# Dynamic Pricing Regulation and Welfare in Insurance Markets*

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**Abstract**

This paper examines the impact of dynamic pricing regulation on market outcomes and social welfare in the U.S. long-term care insurance (LTCI) market. We first provide descriptive evidence that the introduction of rate stability regulation, which limits insurers' ability to increase premiums over the lifetime of a contract, improved rate stability while reducing product variety. To quantify this trade-off, we develop and estimate a dynamic equilibrium model of LTCI where insurers have market power and cannot commit to future premiums. Our estimates suggest that consumers' demand for LTCI is relatively price inelastic. However, insurers do not charge a high markup due to various pricing regulations. Using the estimated model, we conduct counterfactual experiments to assess the welfare effect of dynamic pricing regulation. We find that a stricter rate stability regulation lowers social welfare as the benefit from improved rate stability is outweighed by the cost from reduced product variety.

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# 1 Introduction

Many social insurance programs and private insurance markets are designed to insure individual idiosyncratic risks. These risks include health and mortality risk, long term care, and disability shocks. Substantial progress has been made to understand the quantitative significance of idiosyncratic risks faced by individuals and to better design related government policies. However, scant attention has been given to the difficulty that insurers face in predicting future claims costs and its implications for optimal government intervention. For example, insurers face substantial uncertainties in pricing contracts in relatively young markets, such as the health insurance marketplaces established by the Affordable Care Act and wildfire insurance markets. Insurers selling long-term insurance products also face significant uncertainties as various events could unfold over the lifetime of a contract that affect anticipated claims costs.

One important welfare concern about uncertainties faced by insurers is that the insurers could pass through the risks to consumers by adjusting premiums. To address this issue, the government has increasingly adopted regulations that limit insurers' ability to adjust rates.[1] However, little is known about their welfare effects. On the one hand, dynamic pricing regulation might improve consumer welfare by decreasing uncertainty about future rate increases. On the other hand, it might induce insurers to reduce product variety or charge a higher markup, in which case consumer welfare will be adversely affected.

In this paper, we study the impact of dynamic pricing regulation on the market equilibrium and social welfare in the context of U.S. private long-term care insurance (LTCI). LTCI contracts are long-term contracts in that there is a substantial time lag between the purchase and use of insurance.[2] Insurers are not required to commit to a premium schedule over the lifetime of a contract: they can revise rates for a given buyer cohort subject to the state regulator's approval. In addition to being a relatively young insurance product, the dynamic feature of LTCI contracts makes it hard for insurers to accurately predict future claims costs.[3] Consequently, premium rate increases were very common based on insurers' revisions to their forecasted claims costs. To reduce uncertainty about future rate increases,

[1]For example, in health insurance, the Department of Health and Human Services along with state governments establish effective rate review programs such that any health insurance plan (individual or small group plan) with a proposed rate increase of 10% or above is scrutinized by independent experts.

[2]The average purchase age is 60, while the average age at first entry into nursing homes is 83 (Ko, 2021).

[3]To accurately anticipate claims costs, insurers need to predict not just health and mortality risk, but also formal care costs and lapse rates over the next 20 years as well as the availability of family care that could substitute for formal care services.

many states adopted new standards in their oversight of the LTCI industry in the early 2000s (Rate Stability Regulation of 2000). The new standards were designed to deter rate increases for existing consumers. This paper studies the design of dynamic pricing regulation by developing and estimating an equilibrium model of LTCI.

Understanding the oversight of the LTCI industry is important in its own right. Long-term care is one of the largest uninsured financial risks faced by elderly Americans. Formal long-term care expenses totaled over $310 billion in 2013, which is close to 2% of GDP.[4] Long-term care spending is expected to further increase with population aging. However, only 10% of the elderly own LTCI. The existing literature explains the low take-up rate through various demand channels, such as Medicaid's crowd-out effect on the demand for private insurance, informal care provided by family members, and adverse selection. However, these channels may not explain the substantial decline in the number of plans and insurer participation in the LTCI market witnessed in the last two decades. During this period, the number of active plans declined by more than 90%, and the number of insurers selling new contracts plunged from over 100 to a dozen. (NAIC, 2016). This period overlaps with the time when states implemented new regulation standards to promote rate stability in the LTCI industry. By acting as financial frictions to insurers, such regulations might lead to lack of quality plans in the market, a supply channel often discussed as a potential reason for the low take-up rate (e.g., Ameriks et al. (2016)).

We start by providing descriptive evidence for the effect of the rate stability regulation on insurers. We use regulatory filings submitted by LTCI companies to the National Association of Insurance Commissioners (NAIC) between 2000-2016 and rate increase data obtained from the California Department of Insurance for years 2007-2017. Using variations in states' adoption of the rate stability regulation, we find the suggestive evidence that the regulation reduced rate increases, reaching its intended goal of improving rate stability. However, we also find the evidence that the regulation significantly reduced the number of plans and insurers available to consumers.

To quantify this trade-off surrounding dynamic pricing regulation, we develop an equilibrium model of LTCI. There exist risk averse consumers who decide whether to purchase private LTCI. Medicaid is incorporated as free public LTCI for consumers with limited assets. Risk-neutral insurers face uncertainty about future claims costs and decide how many products to sell and how to price their products. They are subject to two pricing regulations:

[4]Source: Kaiser Family Foundation, https://www.kff.org/medicaid/report/medicaid-and-long-term-services-andsupports- a-primer/.

1) rate stability regulation which makes it costly for insurers to revise premiums over the lifetime of a contract, and 2) loss ratio regulation which penalizes insurers for charging an initial rate that is different from the regulator's target level. The model incorporates two key assumptions that are empirically grounded. First, insurers exercise market power. Second, insurers cannot commit to future premiums. These two features depart from standard models of long-term insurance which assume competitive markets where insurers can credibly commit (e.g., Cochrane (1995) and Hendel and Lizzeri (2003)). Due to lack of commitment, insurers in our model have an incentive to pass through their claims risks to consumers to maximize profits. The rate stability regulation is a policy tool that forces insurers to smooth prices over the lifetime of a contract.

We follow Berry et al. (1995) to estimate our model. To identify our demand-side parameters, we exploit variations in states' adoption of the rate stability regulation, which can create a plausibly exogenous variation in observed contracts. The demand estimates suggest that consumers' preferences are relatively inelastic with respect to initial rates and product variety: the elasticity with respect to initial rates is -0.1056, while the elasticity with respect to product variety is 0.1710. We then estimate our supply-side parameters using the estimated demand parameters and claim data. Despite low demand elasticity, our supply estimation finds that insurers do not charge a high markup due to the presence of pricing regulations. We therefore find that supply-side regulations are important in explaining observed price dynamics of LTCI contracts.

Using the estimated model, we conduct counterfactual experiments to evaluate welfare effects of supply-side regulations. First, we examine the effect of rate stability regulation. On the one hand, it might increase welfare by reducing risk averse consumers' uncertainty about future rate increases. On the other hand, it might decrease welfare by inducing insurers to reduce product variety or to charge a higher markup. The results reveal that the latter channel dominates the former: tightening rate stability regulation reduces not only insurer profits, but also consumer welfare. This is mainly because a stricter version of the regulation results in a substantial decline in product variety which offsets the benefit from improved rate stability.

Next, we examine what happens when the government requires insurers to target a higher loss ratio in setting initial rates. We find that the regulation leads to a reduction in prices and product variety, but their magnitude is very modest. As a result, there is a negligible effect on consumer welfare. In contrast, insurer profits decline substantially due to the higher regulatory cost.

Finally, we study whether the effect of supply-side regulations depends on demand-side policies. We find that when Medicaid benefits are more generous, the welfare loss associated with tightening the rate stability regulation is smaller. The result suggests that supply-side regulations of the LTCI industry might have a limited effect on consumer welfare when the coverage of public insurance is sufficiently generous. The result highlights the potential importance of interactions between supply-side and demand-side policies.

This research contributes to three strands of literature on social insurance and insurance markets. First, it contributes to the growing literature that evaluates the welfare effects of LTCI. Most studies in this field examine demand-side channels, such as the presence of Medicaid (Brown and Finkelstein, 2008) and informal care through family (Mommaerts, 2020; Ko, 2021). These studies typically model LTCI as a homogeneous product and focus on aggregate enrollment. A recent paper by Braun et al. (2019) studies insurers' incentive to deny consumers of coverage in a static LTCI market equilibrium with the monopolistic insurer.[5] Our study contributes to this literature by estimating an insurer-level consumer demand that accounts for price dynamics of LTCI contracts and heterogeneity across insurers, including product variety offered. We also make a novel contribution by studying welfare implications of supply-side regulations in a framework that accounts for the imperfectly competitive market structure of LTCI.

Second, this study is related to the large literature that investigates policy designs in insurance markets. Most studies in this field focus on demand-side frictions, such as adverse selection or moral hazard (see Einav et al. (2010) for an excellent survey). A few studies investigate supply-side regulations (e.g., capital requirements) and argue that they act as financial frictions to insurers which significantly affect premiums in life insurance and annuity markets (Koijen and Yogo, 2015, 2016). The most related paper is Koijen and Yogo (2018) which studies how supply-side regulations affect both premium and product quality, as we do in this paper. Our work complements theirs by focusing on how the dynamic nature of insurance contracts is affected by pricing regulations.

Finally, our work adds to the literature on long-term insurance. Cochrane (1995) and Hendel and Lizzeri (2003) study optimal long-term insurance and focus on welfare implications of premium fluctuations which create reclassification risk to consumers. Handel et al. (2015), Handel et al. (2017), and Fleitas et al. (2018) quantitatively assess the welfare cost of reclassification risk. Atal (2019) and Atal et al. (2020) empirically study long-term health

[5]See also Liu and Liu (2020) who show evidence that political factors such as election cycles affect premium changes, insurers' cash flows, and the decision to sell LTCI.

insurance in Chile and Germany. Existing studies in this field assume perfectly competitive insurance markets and focus on premium determination. We complement the literature by studying an imperfectly competitive long-term insurance market where both price and non-price characteristics are endogenously determined.[6]

The rest of this paper proceeds as follows. Section 2 presents the institutional background. Section 3 presents the data and descriptive evidence. Section 4 presents the model. Section 5 presents the estimation results. Section 6 presents the counterfactual results. Section 7 concludes.

# 2 Institutional Background

### Long-term care in the U.S.

Long-term care is defined as assistance with basic personal tasks of everyday life, called Activities of Daily Living (ADLs) or Instrumental Activities of Daily Living (IADLs).[7] Declines in physical or mental abilities are the main reasons for requiring long-term care. In the U.S., over 60% of individuals aged 85 and older require assistance with daily tasks (Ko, 2021). However, not everybody will require long-term care in late-life: 32% (19%) of healthy 60-year-old men (women) will never need long-term care until their death (Ko, 2021). This suggests there are substantial risks surrounding how much long-term care one would need in late life.

Formal long-term care expenditure is one of the largest financial risks faced by the elderly in the U.S. The median annual rate for nursing home care was close to $100,000 in 2017,[8] and formal long-term care expenses totaled over $310 billion in 2013, which is close to 2% of GDP.[9] Medicaid is a means-tested public insurance program which covers formal long-term care expenses for eligible individuals with limited assets and incomes. It is the biggest payer for total long-term care payments accounting for about 51%, followed by other public insurance programs (21%), out-of-pocket (19%), and private LTCI (8%).[10]

[6] There is also a growing studies that examine why consumers sometimes lapse insurance contracts in long-term insurance (e.g., Fang and Kung (2020) and Gottlieb and Smetters (2021)). We take the lapsation as given in this paper and instead explore its implication to insurer behaviors.

[7] Examples of ADLs include bathing, dressing, using the toilet, and getting in/out of bed. IADLs refer to activities that require more skills than ADLs such as using the telephone and taking medication.

[8] Source: Genworth, https://www.genworth.com/aging-and-you/finances/cost-of-care.html.

[9] Source: Kaiser Family Foundation, https://www.kff.org/medicaid/report/medicaid-and-long-term-services-andsupports- a-primer/.

[10] Ibid.

### Long-term care insurance market

Private LTCI market is relatively young, and modern insurance products were introduced in the late 1980s (Society of Actuaries, 2014). Typical LTCI contracts cover both facility and paid home care provided by employees of home care agencies. In 2002, about 80% of the LTCI contracts sold were individual policies, and group policies which are purchased through employers only accounted for 20% (US Government Accountability Office, 2008). A daily benefit cap specifies the maximum amount a LTCI policy will pay on daily basis toward the cost of care. A benefit period specifies the maximum length of time over which the policy will provide coverage. In 2000, the average daily benefit cap was about $100, and benefit periods ranged widely from 1 year to lifetime coverage (Brown and Finkelstein, 2007). The average purchase age is 61 years, but most people do not use insurance until they turn 80 (Broker World, 2009-2015).

Contracts sold on the LTCI market are long-term contracts in the sense that there is an average time lag of 20 years between the purchase and use of insurance. Insurers commit to certain contract characteristics. First, contracts are guaranteed renewable in the sense that an insurance company cannot cancel coverage as long as premiums are paid. Second, insurers cannot change a single consumer's premium over the lifetime of the contract based on changes in individual circumstances (e.g., deterioration in health).[11] However, insurers are not required to commit to a certain premium schedule at buyer cohort level. They can submit rate increase requests to state governments for an entire class of consumers if they can successfully show that the class's accumulated and expected premium payments and investment returns are insufficient to cover expected claims.

Lapses, where policies terminate due to failure of premium payments, result in forfeiture of any future benefits (Brown and Finkelstein, 2007). In practice, lapses are very rare in the industry: the overall lapse rate was 2.7% for years 2005-2007, and 2% for 2008-2011.[12]

### Rate Stability Regulation of 2000

Oversight of the LTCI industry is largely the responsibility of states. Although it is up to states to decide whether they adopt federal standards established by NAIC, many state

[11] At the time of the initial purchase, insurers can charge different rates depending on individual health conditions or deny coverage altogether.

[12] Source: Society of Actuaries, https://www.soa.org/resources/experience-studies/2016/research-ltc-insurance/.

insurance departments regulate their LTCI market based on NAIC's Long-Term Care Insurance Model Regulation (Model #641) which was first adopted in 1987 (CIPR, 2016). This paper focuses on revisions to Model #641 which were adopted in 2000 to improve rate stability (Rate Stability Regulation of 2000).

Prior to 2000, states used a minimum loss ratio (ratio of incurred claims to earned premiums) to determine whether initial LTCI rates and subsequent rate increases were adequate (CIPR, 2016). Specifically, Model #641 stated that insurers must demonstrate an expected loss ratio of at least 60% (US Government Accountability Office, 2008). While the loss ratio standard was designed to limit initial rates, it was not effective in preventing insurers from setting initial rates that were too low and imposing large future rate increases.

To improve rate stability, in 2000, the NAIC adopted a set of new standards to establish more rigorous requirements insurers must satisfy when setting initial premiums and rate increases. First, the Rate Stability Regulation of 2000 removed the minimum loss ratio test for initial rate filings. Instead, it requires insurers to provide an actuarial certification that an initial premium is adequate to cover expected costs over the life of a policy, even under "moderately adverse conditions," with no future rate increases. In doing so, actuaries must include a margin for error in their pricing assumptions (US Government Accountability Office, 2008). This new standard for initial rate filings might increase a policy's initial premium but reduce the likelihood of future rate increases.

Second, while the Rate Stability Regulation of 2000 no longer requires insurers to meet the minimum loss ratio of 60% for initial rates, it requires insurers to meet a higher minimum loss ratio of 85% for revenues associated with rate increases (US Government Accountability Office, 2008). Such a higher loss ratio standard for rate increases might improve rate stability by limiting insurers' profits from rate increases.

Third, the Rate Stability Regulation of 2000 requires an insurer to report data on premiums earned and claims incurred for at least 3 years after implementing a rate increase (US Government Accountability Office, 2008). If the reported data are inconsistent with the insurer's initial justification for rate increases, states can require the insurer to reduce the rates. Other standards adopted in the Rate Stability Regulation of 2000 include disclosure of past rate increases of the same or similar policies to potential consumers. The new standards of the Rate Stability Regulation only apply to policies issued after a state incorporates the changes into its laws and regulation (CIPR, 2016).

As with all standards established by the NAIC for the regulation of the LTCI industry, it was up to states to determine whether they adopt the Rate Stability Regulation of 2000. For each state, Table A.1 in Appendix reports whether and when the state implemented the regulation. Between 2001 and 2012, 41 states adopted the rate stability regulation. A total of 23 states adopted the Rate Stability Regulation between 2001-2004, and the number of states adopting the regulation reached its peak in 2003. As we will show below, this period overlaps with the time where the LTCI industry experienced a sharp decrease in available plans and active insurers.

# 3 Data and Descriptive Evidence

## 3.1 Data Sources

Our main data come from the Long-Term Care Insurance Experience Reports submitted annually to the NAIC by all insurers operating in the LTCI line of business in the U.S. There are multiple forms that the NAIC requires LTC insurers to file, which have different reporting levels.

To exploit state variations in adoption of the Rate Stability Regulation, we use Form C reports submitted to the NAIC between 2000 to 2007.[13] Form C are annual reports which provide state-plan-level information about enrollment, new sales, premiums collected and claims incurred. Starting in 2009, the NAIC implemented entirely new forms, and reports at the state-plan-level are no longer available.

To provide empirical facts about the nationwide trend of the LTCI industry, we use nationwide reports which provide a plan's experience across all states where it is sold: such plan-level information is found in Form A for years 2000-2008, and in Form 2 for years 2009-2016.

We complement the NAIC data with rate increase data obtained from the California Department of Insurance for years 2007-2017. Any insurer who operated in California in the last 10 years is required to submit its rate increase history in all of its active states to the California Department of Insurance. This dataset provides state-plan-level information about rate increase requests and approvals. We link the plans in the NAIC data to the rate increase data using unique plan identifiers found in both datasets.

[13] While Form C reports were submitted until 2008, we do not use the 2008 reports as plans' initial rates cannot be computed.

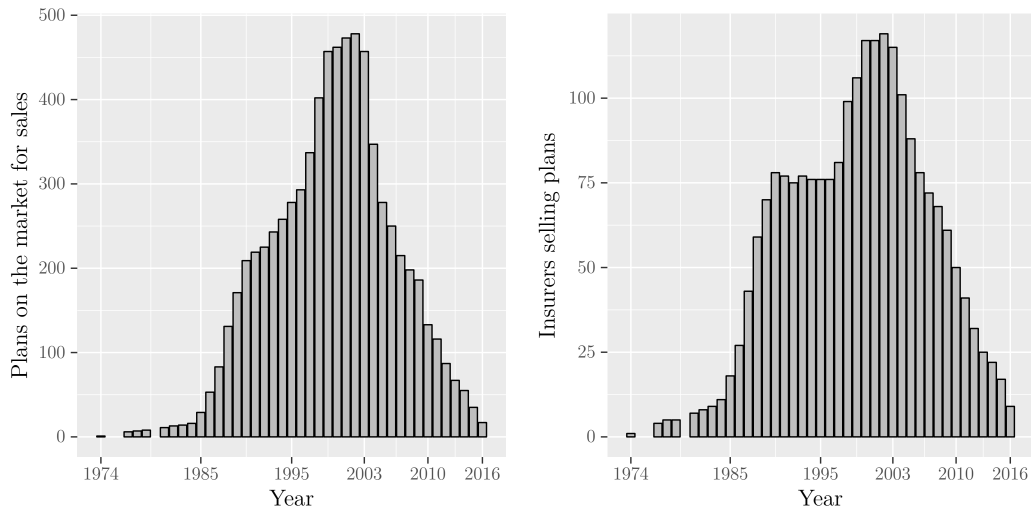



Figure 1: Active plans and insurers by year
*Notes:* Data = Form A and Form 2 NAIC reports. See Appendix B for the sample construction. The figure reports, for each year, the number of active plans and active insurers.

## 3.2 Nationwide Supply After Rate Stability Regulation

We first use nationwide NAIC reports to document a sharp decrease in the supply size of the LTCI industry in the last two decades. The NAIC data provide information about a plan's first and latest issue year. Based on this information, we can infer the number of active plans on the market for years where we do not have NAIC reports, i.e., years before 2000. Appendix B provides details on how we construct our sample from the NAIC Form A and Form 2 reports.

Figure 1 reports, for each year between 1974 and 2016, the number of active plans and insurers. We say a plan is active if the plan has strictly positive sales; we say an insurer is active if it has at least one active plan.[14] The number of active plans and insurers reached its peak in 2002 but experienced a very sharp decrease starting in 2003. As mentioned earlier, the number of states adopting the rate stability regulation reached its peak in 2003.

The left panel in Figure 2 shows the number of exiting plans by year. We say a plan exits if it no longer has positive sales.[15] The panel shows that there is a spike in the number of

[14] For years before 2000, we infer the numbers using the first and latest issue years. Insurers who had sold plans before 2000 but exited the market and had zero covered lives by 2000 do not have to report to the NAIC in 2000 and onward. As these insurers are missing in our sample, Figure 1 may under-represent the supply size for earlier years.

[15] Insurers still have to file regulatory forms to the NAIC for plans that have exited the market as long as they have existing consumers.

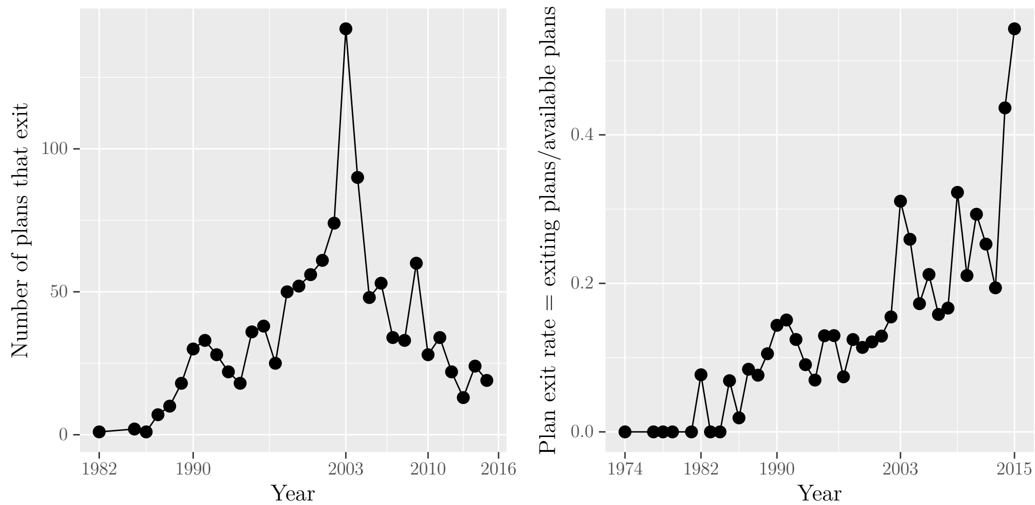



Figure 2: Exiting plans by year
*Notes:* Data = Form A and Form 2 NAIC reports. See Appendix B for the sample construction. The figure reports, for each year, the number of exiting plans (left panel) and exit rate (right panel).

exiting plans in 2003. The right panel in Figure 2 shows the exit rate by year. The exit rate is defined as the ratio of exiting plans to active plans. The panel shows that the exit rate increased sharply in 2003 and has remained high since then.

## 3.3 Descriptive Evidence on Effect of Rate Stability Regulation

### Insurer participation and initial rates

In this section, we use variations in states' adoption of Rate Stability Regulation of 2000 to provide descriptive evidence on the effect of the regulation on insurer participation and initial rates. To this end, we use Form C NAIC reports which are available for years 2000-2007. We use an event study framework to report changes in LTCI market outcomes at the state level. The model that we estimate is the following:

$$y_{st} = \alpha + \sum_{k=-2}^{2} \beta_k I_{stk} + \tau_t + \eta_s + \varepsilon_{st}. \tag{1}$$

For the dependent variable, we use (i) the number of active plans, (ii) the number of active insurers, and (iii) the median initial rate in each state $s$ in year $t$. $I_{stk}$ is an indicator for being $k$ years since the state's implementation of the Rate Stability Regulation.

The regression sample comes from 24 states that implemented the regulation between 2002-2005. This is because we control for 2 years before and after the adoption of the regulation, and Form C reports are available for years 2000-2007. We further restrict to plans making positive sales in at least one year over the sample period. This is to exclude plans that had already exited the market by 2000.

Figure 3 reports the estimated $\beta_k$'s in equation (1). The adoption of the regulation is negatively correlated with product variety and insurer participation in a state. In two years since the adoption, the number of plans decreased by 10, and the number of insurers went down by two. The mean initial rate increased by $600, although the estimate is statistically noisy. To sum, the evidence reported in Figure 3 suggests that the regulation had a negative impact on consumers by reducing product variety and insurer competition. However, its overall impact on consumer welfare also depends on by how much the regulation reduced premium fluctuations. In what follows, we provide suggestive evidence for the positive effect of the regulation in improving rate stability.

**Rate increases**

We use the rate increase data obtained from the California Department of Insurance for years 2007-2017 to examine how the Rate Stability Regulation might have affected rate increases. The rate increase data are at the plan-state-request year level. For each request, we observe the plan's first issue year and the requested and approved range of increases (e.g., 10-30%). For each plan-state combination found in the data, we categorize the plan as sold before the rate stability regulation if its first issue year is before the state's regulation adoption year; otherwise, we categorize the plan as sold after the regulation.[16] The regulation applies only to plans that are issued after the implementation of the regulation.

Tables B.2 and B.3 in Appendix provide summary statistics of the rate increase sample. It shows that compared to plans sold before the Rate Stability Regulation, plans sold after the regulation have a lower chance of getting their rate requests approved and are granted lower increases. However, in any given state, plans sold after the regulation are on average younger than plans sold before the regulation by definition: this is well demonstrated in the second to the last row in Table B.3.[17] As insurers might be less likely to file a rate increase

[16]If a state has never adopted the regulation, all of its plans are categorized as sold before the regulation.
[17]We define a plan's age as the years since its first issue.

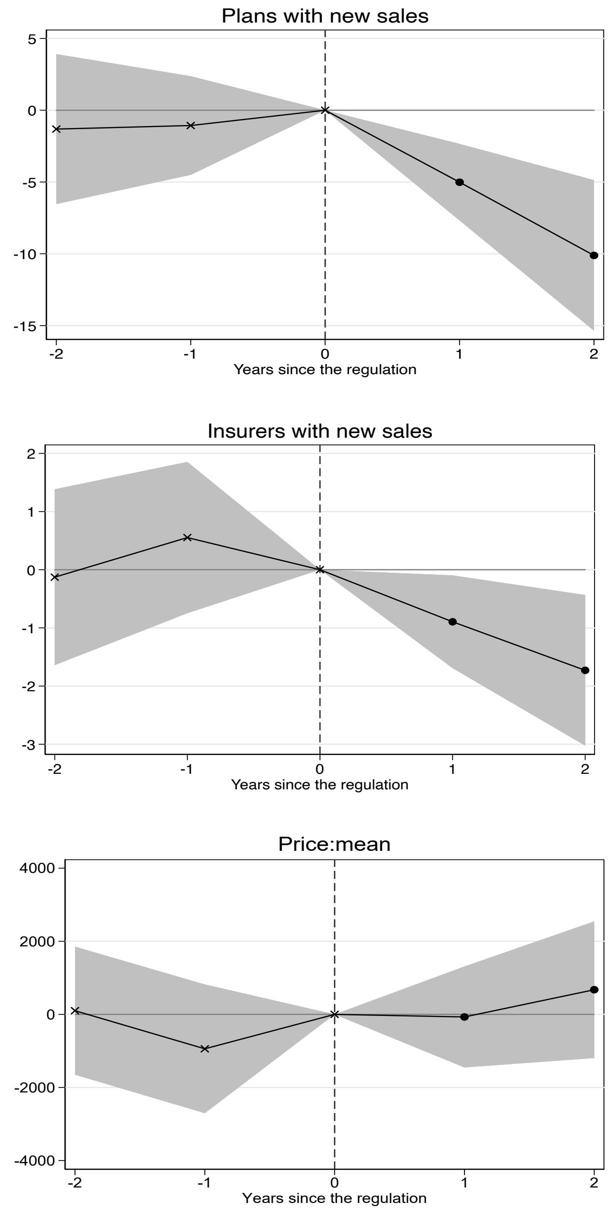



Figure 3: State-level Changes in LTCI Outcomes

*Notes:* Data = Form C NAIC reports 2000-2007. The sample consists of plans sold in 24 states that implemented the Rate Stability Regulation between 2002-2005. The figure reports the estimates of $\beta_k$'s in equation (1). The gray area indicates 95% confidence intervals. Standard errors are clustered by state.

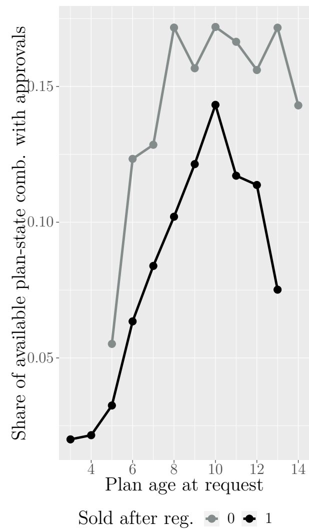



Figure 4: Rate increases: extensive margin

*Notes:* Data = Rate increase data and Form 2 NAIC reports. See Appendix B for the sample construction. Conditional on plan age and whether the plan was sold before or after the state's enactment of the Rate Stability Regulation of 2000, the figure reports the share of available plan-state combinations obtaining rate increase approvals.

request for relatively young plans, it is important to condition on plan age to examine how the regulation might have affected rate increases.

Figures 4 and 5 compare rate increases between plans sold before and after states' adoption of the Rate Stability Regulation, conditional on plan age. Figure 4 reports, conditional on plan age and whether the plan was sold before or after the state's enactment of the regulation, the share of available plan-state combinations that obtain a rate increase approval. The figure reveals that for all plan ages available in the data, policies that are sold after the regulation are less likely to obtain a rate increase approval.

Figure 5 shows, conditional on plan age, the mean approved rate increase and how large it is relative to the requested amount. While the mean approved rate increase is not always lower for plans sold after the regulation, its magnitude relative to the requested amount is indeed much smaller for plans sold after the regulation (except for very young plan ages where we do not have enough observations).

To sum, the results in Figures 4 and 5 provide suggestive evidence that the Rate Stability Regulation might have achieved its intended goal of stabilizing future rate increases. However, this benefit should be weighed against the possible cost of the regulation documented

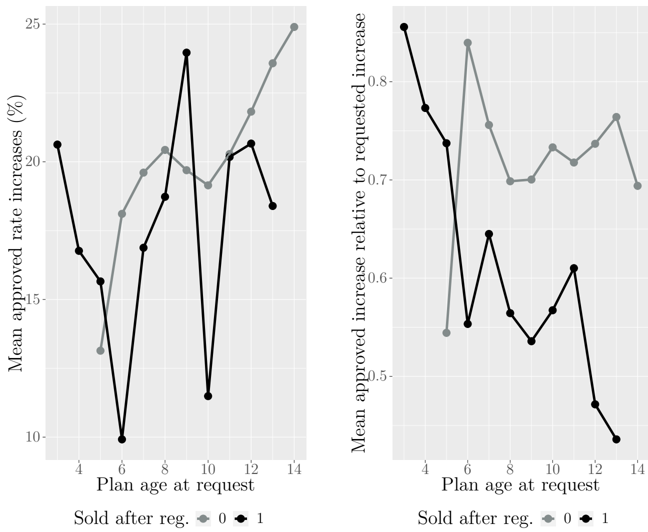



Figure 5: Rate increases: intensive margin

*Notes:* Data = Rate increase data. Conditional on plan age and whether the plan was sold before or after the state's enactment of the rate stability regulation, the left graph reports the mean approved rate increase, and the right graph reports the mean approved increase relative to the requested increase. For example, if an insurer requested an average increase of 40% for a plan and was approved of 10%, then the approved rate increase relative to the requested is $\frac{10}{40}$.

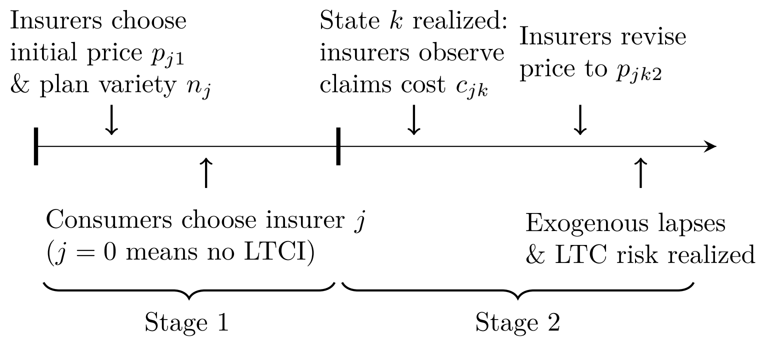
in Figure 3: a reduction in plan availability. The next section develops a model that will enable us to quantify this trade-off of the regulation.

# 4 Model

## 4.1 Environment

There are $M$ LTCI markets which are defined by a geographical state and calendar year. Each market consists of a finite number of insurers and a unit mass of potential consumers. Within each market, there exist two stages. Figure 6 summarizes the timing of events. In stage 1, each insurer chooses the number of plans to offer and sets a representative price. Consumers observe the menu of insurance options available and make their insurance purchase decision. Remaining uninsured is a feasible choice, in which case consumers with limited assets can qualify for means-tested public LTCI, Medicaid. In stage 2, insurers receive a signal about their claims costs and revise their premiums determined in the first stage. Consumers who purchased insurance in stage 1 terminate their contract according to an exogenously given

Figure 6: Timing of events




probability. At the end of stage 2, formal care utilization takes place, and insurers' claims costs are realized.

We assume insurers cannot commit to second-stage premiums. This is an appropriate assumption because during our sample period, LTC insurers did not offer state-contingent contracts.[18] The model incorporates two important regulations that affect insurers' pricing decisions: 1) rate stability regulation which makes it costly for insurers to increase premiums in the second stage, and 2) loss ratio regulation which penalizes insurers for charging an initial rate that is different from the regulator's target level.

### Stage 1: Firms' initial pricing and plan offering and consumers' insurance choice

We now define the payoff functions of consumers and insurers. For an expositional purpose, we suppress the notation of market characteristics $m$, although all insurer-level variables (premium, plan characteristics, market share, regulatory costs, and claims) are market specific. Consumer $i$'s flow utility from purchasing a contract sold by insurer $j$ in stage 1 is

$$\tilde{u}_{ij1} \quad = \quad \alpha u(y_i - p_{j1}) + \gamma n_j + \xi_j + \varepsilon_{ij} \tag{2}$$

where $y_i$ is consumer $i$'s income, $p_{j1}$ is insurer $j$'s premium in stage 1, $n_j$ is the number of plans offered by insurer $j$, $\xi_j$ is insurer $j$'s other non-price characteristics, and $\varepsilon_{ij}$ represents consumer $i$'s insurance choice-specific taste shock. The function $u$ represents consumers' utility over income and exhibits risk aversion. Consumers' utility from contracting with

[18]More recently, insurers started offering long-term contracts that guarantee a constant premium stream. These contracts are usually bundled with life insurance.

insurer $j$ depends on the number of plans that insurer $j$ offers on the market, $n_j$. This captures the idea that wider product variety might allow consumers to choose a better quality plan based on their needs. The term $\xi_j$ captures insurer $j$'s non-price characteristics that consumers might value, such as brand fixed effects.

If consumer $i$ remains uninsured, then her utility in stage 1 is given by

$$\tilde{u}_{i01} = \alpha u(y_i) + \varepsilon_{i0} \tag{3}$$

where $\varepsilon_{i0}$ represents the consumer's idiosyncratic taste of not purchasing any plan.

In stage 1, insurers decide how many plans to offer and set a representative premium. Insurer $j$'s profit in stage 1 is

$$\Pi_{j1} = p_{j1}s_{j1} - C_j^v(n_j) - C_j^l(p_{j1} - \tilde{\mu}_j) \tag{4}$$

where $s_{j1}$ is the number of enrollees for insurer $j$ in stage 1, and $C_j^v(n_j)$ denotes the total cost of offering $n_j$ plans. $C_j^l$ is the cost of setting a premium that is different from the insurer's target premium $\tilde{\mu}_j$ which is set by the government. The government sets $\tilde{\mu}_j$ based on the insurer's anticipated claims to ensure a certain level of loss ratio. We allow the regulatory cost $C_j^l$ to be insurer-specific, capturing the idea that the actual enforcement of the regulatory standards set by the NAIC often depends on the regulator's tastes (Liu and Liu, 2020). As we assume long-term care utilization takes place at the end of the second stage, insurers do not incur any claims cost in stage 1.[19]

### Stage 2: Firms' revised pricing

There are $K$ possible states of the world in stage 2, and each state happens with probability $\pi_k$ where $k = 1, ..., K$. When state $k$ is realized, insurers learn that the expected claims cost from their existing cohort of consumers is equal to $\mu_{jk}$.[20] Insurers then decide whether to increase the initial premium $p_{j1}$, and if so, by how much. Insurers are subject to rate stability regulation which makes it costly for them to increase rates. Furthermore, there

[19] We assume there is no administrative cost of offering LTCI. While Braun et al. (2019) find that administrative cost is important in explaining the low take-up rate of LTCI, we abstract from it as we do not have data on administrative cost at the insurer level.

[20] Although we are not explicit about how insurers learn the realized state, one can consider that they update their beliefs based on realized claims from recent and older cohorts, in addition to changes in expected claims from the current cohort.

are reputation costs that insurers incur when they raise premiums. This is to reflect the idea that future consumers may have reduced preference for insurers that are known to increase premiums ex-post. $C^{rs}_{jk}(p_{j1}, p_{jk2})$ represents the total regulation and reputation cost associated with revising the premium from $p_{j1}$ to $p_{jk2}$ when the realized state is $k$ in stage 2.

At the beginning of the second stage, consumers terminate their contract with probability $\delta_k$ when the realized state of the world is $k$. If consumers let their policies lapse, then they become uninsured against long-term care spending shocks unless they qualify for Medicaid by having a sufficiently low income.[21] We assume that the probability of lapsation is exogenous and does not depend on second-stage premiums.[22]

When the realized state is $k$, consumer $i$'s expected utility from holding the contract sold by insurer $j$ is

$$\tilde{u}_{ijk} = (1 - \delta_k) u_{ijk,stay} + \delta_k u_{ik,lapse} \tag{5}$$

where $u_{ijk,stay}$ is consumer $i$'s utility from keeping the existing contract sold by insurer $j$, and $u_{ik,lapse}$ is the utility from lapsing the contract. The utility from retaining the current contract is given by

$$\begin{aligned} \tilde{u}_{ijk,stay} &= u_{ijk,stay} + \tilde{\varepsilon}_{i1} &(6)\\ &= \underbrace{\alpha u(y_i - p_{jk2}) + \gamma n_j + \xi_j}_{=u_{ijk,stay}} + \tilde{\varepsilon}_{i1} &(7)\end{aligned}$$

where $\tilde{\varepsilon}_{i1}$ represents the idiosyncratic taste from staying with the existing insurer. As we assume full coverage LTCI contracts, consumers do not face any long-term care spending

[21] We assume switching to a different insurer in stage 2 is not a feasible option for consumers. This is empirically grounded as most insurers do not sell contracts to individuals older than 70: sales made to individuals aged 70+ account for less than 5% (Broker World, 2009-2015).

[22] This assumption is motivated by the fact that the lapse rate is in general very low in the LTCI market and is concentrated in a few years after the initial purchase. Previous researches highlight idiosyncratic reasons as the key driver behind lapses. For example, Gottlieb and Smetters (2021) find that consumers forgetting to pay the premium is the most important reason of lapsation in life insurance. The main result of this paper would also be robust to an alternative model where consumers optimally choose whether to lapse by observing the second-period premium, as long as they face the cost of lapsation to rationalize the data. Given the low lapse rate in the data, the model would predict that consumers are not sensitive to rate increases. As a result, insurers would have an incentive to increase rates in the second stage, and the regulatory cost would again be the key determinant of price dynamics.

risk if they keep their contract. The utility from lapsing the contract is given by

$$\begin{aligned} \tilde{u}_{ik,lapse} &= u_{ik,lapse} + \tilde{\varepsilon}_{i2} && (8) \\ &= \underbrace{\int_{\lambda} \alpha u(y_i - oop(\lambda, y_i)) f_k(\lambda) d\lambda}_{=u_{ik,lapse}} + \tilde{\varepsilon}_{i2}. && (9) \end{aligned}$$

$\lambda$ is a random variable which represents the consumer's LTC expenses. It is distributed according to the PDF $f_k(\lambda)$ where $k$ represents the aggregate state of stage 2. In the first stage, neither firms nor consumers know the exact distribution of $\lambda$. What they know is that (1) there are $K < \infty$ candidate distributions of $\lambda$, and (2) the probability that $\lambda$ follows the PDF $f_k(\cdot)$ is $\pi_k \in [0, 1]$. We assume the distribution of $\lambda$ is realized and observed by firms and consumers at the beginning of the second period. This implies that there is symmetric learning. The function *oop* represents consumers' out-of-pocket LTC costs which depend on their income $y_i$. This is to capture possible benefits from means-tested Medicaid. $\tilde{\varepsilon}_{i2}$ represents the taste shock associated with terminating the contract.

If consumer $i$ did not purchase any LTCI contract in stage 1, then the consumer's utility in stage 2 is simply

$$u_{ik,unins} = \int_{\lambda} \alpha u(y_i - oop(\lambda, y_i)) f_k(\lambda) d\lambda. \qquad (10)$$

Insurer $j$'s profit from the second stage when the realized state is $k$ is

$$\Pi_{jk2} = (p_{jk2} - \mu_{jk}) s_{jk2} - C^{rs}_{jk}(p_{j1}, p_{jk2}). \qquad (11)$$

$s_{jk2}$ is the insurer's market share in stage 2 which could be different from its first stage market share due to possible lapses by consumers. $\mu_{jk}$ is the expected claims cost given the realized state of the world $k$, and $C^{rs}_{jk}(p_{j1}, p_{jk2})$ is the adjustment cost associated with revising premiums. Similar to the regulation on the initial premium ($C^{l}_{j}$), we allow the adjustment cost to be insurer-state specific to capture regulators' idiosyncratic taste in approving rate increases (Liu and Liu, 2020). We assume there is an upper bound on premiums that can be set by insurers ($p_{jk2} \leq \overline{p}_k$) such that LTCI remains affordable even to low-income households.

## 4.2 Analysis

**Consumer's optimal insurance choices**

We now characterize the optimal decisions of consumers and insurers. The consumer's expected lifetime utility from purchasing insurer $j$'s plan in stage 1 is

$$\tilde{v}_{ij} = \underbrace{\alpha u(y_i - p_{j1}) + \gamma n_j + \xi_j + \beta_c \sum_k \pi_k E_{\tilde{\varepsilon}_i}[\tilde{u}_{ijk}]}_{=v_{ij}} + \varepsilon_{ij} \tag{12}$$

where $\beta_c$ is the consumer's discount factor. As $\tilde{\varepsilon}_i$ has a Type I EV distribution, we can express $v_{ij}$ as

$$v_{ij} = \alpha u(y_i - p_{j1}) + \gamma n_j + \xi_j + \beta_c \sum_k \pi_k \ln\left(\exp(u_{ijk,stay} + \exp(u_{ik,lapse})\right). \tag{13}$$

The consumer's expected lifetime utility from not purchasing any insurance in stage 1 is

$$\tilde{v}_{i0} = \underbrace{\alpha u(y_i) + \beta_c \sum_k \pi_k u_{ik,unins}}_{=v_{i0}} + \varepsilon_{i0}. \tag{14}$$

As we assume insurance choice-specific shocks are *i.i.d.* Type I EV shocks, we can characterize individual $i$'s insurance choice probability as

$$s_{ij1} = \frac{\exp(v_{ij})}{\sum_{j'} \exp(v_{ij'})}. \tag{15}$$

Insurer $j$'s first-period market share is given as

$$s_{j1} = \int s_{ij1}(p) g(y_i) dy_i. \tag{16}$$

The insurer's second-period market share in state $k$ is given by $s_{jk2} = (1 - \delta_k)s_{j1}$.

**Firm's optimal price setting and plan offering**

In stage 2, given the realized state $k$, each insurer $j$ chooses the revised premium by maximizing its state-specific profit:

$$\Pi_{jk} = \underset{p_{jk2} \leq \overline{p}_k}{\mathrm{Max}} (p_{jk2} - \mu_{jk}) s_{jk2} - C^{rs}_{jk}(p_{j1}, p_{jk2}) \tag{17}$$

The optimal second-period premium is given by the following first-order condition:

$$s_{jk2} - \frac{\partial C_{jk}^{rs}}{\partial p_{jk2}} \leq 0 \tag{18}$$

We allow for a possible corner solution, $p_{jk2} = p_{j1}$, where insurers decide not to increase the premium in the second stage. This may happen if the rate stability regulation imposes a fixed cost of revising the premium. Given the optimal sequence of $\{p_{jk2}\}_{k=1}^{K}$ which is a function of the initial premium $p_{j1}$ and the variety of plans $n_j$, insurer $j$ in stage 1 chooses $p_{j1}$ and $n_j$ by maximizing its total profit over the lifetime of the insurance contract:

$$\underset{p_{j1},n_j}{\text{Max}}\ p_{j1}s_{j1} - C_j^v(n_j) - C_j^l(p_{j1} - \tilde{mu}_j) + \beta_f \sum_k \pi_k \Pi_{jk} \tag{19}$$

where $\beta_f$ is the firm's discount factor. The optimal initial premium $p_{j1}$ and number of plans $n_j$ are determined by the following first-order conditions:

$$s_{j1} + p_{j1}\frac{\partial s_{j1}}{\partial p_{j1}} - \frac{\partial C_j^l}{\partial p_{j1}} + \beta_f \sum_k \pi_k \frac{\partial \Pi_{jk}}{\partial p_{j1}} = 0 \tag{20}$$

$$p_{j1}\frac{\partial s_{j1}}{\partial n_j} - \frac{\partial C_j^v(n_j)}{\partial n_j} + \beta_f \sum_k \pi_k \frac{\partial \Pi_{jk}}{\partial n_j} = 0 \tag{21}$$

We characterize a Nash equilibrium in each market such that the vector of premiums and product variety $(p_{j1}, \{p_{jk2}\}_{k=1}^{K}, n_j)$ for each insurer $j$ satisfies equations (18), (20), and (21). From this characterization, it is transparent that the lack of insurer commitment on future rates leads to premium uncertainty for consumers in the second stage. Because there is no competition among insurers in the second stage, insurers have an incentive to follow a premium profile where they first set a relatively low price to lock in consumers and increase the premium later (to the point that it is still affordable to consumers). How much insurers can raise the premium depends on the regulatory and reputation constraints, which differ depending on the realization of state $k$. For example, in second-period states where the expected claims are low and insurers face a high cost of increasing the premium, they may not revise their rates. In other states where the regulatory and reputation cost is small, they may significantly increase their premium to take advantage of locked-in consumers.

### 4.3 Model Discussion

#### Lack of commitment

If insurers are able to commit to a premium schedule in the first stage, the model should predict that the second-stage premium is the same across all realized states $k = 1, ...K$.[23] Then, consumers face no premium uncertainty, and as a result, the rate stability regulation simply distorts the market equilibrium. One natural question is whether one should formulate the problem using a limited commitment model with financial frictions, where insurers can implicitly (but not explicitly) commit to a premium schedule but may revise their contract when their financial constraint binds. We do not pursue this route, mainly because it is not possible for us to characterize the actual financial constraints faced by insurers in a credible manner.[24]

#### Insurer entry and exit

We do not explicitly model insurers' entry/exit decisions. This is because there are too many fringe firms in the data, and endogenizing all of their entry/exit decisions would make estimation computationally infeasible. Instead, when we take our model to the data, we assume there is a representative minor firm which consists of small and local insurers. The entry/exit decisions of the fringe firms are therefore captured by the number of plans offered by this representative minor firm.

#### Plan varieties and adverse selection

An insurer's choice of product variety depends on the profitability from enrolling an additional consumer, consumers' willingness to pay for product variety, and the insurer's marginal cost of increasing product variety. As pointed out by Spence (1975), it is ambiguous whether product variety is under-supplied or over-supplied in an imperfectly competitive economy.

Our model does not account for adverse selection which might have complex implications for the welfare effect of plan varieties. In the presence of adverse selection, insurers could

[23]The second-stage premium can still differ from its first-stage value if consumers' income changes between the first and second stages.

[24]By assuming that insurers cannot commit to a premium schedule, our model may overpredict the effect of premium fluctuations on consumer welfare relative to a limited commitment model. If so, our model can possibly provide an upper bound on the consumer welfare gain from the rate stability regulation.

offer a menu of policies to risk screen consumers, as found in Braun et al. (2019). Admittedly, studying the regulatory effect on adverse selection is an interesting avenue to pursue. However, the NAIC data provide very limited information about plan characteristics. In particular, we do not observe plan generosity which is crucial in the analysis of risk screening. In fact, we are not aware of datasets that have information about plan coverage for all insurers that operate in the U.S. Note that our model abstracts from insurance rejections where private information is known to have the most severe impact (Hendren, 2013): all consumers in our model are healthy enough to purchase insurance. Therefore, we suspect that the extent of adverse selection will be limited within our framework.

#### Medicaid and other types of insurance

We explicitly account for Medicaid which acts as means-tested public LTCI. As found in Brown and Finkelstein (2008), Medicaid substantially lowers the demand for private insurance, especially among low-income individuals. There are two other ways to potentially insure against formal LTC expenses that we do not model. First, we do not consider consumers' ability to save, which acts as self insurance.[25] Second, our model does not have family insurance where disabled individuals rely on informal care for the help that they require (Mommaerts, 2020; Ko, 2021). As we abstract from these other insurance channels, our model could over predict the demand for LTCI. This is a comprise we need to make to model the complex supply side of the LTCI market that accounts for imperfect competition and regulatory constraints.

#### Aggregate risk

Insurers in our model face risk about their future claims. The sources of this risk include uncertainty over health, mortality, preference for formal care, and LTC costs. There may be other types of aggregate risk that insurers face, such as interest rate risk and insolvency risk. These macroeconomic risks affect insurer's financial position, which affects pricing of insurers (e.g., Koijen and Yogo (2015)) Although it is very interesting to explore their impacts on LTCI markets, for the sake of the tractability of analysis, we focus on the time period (pre Great Recession) where macroeconomic risks to insurers were relatively mild.

[25] Papers like Lockwood (2018), Mommaerts (2020) and Ko (2021) incorporate savings in a life-cycle savings model and analyze the demand for LTCI.

# 5 Estimation

## 5.1 Empirical Specification

### 5.1.1 Time Horizon

Our theoretical model only considers two stages of life-cycle in retirement. We assume the first stage lasts $n_1$ years, and the second stage lasts $n_2$ years. That is, at the beginning of the first stage, consumers make insurance choices and pay the premium for $n_1$ years. There is no long-term care risk in the first stage. Then, at the beginning of the second period, insurers revise their premiums. If consumers keep their contract, then they pay the revised premium for $n_2$ years; if they terminate their contract (or if they didn't purchase insurance in the first stage), then they pay for formal long-term care with their out-of-pocket money for $n_2$ years. We assume that both consumers and insurers have the same annual discount factor ($\beta = \beta_c = \beta_f$) and set $\beta = 0.97$. We assume the first stage lasts $n_1 = 8$ years, and the second stage lasts $n_2 = 4$ years.[26] For notational simplicity in what follows, we define the following time horizon scales:

$$B_1 = \frac{1 - \beta^{n_1}}{1 - \beta} \tag{22}$$

$$B_2 = \frac{1 - \beta^{n_2}}{1 - \beta} \tag{23}$$

### 5.1.2 Consumer Income and Assets

For information about consumer income and assets, we turn to the Health and Retirement Study (HRS) which has surveyed a representative sample of elderly Americans every two years since 1992. In the first stage, we assume consumers' per-period resources are equal to their annual income, which includes social security retirement income, employer pension, annuity income, and other income. In the second stage, we assume consumers' per-period resources are equal to their annual income *plus* their assets. This is because (1) the eligibility of Medicaid depends on total resources which include assets, and (2) our model does not have savings. We consider three consumer groups whose resources correspond to the 20th, 50th, and 80th percentiles of the sample distribution.

[26]The results are robust to using different values of $n_1$ and $n_2$.

#### 5.1.3 Long-Term Care Risk and Medicaid

We calibrate the costs of LTC such that the mean lifetime LTC expenses are around \$60,000, and the mean lifetime LTC expenses conditional on using LTC throughout the second stage is around \$100,000 (Kemper et al., 2005/2006). Specifically, we assume that in each year of the second stage, consumers use formal LTC services with probability 0.6 which results in annual LTC costs of $\$100,000/n_2$. For consumers whose net resources become negative after paying for LTC costs, Medicaid ensures a consumption floor of \$1.[27]

#### 5.1.4 Utility Function

We assume consumers' utility over income follows a log function, $u(y) = \ln(y)$.

#### 5.1.5 Cost Function

We assume the following functional forms for firms' costs:

$$C^{rs}_{jk}(p_{j1}, p_{jk2}) = \begin{cases} c^0 + \frac{c^1_{jk}}{2}(p_{j1} - p_{jk2})^2 & \text{if } p_{jk2} > p_{j1} \\ 0 & \text{if } p_{jk2} = p_{j1} \end{cases} \tag{24}$$

$$C^l_j(p_{j1} - \tilde{\mu}_j) = \frac{c^l_j}{2}(p_{j1} - \tilde{\mu}_j)^2 \tag{25}$$

$$C^v_j(n_j) = \frac{c^v_j}{2} n_j^2 \tag{26}$$

The cost of the rate stability regulation $C^{rs}_{jk}$ incorporates a fixed cost component ($c^0$) associated with increasing the premium. This is to rationalize the fact that a significant number of insurers do not increase rates in the data.

We specify the minimum loss regulation such that costs are incurred whenever the firm's initial premium $p_{j1}$ deviates from its target price set by the government $\tilde{\mu}_j$. We assume the government sets $\tilde{\mu}_j$ such that the loss ratio reaches a certain target level, $lr_{target}$. For the purpose of determining $\tilde{\mu}_j$, the government assumes there are zero lapses and the premium remains constant. Then, the target loss ratio will be achieved if $p_{j1}$ is equal to

$$\tilde{\mu}_j = \frac{\beta^{n_1} B_2 \sum \pi_k \mu_{jk}}{lr_{target}(B_1 + \beta^{n_1} B_2)} \tag{27}$$

[27]The implicit assumption is that the type of formal care services used is nursing home care which already provides basic food and housing.

where the numerator is the expected present discounted value of claims. We set $lr_{target} = 0.8$, which falls in the range of targeted loss ratio during our sample period. We allow $c_j^l$ to vary across insurers and markets. The parameter will therefore capture policy changes to loss ratio regulation during our sample period.

## 5.2 Estimation Strategy

As with many other equilibrium models, we proceed our estimation in two steps: we first estimate the demand side, followed by the supply side.

### 5.2.1 Demand Estimation

**Prediction of second-stage premium increases**

We follow the estimation strategy in Berry et al. (1995) to recover demand parameters. One empirical challenge we face is that for the second stage of our model, we only observe revised premiums for the realized state of the world. That is, we do not observe $p_{jk2}$ for all $k = 1, ..., K$.

We address the challenge by estimating the distribution of rate increases using a finite mixture model. Let $r_{ijs}$ denote the cumulative rate increase for plan $j$ sold by insurer $i$ in state $s$ observed during the sample period. Define $y_{ijs} = \ln(r_{ijs} + 1)$ which is a monotonic transformation of $r_{ijs}$. We represent the density of $y_{ijs}$ by the following finite mixture model:

$$f(y_{ijs}) = \sum_{g=1}^{G} \pi_{gs} f_g(y_{ijs} | x'_{ij}\beta_g) \tag{28}$$

Specifically, we set $G = 2$. For $g = 1$, we assume the price increase is degenerate and is equal to zero with probability one. This is because in our data, about 55% of observations report zero rate increases over the sample period. For $g = 2$, we assume the price increase follows a normal distribution.

We estimate $\{\pi_{gs}, \beta_g\}_{g,s}$ by a maximum likelihood estimator. Then, we obtain the predicted premium increase for each state of world by using quantile values of the estimated distribution. Specifically, we express the expected price increase as

$$E[y_{ijs}] = \pi_{g=1,s} E_1[y_{ijs}] + \pi_{g=2,s} E_2[y_{ijs}] \tag{29}$$

where $E_1$ and $E_2$ are expectation operators using densities $f_{g=1}$ and $f_{g=2}$, respectively. Alternatively, we can express the expected increase as:

$$E[y_{ijs}] = \pi_{g=1,s} E_1[y_{ijs}] + \pi_{g=2,s} \left( \sum_{k=2}^{K} Pr(q_{k-1} < y_{ijs} \leq q_k) E_2[y_{ijs} | q_{k-1} < y_{ijs} \leq q_k] \right) \quad (30)$$

where $q_k$ represents the $k^{th}$ quantile value of the second class distribution. Define the probability that the second-period state is $k \in \{1, ..., K\}$ as the following:

$$\pi_{ks} = \begin{cases} \pi_{g=1,s} \text{ if } k = 1 \\ \pi_{g=2,s} Pr(q_{k-1} < y_{ijs} \leq q_k) \text{ if } k = 2, ..., K \end{cases} \quad (31)$$

Then we can rewrite the expected price increase as:

$$E[y_{ijs}] = \pi_{k=1,s} E_1[y_{ijs}] + \sum_{k=2}^{K} \pi_{ks} E_2[y_{ijs} | q_{k-1} < y_{ijs} \leq q_k] \quad (32)$$

We predict a plan's price increase when the second-period state is $k$ as the following:

$$E[y_{ijs} | \pi_{ks} = 1] = \begin{cases} 0 \text{ if } k = 1 \\ E_2[y_{ijs} | q_{k-1} < y_{ijs} \leq q_k] \text{ if } k = 2, ..., K \end{cases} \quad (33)$$

Combined with the NAIC data on initial rates, we recover premiums for all possible states of the second stage. We set $K = 5$.

**Estimation of demand-side parameters**

The key primitive of the demand model is $(\alpha, \gamma)$, which comprises consumption utility scale and product variety utility scale. To estimate these demand-side parameters, we first specify that the unobserved characteristics of insurer $j$, $\xi_{jt}$, follows

$$\xi_{jt} = \xi_j + \xi_t + \Delta\xi_{jt}. \quad (34)$$

We explicitly control for insurer and time fixed effects, and the remaining variation in unobserved characteristics is $\Delta\xi_{jt}$, changes in consumer's unobserved taste for insurer $j$. The key challenge in our demand estimation is the issue of endogeneity of premiums and plan variety, where these product characteristics are set by insurers to reflect unobserved demand changes.

We exploit a number of plausibly exogenous variations to address this issue. First, we exploit cross market variations in the spirit of Hausman (1996) and Nevo (2001) and instrument prices using insurers' own prices in other markets. Our identification assumption is that there may be common supply shocks across geographic areas that affect prices, which are uncorrelated with demand. For example, insurers may update their beliefs about future claims cost based on the realized claims costs from their existing buyer cohorts. As long as insurers' updated beliefs are uncorrelated with unobserved demand from potential buyers, this works as a valid instrument. Second, we exploit variations in states' adoption of the rate stability regulation. We assume that the implementation of supply-side regulations is orthogonal to changes in consumers' unobserved demand.

Formally speaking, our moment conditions are given as

$$cov(z_{jt}, \Delta\xi_{jt}) = 0 \quad (35)$$

$$cov(z_{1jt}, p_{jt}) \neq 0 \quad (36)$$

$$cov(z_{2jt}, n_{jt}) \neq 0 \quad (37)$$

where $z_{jt} = (z_{1jt}, z_{2jt})$. $z_{1jt}$ is insurer $j$'s average premium in other markets, and $z_{2jt}$ is the change in the number of plans offered by insurer $j$ in the year when the state adopted the regulation.

The estimation is implemented by the standard Generalized Method of Moment. We use a contraction mapping to recover $\xi_{jt}$ as in Berry et al. (1995). Given other demand parameter estimates, we solve for $\xi_{jt}$ that rationalizes the observed market share of each insurer. We then calculate $\Delta\xi_{jt}$ and evaluate the moment conditions.

### 5.2.2 Supply Estimation

#### Prediction of second-stage claims

For the supply side, we estimate the parameters that enter the cost functions (24), (25), and (26) using firms' optimality conditions. To do so, we need demand estimates and data on premiums and claims. As we did for demand estimation, we use observed initial prices $p_{j1}$ and estimated state-contingent prices $p_{jk2}$. We estimate state-contingent claims $\mu_{jk}$ outside the model based on a procedure similar to the one used in the estimation of $p_{jk2}$. Specifically, for a given geographic state $s$, we define quantiles of the claims distribution based on the probability of the state of the world $\{\pi_{ks}\}_{k=1}^{K}$ estimated in equation (31). We then compute the mean claims for each quantile conditional on insurer characteristics, which we use as $\mu_{jk}$. Using estimated claims and premiums, the model predicts a mean loss ratio of 60% which is reasonable.

### Estimation of rate stability regulation cost

We first estimate the parameters that enter the rate stability regulation cost function which include the fixed cost component $c^0$ and the coefficient $c^1_{jk}$. Note that we cannot separately identify $c^0$ and $c^1_{jk}$ without imposing further functional form assumptions. We assume that $c^1_{jk} \sim \ln N(\mu_c, \sigma_c)$. Let $F$ denote the cumulative distribution function of $c^1_{jk}$, and let $f$ denote its probability density function.

Suppose $p_{jk2} > p_{j1}$. The first-order condition of the firm's second-stage optimization problem implies

$$c^1_{jk}(p_{jk2} - p_{j1}) = s_{jk2} \tag{38}$$

The individual likelihood contribution is

$$\begin{aligned} Pr(p_{jk2}) &= Pr\left(c^0 < (p_{jk2} - p_{j1})s_{jk2} - \frac{c^1_{jk}}{2}(p_{j1} - p_{jk2})^2\right) \times \ln N\left(c^1_{jk} = \frac{s_{jk2}}{p_{jk2} - p_{j1}}\right) &(39) \\ &= F\left(\frac{(s_{jk2})^2}{2c^0}; \mu_c, \sigma_c\right) \times f\left(\frac{s_{jk2}}{p_{jk2} - p_{j1}}; \mu_c, \sigma_c\right) &(40) \end{aligned}$$

Suppose instead $p_{jk2} = p_{j1}$. Let $p^*_{jk2}$ be the interior solution that satisfies

$$c^1_{jk}(p^*_{jk2} - p_{j1}) = s_{jk2} \tag{41}$$

Then, the likelihood contribution is

$$\begin{aligned} Pr(p_{jk2} = p_{j1}) &= Pr\left(c^0 > (p^*_{jk2} - p_{j1})s_{jk2} - \frac{c^1_{jk}}{2}(p_{j1} - p^*_{jk2})^2\right) &(42) \\ &= 1 - F\left(\frac{(s_{jk2})^2}{2c^0}; \mu_c, \sigma_c\right) &(43) \end{aligned}$$

Our maximum likelihood estimator solves the following problem:

$$\max_{c^0,\mu_c,\sigma_c} \quad \sum_{j,k} 1(p_{jk2}=p_{j1}) \log\left(1-F\left(\frac{(s_{jk2})^2}{2c^0};\mu_c,\sigma_c\right)\right)$$
$$+1(p_{jk2}>p_{j1}) \log\left(F\left(\frac{(s_{jk2})^2}{2c^0};\mu_c,\sigma_c\right) f\left(\frac{s_{jk2}}{p_{jk2}-p_{j1}};\mu_c,\sigma_c\right)\right) \tag{44}$$

The resulting estimates do not point identify the regulatory cost $c^1_{jk}$ for state $k$ of the world where insurer $j$ does not increase its premium, i.e., $p_{jk2}=p_{j1}$. However, we need an estimate of $c^1_{jk}$ to estimate the rest of the cost parameters and also to do counterfactuals. Therefore, for observations with $p_{jk2}=p_{j1}$, we predict $c^1_{jk}$ using the estimated distribution of $c^1_{jk}$ and firms' optimality condition. Define the threshold $c^{1*}_{jk}$ which makes insurer $j$ indifferent between increasing and not increasing its premium:

$$c^{1*}_{jk} = \frac{(s_{jk2})^2}{2c^0} \tag{45}$$

We set the regulatory cost $c^1_{jk}$ as

$$c^1_{jk} = \begin{cases} E[c|c>c^{1*}_{jk}] & \text{if } p_{jk2}=p_{j1} \\ \frac{s_{jk2}}{p_{jk2}-p_{j1}} & \text{if } p_{jk2}>p_{j1} \end{cases} \tag{46}$$

**Estimation of loss ratio regulation cost**

Next, we estimate the parameter that enters the cost function associated with loss ratio regulation, $c^l_j$, using the the first-order condition with respect to $p_{j1}$:

$$\begin{aligned} c^l_j(p_{j1}-\tilde{\mu}_j) \quad &= \quad B_1\left(s_{j1}+p_{j1}\frac{\partial s_{j1}}{\partial p_{j1}}\right) \\ &+\beta^{n_1}B_2\sum_k \pi_k\left((p_{jk2}-\mu_{jk})\frac{\partial s_{jk2}}{\partial p_{j1}} - 1(p_{j1}\neq p_{jk2})c^1_{jk}(p_{jk2}-p_{j1})\right) \end{aligned} \tag{47}$$

**Estimation of product variety cost**

Lastly, we recover the parameter that enters the cost function associated with offering $n_j$ plans, $c^v_j$, using the following first-order condition with respect to $n_j$:

$$c^v_j n_j = B_1 p_{j1}\frac{\partial s_{j1}}{\partial n_j} + \beta^{n1}B_2\sum_k \pi_k(p_{jk2}-\mu_{jk})\frac{\partial s_{jk2}}{\partial n_j} \tag{48}$$

| | (1) Major firms | (2) Merged minor firms |
|---|---|---|
| Mean initial premium | 1874 | 2320 |
| Mean initial market share | 0.016 | 0.028 |
| Mean insurer's number of plans in a mkt ($n_j$) | 2 | 28 |
| Mean rate increases | | |
| : $r_{k=1}$ | 0 | 0 |
| : $r_{k=2}$ | 0.19 | 0.07 |
| : $r_{k=3}$ | 0.33 | 0.12 |
| : $r_{k=4}$ | 0.48 | 0.18 |
| : $r_{k=5}$ | 0.8 | 0.31 |
| Mean probability of second-stage states | | |
| : $\pi_{k=1}$ | 0.38 | 0.39 |
| : $\pi_{k=2}$ | 0.15 | 0.15 |
| : $\pi_{k=3}$ | 0.15 | 0.15 |
| : $\pi_{k=4}$ | 0.15 | 0.15 |
| : $\pi_{k=5}$ | 0.15 | 0.15 |
| Observations | 2279 | 408 |

Table 1: Summary statistics of the estimation sample
*Notes*: Column (1) reports summary statistics of major firms, and Column (2) reports summary statistics of merged minor firms.

## 5.3 Estimation Sample

For initial premiums and first-period market shares, we use the NAIC data which are available at the plan-state-year level. We define a market at the state-year level. As there are 8 report years available (2000-2007), and for each year we observe 50 states plus D.C., we have $8 \times 51 = 408$ markets in total. For the number of potential consumers, we use the population aged 60 in a given market. This is based on the empirical fact that the average purchase age of LTCI is around 60 (Broker World, 2009-2015).

Within each market, the mean number of active insurers is 20. However, on average, 6 firms account for 80% of the total market sales, suggesting that LTCI markets are highly concentrated. To reduce the computational burden, we assume the following. For each market, we rank insurers based on their sales. Then, we keep all insurers who account for the top 80% of the market sales. We refer to these insurers as major firms. We merge the rest of the insurers who account for the bottom 20% of the market sales into one representative minor firm. By doing so, we reduce the average number of insurers in a market from 20 to $6 + 1 = 7$.

For each insurer in a given market, we identify the insurer's dominant plan as the one

| Parameter | Notation | Estimate |
|---|---|---|
| Consumption utility scale | $\alpha$ | 0.0842 |
| Product variety utility scale | $\gamma$ | 0.0026 |
| Demand elasticity | | |
| With respect to initial premium | $\frac{\partial \ln s_{j1}}{\partial p_{j1}}$ | -0.1056 |
| With respect to product variety | $\frac{\partial \ln s_{j1}}{\partial n_j}$ | 0.1710 |

Table 2: Demand parameter estimates
*Notes*: The table reports the demand parameter estimates.

with the largest sales. We use the initial premium and sales of dominant plans to construct the variables $p_{j1}$ and $s_{j1}$. We use each insurer's number of plans offered on the market to construct the variable $n_j$.

Table 1 reports the summary statistics of the estimation sample, separately for major and merged minor firms. Rate increases and probabilities of second-stage states are predicted using the algorithm described earlier in Section 5.2. We find that major firms increase the premium in the second stage by a greater margin than minor firms. Representative minor firms have a much greater number of plans, and this is based on the fact that we aggregate the number of plans offered by fringe firms.

## 5.4 Estimation Results

Table 2 presents demand side parameter estimates. We find that the consumption utility scale is about 0.08. Similarly, we find that the consumer positively values the variety of plans offered by insurers ($\gamma = 0.003$). To interpret these coefficients, we report the demand elasticity with respect to the first period premium ($p_{j1}$) and with respect to the variety of plans ($n_j$). We calculate these elasticities by assuming that consumers stay with the same insurer and are subject to changes in premiums (product variety) in both periods.[28] We find that the mean elasticity with respect to the premium is -0.1056, which is relatively small. We find that the elasticity with respect to the variety of plans is higher at 0.1710.

Our demand estimates suggest that consumers are relatively insensitive to premium and product variety. The result suggests that premium subsidies may not be effective in increasing the demand for LTCI. This is consistent with existing studies (e.g., Brown and Finkelstein (2008)) which argue that the level of premiums is not sufficient to explain the low take-up

[28]We calculate the demand elasticity when the product characteristics change in both periods as consumers' insurance choice depends on lifetime utility.

| Parameter | Notation | Mean | Std. |
|---|---|---|---|
| Rate stability regulation cost | | | |
| : Fixed cost | $c^0$ | 0.2780 | - |
| : Mean of $\ln(c^1_{jk})$ | $\mu_c$ | -10.2420 | - |
| : Std. of $\ln(c^1_{jk})$ | $\sigma_c$ | 2.5553 | - |
| : Cost | $C^{rs}_{jk}$ | 8.24 | 17.59 |
| Loss ratio regulation cost | | | |
| : Coefficient | $c^l_j$ | 0.0000 | 0.0017 |
| : Cost | $C^l_j$ | 11.59 | 289.22 |
| Product variety cost | | | |
| : Coefficient | $c^v_j$ | 1.6509 | 6.0085 |
| : Cost | $C^v_j$ | 22.76 | 66.86 |

Table 3: Supply parameter estimates
*Notes*: The table reports summary statistics of the supply parameter estimates. Some of the estimates are insurer-market specific, in which case we report the associated standard deviation.

rate of LTCI and find other factors such as Medicaid as a more relevant explanation. Our conclusion is drawn from a different identification strategy which accounts for insurer-level demand and price variations across insurers. Moreover, it suggests that insurers can exercise significant market power.

Table 3 shows the cost parameter estimates. On average, insurers pay 8.24 for increasing their rates and 11.59 for setting an initial price that is different from the regulator's target level. As the average market share is 0.028, we can express the per enrollee regulatory cost associated with rate stability regulation as \$294.29 (8.24/0.028) and the per enrollee cost associated with loss ratio regulation as \$413.94 (11.59/0.028). Such large regulatory costs are needed to rationalize relatively low premiums in the data, despite the lack of price sensitivity by consumers.

# 6 Counterfactual Policy Experiments

In this section, we use our estimated model to examine the effect of supply-side regulations on the market equilibrium and welfare. We study the effect of changing the strictness of rate stability regulation, loss ratio regulation, and interactions between supply-side regulations and demand-side policy intervention. For each counterfactual, we numerically solve for a new equilibrium. To calculate the impact on welfare, we calculate consumers' expected utility

| | (1) Stricter rate stability regulation | (2) More lenient rate stability regulation |
|---|---|---|
| *Panel A. Changes in equilibrium outcomes (%)* | | |
| First stage premium | 0.5324 | 0.0434 |
| Second stage premium | -12.5632 | 4.7200 |
| Product variety | -6.0095 | 2.7405 |
| Total enrollment | -0.3648 | 0.2029 |
| *Panel B. Changes in welfare (%)* | | |
| Consumer welfare | -0.0329 | 0.0404 |
| Insurer profit | -4.0659 | 1.4194 |

Table 4: Counterfactual effect of rate stability regulation

*Notes*: Column (1) reports counterfactual results from tightening the rate stability regulation, $\hat{c}^1_{jk} = 4c^1_{jk}$. Column (2) reports counterfactual results from relaxing the rate stability regulation, $\hat{c}^1_{jk} = 0.8c^1_{jk}$. In both columns, all outcomes are expressed in percent changes from the estimated benchmark economy.

and use it to obtain the consumption equivalent variation.[29]

## 6.1 Effect of Rate Stability Regulation

The first policy experiment is to examine the effect of rate stability regulation. Theoretically, the welfare impact is ambiguous. As shown in equation (20), the direct effect of the policy is to reduce the premium variance in the second stage. This will benefit risk averse consumers. However, it also implies that insurers cannot charge premiums contingent on the realized claims costs, lowering their expected profit in the second stage. If this profit loss is large relative to consumers' gain from consumption smoothing, insurers will have an incentive to reduce the variety of plans and increase initial premiums in the first stage. These two channels may negatively impact consumer welfare.

Panel A of Column (1) in Table 4 reports the effect of tightening rate stability regulation on equilibrium outcomes. When the regulation imposes a higher cost on insurers for revising their rates, premiums in the second stage decrease relative to the benchmark equilibrium. Specifically, when the coefficient $c^1_{jk}$ increases by 4 times, the second-stage premiums decrease by 12.56%. The first-stage premiums show a very modest increase of just 0.53%. Interestingly, there is a substantial reduction in product variety offered by insurers: the number of products decreases by 6%. The total enrollment in LTCI shows a modest reduction

[29]More computational details can be found in the Online Appendix.

of just 0.37%. Overall, the counterfactual results are consistent with descriptive evidence documented in Section 2.

Panel B of Column (1) reports the effect of tightening the rate stability regulation on firm profits and consumer welfare. As expected, stricter regulation results in lower insurer profits. Consumer welfare, measured by the consumption equivalent variation, decreases by 0.03%. The results suggest that stricter rate stability regulation leads to a loss in social welfare.

Panel A of Column (2) of Table 4 reports counterfactual results from relaxing rate stability regulation. The effects on equilibrium outcomes are opposite to those from tightening the regulation, except for the impact on initial premiums. When the regulation is relaxed, the first-stage premiums increase as they did when we tightened the regulation, although the magnitude is smaller. This result suggests that the effect of rate stability regulation on initial premiums can be theoretically ambiguous. More lenient regulation incentivizes insurers to set a lower initial premium to lock in consumers. However, such incentives also depend on the degree of insurer competition and responses in the number of products offered. For example, if the market is highly concentrated, insurers may not necessarily lower the initial premium to attract consumers. Moreover, insurers can increase consumers' value for LTCI by widening product variety.

Panel B of Column (2) reports the welfare effect of relaxing rate stability regulation. We find that a more lenient version of the regulation increases not only insurer profits but also consumer welfare. The result implies that consumers' benefit from wider product variety is greater than their loss from higher price volatility.

We want to highlight the finding that rate stability regulation has a modest impact on consumer welfare and LTCI enrollment, despite its relatively large impact on rate increases. This is mainly due to firms' responses in their product variety decisions, which have an opposite effect on consumer welfare. Despite the welfare loss generated by tightening the regulation, it is important to note that completely eliminating the regulation may lead to a substantial loss in consumer welfare. Our model predicts that insurers have an incentive to increase the premium as high as possible subject to consumers' participation constraint. One must therefore explicitly account for these welfare tradeoffs in designing the regulation.

## 6.2 Effect of Loss Ratio Regulation

We now examine the effect of changing loss ratio regulation. Specifically, we increase the loss ratio targeted by the regulator from 0.8 to 0.9. The result is reported in Table 5.

| | Higher loss ratio targeted by the regulator |
|---|---|
| *Panel A. Changes in equilibrium outcomes (%)* | |
| First stage premium | -0.0252 |
| Second stage premium | -0.0202 |
| Product variety | -0.0425 |
| Total enrollment | 0.0395 |
| *Panel B. Changes in welfare (%)* | |
| Consumer welfare | 0.0030 |
| Insurer profit | -23.9623 |

Table 5: Counterfactual effect of loss ratio regulation
*Notes*: The table reports counterfactual results from increasing the target loss ratio from 0.8 to 0.9. All outcomes are expressed in percent changes from the estimated benchmark economy.

Premiums decrease in both first and second stages. The reduction in first-stage premiums is a direct consequence of tightening loss ratio regulation. Due to the presence of rate stability regulation, insurers also decrease the rates in the second stage. The table shows that these changes in premiums are very modest. There is also a modest reduction in product variety. While the changes in premiums and product variety are small, there is a substantial reduction in insurer profit due to a higher regulation cost. As changes in equilibrium contracts are small, there is only a modest response in the insurance take-up rate and consumer welfare, which increase by a small magnitude.

The results suggest that loss ratio regulation has a direct impact on insurer profit, while having a limited effect on consumer welfare. An important caveat is that the results can be sensitive to how one models loss ratio regulation. We formulate loss ratio regulation as a soft constraint to insurers, based on the fact that the regulator reviews prices submitted by insurers case by case. However, one can also model loss ratio regulation as a hard constraint, in which case the regulation will have a larger impact on insurer pricing.

## 6.3 Interaction between Supply-Side and Demand-Side Policies

Many existing studies have identified Medicaid as an important demand-side policy that explains the low take-up rate in the LTCI market. We now examine whether the effectiveness of supply-side policies interacts with the generosity of Medicaid. To do this, we first simulate an economy with a more generous Medicaid program which provides a higher consumption floor. Then, we introduce stricter rate stability regulation to this counterfactual economy.

| | Stricter rate stability regulation under more generous Medicaid |
|---|---|
| *Panel A. Changes in equilibrium outcomes (%)* | |
| First stage premium | 0.5590 |
| Second stage premium | -10.9089 |
| Product variety | -4.8149 |
| Total enrollment | -0.0161 |
| *Panel B. Changes in welfare (%)* | |
| Consumer welfare | -0.0002 |
| Insurer profit | -5.7540 |

Table 6: Interaction between supply- and demand-side policies
*Notes*: The table reports the effect of tightening rate stability regulation ($\tilde{c}^1_{jk} = 4c^1_{jk}$) under more generous Medicaid. All outcomes are expressed in percent changes from the economy with more generous Medicaid.

Table 6 reports the results. Note that Column (1) of Table 4 shows the effect of stricter rate stability regulation when Medicaid is less generous. Compared to Column (1) Table 4, there is a smaller change in total enrollment and consumer welfare when Medicaid benefits are more generous. The result suggests that supply-side regulations of the LTCI industry might have a limited effect on consumer welfare when the coverage of public insurance is generous enough.

# 7 Conclusion

In this paper, we examine the effects of insurer-side regulations on market outcomes and welfare in the LTCI industry. We start by documenting descriptive evidence that the introduction of the rate stability regulation reduced premium volatility faced by policyholders at the expense of reduced product variety. To quantify this trade-off, we develop and estimate a dynamic equilibrium model of LTCI where insurers face uncertainty about future claims costs. The model incorporates various frictions, including imperfect competition and regulatory costs. By estimating the model, we show that consumers are relatively less sensitive to initial prices and product variety, which might incentivize insurers to exercise market power. However, such incentive is muted by supply-side regulations that limit insurers' ability to adjust premiums.

We use the estimated model to conduct counterfactual experiments and explore the welfare impacts of various supply-side regulations. Among other things, we find that dynamic pricing regulation which limits premium fluctuations reduces social welfare. This is mainly because the benefit of improved rate stability is outweighed by the cost of reduced product variety. We show that the magnitude of the welfare impact depends on the generosity of demand-side policies, such as Medicaid.

Our paper takes a first step to address market design problems in insurance markets where dynamic contracting and imperfect competition are relevant. In doing so, we have made several simplifying assumptions which could be relaxed in future research. First, we do not explicitly model adverse selection. It would be interesting to explore how adverse selection affects the efficiency of supply-side regulations. Second, there are other interesting supply-side policies that the paper does not incorporate. For example, it would be interesting to examine the effect of capital requirements on insurers' dynamic pricing and plan offering decisions. Lastly, it would be interesting to extend the model to incorporate a commitment technology and allow insurers to choose whether they commit to future premium rates.

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# Appendix

## A States' Adoption of Rate Stability Regulation

| State | Has Adopted Regulation | Implementation Year |
|---|---|---|
| Alabama | 1 | 2006 |
| Alaska | 0 | |
| Arizona | 1 | 2005 |
| Arkansas | 1 | 2006 |
| California | 1 | 2002 |
| Colorado | 1 | 2007 |
| Connecticut | 0 | |
| Delaware | 1 | 2005 |
| District of Columbia | 0 | |
| Florida | 1 | 2003 |
| Georgia | 1 | 2008 |
| Hawaii | 1 | 2008 |
| Idaho | 1 | 2001 |
| Illinois | 1 | 2003 |
| Indiana | 0 | |
| Iowa | 1 | 2003 |
| Kansas | 1 | 2003 |
| Kentucky | 1 | 2003 |
| Louisiana | 1 | 2005 |
| Maine | 1 | 2004 |
| Maryland | 1 | 2002 |
| Massachusetts | 0 | |
| Michigan | 1 | 2007 |
| Minnesota | 1 | 2002 |
| Mississippi | 0 | |
| Missouri | 1 | 2004 |
| Montana | 1 | 2009 |
| Nebraska | 0 | |
| Nevada | 0 | |
| New Hampshire | 1 | 2012 |
| New Jersey | 1 | 2006 |
| New Mexico | 1 | 2004 |
| New York | 0 | |
| North Carolina | 1 | 2003 |
| North Dakota | 1 | 2004 |
| Ohio | 1 | 2003 |
| Oklahoma | 1 | 2001 |
| Oregon | 1 | 2006 |
| Pennsylvania | 1 | 2002 |
| Rhode Island | 1 | 2008 |
| South Carolina | 1 | 2010 |
| South Dakota | 1 | 2002 |

| | | |
|---|---|---|
| Tennessee | 1 | 2004 |
| Texas | 1 | 2002 |
| Utah | 1 | 2003 |
| Vermont | 1 | 2010 |
| Virginia | 1 | 2003 |
| Washington | 1 | 2009 |
| West Virginia | 1 | 2009 |
| Wisconsin | 1 | 2002 |
| Wyoming | 0 | |
| Total | 41 | |

Table A.1: States' Adoption of the Rate Stability Regulation of 2000
*Notes*: The table reports whether each state (plus District of Columbia) has implemented the Rate Stability Regulation of 2000 established by the NAIC, and if so, what year the regulation was adopted.

# B Sample Construction

## B.1 Sample for Figure 1

Nationwide experience at the plan-level is found in Form A for years 2000-2008 and in Form 2 for years 2009-2016. Both Form A and Form 2 reports provide information about the year a plan was first issued, the plan's new sales, lives covered, premiums earned and claims incurred during the report year. Additionally, Form 2 contains information about the type of a plan (individual vs. group) and the plan's latest issue year. Having information about the plan type is useful as plans sold to individuals are quite different from plans sold to groups. The latest issue year is also very useful because we can use this variable (together with the first issue year) to infer the number of plans on the market for years where we do not have the NAIC reports, i.e., years before 2000. For these reasons, we restrict to individual plans that are observed in Form 2. This restriction implies that we drop plans that are observed only in Form A and not in Form 2. Table B.1 provides summary statistics of the sample used to draw Figure 1.

## B.2 Sample for Figures 4 and 5

From the rate increases data obtained from the California Department of Insurance for years 2007-2017, we first drop observations that satisfy any of the following conditions:

- Policy identifier is missing

| | |
|---|---|
| Year the sample period begins | 2000 |
| Year the sample period ends | 2016 |
| # of plans | 1179 |
| # of plans found in Form A and Form 2 | 631 |
| # of plans found only in Form A | 0 |
| # of plans found only in Form 2 | 548 |
| # of insurers | 184 |
| # of insurers found in Form A and Form 2 | 141 |
| # of insurers found only in Form A | 0 |
| # of insurers found only in Form 2 | 43 |
| Obs (plan-year level) | 11386 |

Table B.1: Plan-Year-Level Data from NAIC Form A and Form 2
*Notes:* The sample is constructed from NAIC Form A (2000-2008) and Form 2 (2009-2016). The type of a plan (whether it is sold in an individual or group market) is found only in Form 2. To restrict to individual plans, we exclude plans found only in Form A.

- State identifier is missing
- Rate increase request year is missing
- First issue date of the policy is missing or takes incredible values
- Requested rate increase amount is missing or the maximum requested amount is zero
- Approved rate increase amount is missing or still pending
- Multiple policy category values are reported (policy category specifies whether the policy covers institutional care, home care etc.)

Table B.2 provides basic summary statistics of the rate increase sample. The sample period is from 2007 to 2017 and all 50 states plus DC are observed. On average, the plan's age at the time of a rate increase request is about 15 years, insurers request a rate increase of 37-42%, and are approved of 21-24%. About 89% of the requests are approved of a strictly positive rate increase. Table B.3 reports summary statistics by whether a request was for a plan issued before or after the enactment of the Rate Stability Regulation. On average, for plans sold after the state regulation, the approval rate and the requested and approved rate increases are all lower.

We take the following steps to draw Figure 4. For any plan age, using the nationwide Form 2 reports available for years 2009-2016, we compute the number of plan-state combinations where the plan was issued before the state enacted the regulation. Since Form 2 asks for

| | |
|---|---|
| Year the sample period begins (earliest request year) | 2007.00 |
| Year the sample period ends (latest request year) | 2017.00 |
| # of insurers | 59.00 |
| # of policies | 6005.00 |
| # of individual policies | 5604.00 |
| # of states | 51.00 |
| # of states where the regulation has been implemented | 41.00 |
| Avg policy age (years) at request | 15.10 |
| Share where the policy was sold after the regulation | 0.06 |
| Approval rate (approved upper bound > 0) | 0.89 |
| Share where approved upper bound < requested | 0.39 |
| Share where approved upper bound = requested | 0.49 |
| Share where approved upper bound > requested | 0.01 |
| Avg requested lower bound (%) | 37.22 |
| Avg requested upper bound (%) | 42.29 |
| Avg approved lower bound (%) | 21.44 |
| Avg approved upper bound (%) | 24.21 |
| Number of requests (at policy-state-request year level) | 35326.00 |

Table B.2: Summary Statistics of Rate Increase Data from CA Dept. of Insurance
*Notes*: The data are at the plan-state-request year level. Some insurers specify a range of the rate increase, e.g., 10-30%. In this case, we refer to 10% (30%) as the lower (upper) bound of the rate request. We say a rate request was approved if the approved upper bound is strictly greater than zero.

the nationwide experience rather than the statewide experience, we assume each policy observed in Form 2 was sold in all 50 states and DC. Then, we use the rate increase data to compute what share of these plan-state combinations filed a rate increase and obtained an approval. We repeat the steps for plan-state combinations where the plan was issued after the enactment of the regulation.

# C Additional Tables and Figures

| | Sold before reg. | Sold after reg. |
|---|---|---|
| Approval rate (approved upper bound > 0) | 0.90 | 0.74 |
| Avg requested lower bound (%) | 37.56 | 31.51 |
| Avg requested upper bound (%) | 42.62 | 36.86 |
| Avg approved lower bound (%) | 21.78 | 15.69 |
| Avg approved upper bound (%) | 24.57 | 18.09 |
| Avg policy age (years) at request | 15.49 | 8.69 |
| Number of requests | 33344.00 | 1982.00 |

Table B.3: Rate Increases of Plans Sold Before vs. After Rate Stability Regulation
*Notes*: The table compares the rate request summary statistics of the plans sold before and after the implementation of the rate stability regulation. All the requests filed in the 10 states that never implemented the regulation are included in the Sold before reg. column.

# D Consumer Welfare

We calculate changes in the consumer welfare in conterfactual policy experiments by deriving the consumption equivalent variation. To do so, we first calculate consumer's expected utility. It is given by

$$\begin{aligned} EV_i &= \log(\sum_{j=1}^{J}\exp(v_{ij})) && (49)\\ &= \log(\sum_{j=1}^{J}\exp(\alpha\sum_t B_t u(c_{ijt}) + \overline{v}_{ij})) && (50)\end{aligned}$$

where $\overline{v}_{ij} = v_{ij} - \sum_t B_t u(c_{ijt})$. Denote the welfare in a new counterfactual equilibrium by $EV_i^{new}$. Then, we solve for $\Delta$ such that

$$EV_i^{new} = \log(\sum_{j=1}^{J}\exp(\alpha\sum_t B_t u((1+\Delta)c_{ijt}) + \overline{v}_{ij})) \quad (51)$$

This is equivalent to

$$\begin{aligned} \exp(EV_i^{new}) &= \sum_{j=1}^{J}\exp(\alpha\sum_t B_t u((1+\Delta)c_{ijt}) + \overline{v}_{ij}) && (52)\\ &= \sum_{j=1}^{J}\exp(\alpha\sum_t B_t u(c_{ijt}) + \overline{v}_{ij})\exp\alpha\sum_t B_t\log((1+\Delta))) && (53)\\ &= \exp(EV_i)\exp(\alpha\sum_t B_t\log((1+\Delta))) && (54)\end{aligned}$$

where we use the functional form of the utility function, $u(c) = \log(c)$. Then, after some algebra, we have

$$\log\left(\frac{\exp(EV_i^{new})}{\exp(EV_i)}\right) = \alpha \sum_t B_t \log((1+\Delta))) \tag{55}$$

and we can therefore characterize $\Delta$ as

$$1 + \Delta = \exp\left(\frac{EV_i^{new} - EV_i}{\alpha \sum_t B_t}\right) \tag{56}$$