Multidimensional Barriers to Entry in the Insurance Industry

Sabrina Du*

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Abstract

In this paper, we propose and estimate a multi-agent model of entry. Estimations are conducted at each market-year level such that we could disentangle the relative importance of barriers to entry across three dimensions: geographic, product, and time. Barriers to entry exist and are quite substantial in the insurance industry. Overall, we find *de novo* entrants are the ones that most subject to barriers to entry across all markets. On average, expanding within a state is as costly as expanding within a product line. With further examinations, we discover that product-specific knowledge plays a critical role in successful expansions, and it is relatively more important than state-specific connections. Among all product lines, expertise in mortgage guaranty insurance creates the most barriers, and these barriers are most subjected to impacts of the financial crisis.

JEL Codes: G22, L10, L13, L22

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*__Contact Author__ Fox School of Business, Temple University, sabrina.du@temple.edu

1 Introduction

Barriers to entry are widely believed to be a vital component that influences competitiveness and performance in an industry. It is a driver that shields incumbents from profit distortions created by new entrants and motivates newcomers and antitrust organizations to seek novel ways to overcome it. As barriers to entry have drawn substantial attention among economists, we know that various barriers exist and play different roles across industries (Karakaya and Stahl, 1989). Furthermore, new competitors are not all alike. They could overcome some burden of entry barriers according to the private information and pre-entry resources they possessed about the targeted markets (Hines, 1957). With that being said, *de novo* entrants would face more entry barriers than diversifying entrants. How about its impact on different diversifying entrants? What information is more valuable for market entry? These are the questions we intend to explore.

In this paper, we examine the relative importance of geographic and product-specific barriers to entry. We propose and estimate a multi-agent model of entry using firm-specific financial data from nearly every property-casualty insurance firm operating in the U.S. from 1996 to 2017. We find that, on average, it is equally costly for insurance firms to expand across state borders as it is to start a new line of business in the same state. However, averaging masks considerable heterogeneity. We find that cross-product expansions face more barriers than cross-state expansions, due to lack of product-specific expertise. Although a company expand to a highly related business line, the entry barriers would still vary wildly across different states.

Understanding the nuances of entry barriers is vital to U.S. antitrust law, and there is a long history of study in economics.[1] Barriers to entry have largely been found in industries that produce tangible goods such as aviation, pharmaceutical, manufacturing, and retail industries. Several important structural barriers observed in the literature are economies of

[1]For instance, Bain (1956); Stigler (1968); Demsetz (1982).See Carlton (2004) and McAFee et al. (2004) for an overview. In this article, we stick to Stigler's definition to consider barriers to entry as costs that must be borne by newcomers in market entry.

scale, absolute or variable cost advantages, product differentiation, switching cost, and incomplete information.[2] However, entry conditions can vary wildly across industries (Bresnahan et al., 1987).[3] We instead examine how entry barriers differ for firms *within* an industry. In the financial service industry, barriers typically arise from regulatory requirements and/or economies of scale (McShane et al., 2012; Carow, 2001).

The insurance industry is an excellent laboratory to answer this question because insurance markets are defined by law. Insurance firms are regulated at the state level, and each product line definition is strictly regulated.[4] It is rare and difficult for consumers to purchase an insurance product that is not admitted in their state, even if the insurer already sells a different product in the same state or the same product in a different state.[5] This clearly delineates two separate channels of entry barriers. Firms expanding into a new state will have to bear the costs of state regulatory compliance, set up offices, develop brand recognition, and hire local talents. Meanwhile, these barriers could somewhat be offset by firms' pre-entry resources and capabilities, such as specialized underwriting knowledge, in the original markets. Firms expanding into a new product line will have to develop new pricing models. This barrier could be substantial even if firms could redeploy the local market knowledge and distribution network. Fier et al. (2017) argue that the complexity and potential costs associated with developing new pricing schemes and appropriate policy coverages are sub-

[2]See Pehrsson (2009) for detailed review of literature.

[3]Lieberman (1987) finds that incumbents enjoy higher profits if they allow entry, instead of deterring entry, in markets with steep learning curves. Karakaya and Stahl (1989) and Song et al. (1999) survey executives from different industries and find that the barriers to entry are different in markets between manufacturing and service goods. Mata (1993) discovers that barriers to entry differ across the various pre-entry position of the potential entrant.

[4]In contrast, one primary concern in prior market entry literature is that the market definition is relatively "arbitrary." For example, it uses how far consumers can drive to define a local market (e.g. Bresnahan and Reiss, 1991). Moreover, it is not easy to delineate products within the industry by relying only on the industry classification codes (e.g., SIC/NAICS codes).

[5]There are two exceptions. One is the surplus lines market, which consists of a group of non-admitted specialized insurers, providing coverages that are not available in the admitted market. By law, a surplus line insurer only can write, in most states, new insurance coverages or coverages that are rejected by the admitted insurers. This market is regulated differently from the admitted market. A licensed surplus line broker is mandatory to monitor surplus line transactions in addition to the capital and solvency requirements overseen by the domiciliary state. The other one is the risk retention group, which are liability insurers that only serve its owners. It could directly write policies across states without obtaining licenses as long as it is licensed in the domiciliary state. Overall, these two types of insurer only account for a tiny fraction of the sample.

stantially outweighing the costs of geographic expansions. *De novo* entrants will have to do both.

Few studies have directly examined barriers to entry in the insurance industry. Instead, prior studies have drawn inferences on entry barriers from examining the relationship between post-entry competition and firm performance.[6] Leverty (2012) estimates the costs of regulatory compliance and shows that it deters entry and hinders competition in the liability insurance market. All prior studies have an implicit assumption that the number of firms in the market is an exogenous factor embedded in the market. However, the number of firms in the market is an equilibrium outcome of market conditions *and* strategic interactions among companies.

We account for this endogeneity by developing a multi-agent model of endogenous entry with heterogeneous entry costs. Similar to Bresnahan and Reiss (1991) and Berry (1992), the observed entry decision is an indicator of underlying market profitability, and it implicitly determines the nature of competition among firms in the market. We assume firms predict their potential, post-entry, profits in a market based on: publicly available financial data, the potential actions of other firms, and market-specific entry costs. Firms then compete in an entry game where the firms with the highest expected profits enter sequentially until the marginal entering firm has zero profit, and a Nash Equilibrium is reached.

We extend the literature in two ways. We provide the first, to our knowledge, examination of entry barriers in the insurance industry that accounts for endogenous entry decisions. We find that entry barriers exist and are substantial. Second, we extend the general literature on entry barriers by explicitly modeling within-industry heterogeneity and delineating impacts from different dimensions. We find that geographic and product-specific barriers are similar on average. However, closer examination depicts a wide variation in barriers imposed by product-specific expertise across states.

[6]For example, Carroll (1993); Bajtelsmit and Bouzouita (1998); Choi and Weiss (2005); Pope and Ma (2008); Cole et al. (2014).

The remainder of the paper proceeds as follows: Section 2 introduces our market entry model. Section 3 describes the data and sample. Section 4 describes the estimation procedure, presents the results, and discusses the findings. Section 5 concludes the paper.

2 Model and Solution

In this section, we introduce the market entry model, discuss the relevant assumptions, and describe the solution mechanism.

2.1 Market Entry Model

We model a multi-agent entry game.[7] We separate a firm's potential post-entry profits in a given market into three, additively separable, portions: the firm's expectations about the market's long-term profitability, the equilibrium actions of other players, and the initial barriers for the firm to enter the market. Firms with positive expected post-entry profits enter, and those with negative expected post-entry profits do not. The post-entry profits $\Pi_{i,p,s,t}$ for firm i, selling product p, in state s, in year t, where $N_{s,p,t}$ firms compete are

$$\Pi_{i,p,s,t} = \widehat{\pi_{i,p,s,t-1}}(\theta) + \delta ln(N_{s,p,t}) + S_{i,s,p,t} + P_{i,s,p,t} + D_{i,s,p,t} + \varepsilon_{i,p,s,t} \tag{1}$$

$$\pi_{i,p,s,t-1}(\theta) = \begin{cases} \theta_i + \theta_p + \theta_s + \nu_{i,p,s,t-1}, & \text{if i is an existing company} \\ \theta_p + \theta_s + \nu_{p,s,t-1}, & \text{if i is a start-up company} \end{cases} \tag{2}$$

Where $\pi_{i,p,s,t-1}(\theta)$ represents the portion of profits that is independent of other firms' decisions for firm i if it would enter market $\{s, p\}$. $\pi_{i,p,s,t-1}(\theta)$ is parameterized by θ, which we estimate through a fixed effects model that decomposes the firm, state, and product-specific portions of the financial performance of firms in the prior year. Profits of start-up

[7] Importantly, we are *only* modeling entry. We take the incumbent firm's decisions as given. We discuss the rationality and implications of this decision in Section 2.2.

companies will only depend on state and product-specific impacts. Importantly, because $\pi_{i,p,s,t-1}(\theta)$ does not depend on the actions of other firms, θ can be estimated outside of the entry game. Essentially, we are taking the traditional structure-conduct-performance approach as a baseline and modifying it to account for the actions of other firms. The assumption that this can be done in an additively separable manner dramatically reduces the dimensionality of coefficients dependent on the actions of other firms.

The firm fixed-effect θ_i captures both the public and individual heterogeneity in firms' capabilities. For instance, firms with certain existing competitive advantages, such as superior underwriting capacity, economies of scale, or brand effects, would lead to a higher expected profit in market $\{s, p\}$.[8] The product fixed-effect θ_p captures the heterogeneity in characteristics, embedded in each product line, that have differential impacts on profits from factors such as risk exposures, underwriting cycles, and economic climate. Different reserving behavior in long-tail and short-tail lines could result in distinct investment gains (losses) at the state of good (bad) economics. For instance, the financial crisis struck the profits of financial and mortgage guaranty lines much more severely than other lines. The state fixed-effect θ_s captures the public heterogeneity in profit levels across different states. On the demand side, it could be differences in market size, such as population and income in each state. On the supply side, these disparities will mostly root from state-specific insurance regulations: company and producer licensing, product form and price regulation, and insolvency monitoring.[9]

$\Pi_{i,p,s,t}$ is determined by the expected independent profits, the number of equilibrium firms in the market, and a vector of dummy variables that classify firms into same-state expansion $S_{i,s,p,t}$, same-product expansion $P_{i,s,p,t}$, and *de novo* entry $D_{i,s,p,t}$ in market $\{s, p\}$.[10]

[8] If firm i is a start-up firm, θ_i will be zero. $\widehat{\pi_{i,p,s,t-1}}$ would only capture the expected profit based on state and product effects because there are no pre-existing firm-specific resources.

[9] See the NAIC State Insurance Regulation document for more details: https://www.naic.org/documents/consumer_state_reg_brief.pdf

[10] Note that we define *de novo* entry as firms that have never operated in either the same state or same line. It could be a new start-up in market $\{s, p\}$, or an existing firm that does not write business in either the same state or the same product line. For instance, a firm that underwrites workers' compensation insurance in Pennsylvania is a *de novo* entry if the targeted market is automobile insurance in Georgia.

$S_{i,s,p,t}$, $P_{i,s,p,t}$, and $D_{i,s,p,t}$ represent the relative difficulty in entering market $\{s,p\}$ in year t for different firms. If a market has a $S_{i,s,p,t} > D_{i,s,p,t}$, then firms who already operate in the same state will have an advantage over potential *de novo* entrants. If a market has $P_{i,s,p,t} > S_{i,s,p,t} > D_{i,s,p,t}$, then firms operating in the same state will still have an advantage over potential *de novo* entrants, but not as big of an advantage as firms that operate in the same line, but in a different state. $\delta ln(N_{s,p,t})$ is a simplified, non-linear function of $N_{s,p,t}$, the equilibrium number of firms in market $\{s,p\}$ in year t where δ measures the change in demand as more entries occur.

2.2 Discussion of Assumptions

Here, we list the main assumptions we are making in our model and discuss the benefits and external validity of each assumption.

Assumption 1: Order of Entry Market entry games do not always yield a unique equilibrium. Ideally, we would model firms' entry decisions simultaneously. However, we will encounter multiple solutions for the same set of parameters, and thus the mapping from parameters to equilibrium outcome will not be uniquely identified.[11] One solution often used in the literature has firms make their entry decisions sequentially, such that a unique pure-strategy equilibrium exists. Following the literature, we assume that potential profits determine firms' order of entry in the market. This ordering will always lead to a unique equilibrium.

Assumption 2: Only Modeling Entry Decisions We do not model the exit decisions of incumbents. Factors contributing to entry costs are likely entirely different from those affecting exit costs. Market exit does not frequently occur in the insurance industry. When it does, it is typically induced by special events, such as the asbestos liability crisis, rather than by the nature of competition in the market.[12] Normally, insurers have three ways to exit a market: (1) Stop writing new insurance policies and wait for all in-force policies to "run-

[11] See Bresnahan and Reiss (1991) for more discussions on solving empirical models in multi-agent discrete games.
[12] In our sample, less than 1% of incumbents exit the market.

off;" (2) Cancel all policies, if state regulation permits, and refund (unearned) premiums to customers. These two approaches are expensive and rarely executed because it may result in reputation damage among customers, producers, and regulators. (3) Transfer existing policies to reinsurers through what is called portfolio reinsurance contracts. By doing so, the firm would still stay as an active incumbent by our definition. Examining the fixed costs and sell-off values of exiting insurers is beyond this paper's scope, but it is an excellent avenue for future research. Instead, we assume that all incumbents stay in the market.

Assumption 3: Static Model Firms make entry decisions based on expected long-run profits. However, our model is a static game. Thus we are not explicitly matching any future cash flows if firms continue to operate in the market or if, in the future, other firms enter. Several dynamic models use semi-parametric techniques to achieve comparable computational intensity as static models, such as Pakes et al. (2007), Aguirregabiria and Mira (2007), and Bajari et al. (2007). However, these models still heavily rely on distributional and linearity assumptions and require explicitly modeling firm-specific demand and cost functions.[13] Our goal is to decompose the relative importance of geographic and product-specific barriers for new entrants. A static model that significantly reduces the computational burden and yields partial-equilibrium solutions is sufficient.

There are two main downsides to this approach: First, our estimated costs of entry are not comparable in an absolute sense, only relative to each other. If $S_{i,s,p,t} = 5$ and $D_{i,s,p,t} = 4$, then we can say potential same-state entrants have an advantage over potential *de novo* entrants. Nevertheless, since we fit our model using entry (and non-entry) decisions and *relative* profit levels, we cannot conclude that the state-based entry barrier is exactly 1 unit in profit.

The second downside is that we are unable to examine counterfactual decisions or make any causal claims. Our model is partially reduced-form and is not casual. We do not directly observe (or model) prices and costs of firms, and we do not exploit exogenous variation in

[13] Dynamic models are also required to disentangle the differential cost impacts between incumbents and new entrants in market entry decisions. Since we do not model exit decisions, this does not matter to us.

either. Questions like "How do prior-approval rate regulation laws impact entry costs?" and "Do entry barriers increase prices?" are unanswerable in our framework. Instead, we are examining correlations in the existing equilibrium and not making causal claims.

Assumption 4: Fixed Effects Model Similar to the semi-parametric estimators in Pakes et al. (2007), we introduce an entry value that is proxied by the expected post-entry profits according to the firm-, state-, and product-fixed effects, and treat these estimates as actual values in the parametric estimation in the second stage in equation (1). Estimates from a fixed-effects model capture the global impacts on profits from demand and cost shifters embedded in the past market structure. This abstracted profit estimates dramatically alleviate the computational burden by reducing the number of estimated parameters. However, the estimated entry values may be less precise than a model that includes a set of observable characteristics.

One can construct a fixed-effects model with specific functional forms for market demand and company costs with a rolling sample period. However, concerns from the serially correlated unobservables across years need to be addressed. Alternatively, the expected profit can be a function of variable profits and fixed costs, similar to the one in Berry (1992). In that case, the algorithm needs to compute a sophisticated fixed point or matrix inverse at each iteration when evaluating the objective function.

An additional assumption of our fixed effects model is that a firm's expectation about a market's profitability at t relies only on the realized profits of firms at $t-1$.[14] The alternative would be to include more years of data, and more variables, in the profitability function. However, we do not observe an equal amount of past data for each firm. We only observe one year of past data for entry decisions in 1997, whereas we observe 11 years for firms in 2007. Because we are interested in how barriers have evolved over time, we do not want earlier estimates to have more measurement error than later estimates.

[14]This is equivalent to assuming profits, at the level than can be captured by the firm, state, and line fixed effects, are a Markov process.

2.3 Solution Mechanism

A Nash equilibrium for the model occurs when, given the actions of all the other firms, no entering firm makes a negative profit, and every non-entering firm would make a negative profit if they entered instead. Because we assume firms make their entry decisions in order by potential profitability, and we need to find the marginal firm such that the next firm entering would flip their expected profits from positive to negative.

First, we establish the order of entry by constructing a predicted "monopoly entry" profit by assuming only one new entrant in the market, as shown in equation (3). $\widehat{\Pi_{i,p,s,t}}|(N_k^1)$ is the post-entry profits that firm i could earn for being the only new entrant in the market, given all incumbents stayed.[15]

$$\widehat{\Pi_{i,p,s,t}}|(N_k^1) = \widehat{\pi_{i,p,s,t-1}}(\theta) + \delta ln(N_k^1) + S_{i,s,p,t} + P_{i,s,p,t} + D_{i,s,p,t} + \varepsilon_{i,p,s,t} \tag{3}$$

Because the cost of new entrants is monotonic and additively separable, this order will be preserved no matter how many firms enter. Specifically, because of the symmetric, to all entering firms, marginal impact on demand δ, we can assign a ranked order, $r = 1, 2, \ldots, n$, to all potential entrants according to $\widehat{\Pi_{i,p,s,t}}|(N_k^1)$. This ranking decides firm i's decision order and it will not change as more entries occur. For example, firm A has a higher "monopoly entry" profit than firm B. When more firms enter this market, the changes in profit only come from $\delta ln(N)$, and the amount is the same for both firm A and B. Thus, the ranking will not be affected by how many more entries in the market.

To solve the model, we calculate the predicted profit for each firm if they were the marginal entrant by substituting $N_{s,p,t}$ with N_k^r into equation (1). N_k^r equals to the number of incumbents in the market $\{s, p\}$ plus r new entrants. Firms with positive profit as the marginal entrant will always have a positive profit if the number of entrants is fewer than their rank, and firms with negative marginal-entrant profit will always have a negative profit

[15] N_k^1 is the total number of firms in the market and equals to the number of incumbents k plus the only new entrant.

if more firms enter. Thus the firm with the smallest positive marginal-entrant profit will be the marginal entrant. Specifically, the predicted entry decision for each potential entrant is

$$Enter(\delta, N_k^r, S_{i,s,p,t}, P_{i,s,p,t}, D_{i,s,p,t}) = \begin{cases} 1, & \text{if } \widehat{\Pi_{i,p,s,t}} > 0 \\ 0, & \text{otherwise} \end{cases}.$$

3 Data

The insurance industry provides an excellent environment to explore the market entry game among firms due to its rich firm-market level data. In the insurance industry, each firm has the choice of operating among 17 product lines in any of the 50 states and Washington, D.C..[16] On the demand side, consumer purchases usually occur locally such that the products they buy comply with domestic state laws and regulations.[17] Therefore, the market definition in the insurance industry, by law, is defined as the state-line market, and we have a total of 867 markets each year.[18] Markets with no entrants are dropped in the estimation.[19]

The data is from the National Association of Insurance Commissioners (NAIC) annual statements from 1996 to 2017. It represents over 95% of total premiums written in the U.S.. We identify entry by firms' direct premiums written, and it must exceed 0.01% of the total market share to be considered an entry. A firm is treated as an incumbent if it appeared in the market last year. Otherwise, it is a potential entrant. Potential entrants are further categorized, based on their relations to the targeted market, into three groups: state-related,

[16] We categorize the lines of business into 17 lines as following: 1. Private passenger auto total; 2. Commercial auto total; 3. Homeowners; 4. Farmowners; 5. Commercial Multiple Peril; 6. Fire; 7. Allied Lines; 8. Inland Marine; 9. Medical Professional Liability; 10. Other Liability; 11. Product Liability; 12. Workers' Compensation; 13. Mortgage Guaranty; 14. Financial Guaranty; 15. Accident and Health; 16. Warranty; 17. All others.

[17] In automobile insurance, for example, each state has different minimum state insurance requirements. Alabama requires a $25,000 limit for bodily injury liability per person, where PA requires a $15,000 limit for bodily injury liability per person.

[18] The market definition is relatively vague in traditional IO literature. For instance, in the hospital industry, the market is identified by how far the customers have to drive. Besides, the assumption that consumers only choose one product from each firm in a market is less likely to be violated in the insurance industry because each customer only buys one insurance policy.

[19] 1,823 markets are dropped for the whole sample period. Most of them are markets either in product lines of Mortgage Guaranty, Financial Guaranty, and Farmowners business or in Washington, D.C..

Table 1: Variable Definitions and Summary Statistics: 1997 - 2017

Variables	Definitions	Mean	SD	Min	Max
Enter	Equals 1 if a firm operates in the market.	0.122	0.327	0	1
Incumbent	Equals 1 if a firm is an incumbent	0.121	0.326	0	1
State-related Entrant	Equals 1 if a firm has business in other product lines in the same state as targeted market	0.444	0.497	0	1
Product-related Entrant	Equals 1 if a firm has business in the same product line as the targeted market but in other states	0.166	0.372	0	1
De novo Entrant	Equals 1 if a firm is neither geographic related nor product related with the targeted market	0.361	0.480	0	1
Profits (Return on net worth)	A measure of insurer's profitability in each market, accounting for after tax underwriting profits and investment gains on insurance transactions	0.041	0.360	-2.794	4.235

product-related, and *de novo* entrants.[20] Profits of entering firms are calculated according to the methodology in the NAIC Report on Profitability by Line by State. This measure captures the profits earned, in terms of underwriting and investment activities, in each market to the net worth committed to the market.[21]

The sample includes all affiliated and unaffiliated independent firms. After screening, the final sample has 12,561,795 observations, at the firm-state-product-year level.[22] Table 1 reports the descriptive statistics and definitions of all variables.

4 Estimation Procedure and Results

In this section we discuss our estimation procedure and present our results. We first examine entry barriers averaged across markets and then discuss heterogeneity across states and across product lines.

[20] Footnote 9 explains that there are two types of *de novo* entrants. In our sample, the number of start-up firms only accounts for roughly 2.4% of all *de novo* entrants.

[21] The return is calculated as the after-tax profits divided by allocated capitals and surplus adjusted by GAAP standards.

[22] We exclude firms with negative direct premiums written, negative policyholders' surplus, and firms under scrutiny. The final sample does not include incumbents as they do no enter the estimation.

4.1 Estimation Procedure

We fit the model through a method of moments procedure. Because we have a small number of entering firms relative to potential entrants, corner solutions and integer issues prevent us from just using the raw number of correct (or incorrect) decisions to fit the model. To address this, we construct a moment condition that returns a weighted ratio of incorrect predictions to correct predictions. Incorrect predictions are firms the model predicts to enter but did not, and those that should not enter but did. Correct predictions are firms that are predicted to enter and do actually enter the market, and those that are not supposed to enter and stay out of the market.

To address corner solutions arising from few firms actually entering, we weight the predictions for firms that do enter by how "close" our model was for them. For firms that we predict will not enter that do, the weighting is their rank order. An entering firm that we predict was never going to enter is a more significant error than one we predict was on the bubble of entering. Likewise, for firms that we predict will enter and do, we use the inverse rank order. If a firm enters that we predicted would definitely enter, that is more correct than one we thought was right on the bubble. Constructing a moment condition like this, instead of using the number of correct or incorrect predictions, can keep us away from corner solutions and discontinuities.

The objective function is evaluated at each state-product market each year. In other words, the parameters are estimated by market by year rather than an overall average. By doing so, we trade the estimation precision of parameters for the possibility to explore heterogeneity in entry position across products, states, and time. It is widely examined in the literature that the equilibrium of an entry game could differ substantially across industries and geographic areas. There is no reason to assume that this game is the same across the time dimension. The timing of entry could reveal additional information on market structure. The estimated parameters should not be used to draw causal relations. Instead, they are just associations revealed by the data.

Parameters are solved via genetic search algorithms, which are a member of the evolutionary algorithms family. It is commonly used in optimization and search problems to conquer difficulties arise from a large set of parameters and data with rough surfaces.[23] In particular, our data is likely to induce multiple local minima such that a gradient-based search algorithm will not work well in finding the optimal solution. Unlike traditional search algorithms, genetic search algorithms evaluate and improve over a set of solutions (called "population") rather than a single one. For minimization, genetic search algorithms evaluate the moment condition for randomly selected points in the population and replace the poorly performed ones by applying random changes to the better-fitted group, generating new points.[24] We also incorporate a gradient-based local search once the genetic search algorithm identifies the best point. It speeds up the convergence to the global minimum. The apparent advantage of genetic search algorithms is the robustness achieved by avoiding local minima. Besides, genetic search algorithms also allow parallel computing, which can drastically speed up the search process.

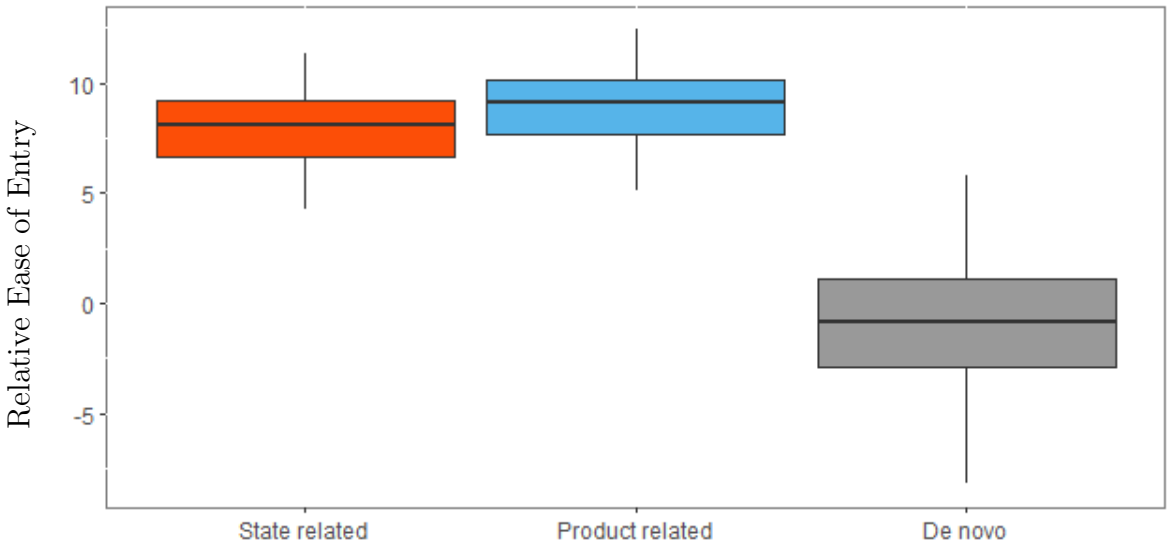
4.2 Entry Barriers on Average

Figure 1 shows the distribution of estimated coefficients for three types of potential entrants across all markets over the sample period. Again, the estimated coefficients do not infer any causal relations to the profitability. Instead, it could be treated as an index of the relative ease of entering a market. We see that, on average, state-related and product-related entrants have an advantage over *de novo* entrants across all markets. Particularly, the coefficients of *de novo* entrants are around zero, consistent with the literature that *de novo* entrants are most affected by entry barriers. As noted in section 3, only 2.4% of *de novo* entrants are start-up firms. With that being said, even for established firms in other

[23] See Golberg (1989)for detailed discussions and convergence results.

[24] Other than mutation, new points could also be generated by combining with the best-known solutions via weighted averaging. The very best solutions are kept as-is in the new population at the next iteration. This process is called "elitism" in the literature.

Figure 1: Entry Barriers of Different Potential Entrants 1997 - 2017

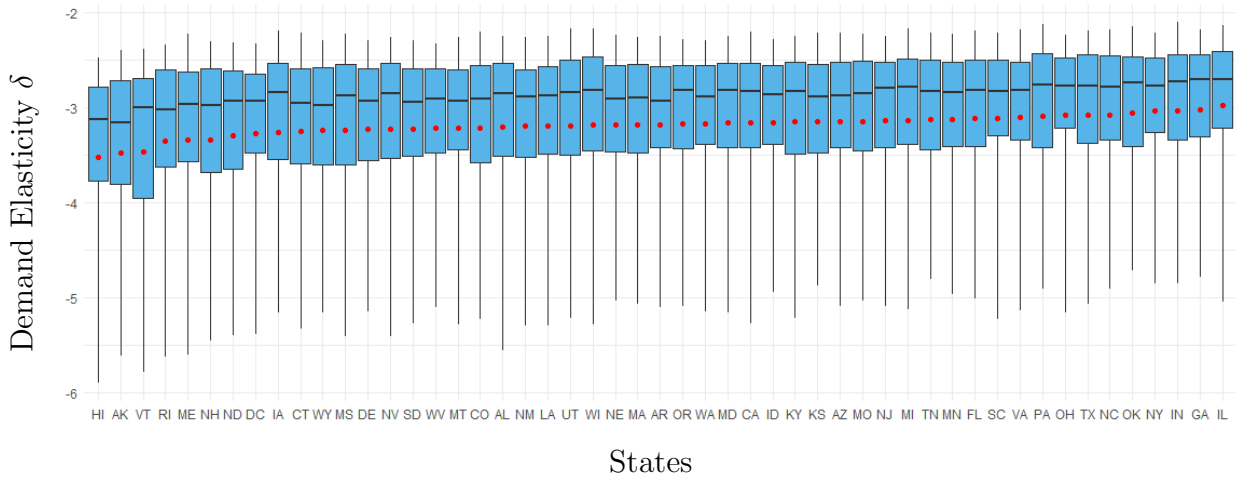


markets, a successful expansion requires specific knowledge to the targeted market. Further, it seems within-state expansion is as costly as within-product expansion.

Figures 2 and 3 display the distribution of estimated demand shifts δ across states and products, respectively. The states and product lines are sorted according to their means (red dots). Overall, the distribution of demand changes does not vary much across different states, as expected. A different picture is observed in Figure 3, where a substantial shift in demand across product lines as more companies in the market. Insurers operate in four product lines: financial guaranty, mortgage guaranty, warranty, and farmowners, would experience a greater demand drop, ceteris paribus, as more competitors enter the market. The underlying reason could be highly correlated with the concentration of these markets, where much fewer insurers are participating.[25] Other than the distinct nature underlies each product line, product differentiation could be another reason for various patterns in demand changes. As a more dynamic market could host more competitors, firms are more likely to develop a

[25]There are less than 20 firms, on average, operate in these four lines across states, while the average number of firms operate in personal automobile insurance is 122.

Figure 2: Distribution of Demand Elasticity across States 1997 - 2017



Notes: Each boxplot displays the distribution of estimated parameter δ across different states. The red dots are the means in each state, and the black bars are the medians. States are sorted by the means.

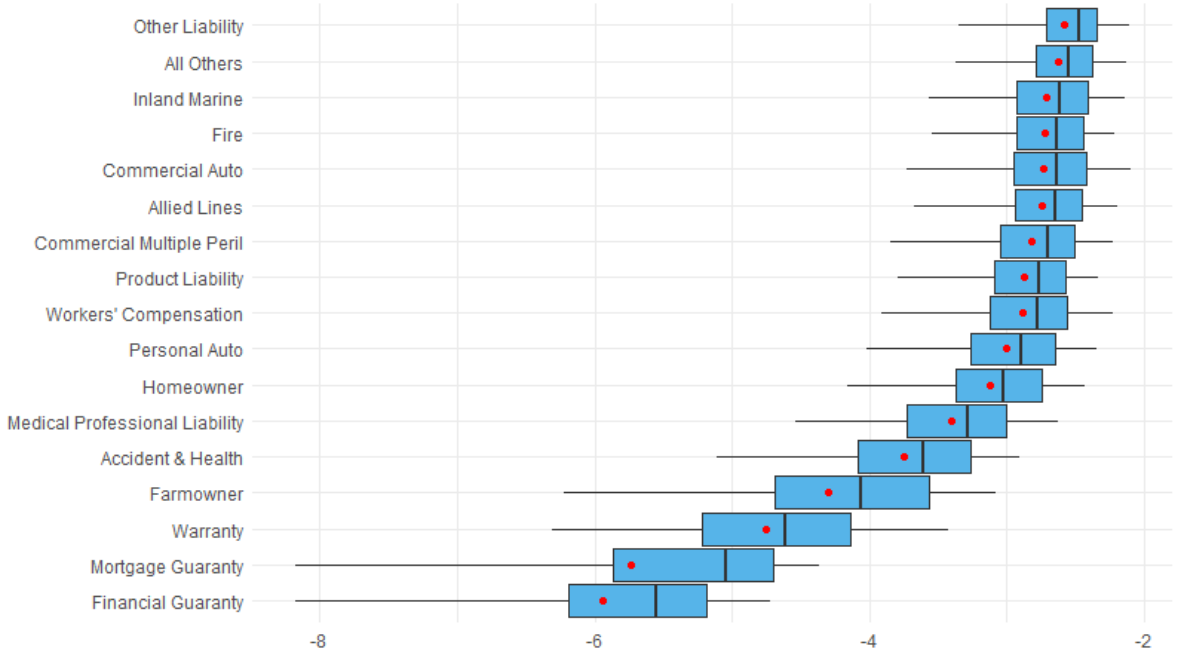
diverse menu of policies to seize the needs of consumers.[26] As a result, these companies may face smaller decreases in demand against new entrants. To summarize, the demand shifts are quite stable in the range of [-4, -2] across all states and most of the product lines.[27]

Figure 4 plots the correlations between the model estimates and the Herfindahl-Hirschman Index (HHI), which is calculated in each state-product market based on the direct premium written. The *weak* correlation between barrier estimates and the HHI is consistent with the critiques in Carlton (2004) that barriers are not simply determined by either the number of firms or the term "vigor of competition." Traditionally, high concentration is usually considered as an indicator of low competition and thus results in a market with high entry barriers. This is not necessarily true because barriers to entry and market concentration could independently influence profitability (Bain, 1951; Mann, 1966). Our barrier estimates are likely to capture the portion of non-price competition, such as investments in product quality and specialized underwriting knowledge. The estimated demand elasticity δ is moderately negatively correlated with the HHI, consistent with the literature that highly concentrated

[26]The policy development could be a collective result of more information flow into the market, and a competition strategy to gain market shares. We are not able to distinguish the channel.

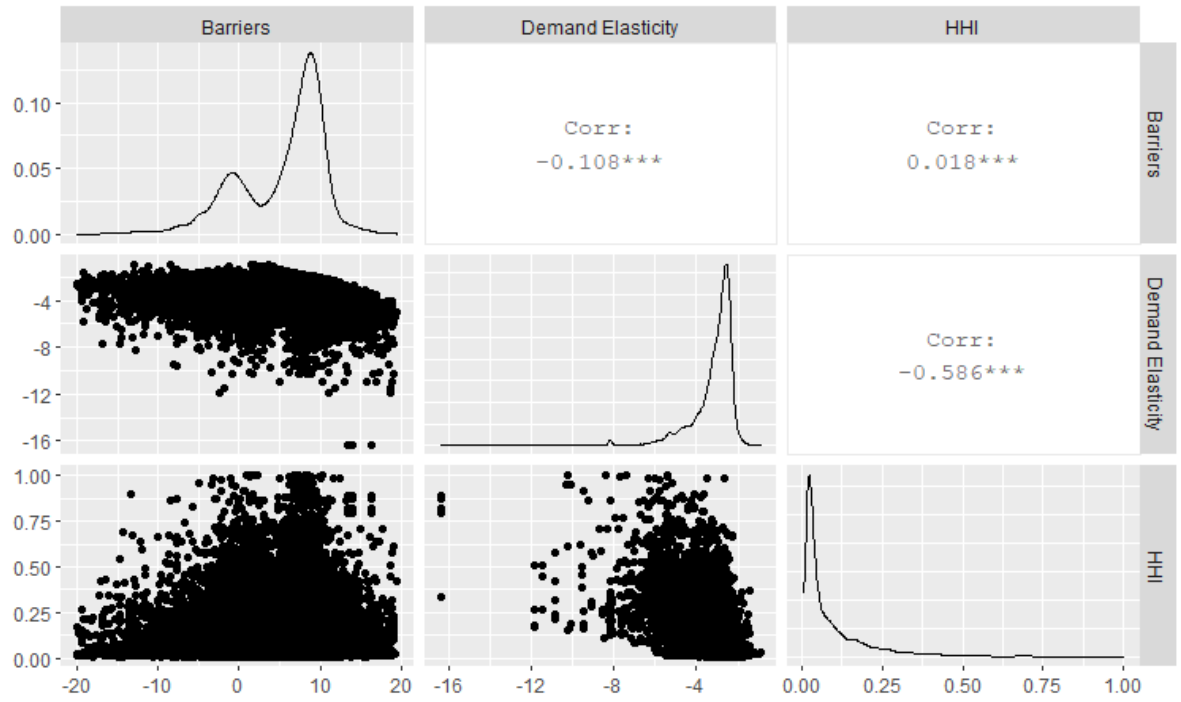
[27]Few exceptions are found in the financial guaranty, mortgage guaranty, warranty, and farmowners business.

Figure 3: Distribution of Demand Shifts across Product lines 1997 - 2017



Notes: Each boxplot displays the distribution of estimated parameter δ across different product lines. The red dots are the means in each product line, and the black bars are the medians. Product lines are sorted by the means.

Figure 4: Correlations between Estimates and Herfindahl-Hirschman Index



Notes: Barriers are the estimates of three types of entrants and demand elasticity is the estimated δ. Herfindahl-Hirschman Index (HHI) is calculated in each state-product market based on the direct premium written.A higher value in HHI means the market is more concentrated.

markets usually have lower demand elasticity. Correlations in Figure 4 indicate that our estimates are basically aligned with the prior literature.

In the following subsections, we subtract the coefficients on *de novo* entrants in each market from those of state- and product-related entrants to further explore relative shifts in entry barriers across dimensions.

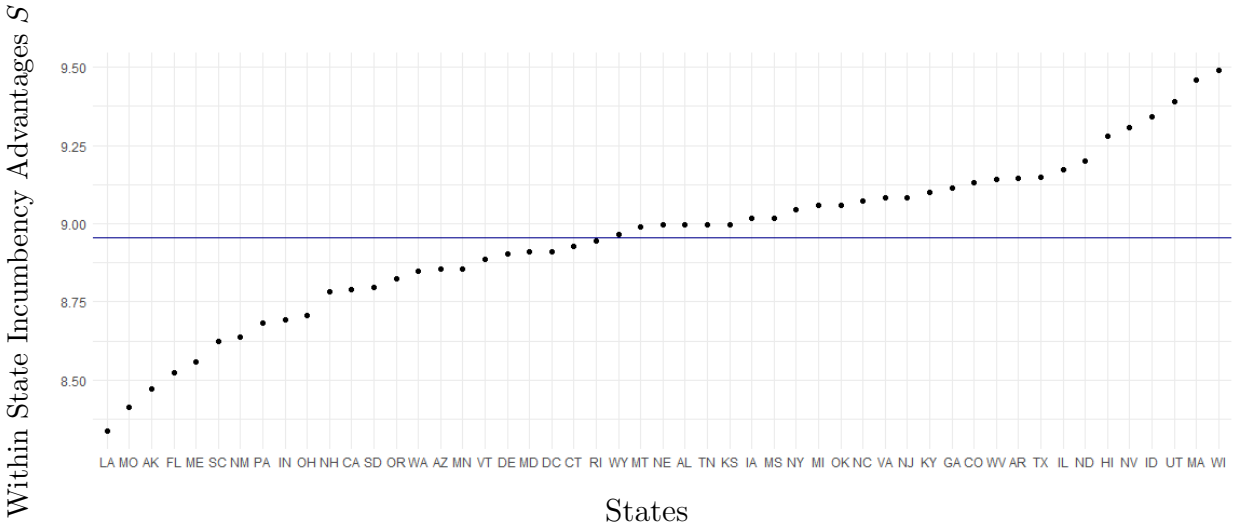
4.3 Variation in Entry Barriers across States

In this section, we explore barriers to entry across states. The estimated parameters here can be considered as an index of the relative advantages over *de novo* entrants. We could not draw any causal implications on the actual profitability based on these estimates. Figure 5 exhibits the average of estimated $S_{i,s,p,t}$ in each state over the sample period. The horizontal line indicates the average across all states. Each point represents the relative advantages of being a state-related entrant over a *de novo* entrant in the targeted state markets. It is also the extent of barriers to entry imposed by state-related entrants. A higher value implies more advantages for within-state expansions and more barriers for cross-state expansions. For example, licensed companies in Wisconsin would have the highest benefits from within-state expansions, averaged across product lines, compared to companies outside of Wisconsin. These benefits will make it more difficult for foreign companies to enter Wisconsin markets; namely, these are barriers. Across all states, Louisiana seems to have the least, relatively, barriers to entry for out-of-state entrants, while Wisconsin has the most. According to the *2019 Insurance Regulation Report Card* conducted by R Street, Louisiana has the worst score in the insurance regulatory environment.[28] The unfriendly regulation environment may deteriorate the benefits of within-state insurers. However, these estimated indices are averaging across all product lines and time, and we could not pinpoint the factors that drive

[28] The score is calculated by a weighted sum of scaled ratings in multiple aspects of the state-based insurance regulation system. It evaluates over politicization, fiscal efficiency, solvency regulation, auto insurance market, homeowners insurance market, residual markets, rate regulation, and underwriting freedom.

these results without further analyses. Nevertheless, we know these variations across states are likely due to each state's regulatory environment for different product lines.

Figure 5: Barriers to Entry in Cross-state Expansions



Notes: Each point is the average of estimated parameter on state-related entrants in each state and the horizontal line is the mean of the whole sample. States are sorted according to their means.

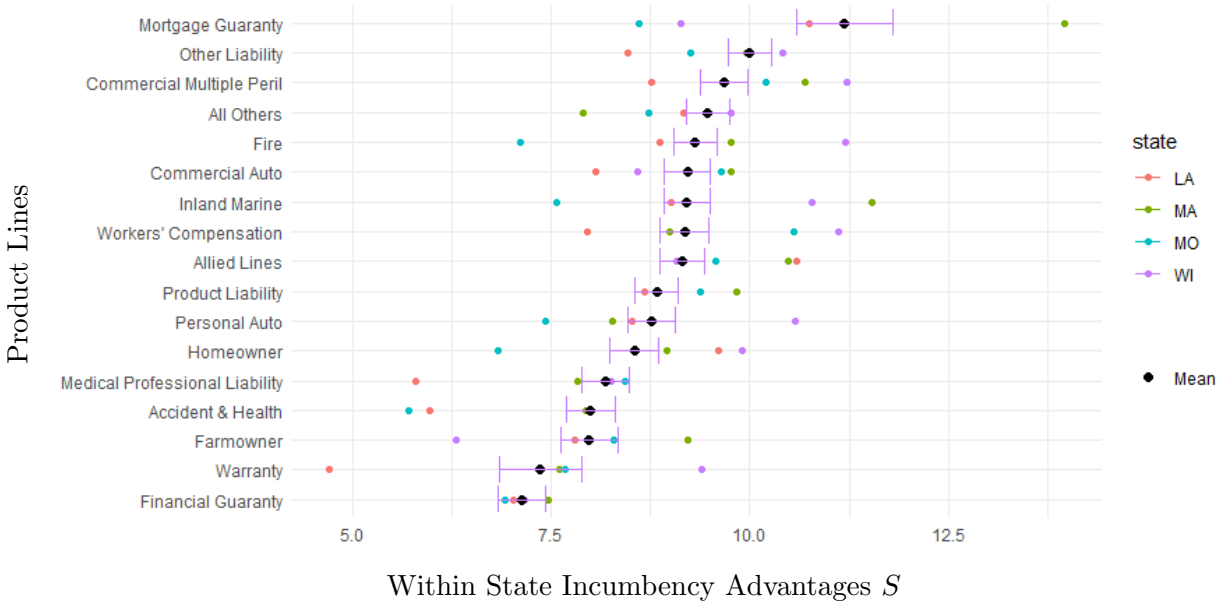
We take a closer look at states with the least and the most barriers to entry (Louisiana, Missouri, Massachusetts, and Wisconsin) to understand how different product lines contribute to these barriers faced by out-of-state entrants. As shown in figure 6, the estimated within-state advantages are averaged across each product line in four states, and the black dots are the means across all states in each product line. A higher value indicates more advantages for companies to expand to a particular product line in the same state, and it also represents more barriers for out-of-state entrants. Among all 17 product lines, it seems most difficult, on average, for an out-of-state company to enter mortgage guaranty markets. One possible reason is that mortgage insurance markets are not only overseen by each state department of insurance but also subjected to intensive supervision by the agencies of the government-sponsored enterprises (e.g., Fannie Mae and Freddie Mac).[29] The high compli-

[29] Government-sponsored enterprises are the major purchasers of mortgages insured by the private insurers. Thus, they are also responsible for developing a set of standards to ensure private insurers are capable to withstand severe stress tests.

ance costs may create a substantial barrier for out-of-state entrants, and it could effectively prevent hit-and-run entries.

The barriers for out-of-state entrants stay relatively higher in Wisconsin than other states in most of the product lines. These patterns could occur due to some state-wide factors that protect domestic companies. Compared to the amount of direct premium written in Wisconsin, the number of domestic insurers is unusually high.[30] Grace and Sjoquist (2019) show that a relatively higher portion of companies domiciled in Wisconsin to minimize their premium tax rate. Lower premium taxes could be a cost advantage for within-state expansions, as well as a barrier for out-of-state entrants. Overall, product-specific specialties create a wide variation in barriers for cross-product expansions, even companies already established local network in a given state.

Figure 6: Barriers to Entry in Cross-state Expansions across Product Lines in Louisiana, Missouri, Massachusetts, and Wisconsin



Notes: Each point is the average of estimated parameter on state-related entrants in corresponding states. The black dot is the average of a particular product line across all states and its 95% confidence interval. S is estimated parameters for state-related entrants in the profit function.

[30] In the 2019 Insurance Department Resources Report, there are 167 domestic insurers in Wisconsin, ranked No.4. The top three states are Texas, Illinois, and New York. However, These states have a much larger direct premium written than Wisconsin.

We showed that substantial variations exhibited in cross-product expansions within a state, now we turn to explore how barriers change for within-product entrants across states. We pick the two most popular insurance products for illustration, and these two products account for more than 50% of the total market premiums in property-casualty insurance. As can be seen in Figure 7, each blue (red) point represents the relative advantages of entering personal auto (homeowners) business in each state, given that companies have a pre-existing business in personal auto (homeowners) insurance in other states.

For example, companies that operate in personal auto insurance in other states have a minimal advantage to enter personal auto insurance in North Carolina. In other words, the product-specific knowledge, such as underwriting expertise in personal auto insurance, is not very useful in building barriers for *de novo* entrants in North Carolina. It is not so surprising because North Carolina has a long history under the stringent supervision of the North Carolina Rate Bureau, where the price of personal auto insurance is set collectively.[31] In a market like this, there are fewer barriers for new insurers that operate in other product lines because such a system would reduce the incentive for accurate risk assessments, which require proficient underwriting knowledge in personal auto insurance. They can enter the market relatively easily. It is also consistent with Fier et al. (2017) that the complexity of pricing and coverage underwriting is a major cost preventing insurers from expanding across product lines.

At the other end in Figure 7, companies that equipped with knowledge in personal auto insurance would have much more significant advantages over *de novo* entrants to enter Georgia. The relative advantages almost double those that enter North Carolina. These advantages also imply that companies that do not have experience in personal auto insurance can face more barriers to entering Georgia's personal auto market. The recent turbulence in regulating auto insurance rate, combined with the sharp rise in premiums due to increasing

[31] The auto insurance cartel was broken up in 2013. It means a large portion of the sample is still under strict rate-setting in auto insurance in North Carolina.

loss ratios in Georgia, emphasizes the importance of underwriting expertise.[32] We plot the relative benefits of having specific knowledge in homeowners' insurance across different states (red dots) in Figure 7. Albeit these two products are often sold together, there is no visible pattern indicating similarities between barriers created by auto insurance and homeowner's insurance-specific knowledge in a state.[33,34] Up to this point, we can only say that state environment forms different preferences on product-specific expertise.

To reveal more information on state-level variations in entry barriers, we regress the estimates on state-level regulations and other characteristics with both state and year fixed effects. Results are reported in Table 2. In general, we do not observe a significant impact on insurance rate regulation. In addition, a set of state-level tort reforms are included, as well as the interactions with being in a liability line because tort reforms are most influential to liability businesses. On average, the cap on non-economic damages reform is negatively associated with entry barriers, and this negative correlation is mitigated in the liability markets. More urbanized states are associated with higher barriers to entry nay due to the higher costs of starting a business. The negative coefficients on the percentage of college degree and unemployment rate indicate that these states may employ business-attraction policies to retain local talents and lower unemployment rates. In column (2), we regress the demand elasticity estimates δ on the state characteristics. The results are consistent with patterns in Figure 2 that demand shifts are not caused by state characteristics but product characteristics.

Next, we explore further to understand whether the state- or product-specific knowledge leads to more advantageous entry in targeted states. As shown in Figure 8, the colored points represent relative advantages of different types of entrants over *de novo* entrants. Overall, the product-specific expertise dominates state-specific knowledge in all states. It implies

[32] Georgia lifted the prior approval in auto insurance rate in 2008 and imposed back strict rate regulation in 2012.

[33] Berry-Stölzle et al. (2012) report a high relatedness score of 0.943 between homeowners and auto insurance.

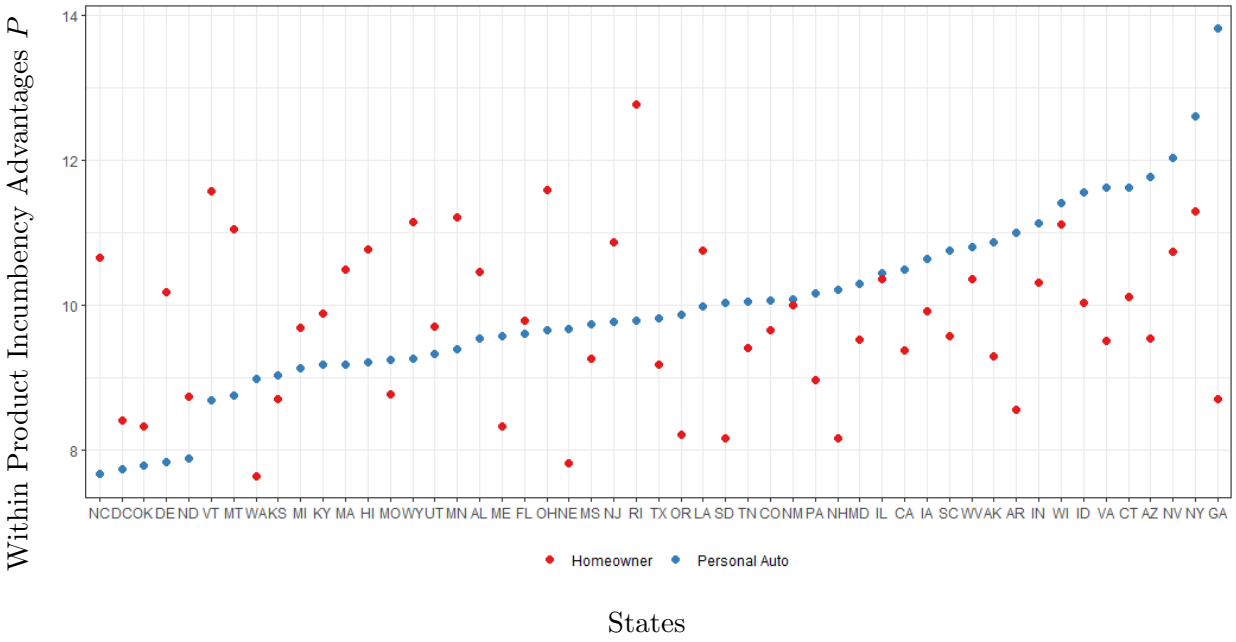
[34] In an unreported graph that sorts states by its relative advantages of within homeowners insurance expansions, we find that Rhode Island has the most significant barriers to entry for *de novo* entrants in homeowner's insurance and it is almost double that of Washington.

Table 2: Impacts of Regulations and State Characteristics on Barriers and Demand

VARIABLES	(1) Barriers Estimates	(2) Demand Elasticity δ
Liability	−0.198	0.310***
Rate Regulation	0.002	0.029
Tort Reforms		
Non-economic Damages	−0.291*	−0.002
Punitive Damages	0.219	−0.017
Collateral Sources	−0.159	−0.058
Joint and Several Liability	−0.004	0.007
Liability × Non-economic Damages	0.282 **	0.002
Liability × Punitive Damages	0.142	−0.003
Liability × Collateral Sources	−0.073	0.046 **
Liability × Joint and Several Liability	0.226	0.017
State Characteristics		
Population Density	−0.002	0.001*
Urbanization	6.339***	−0.507
Union Rate	−0.032	0.004
Percentage of College Degree	−5.439***	0.713
Wage	0.000	−0.000
Unemployment Rate	−0.062*	−0.001
Government Ideology	−0.000	0.001
Constant	7.746***	−3.331***
R-squared	0.007	0.042
Observations	31,206	
Year FE	YES	
State FE	YES	

Notes: The dependent variable in column (1) is the barriers estimates for both state- and product-related entrants, already subtracted the barriers faced by *de novo* entrants. The dependent variable in column (2) is the estimated demand elasticity δ.

Figure 7: Barriers to Entry in Cross-state Expansions across States: Auto & Homeowner



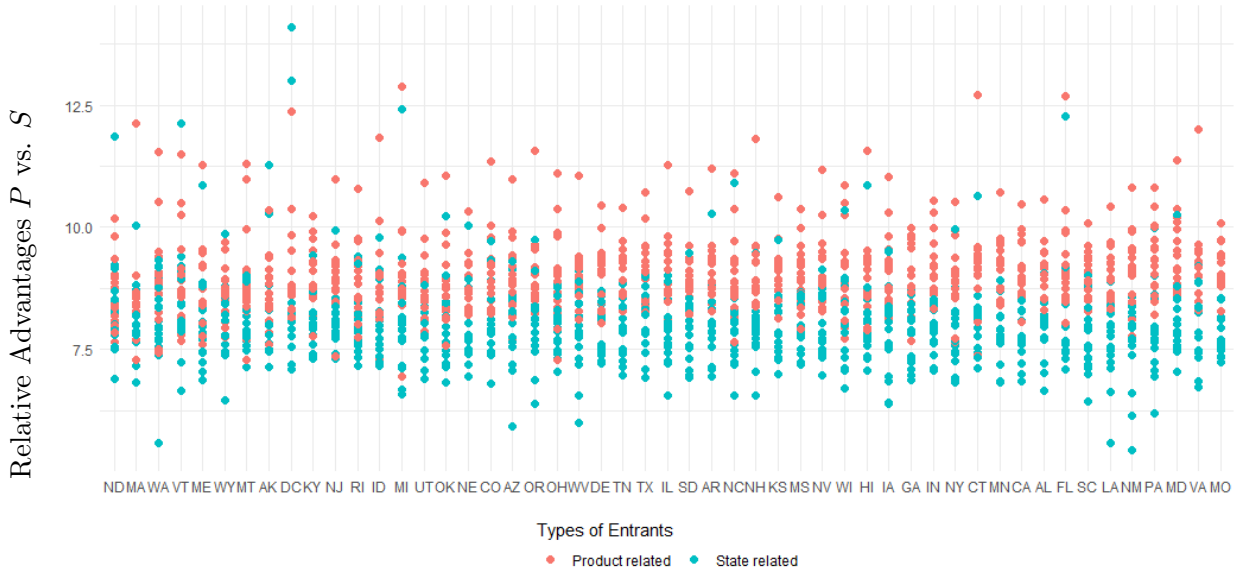
Notes: Each point is the average of estimated parameters on product-related entrants. We focus on personal auto and homeowner insurance only, therefore, each dot represents the ease of expanding either personal auto or homeowner business to targeted states. States are sorted according to the means in personal auto insurance markets. P is estimated parameters for product-related entrants in the profit function.

that, in general, within-state (cross-products) expansions are likely to face more barriers than within-product (cross-states) expansions in any given state markets. The difference between the two barriers is more severe in states like Missouri, Virginia, and Maryland, and less substantial in states like North Dakota, Massachusetts, and Washington. Based on our estimates, we are unable to tease out the state-wide factors that contribute to these inequalities, but it will be an interesting research question for future studies.

4.4 Variation in Entry Barriers across Products

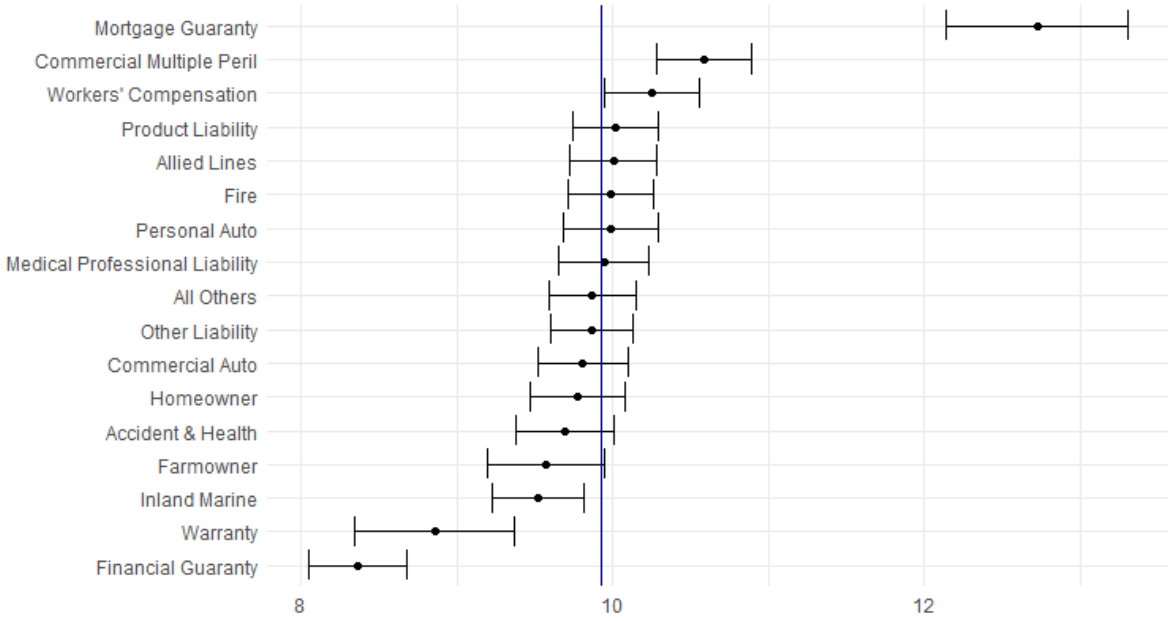
Figure 8 shows that product-specific expertise, in general, creates more barriers for new entrants, indicating same-product expansions are relatively easier. In this section, we aim to separate the barriers created by different product lines. Figure 9 plots the relative benefits for product-related entrants across each line and its 95% confidence interval. The blue line is the average across all product lines. On average, product-related entrants have a similar

Figure 8: State vs. Product Barriers to Entry across states



Notes: P and S are estimated parameters for product- and state-related entrants, respectively, represented in different colors. States are sorted by the averaged differences between estimates of product- and state-related entrants across all product lines.

Figure 9: Barriers to Entry in Cross-product Expansions across Product Lines



Notes: Each point is the average of estimates for product-related entrants P in each line. The 95% confidence interval is marked. Product lines are sorted by the mean. The blue line is the average across all product lines.

distribution of relative advantages over *de novo* entrants for most of the product lines. We observe an interesting finding that two product lines - mortgage guaranty and financial guaranty, that are subjected to the "monoline" licensing requirement exhibit completely different patterns. Being in mortgage guaranty insurance establishes the greatest advantages in within-product expansions. With that being said, it is challenging to enter mortgage guaranty insurance without prior expertise. Furthermore, the high underwriting and quality control standards enforced by the Mortgage Guaranty Insurance Model Act also contribute to the high entry barriers in this product line. As mentioned above, insurers that participate in mortgage guaranty insurance work closely with government-sponsored enterprises and subject to their supervisions. This unique experience is hard to mimic by *de novo* entrants.

However, knowledge in financial guaranty insurance is less advantageous for within-product expansions. It also means that companies that have businesses in other product lines face relatively fewer barriers to enter financial guaranty markets. Financial guaranty insurance companies are also subjected to the "monoline" licensing requirements. However, multiline companies can still enter financial guaranty business by setting up a monoline subsidiary.[35] The nature of financial guaranty insurance is to use insurers' high financial ratings to "guarantee" scheduled bond payments. Thus, the barriers in financial guaranty products are mostly formed by the high capital requirements to maintain high ratings rather than the underwriting knowledge.

4.5 Variation in Entry Barriers across Time

Our estimates are at market-year levels such that we could observe how the barriers change across time. In this section, we explore how the financial crisis changes the distribution of barriers to entry. Figure 10 plots the distribution of relative advantages of within-state expansion before and after the financial crisis. The blue dots at the bottom are differences

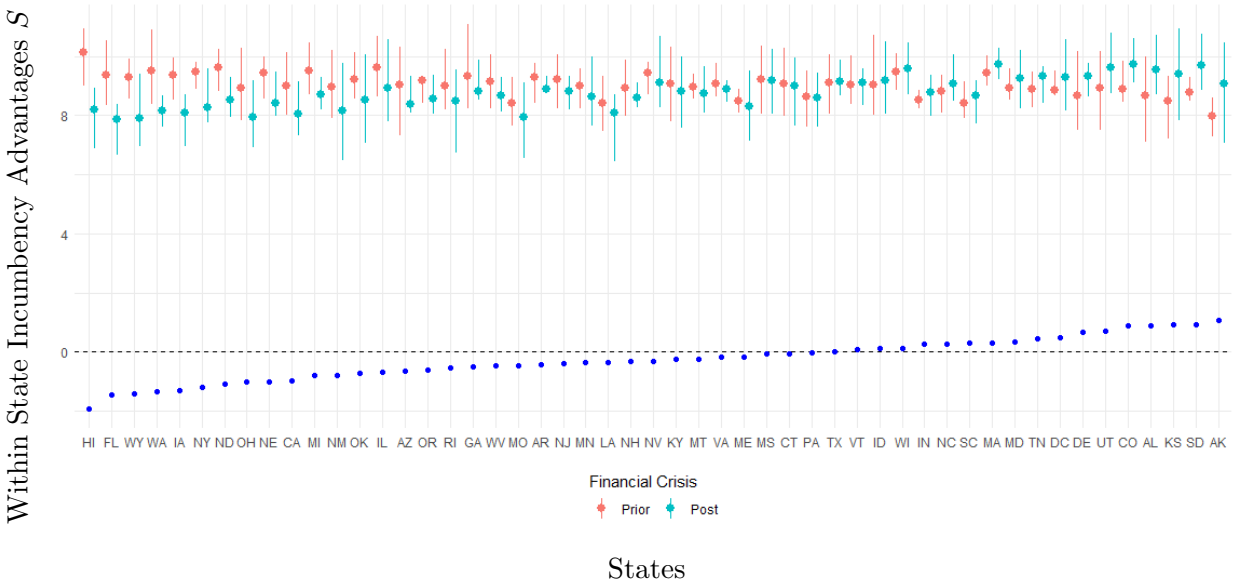
[35] According to Financial Guaranty Insurance Model Act, these "monoline" insurers may be able to write surety, credit, and residual value insurance under applicable provisions. NAIC has transition provisions that allow licensed multiline insurers to write financial guaranty insurance in states without a financial guaranty insurance statute. However, these companies only can write for a specific period and subject to other conditions.

in means of two time periods. The financial crisis is defined as in 2008 and 2009. States are sorted according to the changes in means prior and post the financial crisis (blue dots). For instance, Hawaii and Florida have the most substantial downward shift in cross-state barriers after the financial crisis. South Dakota and Alaska have the most significant upward move after the financial crisis. In Figure 10, most of the states have downward shifts in the averaged state barriers. It seems counter-intuitive because we may expect state regulators are likely to enhance their insolvency monitoring after the financial crisis. After all, insurers are exposed to higher insolvency risk during the financial crisis. If it is true, the state barriers should be higher. The average advantages in Figure 10, however, are aggregated across all product lines. The deceases in state barriers may not be driven by financial crisis only, and also include the impacts of other events like natural disasters (e.g., Tornado Super outbreak in 2011, hurricane Sandy in 2012, hurricane Matthew in 2016). All these factors are possible to lower the cost advantages of state-related entrants over *de novo* entrants. The need for extra underwriting capacity in catastrophic risks could also contribute to the distributional shifts in state barriers. However, it is also possible that the decreasing trend we observed is merely due to negative externalities caused by the financial crisis. In general, the impacts from time dimension is important to model entries, especially for dynamic models that rely heavily on distributional assumptions in the future.

Averaging in Figure 10 covers substantial heterogeneity in different product lines. Thus, we show the changes in two insurance segments that are likely to be significantly affected by the financial crisis: mortgage guaranty and financial guaranty insurance in Figures 11 and 12, respectively. The number of entries in mortgage guaranty markets shrink dramatically after 2005 and only has one market that has entries in 2008 and 2009.[36] The averaged benefits of state- and product-entrants over *de novo* entrants are quite volatile over time. Mortgage guaranty markets have incredibly high barriers in states like Massachusetts, Virginia, and Washington in 2005, and those markets drove up the average in 2005. On the other hand,

[36]The only market that has entry is Vermont in 2008 and North Dakota in 2009.

Figure 10: Shifts in State Barriers after Financial Crisis

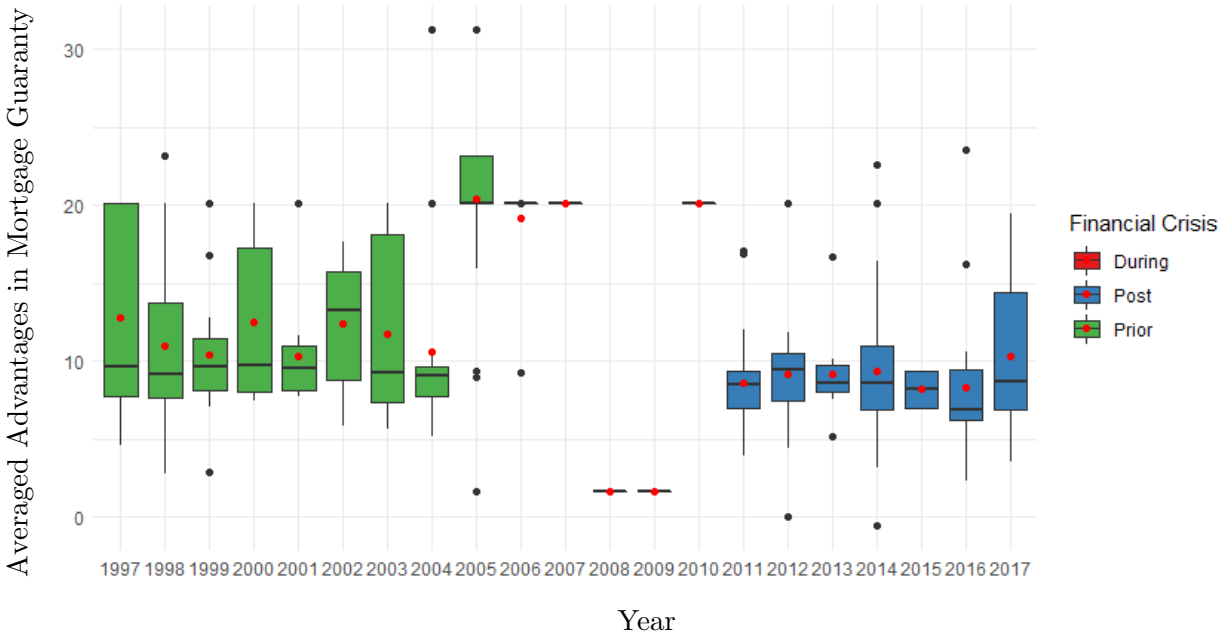


Notes: Red lines stand for the distributions of averaged advantages across all product lines before the financial crisis, while the green lines are those after the financial crisis. The dots on lines are means in each category. States are sorted according to the means before the financial crisis. The changes in averaged advantages after the financial crisis are marked in blue points, in raw values, and the horizontal dashed black line is the smallest changes. The financial crisis is defined in 2008 and 2009.

the averaged barriers in financial guaranty markets are relatively stable. We also check the distributions of other product lines over time and find that other product lines are not affected by the financial crisis.[37] In general, market entries are more significantly impaired in mortgage guaranty than any other products after the collapse of the housing market in 2008. We believe the structural shifts in state barriers in Figure 10 are likely driven by changes in barriers in the mortgage guaranty markets. Other than that, the state barriers stay relatively stable across time in other product lines.

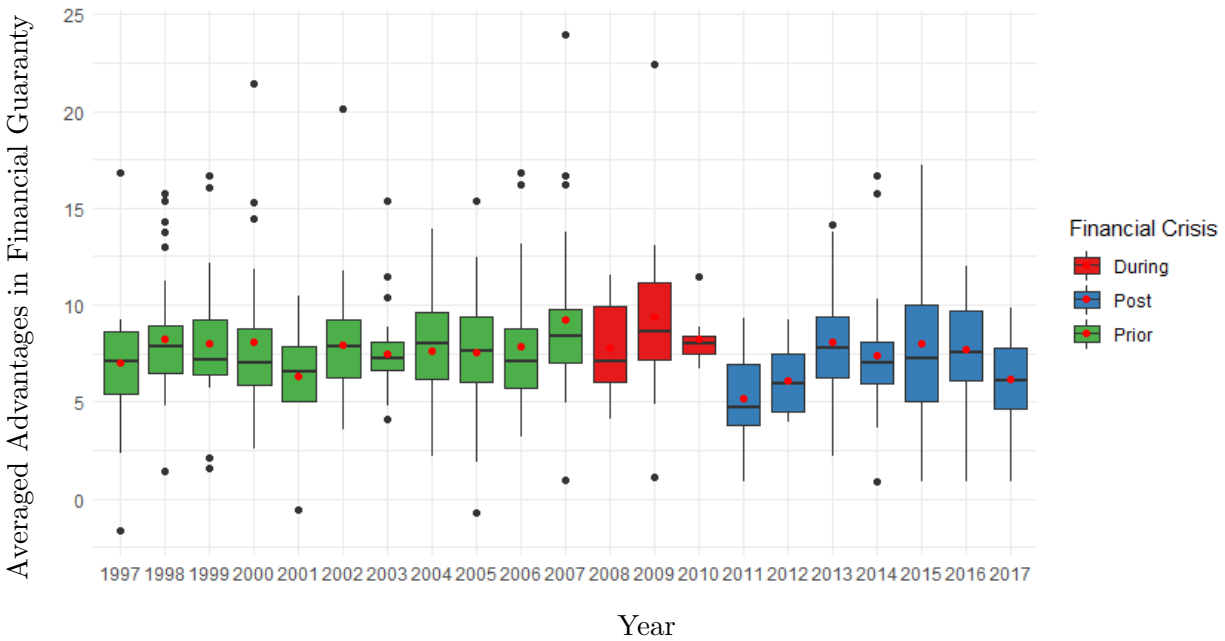
[37] We also checked the impacts of some catastrophic events such as the September 11 attack in 2001 and hurricane Katrina in 2005. We do not observe a structural change in barriers caused by these events.

Figure 11: Distribution of Barriers in Mortgage Guaranty Insurance across Time



Notes: Each box is the distribution of averaged advantages in mortgage guaranty markets across all state- and product-related entrants. The dots are means in each year. In addition, we consider 2008 and 2009 are the time during financial crisis.

Figure 12: Distribution of Barriers in Financial Guaranty Insurance across Time



Notes: Each box is the distribution of averaged advantages in financial guaranty markets across all state- and product-related entrants. The dots are means in each year. In addition, we consider 2008 and 2009 are the time during financial crisis.

5 Conclusions

In this paper, we propose and estimate a simple multi-agent model of entry that allows us to study the relative importance of geographic and product-specific barriers to entry. This model differs from the prior market entry literature that generates overall averaged estimates across markets. Our estimated parameters are at each market-year level. These estimates are used to conduct a case study, exploring the barriers to entry across three dimensions: geographic, product, and time.

We find that barriers to entry exist and are substantial in the insurance industry. Overall, *de novo* entrants are most subjected to barriers to entry, and within-state expansions, on average, are as costly as within-product expansions. A closer examination reveals that product-specific information, such as underwriting expertise, pricing schemes, and coverage designs, is relatively more important than state-specific connections for insurers that expand to a given market. However, we could not quantify this "relativity" and draw inferences on post-entry profitability. Moreover, we find that state characteristics could create wild variations in entry barriers even for highly related product lines, such as personal auto and homeowners' insurance. It would be interesting to see how barriers to entry in related products are clustered. Among all product lines, on average, mortgage guaranty markets create the most barriers to new entrants. Finally, we explore the impacts of time dimension by conducting an event study on special events like the financial crisis. We find consistent results that most of the property-liability lines are not substantially impaired by the financial crisis, except for mortgage guaranty, such that there is no noticeable shift in the distribution of barriers.

Our exploration is like a case study to reveal the associations underlying the data. However, we could not pinpoint the exact channels that drive these findings and test the impacts on post-entry profits.

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