' symmetric fixed costs of entry in county B. In the figure, the symmetric fixed cost of entry for a given county is either small (C) or large $(7C)$ with $C = 20$. The rest of the parameters are set such that when $C_i^c = 7C$, no insurer can earn a positive profit in county c regardless of the market structure. That is, even the optimal monopoly profit after paying the fixed cost is less than zero. Specifically, the figure holds constant the rest of the parameters as the following: (1) county A and county B have the same log-normal health expenditure distribution with $\mu_A = \mu_B =$5.67 and $\sigma_A = \sigma_B =$0.25 implying the mean expenditure of \$300 and the standard deviation of \$75, (2) the county population size is $\lambda_A = \lambda_B = 1$, (3) $D = 0.05C$, i.e., there is a small reduction in administrative costs when insurers offer a single rating area plan instead of two county-specific plans, (4) the standard deviation of the noisy price signal is $\sigma_s =$150 and the risk aversion parameter is $\rho =$1.

2, then insurer 1 would enter both counties.[13] This implies that asymmetric entry costs *and* the competitive concern jointly help sustain market segmentation as an equilibrium outcome.

4.4 Testable Implications

The model implies that we can categorize various factors that could be important for insurers' entry decisions into those that result in a positive correlation among insurers' entry statuses and those that result in a negative correlation. Symmetric fixed costs of entry and common market characteristics (such as risk distributions and market size) belong to the former while asymmetric

[13] The parameters used to generate Figure 7 ensure that insurer 1's optimal monopoly profit in county B after paying the large entry cost is still greater than zero. See the notes of the figure for more details.

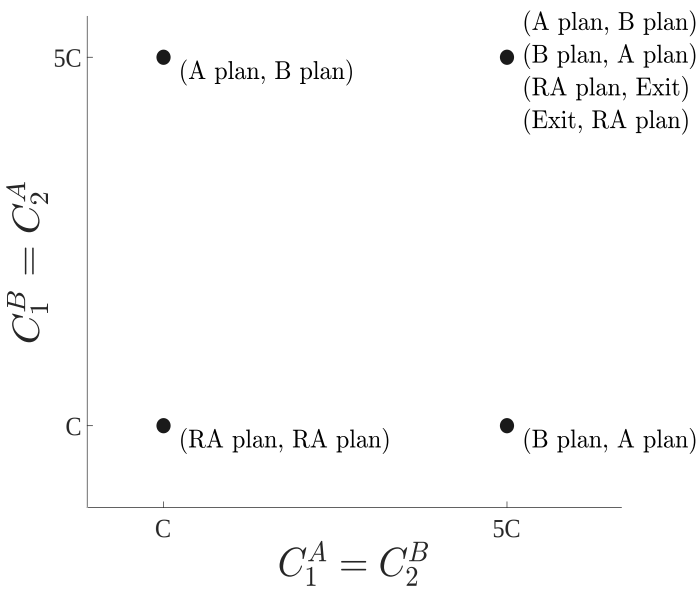

Figure 7: Asymmetric Fixed Costs and Nash Equilibrium

Notes: The figure reports the Nash equilibrium market structures when insurers have asymmetric fixed costs in the sense that $C_i^c = C_{i'}^{c'}$ for $i \neq i'$ and $c \neq c'$. The x-axis represents insurer 1's fixed cost of entry in county A which is equal to insurer 2's fixed cost of entry in county B. Similarly, the y-axis represents insurer 1's fixed cost of entry in county B which is equal to insurer 2's fixed cost of entry in county A. In the figure, C_i^c is either small (C) or large ($5C$) with $C = 20$. The rest of the parameters take exactly the same values as those used to generate Figure 6 (see the notes for details). Note that under this set of parameter values, the optimal monopoly profit in county $c = A, B$ after paying the large fixed cost of $5C$ is still greater than zero. This implies that market segmentation observed in equilibrium would not have been possible without competitive pressure. For example, if there were only insurer 1 in the entire rating area, insurer 1 would be active in both counties regardless of whether C_1^c is small (C) or large ($5C$).

fixed costs and competitive pressure belong to the latter. In what follows, we develop a novel correlation test based on this implication, and further highlight the main driving forces for the insurers' partial rating area offering in the marketplaces.

5 Correlation Test

In this section, we develop a statistical test to examine whether insurers' county-level entry decisions are positively or negatively correlated in a rating area. If the test favors a positive correlation, then it implies that common market characteristics or symmetric fixed costs of entry are the primary considerations for insurers. In contrast, if the test favors a negative correlation, then it implies that market segmentation is prevalent in the marketplaces which could arise due to asymmetric fixed costs of entry or competitive pressure.

5.1 Correlation Construction

Using the notations introduced in Section 3, we construct a nonparametric measure of correlation. For each insurer i active in rating area r, $i \in \mathcal{I}_R(r)$, and for each county that belongs to the rating area, $c \in \mathcal{C}(r)$, define an indicator $O(i,c)$ as follows:

$$O(i,c) = \begin{cases} 1 \text{ if } i \in \mathcal{I}_C(c), \\ 0 \text{ if } i \notin \mathcal{I}_C(c) \end{cases} \tag{10}$$

where $\mathcal{I}_C(c)$ is the set of insurers active in county c.

Define $\tilde{\mathcal{I}}_R(r) \subset \mathcal{I}_R(r) \times \mathcal{I}_R(r)$ as the set of all 2-combinations of $\mathcal{I}_R(r)$. For example, if $\mathcal{I}_R(r) = \{i_1, i_2, i_3\}$, then the set $\tilde{\mathcal{I}}_R(r)$ consists of three pairs of insurers, $\tilde{\mathcal{I}}_R(r) = \{(i_1,i_2),(i_1,i_3),(i_2,i_3)\}$. The number of elements in $\tilde{\mathcal{I}}_R(r)$ equals $\begin{pmatrix} |\mathcal{I}_R(r)| \\ 2 \end{pmatrix}$. Similarly, define $\tilde{\mathcal{C}}(r) \subset \mathcal{C}(r) \times \mathcal{C}(r)$ as the set of all 2-combinations of $\mathcal{C}(r)$. The number of all possible 2-combinations is $\left|\tilde{\mathcal{C}}(r)\right| = \begin{pmatrix} |\mathcal{C}(r)| \\ 2 \end{pmatrix}$.

For each pair of insurers active in the rating area $(i,i') \in \tilde{\mathcal{I}}_R(r)$ and for each pair of counties that belong to the rating area $(c,c') \in \tilde{\mathcal{C}}(r)$, we define $o(i,i';c,c')$ as the following:

$$o(i,i';c,c') = \begin{cases} 1 & \text{if } O(i,c) = O(i',c) \text{ and } O(i,c') = O(i',c'), \\ -1 & \text{if } O(i,c) \neq O(i',c) \text{ and } O(i,c') \neq O(i',c'), \\ 0 & \text{otherwise.} \end{cases} \tag{11}$$

In words, $o(i,i';c,c')$ takes value 1 if insurers i and i' are completely aligned regarding their entry decisions in counties c and c'; -1 if they are completely opposed; and 0 for any other cases.

For a given rating area r, we define $CORR(r)$ as the *average* value of $o(i,i';c,c')$ over all possible insurer pairs $(i,i') \in \tilde{\mathcal{I}}_R(r)$ and county pairs $(c,c') \in \tilde{\mathcal{C}}(r)$:

$$CORR(r) = \frac{1}{\begin{pmatrix} |\mathcal{I}_R(r)| \\ 2 \end{pmatrix} \cdot \begin{pmatrix} |\mathcal{C}(r)| \\ 2 \end{pmatrix}} \sum_{(i,i') \in \tilde{\mathcal{I}}_R(r)} \sum_{(c,c') \in \tilde{\mathcal{C}}(r)} o(i,i';c,c'). \tag{12}$$

In words, $CORR(r)$ measures the average alignment of insurers' entry decisions across counties in a given rating area. We say insurers' county entry decisions are positively correlated in rating area

r if $CORR(r) > 0$ and negatively correlated if $CORR(r) < 0$.

Illustrative Examples. Consider the model presented in Section 4. If all insurers avoided county B and were active in county A only, then $CORR(r)$ would be 1. If insurer 1 were active in county A only and insurer 2 were active in county B only, then $CORR(r)$ would be -1. More illustrative examples are presented in Appendix C.

5.2 Empirical Correlations

We compute the correlation measure $CORR(r)$ for each rating area in our sample. To examine if there were any meaningful changes in the correlation between insurers' entry choices from 2016 to 2017, we also use the 2017 Marketplace PUF (see Appendix F for more details about the 2017 Marketplace data).[14] To compute the correlation measure $CORR(r)$, we restrict to rating areas with at least two insurers. This restriction reduces the number of rating areas from 259 to 247 in the 2016 sample, and from 267 to 205 in the 2017 sample.[15] The greater reduction in the 2017 sample implies that the degree of competition decreased quite substantially from 2016 to 2017.

Table 9 reports the empirical correlations computed for years 2016 and 2017. In 2016, there was partial entry in about 55% of the rating areas. That share increased to 62% by 2017, implying that partial rating area offering was still prevalent in 2017. Among the rating areas with partial entry, 90% had a strictly positive correlation in 2016. That share decreased to 62% in 2017. Correspondingly, the mean correlation decreased from 0.37 in 2016 to 0.25 in 2017. The main implication from Table 9 is that positive correlations are much more likely to be observed in both years 2016 and 2017, despite the increase in the number of rating areas with negative correlations.

Entry Cost Correlation. We can also use our correlation measure to determine if insurers' fixed costs of entry are positively or negatively correlated within a rating area. For example, if we found that insurers' county entry decisions for their Medicare Advantage plans had been positively correlated before the ACA, then the result would imply that insurers faced relatively symmetric fixed costs of entry in the ACA marketplaces, contributing to the positive correlations presented in

[14] In 2017, Kentucky transitioned to the federal marketplace. Due to this change, the number of rating areas with multiple counties increased from 259 in 2016 to 267 in 2017.

[15] In the 12 rating areas that are dropped from the 2016 sample due to having a single insurer, there was no partial entry, i.e., $B_3^I(r) = 1$. Also, no partial entry was observed in the 62 rating areas with a single insurer in year 2017.

	Year 2016	Year 2017
# of RAs with partial entry, $B_3^I(r) < 1$	135	126
: # of RAs with $CORR(r) > 0$	121	78
: # of RAs with $CORR(r) = 0$	2	7
: # of RAs with $CORR(r) < 0$	12	41
: Mean $CORR(r)$ using nonequal weights	0.37	0.25
: Mean $CORR(r)$ using equal weights	0.34	0.13
: Median $CORR(r)$	0.34	0.12
: Standard deviation of $CORR(r)$	0.27	0.36
# of RAs with no partial entry, $B_3^I(r) = 1$	112	79
Observations (RAs)	247	205

Table 9: Empirical Correlations Among Insurers' County Entry Decisions
Notes: The sample is restricted to rating areas with at least two counties and two active insurers. For each rating area with partial entry, we compute its weight as the denominator in Equation (12) divided by the sum of this value for all rating areas with partial entry. These weights are used to compute the mean of $CORR(r)$ using nonequal weights. For rating areas with no partial entry, the correlation measure is one by construction.

Table 9. Using the MA service area data, we compute the correlation among insurers' MA offering decisions in each rating area before the ACA. We denote this correlation measure by $CORR_{MA}(r)$.

We compute the MA correlation measure $CORR_{MA}(r)$ for each of the 135 rating areas that had partial entry in 2016. Figure 8 reports the histogram of $CORR_{MA}(r)$. There is a big mass around zero and the average correlation is almost zero (the mean is 0.07 and the median is -0.05). This suggests that marketplace insurers' county entry decisions in the MA market before the ACA showed no meaningful correlation. While fixed costs of entry may be an important factor for each insurer's county entry decision, they may not be the primary explanation for why insurers' county-level entry decisions in the marketplaces are positively correlated. In other words, the positive correlation that we detect in the ACA marketplaces may be due to common county characteristics and not symmetric fixed costs of entry.

5.3 Test Construction

We now develop a test to determine if insurers' county entry decisions are positively correlated in a *statistically significant* way. We construct a null hypothesis of independent and random entry decisions by insurers and use our correlation measure to determine if the null can be rejected in favor of positive or negative correlations.

Consider a rating area where each insurer decides the set of counties to enter with the constraint

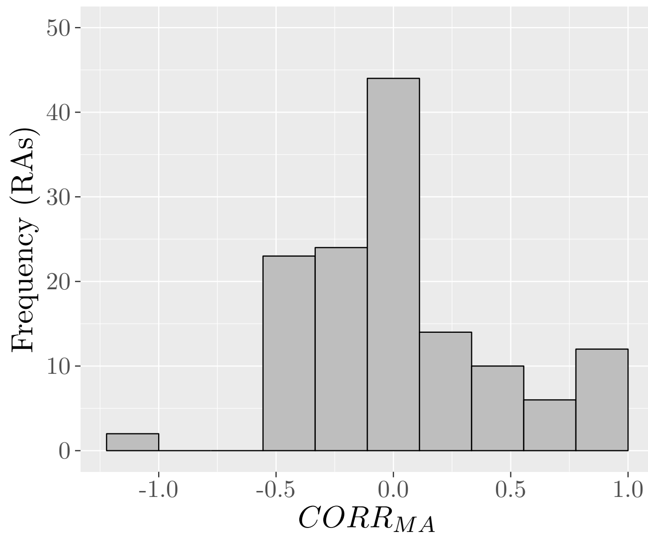

Figure 8: Histogram of Correlation Measure $CORR_{MA}(r)$
Notes: The figure reports the histogram of the MA service area correlation measure, $CORR_{MA}(r)$, computed for each of the 135 rating areas with partial entry in 2016 (reported in the first row of Table 9). The mean is 0.07 and the median is -0.05.

that it has to enter at least one county.[16] Let $a_i \in \{0,1\}^{|\mathcal{C}(r)|}$ denote insurer i's choice, where the kth element in the vector a_i denotes insurer i's entry status in county k. For example, if there are three counties and insurer i chooses $a_i = (1,0,0)$, it implies that insurer i only enters county 1. Let $\mathcal{A}(r)$ denote the set of possible choices, i.e., $a_i \in \mathcal{A}(r)$. The set $\mathcal{A}(r)$ excludes a zero vector because insurers have to be active in at least one county. The number of possible choices is given by

$$|\mathcal{A}(r)| \quad = \quad 2^{|\mathcal{C}(r)|} - 1.$$

For example, consider a rating area with two counties. The choice set $\mathcal{A}(r)$ is given as $\mathcal{A}(r) = \{(1,0),(0,1),(1,1)\}$ and the number of choices in the set is $|\mathcal{A}(r)| = 2^2 - 1 = 3$.

Null Hypothesis. *In a given rating area r, county entry decisions are independent across insurers, and each insurer randomly chooses a set of counties to enter with an equal probability, i.e., each insurer chooses an action in the set $\mathcal{A}(r)$ with probability $\frac{1}{|\mathcal{A}(r)|}$.*

To better illustrate the null, consider a rating area with two counties. Under the null, we have $Pr(a_i, a_j) = Pr(a_i) \cdot Pr(a_j)$ for insurers $i \neq j$ as insurers make independent county entry decisions.

[16] We impose this constraint as we study correlations among insurers that are active in at least one of the counties in the rating area.

The null therefore precludes the competition effect. Also, we have $Pr(d_i = (1,0)) = Pr(d_i = (0,1)) = Pr(d_i = (1,1)) = \frac{1}{3}$ for any insurer i as the null assumes random entry by insurers and therefore precludes the effects of entry costs or common county characteristics.

We can derive the analytical forms of $E[CORR(r)]$ and $\text{Var}[CORR(r)]$ under the null and we detail the derivation in Appendix D. We find that under the null, $E[CORR(r)]$ depends only on the number of counties in the rating area, and as the number of counties approaches to infinity, $E[CORR(r)]$ converges to zero under the null. $\text{Var}[CORR(r)]$ depends only on the number of counties and the number of insurers in the rating area.

We assume all rating area observations are independent, implying that correlation measures $\{CORR(r)\}_{r=1}^{r=R}$ are also independent, where R is the total number of rating areas with at least two insurers and two counties. Define $\overline{CORR} = \sum_{r=1}^{R=1} CORR(r)$, which is the sum of all correlation measures. Then mean and variance of $\overline{CORR}$ under the null are given as the following:

$$E[\overline{CORR}] = \sum_{r=1}^{R} E[CORR(r)], \quad \text{and} \tag{13}$$

$$\text{Var}[\overline{CORR}] = \sum_{r=1}^{R} \text{Var}[CORR(r)]. \tag{14}$$

By the Lindeberg-Lyapunov Central Limit Theorem, we have

$$t_R = \frac{\overline{CORR} - E[\overline{CORR}]}{\sqrt{\text{Var}[\overline{CORR}]}} \xrightarrow{d} N(0,1) \tag{15}$$

as $R \longrightarrow \infty$. Therefore, we reject the null of independence and randomization in favor of a positive correlation if the test statistic t_R is sufficiently large, and we reject the null in favor of a negative correlation if t_R is sufficiently small.[17]

5.4 Test Results

We implement the test for years 2016 and 2017. Table 10 reports the results. For each year, we use two different samples: one sample consists of all rating areas with at least two insurers and two counties, and the other sample is further restricted to rating areas with partial entry. Using the 2016 data, we obtain a very large test statistic (higher than 25) for both samples, so we reject the

[17] In Appendix E, we compare our correlation test with some recent nonparametric tests of affiliation in the auction literature.

	Year 2016		Year 2017	
	All RAs	RAs with Partial Entry	All RAs	RAs with Partial Entry
$\overline{CORR}$	158.42	46.42	95.69	16.69
$E[\overline{CORR}]$	4.04	1.49	2.84	1.42
Var$[\overline{CORR}]$	15.47	3.20	19.60	8.65
t_R	39.25	25.11	20.97	5.19
p-value	<1e-7	<1e-7	<1e-7	2.06e-7
Sample size (R)	247	135	205	126

Table 10: Correlation Test Results

Notes: The table reports the correlation test results for years 2016 and 2017. For each year, we implement the test twice; first, we use all rating areas with at least two insurers and two counties, and second, we further restrict the sample to rating areas where there is partial entry, i.e., $B_3^I(r) < 1$.

null in favor of a positive correlation. The test statistic is much lower when we use the 2017 data, but we can still reject the null in favor of a positive correlation at a very small significance level. The results imply that the desire to avoid high-cost counties has a greater impact on insurers' county-level entry decisions than the desire to avoid competition. We now turn to a regression analysis to identify which common market characteristics are important in explaining the positive correlation that we find.

6 Regression Analysis

We estimate the following equation to understand which factors are the most relevant for the significantly positive correlation that we find:

$$O(i,c) = \alpha \sum_{i' \neq i} O(i',c) + \beta MA_{i,c} + \gamma \boldsymbol{COUNTY}_c + \tau_i + \eta_r + \epsilon_{i,c}. \quad (16)$$

The dependent variable is the indicator for insurer i's entry status in county c as previously defined in Equation (10). For a given insurer, this variable is constructed for each county that belongs to a rating area where the insurer is active. The term $\sum_{i' \neq i} O(i',c)$ represents the number of competing insurers that are active in county c. $MA_{i,c}$ is an indicator for whether insurer i had sold any MA plans in the county before the ACA and it captures insurer-county level entry costs. The vector $\boldsymbol{COUNTY}_c$ includes county characteristics such as residents' average health status, the number of potential marketplace enrollees, and the number of health care providers. We include insurer fixed effects denoted by τ_i and rating area fixed effects denoted by η_r.

Table 11 reports the summary statistics of the regression sample. We use the 2016 Marketplace

PUF and restrict the sample to rating areas with partial entry.[18] Table 12 reports the linear regression results.[19] Column (1) in Table 12 reports the results when we regress an insurer's entry status in a county on the number of competing insurers only. The coefficient estimate for α is positive and statistically significant which is consistent with the correlation test result reported in Table 10. Columns (2)-(5) estimate α controlling for different sets of factors that may be important in explaining the positive correlation among insurers' county entry statuses.

Column (2) estimates α while controlling for $MA_{i,c}$ only. Compared to Column (1), the estimate of α does not change much, implying that insurers' fixed costs of entry are not the primary driver of the positive correlation that we detect.[20] Columns (3)-(5) estimate α conditional on county health measures, market size, and provider availability, respectively. The estimate of α from each of the three regressions is substantially lower than the estimate of α from Column (1). This suggests that such county characteristics are important in explaining the positively correlated entry patterns of insurers. In particular, insurers are less likely to enter counties with worse health measures, smaller market size, and lower urban population share. Finally, Column (6) reports the results when we estimate α conditional on all of the regressors used in Columns (2)-(5). The coefficient estimate on the number of competing insurers is now negative and statistically significant. This suggests that once we control for county health risks, market size, and provider availability, the positive correlation among insurers' entry statuses disappears, and we observe the market segmentation effect.

To summarize, while both county characteristics and competitive pressure affect insurers' decisions to selectively enter counties within a rating area, the former has a greater impact. In particular, insurers avoid counties with a higher share of unhealthy consumers and a lower share of urban population. The findings suggest that providing insurers with subsidies that are better tied to the risk scores of the counties in the insurers' service area may increase insurer participation in counties with unfavorable market conditions.

[18] We also estimate Equation (16) using all rating areas, and the results are qualitatively the same.

[19] We also estimate probit and logit models, and the results are qualitatively the same.

[20] This is consistent with empirical findings presented in Figure 8 which shows that insurers' fixed costs of entry are not correlated in a meaningful way. Note that our theoretical model implies that symmetric (asymmetric) fixed costs of entry would lead to a positive (negative) correlation in insurers' entry patterns.

	Mean	Std.	Min	Max
Insurer sells ACA plans in county	0.71	0.46	0.00	1.00
Competing ACA insurers in county	4.11	2.21	0.00	12.00
Insurer sold MA plans in county	0.36	0.48	0.00	1.00
Obese share	0.31	0.04	0.15	0.45
Smoker share	0.21	0.06	0.06	0.49
No leisurely physical activity share	0.26	0.05	0.11	0.41
Avg physically unhealthy days/mo	3.80	1.07	1.20	8.80
Share with access to physical activity	0.67	0.20	0.01	1.00
Access to good food (0-1)	0.73	0.11	0.09	1.00
Non-elderly pop. below 400% FPL (10k)	6.82	16.51	0.06	269.31
MDs	332.63	1042.46	0.00	13427.00
Hospitals	2.37	4.67	0.00	74.00
Urban population share	0.48	0.29	0.00	1.00
Observations (insurer-county combinations)	6,008			

Table 11: Summary Statistics of the Regression Sample

Notes: The table provides summary statistics of the regression sample. Each observation represents an insurer-county combination. The sample is from the 2016 Marketplace data and is restricted to rating areas with partial entry.

	Insurer's county entry status					
	(1)	(2)	(3)	(4)	(5)	(6)
Competing ACA insurers in county	0.0169**	0.0115	0.0028	-0.0002	-0.0058	-0.0144*
	(0.0077)	(0.0077)	(0.0076)	(0.0078)	(0.0079)	(0.0080)
Insurer sold MA plans in county		0.3685***				0.3415***
		(0.0417)				(0.0422)
Obese share			-0.2361			-0.0388
			(0.2120)			(0.2085)
Smoker share			-0.1150			-0.0758
			(0.0970)			(0.0962)
No leisurely physical activity share			-0.7433***			-0.5512***
			(0.1807)			(0.1740)
Avg physically unhealthy days/mo			-0.0069			-0.0070
			(0.0049)			(0.0049)
Share with access to physical activity			0.1447***			0.0274
			(0.0331)			(0.0346)
Access to good food (0-1)			-0.0072			0.1979**
			(0.0874)			(0.0932)
Non-elderly pop. below 400% FPL (10k)				0.0032***		0.0012
				(0.0005)		(0.0011)
MDs					0.0000	-0.0000
					(0.0000)	(0.0000)
Hospitals					0.0061**	0.0052
					(0.0030)	(0.0043)
Urban population share					0.1202***	0.0892***
					(0.0237)	(0.0287)
Observations (insurer-county combinations)	6,008	6,008	6,008	6,008	6,008	6,008

Table 12: Linear Regression Results

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The table reports the estimates from a linear probability model of whether the insurer is active in a county. All regressions include rating area and insurer fixed effects. Standard errors are clustered by insurer and are reported in parentheses.

7 Conclusion

In this paper, (1) we document the prevalence of the partial rating area offering phenomenon in the ACA marketplaces, where insurers selectively enter a strict subset of the counties within a geographic rating area, and (2) we study the primary motives that drive the phenomenon. Using publicly available data on individual health insurance plans sold in the federally-facilitated marketplaces, we find that about a third of the insurers enter some, but not all, counties of a rating area. We use a simple model of insurer competition to derive a testable implication that (1) if insurers selectively entered counties to avoid servicing markets with unfavorable conditions (higher risk, smaller market size or potentially larger entry costs), then their county entry decisions would be positively correlated, and (2) if they selectively entered counties to segment a rating area and avoid competition, their county entry decisions would be negatively correlated. We propose and implement a novel nonparametric correlation test and find strong empirical evidence for a positive correlation. Our finding implies that the partial rating area offering phenomenon is driven mostly by insurers' avoidance of counties with unfavorable market conditions.

The findings presented in this paper have several policy implications. First, to the extent that insurers can choose not to offer a plan in all counties of a rating area, the ACA community rating regulation based on rating areas only delivers an imperfect government control over insurers' ability to vary premiums by geographic region. Second, if the government aims to increase insurer participation in counties with few marketplace insurers, our findings suggest that the insurers need to be provided with subsidies that are tied to their service areas. Mandating that all plans be offered in all counties of a rating area, including the counties with higher risks and counties where the insurers do not have legacy provider networks, may instead trigger the insurers to exit the rating area altogether.

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A Appendix: Additional Tables

State	Division	RAs	Non Single County RAs	Counties	FFM
Alabama	MSAs+1	13	8	67	1
Alaska	3-Digit Zip Codes	3		29	1
Arizona	Counties	7	5	15	1
Arkansas	Counties	7	7	75	1
California	Counties/3-Digit Zip Codes	19		58	0
Colorado	Counties	9	4	64	0
Connecticut	Counties	8	0	8	0
Delaware	Counties	1	1	3	1
District of Columbia	Counties	1	0	1	0
Florida	Counties	67	0	67	1
Georgia	Counties	16	16	159	1
Hawaii	Counties	1	1	5	1
Idaho	3-Digit Zip Codes	7		44	0
Illinois	Counties	13	12	102	1
Indiana	Counties	17	16	92	1
Iowa	Counties	7	7	99	1
Kansas	Counties	7	7	105	1
Kentucky	Counties	8	8	120	0
Louisiana	Counties	8	8	64	1
Maine	Counties	4	4	16	1
Maryland	Counties	4	4	24	0
Massachusetts	3-Digit Zip Codes	7		14	0
Michigan	Counties	16	15	83	1
Minnesota	Counties	9	9	87	0
Mississippi	Counties	6	6	82	1
Missouri	Counties	10	10	115	1
Montana	Counties	4	4	56	1
Nebraska	3-Digit Zip Codes	4		93	1
Nevada	Counties	4	3	17	1
New Hampshire	Counties	1	1	10	1
New Jersey	Counties	1	1	21	1
New Mexico	MSAs+1	5	2	33	1
New York	Counties	8	8	62	0
North Carolina	Counties	16	16	100	1
North Dakota	MSAs+1	4	2	53	1
Ohio	Counties	17	17	88	1
Oklahoma	MSAs+1	5	4	77	1
Oregon	Counties	7	7	36	1
Pennsylvania	Counties	9	9	67	1
Rhode Island	Counties	1	1	5	0

South Carolina	Counties	46	0	46	1
South Dakota	Counties	4	4	66	1
Tennessee	Counties	8	8	95	1
Texas	MSAs+1	26	16	254	1
Utah	Counties	6	5	29	1
Vermont	Counties	1	1	14	0
Virginia	MSAs+1	12	12	134	1
Washington	Counties	5	4	39	0
West Virginia	Counties	11	10	55	1
Wisconsin	Counties	16	14	72	1
Wyoming	MSAs+1	3	1	23	1
Total		499	298	3,143	38

Table A1: Rating Areas in the State Marketplaces
Notes: The column "Division" reports the way each state is divided into rating areas; MSAs+1 means the state is divided into MSAs plus the remainder of the state not included in a MSA, Counties means rating areas are composed of a single or multiple counties, and 3-Digit Zip Codes means rating areas are composed of a single or multiple 3-digit zip codes. The column "RAs" reports the number of rating areas in each state. The column "Non Single County RAs" reports, for each state that uses counties to define rating areas, the number of rating areas that have two or more counties. The column "Counties" reports the number of counties in each state. The column "FFM" reports whether each state has a federally-facilitated marketplace.

B Appendix: Prevalence of Partial Rating Area Offering based on Plans' Service Area

Section 3 develops three measures of marketing breadth based on insurers' service areas. In this appendix, we use plans' service areas to develop three analogous measures of marketing breadth.

First, for each plan and for each of the rating areas where the plan is offered, we define plan-RA level marketing breadth as the fraction of counties in the rating area where the plan is offered. This measure tells us how broadly a plan covers a rating area. This measure can be represented as follows: for every $r \in \{1, ..., R\}$, and every $p \in \mathcal{P}_R(r)$,

$$B_1^P(p, r) = \frac{|\mathcal{C}_P(p) \cap \mathcal{C}(r)|}{|\mathcal{C}(r)|} \tag{17}$$

where the denominator is the number of counties in rating area r, and the numerator is the number of counties in rating area r where plan p is offered. For example, if plan p is offered in every county in rating area r, then $\mathcal{C}_P(p) \cap \mathcal{C}(r) = \mathcal{C}(r)$, resulting in $B_1^P(p, r) = 1$, i.e., plan p's marketing breadth in rating area r is 1. If plan p is only offered in one of the three counties that form rating area r, then $B_1^P(p, r) = \frac{1}{3}$.

Second, we develop a county level measure to evaluate how completely a county is served by plans that are offered in the county's rating area. Specifically, for each county, we compute the fraction of plans offered in its rating area that are also offered in the county:

$$B_2^P(c) = \frac{|\mathcal{P}_C(c)|}{|\mathcal{P}_R(r) : c \in \mathcal{C}(r)|}, \tag{18}$$

where the denominator is the number of plans that are offered in the rating area to which county c belongs, and the numerator is the number of plans offered in county c. For example, if five plans are offered in the rating area to which county c belongs, but only two of the five plans are offered in county c, then $B_2^P(c) = \frac{2}{5}$.

Lastly, we develop a rating area level measure to quantify how broadly plans serve counties in a rating area. This measure can be computed either by taking the average of the first plan-RA level measure, or by taking the average of the second county level measure. Both methods yield the same result:[21]

$$\begin{aligned} B_3^P(r) &= \frac{1}{|\mathcal{P}_R(r)|} \sum_{p \in \mathcal{P}_R(r)} B_1^P(p,r) \\ &= \frac{1}{|\mathcal{C}(r)|} \sum_{c \in \mathcal{C}(r)} B_2^P(c). \end{aligned} \tag{19}$$

Table B1 reports the summary statistics of the three measures for the 2016 Marketplace PUF described in Table 2. From the first measure $B_1^P(p,r)$, we see that 33% of the 13,029 plan-RA combinations have coverage breadth less than one. This means that one third of the plans are sold to some, but not all of the residents in a rating area. On average, a plan is offered to 81% of counties in a rating area, with a standard deviation of 30%. From the second measure $B_2^P(c)$, we find that,

[21] To see this, note that, for rating area r,

$$\begin{aligned} B_3^P(r) &= \frac{1}{|\mathcal{P}_R(r)|} \sum_{p \in \mathcal{P}_R(r)} B_1^P(p,r) \\ &= \frac{1}{|\mathcal{P}_R(r)|} \sum_{p \in \mathcal{P}_R(r)} \frac{|\mathcal{C}_P(p) \cap \mathcal{C}(r)|}{|\mathcal{C}(r)|} \\ &= \frac{1}{|\mathcal{P}_R(r)|\,|\mathcal{C}(r)|} \sum_{p \in \mathcal{P}_R(r)} |\mathcal{C}_P(p) \cap \mathcal{C}(r)|. \end{aligned}$$

As $|\mathcal{C}_P(p) \cap \mathcal{C}(r)|$ represents the total number of counties in rating area r where plan p is sold, $\sum_{p \in \mathcal{P}_R(r)} |\mathcal{C}_P(p) \cap \mathcal{C}(r)|$ represents the total number of plan-county combinations in rating area r. An alternative expression for the total number of plan-county combinations in rating area r is $\sum_{c \in \mathcal{C}(r)} |\mathcal{P}_C(c)|$.

Measure	Unit	Obs.	Share of Obs. < 1	Mean	Std
$B_1^P(p,r)$	Plan-RA	13,029	0.33	0.81	0.30
$B_2^P(c)$	County	2,335	0.57	0.79	0.25
$B_3^P(r)$	RA	259	0.63	0.87	0.15

Table B1: Plan Coverage Measures

Notes: The table reports summary statistics on the three measures of marketing breadth using plan coverage.

of the 2,335 counties located in rating areas that consist of multiple counties, 57% are excluded by at least one plan offered in their respective rating area. On average, a county is served by 79% of plans in its rating area, with a standard deviation of 25%. From the third measure $B_3^P(r)$, we find that, of the 259 rating areas with multiple counties, about 63% have at least one plan that is not universally offered across counties. On average, rating areas have plan coverage rate of 87%.

C Appendix: More Illustrative Examples of the Correlation Measure

Example 1. Consider rating area r with two counties, c_1 and c_2. There are two insurance companies, insurer 1 and insurer 2, and a total of 5 plans, $\{a, b, d, e, f\}$, that are offered in the rating area. Suppose insurer 1 offers plan a in county c_1 and plan b in county c_2; insurer 2 offers plan d in both counties, plan e in county c_1, and plan f in county c_2. The object $o(1, 2; c_1, c_2)$ as defined in Equation (11) is 1. The correlation measure $CORR(r)$ is computed as

$$\begin{aligned} CORR(r) &= \frac{1}{\binom{2}{2} \cdot \binom{2}{2}} o(1, 2; c_1, c_2) \\ &= 1. \end{aligned}$$

As both insurers are active in all counties of the rating area, we could say that they are perfectly aligned in their county entry decisions, resulting in a correlation measure of one.

Example 2. As in the previous example, consider rating area r with two counties, c_1 and c_2, and two insurance companies, insurer 1 and insurer 2. There is again a total of 5 plans, $\{a, b, d, e, f\}$, that are offered in the rating area. Now suppose that insurer 1 offers plans a and b in county c_1, and insurer 2 offers plans d, e, and f in county c_2. The object $o(1, 2; c_1, c_2)$ as defined in Equation

(11) is -1. The correlation measure $CORR(r)$ is then computed as

$$\begin{aligned} CORR(r) &= \frac{1}{\begin{pmatrix} 2 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 2 \end{pmatrix}} o(1,2;c_1,c_2) \\ &= -1. \end{aligned}$$

As the two insurers perfectly segment the rating area, the correlation measure results in -1.

Example 3. Rating area r again has two counties, c_1 and c_2, but now there are three insurance companies, insurer 1,2, and 3. There is a total of 7 plans, $\{a, b, d, e, f, g, h\}$, that are offered in the rating area. Insurer 1 offers plans a, b and d in county c_1; insurer 2 offers plan e in both counties and plan f in county c_2; and insurer 3 offers plans g and h in county c_2. The objects $o(\cdot,\cdot;\cdot,\cdot)$ as defined in Equation (11) are: $o(1,2;c_1,c_2) = 0, o(1,3;c_1,c_2) = -1, o(2,3;c_1,c_2) = 0$. Thus the correlation measure $CORR(r)$ is computed as

$$\begin{aligned} CORR(r) &= \frac{1}{\begin{pmatrix} 3 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ 2 \end{pmatrix}} \{o(1,2;c_1,c_2) + o(1,3;c_1,c_2) + o(2,3;c_1,c_2)\} \\ &= \frac{1}{3}\{0 + (-1) + 0\} \\ &= -\frac{1}{3}. \end{aligned}$$

While no pair of insurers are perfectly aligned in their county entry decisions, insurer 1 and insurer 3 are perfectly misaligned in their county entry decisions. As a result, the overall correlation measure for the rating area is negative at $-\frac{1}{3}$.

D Appendix: $E[CORR(r)]$ and Var$[CORR(r)]$ under the Null

We derive the analytical forms of $E[CORR(r)]$ and Var$[CORR(r)]$ under the null hypothesis stated in Section 5. For notational simplicity, define function $C(n,k)$ as the combination function

$$C(n,k) = \begin{cases} \frac{n!}{(n-k)!k!} & \text{if } n \geq k, \\ 0 & \text{otherwise.} \end{cases} \tag{20}$$

Analytical Form of $E[CORR(r)]$. For any given pair of insurers (i, i') and a pair of counties (c, c'), the probability that $o(i, i'; c, c') = 1$ is

$$Pr[(O(i,c){=}O(i',c) \text{ and } O(i,c'){=}O(i',c')] = 3\left(\frac{2^{|\mathcal{C}(r)|-2}}{|\mathcal{A}(r)|}\right)^2 + \left(\frac{2^{|\mathcal{C}(r)|-2}-1}{|\mathcal{A}(r)|}\right)^2.$$

The probability that $o(i, i'; c, c') = -1$ is

$$Pr[O(i,c){\neq}O(i',c) \text{ and } O(i,c'){\neq}O(i',c')] = 2\left(\frac{2^{|\mathcal{C}(r)|-2}}{|\mathcal{A}(r)|}\right)^2 + 2\left(\frac{2^{|\mathcal{C}(r)|-2}}{|\mathcal{A}(r)|}\cdot\frac{2^{|\mathcal{C}(r)|-2}-1}{|\mathcal{A}(r)|}\right).$$

The expected value of $o(i, i'; c, c')$ is

$$\begin{aligned} E[o(i,i';c,c')] &= Pr[(O(i,c){=}O(i',c) \text{ and } O(i,c'){=}O(i',c')] - Pr[(O(i,c){\neq}O(i',c) \text{ and } O(i,c'){\neq}O(i',c')] \\ &= \frac{1}{|\mathcal{A}(r)|^2} \\ &= \frac{1}{(2^{|\mathcal{C}(r)|}-1)^2} \end{aligned}$$

which only depends on the number of counties in the rating area. The expected value of $CORR(r)$ under the null is

$$\begin{aligned} E[CORR(r)] &= \frac{1}{C(|\mathcal{I}|,2)\cdot C(|\mathcal{C}|,2)} \sum_{(i,i')\in\tilde{\mathcal{I}}_R(r)} \sum_{(c,c')\in\tilde{\mathcal{C}}(r)} E[o(i,i';c,c')] \\ &= \frac{1}{(2^{|\mathcal{C}(r)|}-1)^2}. \end{aligned}$$

As the number of counties in a rating area approaches to infinity, the mean correlation converges to zero under the null.

Analytical Form of Var$[CORR(r)]$. Express Var$[CORR(r)]$ as

$$\text{Var}[CORR(r)] = E[CORR(r)^2] - (E[CORR(r)])^2. \tag{21}$$

We already computed $E[CORR(r)]$ under the null, so it suffices to derive the expression for $E[CORR(r)^2]$ which can be written as

$$E[CORR(r)^2] = \frac{1}{(C(|\mathcal{I}|,2)\cdot C(|\mathcal{C}|,2))^2} E\left[\left(\sum_{(i,i')\in\mathcal{I}_R(r),(c,c')\in\mathcal{C}(r)} o(i,i';c,c')\right)^2\right]. \qquad (22)$$

We can express the expectation term on the right hand side of the equation as the following:

$$\begin{aligned} E\left[\left(\sum_{(i,i')\in\mathcal{I}_R(r),(c,c')\in\mathcal{C}(r)} o(i,i';c,c')\right)^2\right] &= \sum_{(i,i')\in\mathcal{I}_R(r),(c,c')\in\mathcal{C}(r)} E\left[o(i,i';c,c'^2\right] \\ &+ \sum_{\substack{(i,i'),(\tilde{i},\tilde{i}')\in\mathcal{I}_R(r),(c,c'),(\tilde{c},\tilde{c}')\in\mathcal{C}(r)\\ (i,i',c,c')\neq(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')}} E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\right]. \end{aligned} \qquad (23)$$

The analytical form of $E\left[o(i,i';c,c'^2\right]$ under the null is

$$\begin{aligned} E\left[o(i,i';c,c'^2\right] &= Pr[o(i,i';c,c')=1] + Pr[o(i,i';c,c')=-1] \\ &= \left(3\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + \left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2\right) + \left(2\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 2\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right) \\ &= \frac{2^{2|\mathcal{C}|-1}-2^{|\mathcal{C}|}+1}{(2^{|\mathcal{C}|}-1)^2}. \end{aligned}$$

So we have

$$\sum_{(i,i')\in\mathcal{I}_R(r),(c,c')\in\mathcal{C}(r)} E\left[o(i,i';c,c'^2\right] = C(\mathcal{I},2)\cdot C(\mathcal{I},2)\cdot\left(\frac{2^{2|\mathcal{C}|-1}-2^{|\mathcal{C}|}+1}{(2^{|\mathcal{C}|}-1)^2}\right). \qquad (24)$$

$E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\right]$ can be written as

$$\begin{aligned} E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\right] &= Pr[o(i,i';c,c')=1 \text{ and } o(i,\tilde{i}';c,c')=1] \\ &+ Pr[o(i,i';c,c')=-1 \text{ and } o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')=-1] \\ &- Pr[o(i,i';c,c')=1 \text{ and } o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')=-1] \\ &- Pr[o(i,i';c,c')=-1 \text{ and } o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')=1]. \end{aligned}$$

The exact expression of $E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\right]$ under the null depends on the presence of common insurers between the two pairs of insurers (i,i') and $(\tilde{i},\tilde{i}')$, and the presence of common counties between the two pairs of counties (c, c') and $(\tilde{c}, \tilde{c}')$. We compute the analytical form of $E\left[o(i, i'; c, c') \cdot o(\tilde{i}, \tilde{i}'; \tilde{c}, \tilde{c}')\right]$ under each of the following six cases.

Case 1: There is no common insurer between (i, i') and $(\tilde{i}, \tilde{i}')$. As the null assumes insurers' county entry decisions are independent, we get the following analytical form[22]:

$$\begin{aligned}
E\left[o(i, i'; c, c') \cdot o(\tilde{i}, \tilde{i}'; \tilde{c}, \tilde{c}')|\text{Case 1}\right] &= E\left[o(i, i'; c, c')\right] \cdot E\left[o(\tilde{i}, \tilde{i}'; \tilde{c}, \tilde{c}')\right] \\
&= \frac{1}{|\mathcal{A}|^4} \\
&= \frac{1}{\left(2^{|\mathcal{C}|} - 1\right)^4}.
\end{aligned}$$

Case 2: There is one common insurer between (i, i') and $(\tilde{i}, \tilde{i}')$, and the two pairs of counties are identical, i.e., $(c, c') = (\tilde{c}, \tilde{c}')$.

$$\begin{aligned}
E\left[o(i, i'; c, c') \cdot o(\tilde{i}, \tilde{i}'; \tilde{c}, \tilde{c}')|\text{Case 2}\right] &= 3\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^3 + 1 * \left(\frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right)^3 \\
&+ 2\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^3 + \frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|} \cdot \left(\frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right)^2 + \left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 \cdot \frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|} \\
&- 2\left(2\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^3 + \frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|} \cdot \left(\frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right)^2 + \left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 \cdot \frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right) \\
&= 3\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^3 + 1 * \left(\frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right)^3 \\
&- \left(2\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^3 + \frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|} \cdot \left(\frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right)^2 + \left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 \cdot \frac{2^{|\mathcal{C}|-2} - 1}{|\mathcal{A}|}\right).
\end{aligned}$$

Case 3: There is one common insurer between (i, i') and $(\tilde{i}, \tilde{i}')$, and there is one common county

[22] Note that $(c, c') = (\tilde{c}, \tilde{c}')$ is allowed.

between (c, c') and $(\tilde{c}, \tilde{c}')$.

$$
\begin{aligned}
& E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 3}\right] \\
= \quad & \frac{2^{|\mathcal{C}|-3}-1}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2 + 5\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 2\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} \\
+ \quad & \frac{2^{|\mathcal{C}|-3}-1}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 4\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 2\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} + \frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2 \\
- \quad & 2\left(\frac{2^{|\mathcal{C}|-3}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} + 4\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 3\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right).
\end{aligned}
$$

<u>Case 4</u>: There is one common insurer between (i, i') and $(\tilde{i}, \tilde{i}')$, and there is no common county between (c, c') and $(\tilde{c}, \tilde{c}')$.

$$
\begin{aligned}
& E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 4}\right] \\
= \quad & 9\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 6\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} + \frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2 \\
+ \quad & 8\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 6\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} + \frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + \frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2 \\
- \quad & 2\left(9\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\right)^2 + 5\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|} + \frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\left(\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right)^2 + \frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-2}-1}{|\mathcal{A}|}\right).
\end{aligned}
$$

<u>Case 5</u>: The two pairs of insurers are identical, i.e., $(i, i') = (\tilde{i}, \tilde{i}')$, and there is one common county between (c, c') and $(\tilde{c}, \tilde{c}')$.

$$
\begin{aligned}
E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 5}\right] \quad = \quad & \left(\frac{2^{|\mathcal{C}|-3}-1}{|\mathcal{A}|}\right)^2 + 7\left(\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\right)^2 \\
+ \quad & 2\frac{2^{|\mathcal{C}|-3}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|} + 6\left(\frac{2^{|\mathcal{C}|-3}}{|\mathcal{A}|}\right)^2.
\end{aligned}
$$

<u>Case 6</u>: The two pairs of insurers are identical, i.e., $(i, i') = (\tilde{i}, \tilde{i}')$, and there is no common county

	Number of $\{(i,i';c,c'),(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\}$ Combinations
Case 1	$C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{I}\|-2,2)\cdot C(\|\mathcal{C}\|,2)^2$
Case 2	$2C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{I}\|-2,1)\cdot C(\|\mathcal{C}\|,2)$
Case 3	$4C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{I}\|-2,1)\cdot C(\|\mathcal{C}\|,2)\cdot C(\|\mathcal{C}\|-2,1)$
Case 4	$2C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{I}\|-2,1)\cdot C(\|\mathcal{C}\|,2)\cdot C(\|\mathcal{C}\|-2,2)$
Case 5	$2C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{C}\|,2)\cdot C(\|\mathcal{C}\|-2,1)$
Case 6	$C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{C}\|,2)\cdot C(\|\mathcal{C}\|-2,2)$
Total	$2C(C(\|\mathcal{I}\|,2)\cdot C(\|\mathcal{C}\|,2),2)$

Table D1: Number of $\{(i,i';c,c'),(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\}$ Combinations for Each of the Six Cases
Notes: The table reports the number of $\{(i,i';c,c'),(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\}$ combinations for each of the six cases when we sum over the left-hand side of Equation (25). For $n<k$, $C(n,k)=0$ as defined in Equation (20).

between (c,c') and $(\tilde{c},\tilde{c}')$.

$$\begin{aligned}
E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 6}\right] &= \left(\frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\right)^2+15\left(\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\right)^2\\
&+ 2\frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}+14\left(\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\right)^2\\
&- 2\left(2\frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}+14\left(\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\right)^2\right)\\
&= \left(\frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\right)^2+15\left(\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\right)^2\\
&- \left(2\frac{2^{|\mathcal{C}|-4}-1}{|\mathcal{A}|}\cdot\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}+14\left(\frac{2^{|\mathcal{C}|-4}}{|\mathcal{A}|}\right)^2\right).
\end{aligned}$$

Using the number of $\{(i,i';c,c'),(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\}$ combinations for each of the six cases (reported in Table D1), we obtain the following expression:

$$\begin{aligned}
&\sum_{\substack{(i,i'),(\tilde{i},\tilde{i}')\in\mathcal{I}_R(r),(c,c'),(\tilde{c},\tilde{c}')\in\mathcal{C}(r)\\(i,i',c,c')\neq(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')}} E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')\right] \qquad (25)\\
= &\; C(|\mathcal{I}|,2)\cdot C(|\mathcal{I}|-2,2)\cdot C(|\mathcal{C}|,2)^2\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 1}\right]\\
+ &\; 2C(|\mathcal{I}|,2)\cdot C(|\mathcal{I}|-2,1)\cdot C(|\mathcal{C}|,2)\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 2}\right]\\
+ &\; 4C(|\mathcal{I}|,2)\cdot C(|\mathcal{I}|-2,1)\cdot C(|\mathcal{C}|,2)\cdot C(|\mathcal{C}|-2,1)\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 3}\right]\\
+ &\; 2C(|\mathcal{I}|,2)\cdot C(|\mathcal{I}|-2,1)\cdot C(|\mathcal{C}|,2)\cdot C(|\mathcal{C}|-2,2)\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 4}\right]\\
+ &\; 2C(|\mathcal{I}|,2)\cdot C(|\mathcal{C}|,2)\cdot C(|\mathcal{C}|-2,1)\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 5}\right]\\
+ &\; C(|\mathcal{I}|,2)\cdot C(|\mathcal{C}|,2)\cdot C(|\mathcal{C}|-2,2)\cdot E\left[o(i,i';c,c')\cdot o(\tilde{i},\tilde{i}';\tilde{c},\tilde{c}')|\text{Case 6}\right].
\end{aligned}$$

Using Equations (24) and (25), we obtain the analytical form for $E[CORR(r)^2]$. As the analytical form for $E[CORR(r)]$ has already been computed, we obtain the analytical form for $\text{Var}[CORR(r)]$.

E Appendix: Connections with Affiliation Tests

Here we discuss and contrast our correlation test with some recent nonparametric tests of affiliation in the auction literature. The notion of affiliation is stronger than positive correlation, and it was first introduced into economics by Milgrom and Weber (1982) in auction settings.[23] Affiliation of bidders' signals has testable implications for observable decision variables, such as bids and participation decisions. Since then, various tests have been developed to test affiliation in the context of auctions (Roosen and Hennessy, 2004; de Castro and Paarsch, 2010; Jun et al., 2010; Aradillas-Lopez, 2016). In particular, Aradillas-Lopez (2016) developed a non-parametric test for affiliation of bidders' participation decisions based on the aggregate number of bidders.[24] The test is based on the result that in competitive auctions where bidders' values are affiliated, bidders' participation decisions would also be affiliated. This implies that, under the null hypothesis of affiliation, the aggregate number of bidders in auctions must satisfy some inequality. If the test rejects the null hypothesis of affiliation, it could suggest that bidders are not acting competitively, such as acting in collusion. Indeed, Aradillas-Lopez et al. (2017) use this implication as the basis for testing whether there is evidence for collusion in off-shore oil and gas lease auctions.

One of the main hypotheses that we test in this paper is whether partial rating area offering can be explained by insurers' incentive to segment a rating area and avoid competition. As market segmentation could also be sustained as a result of collusion among insurers, it could be tempting to apply Aradillas-Lopez (2016)'s test of affiliation to our setting. A county will correspond to an auction, and insurers' county entry decisions would correspond to bidders' participation decisions in auctions. Aradillas-Lopez (2016)'s test of affiliation is based on the number of bidders in auctions. Applied to our setting, we would use the number of entering insurers in a county as the analog of the number of bidders in an auction. Using multiple observations of counties, we would compute Aradillas-Lopez (2016)'s test statistic, and decide whether to reject the null of affiliation among insurers' entry decisions in a county. Finding evidence for the null of affiliation would be supportive

[23] For a formal definition of affiliation, see Milgrom and Weber (1982).
[24] Refer to Section 2.5.1 in Aradillas-Lopez (2016) for details.

of the importance of common market level shocks, while finding evidence against the null would be supportive of the market segmentation hypothesis.

However, one key assumption needed to properly implement Aradillas-Lopez (2016)'s test is that bidders' participation decisions are i.i.d. across auctions. Applied to our setting, this assumption would imply that insurers' county entry decisions are i.i.d. across all counties. However, insurers' county entry decisions within a rating area are unlikely to be independent. As in our model, it is reasonable to assume that insurers in a given rating area decide simultaneously which counties to enter with the constraint that premiums of the same plan have to be identical for all counties within the rating area. In this case, insurers' entry decisions in counties that belong to the same rating area would not be independent, and Aradillas-Lopez (2016)'s test would not be applicable. That is why we develop our correlation test which is also nonparametric but is better suited to test the relative importance of common market characteristics and competitive pressure in the context of insurer competition under the geographic rating regulation.

F Appendix: Description of the 2017 Marketplace Data

This appendix provides a brief description of the 2017 Marketplace PUF data. Table F1 describes the data before excluding rating areas that consist of a single county. Table F2 describes the final 2017 Marketplace PUF sample which excludes single county rating areas. Compared to the 2016 Marketplace PUF data described in Tables 1 and 2, the number of states increased by one as Kentucky transitioned to the federal marketplace for year 2017. Despite this change, there are fewer plans and insurers, as several insurers exited the marketplaces. Table F3 describes premiums and copayments of the 2017 marketplace plans. Compared to 2016, premiums increased across all metal levels. Table F4 provides information about insurer participation. Compared to 2016, the average number of insurers participating in a state marketplace decreased from 6.3 to 4.4, the average number of insurers active in a rating area decreased from 4.8 to 2.9, and the average number of active insurers in a county decreased from 3.5 to 2.1. Table F5 provides the summary statistics of the three measures that we developed in Section 3 to quantify insurer marketing breadth relative to rating areas. The results are quantitatively similar to the 2016 measures, implying that partial rating area coverage is still common in the 2017 marketplaces.

Plans	Insurers	Networks	States	RAs	Non Single County RAs	Counties	Plan-RA
3,064	162	288	37	413	267	2,601	12,495

Table F1: 2017 Marketplace PUF Sample Before Excluding Single County RAs
Notes: Only individual health plans offered in federally-facilitated marketplaces are considered. Alaska and Nebraska are excluded as they use zip codes to define rating areas.

Plans	Insurers	Networks	States	RAs	Counties	Plan-RA
2,637	154	272	35	267	2,455	8,048

Table F2: 2017 Marketplace PUF Sample After Excluding Single County RAs
Notes: Only individual health plans offered in federally-facilitated marketplaces are considered. Rating areas that have only one county are excluded. Alaska and Nebraska are excluded as they use zip codes to define rating areas. Florida and South Carolina are excluded as their rating areas always consist of one county.

Metal	Plans	Premium 21	Premium 45	Premium 64	OOP Max	Deductible
Catastrophic	191	221	319	662	7,150	7,150
Bronze	843	268	388	804	5,106	4,547
Silver	1,123	316	457	948	3,865	2,103
Gold	446	406	587	1,217	3,738	991
Platinum	34	434	627	1,302	2,015	232

Table F3: Average Plan Characteristics of the 2017 Marketplace PUF Sample
Notes: Premium 21, 45, and 64 represent the average monthly rate for a non-smoking 21-year-old, 45-year-old, and 65-year-old, respectively. OOP Max represents the annual out-of-pocket maximum.

	Mean	Std.	Min	Max	Obs
# of Active Insurers in a County	2.09	1.13	1	9	2,455
# of Active Insurers in a RA	2.88	1.73	1	9	267
# of Active Insurers in a State	4.40	3.30	1	15	35

Table F4: Insurer Participation in the 2017 Marketplace PUF Sample
Notes: The table reports the summary statistics of insurer participation.

Measure	Unit	Obs.	Share of Obs. < 1	Mean	Std
$B_1^I(i,r)$	Insurer-RA	769	0.34	0.81	0.30
$B_2^I(c)$	County	2,455	0.38	0.80	0.28
$B_3^I(r)$	RA	267	0.47	0.87	0.18

Table F5: Insurer Coverage Measures from the 2017 Marketplace PUF Sample
Notes: The table reports summary statistics on the three measures of marketing breadth using insurer coverage.