Could a Website Really Have Doomed the Health Exchanges?

Multiple Equilibria, Initial Conditions and the Construction of the Fine*

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Abstract

Public attention has focused on how the launch of the national health exchanges could impact the types of risks who initially enroll and thereby affect future premiums and enrollment. We introduce simple dynamics into a standard model of insurance under adverse selection to show that such "initial conditions" can indeed matter. When firms are price-takers, the market can converge to a Pareto-inferior "bad" equilibrium if there are at least three equilibria, which we suggest has empirical support. Strategic pricing eliminates Pareto dominated equilibria but requires non-localized common knowledge of preference and risk distributions. Changing the fine on non-participants from a fixed amount to a fraction of equilibrium prices increases the range of initial conditions consistent with reaching the "good" equilibrium while reducing the "badness" of the bad equilibrium — all without increasing the fine value in the good equilibrium. Allowing insurers to quickly change prices can encourage them to experiment with strategic pricing if market fundamentals are not perfectly known, increasing the chance of reaching the good equilibrium independently from initial conditions.

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1 Introduction

The Patient Protection and Affordable Care Act ("ACA" for short) limits the degree to which insurers can price discriminate based on age and preexisting conditions. Enrolling healthier people, especially younger individuals, is, therefore, widely regarded as important for avoiding high premiums. The government aims for at least 40 percent of enrollees to be between the ages 18 and 35.

The ACA rollout, however, contains initial conditions that may have discouraged healthy individuals from enrolling. First, there were several issues with the main website at launch.[1] Second, to prevent adverse selection, the ACA levies a fine (the "shared responsibility penalty") on individuals who do not enroll. But the size of that fine is quite small in 2014, equal to the greater of $95 or 1% of income, even though increasing in future years. Third, because some households on the individual health insurance market lost their coverage, the government announced on November 14, 2013 that it is allowing individual state insurance commissioners to extend canceled policies by one year.

A potential counterbalancing effect is the fact that, if the initial enrollment deadline is missed, subsequent enrollment is delayed until the next "open enrollment season" even when a person gets sick. However, this effect is weakened during the initial year of the ACA implementation since open enrollment occurs twice in 2014, roughly six months apart, in order to make its timing consistent with Medicare's open enrollment season in future years.[2]

Numerous media outlets have focused on the importance of getting younger people to enroll in order to avoid higher prices in the future. Interestingly, this discussion has been based on the standard terminology from the textbook treatment of adverse selection going back to Akerlof (1970). For example, remarking on the problems related to the website, *The Economist* (November 23, 2013) put it this way:

> Insurers have set their premiums on the assumption that lots of young, healthy people would be compelled to buy their policies. But if it takes dozens of attempts to sign up, the people who do so will be disproportionately the sick and desperate. Insurers could be stuck with a far more expensive pool of customers than they were expecting, and could have no choice but to raise prices

[1] Many young shoppers with new employers also have to separately submit payroll stubs, re-confirm their health exchange status at a later time, and then contact the insurer to make payment. These process breaks may reduce conversions as well, especially for consumers who are not strongly attached to the outcome.

[2] For 2014 only, there will effectively be two open enrollment periods, the first one from October 1, 2013 - March 31, 2014 and the second one from October 15 - December 7, 2014 to coincide with Medicare open enrollment. In future years, enrollments will occur once per year, coinciding with the Medicare dates.

> next year. That would make Obamacare even less attractive to the young "invincibles" it needs to stay afloat. (p. 15)

Similarly, commenting on allowing individual state insurance commissioners to extend canceled policies, Bloomberg (December 20, 2013) reports that "[i]nsurers said the exemptions may keep younger, healthier people from buying new coverage through Obamacare, a demographic that is needed to bring balance to the new government-run insurance marketplaces." Or, as the *The Economist* (November 23, 2013) wrote: "A bigger risk is that the 'fix' harms the rest of Obamacare. The insurance lobby points out that Mr Obama's plan will dissuade healthy people from buying more generous, costly coverage on the exchanges. This will leave insurers with a more sickly pool than they expected. That could drive up prices for 2015."

However, the textbook theory of insurance unraveling is not specified in terms of initial conditions but as the equilibrium of a static system of insurance cost and demand equations across risk types. Moreover, most of the insurance literature has implicitly focused on either linear demand and cost curves (see e.g. Cutler and Reber, 1998, Einav and Finkelstein, 2011, Hackmann et al., 2013) or strategic insurers (Einav et al., 2010), both of which give rise to a unique equilibrium that is reached no matter which initial conditions we start from.[3] That equilibrium emits a degree of risk pooling ranging from full pooling to no pooling ("unraveling"), or something in between (where only some of the lower risk types drop out of the market), but there is not much role for initial conditions in affecting the eventual outcome. In the context of the ACA, the standard textbook model suggests that either the policy is destined to be "successful" (i.e., it pools risk across many risk types) or it is destined to "fail" (it does not successfully pool risk across many types). For example, Handel et al. (2013) analyze a model of the ACA health exchanges with a unique equilibrium and conclude that it may eventually involve limited degrees of risk pooling. So was the media frenzy and the concern by policymakers about the ACA's initial conditions much to do about nothing? Or, is it indeed possible that initial conditions could actually matter?

In this paper, we add simple dynamics to the textbook model of competitive insurance markets under adverse selection, building upon Akerlof (1970), Wilson (1977, 1980) and the recent work of Einav et al. (2010) and Einav and Finkelstein (2011), but without assuming a shape for cost and demand curves. We show that initial conditions can indeed matter for the eventual outcome if (i) insurers are competitive price-takers, and if (ii) there exist at least three competitive equilibria. In the case of exactly three equilibria, one

[3] See also Mahoney and Weyl (2013) who consider the interaction between market power and selection in a model with a unique equilibrium.

equilibrium is unstable and other two are stable. The "good" stable equilibrium provides more coverage at a lower price relative (in fact, is Pareto superior) to the "bad" stable equilibrium. While some of the earlier insurance literature, including Wilson (1980), has pointed out the potential for multiple equilibria, we believe that we are the first to provide conditions that explicitly distinguish between stable and unstable equilibria. For policy purposes, only stable equilibria matter. For example, we show that if a model only has two equilibria, then only one of them can be stable, and initial conditions do not matter.

Using data on average costs from the Medical Expenditure Panel Survey, we then provide a simple calibration of insurance demand that suggests that the presence of three competitive equilibria is, in fact, consistent with moderate levels of risk aversion. The reason is that medical expenditures tend to be fairly concentrated within the pre-Medicare population, thereby producing very non-linear willingness-to-pay and average cost curves. Multiple crossings, therefore, may emerge naturally.

We also find that the functional form of the fine, and not just its size, plays a potentially important role in the presence of multiple equilibria. The ACA uses an "absolute" fine, which, as noted earlier, is equal to the greater of 1% of income or $95 in 2014, growing by pre-determined amounts over the subsequent two years.[4] In contrast, the Massachusetts health care reform law, enacted in 2006, levied a "relative" fine equal to 50% of the smallest yearly premium for qualified plans available in the market.[5] The "relative" fine, therefore, effectively grows with the amount of adverse selection. We show that the relative fine increases the likelihood of reaching the good equilibrium, even when the absolute and relative fines are normalized to be equal in value at the point of the good equilibrium. Moreover, even if the bad equilibrium is reached under the relative fine, its "badness" is strictly less than under the absolute fine. Put differently, a re-construction of the fine toward a relative basis is more likely to expand coverage (achieve the good equilibrium) while reducing the badness of the worst outcome, all without costing non-insured consumers anything more in the desired, good equilibrium with a high number of individuals covered at a low premium.[6]

However, if firms set premiums strategically in a Nash equilibrium and have common knowledge (about the distribution of risk types and individual attributes like preferences, loss amounts, and wealth), then the popular media concerns about the system unraveling

[4] In 2015, the fine grows to greater of 2% of income or $325; by 2015, it is the greater of 2.5% of income or $695. Thereafter, the minimum dollar penalty grows with the general inflation level.

[5] This fine has since been updated to be consistent with the ACA requirements.

[6] Hackmann et al. (2013) compute the optimal absolute level of the fine in a model calibrated to the Massachusetts health exchanges. However, their model is static and assumes linear demand and cost curves, thus excluding the possibility of multiple equilibria and any difference between absolute and relative fines.

over time because of a bad first year are without merit: only a single equilibrium exists in this case (see e.g. Einav et al., 2010) and the market converges to it independently from initial conditions. In particular, if premiums were set at a high value, consistent with a Pareto dominated equilibrium under price-taking, then a profitable deviation would exist for any insurer that lowers its premium.

The required assumption of perfect information about the full set of fundamentals of the market, though, may be quite strong in this context. Whereas perfect competition only requires local knowledge of the demand curve, strategic pricing requires *global* knowledge. Experimenting with prices to discover market fundamentals could be quite expensive in the strategic setting, especially if insurers are unable to quickly adjust prices in response to pricing mistakes. In practice, ACA prices are legally rigid in two ways. First, ACA premiums can be adjusted infrequently, typically to coincide with the annual "open enrollment" period. Second, premium increases must be justified under existing laws in many states and now at the federal level.

In fact, in the numerous media articles discussing the importance of the initial health mix for future prices, we could not find evidence that suggested that an insufficient mix of younger enrollees might actually lead insurers to *reduce* premiums, in order to improve the risk pool, compatible with strategic pricing. Consistently, Cutler and Reber (1998) Monheit et al. (2004) and Clemens (2014) provide evidence of repeated marginal price changes that suggest that insurers do not a priori know the entire shape of the demand and cost curves in the market and locally adjust premiums in response to profits or losses they experience.

In sum, we characterize situations in which initial conditions could cause the health exchanges to converge to a bad equilibrium, even if the exchanges are well designed relative to the good equilibrium. We provide some evidence for the potential of multiple equilibria in this market. Changing the construction of the fine from an absolute form to a relative basis widens the range of initial conditions under which the good equilibrium eventually emerges while reducing the badness of the bad equilibrium. However, equilibrium multiplicity may persist. Reducing the legal frictions to price adjustments improves the chances that the good equilibrium emerges by incentivizing insurers to experiment with lower prices when the distribution of risk types and other market fundamentals are not well known.

The rest of this paper is organized as follows. Section 2 presents a simple insurance model within the price-taking setting; extensions of this model are presented in Appendix B. Section 3 generalizes this price-taking model to a dynamic setting and demonstrates how initial conditions can matter when multiple equilibria exist. This section also

presents some quantitative evidence about the potential for multiple equilibria as well as examples of pricing dynamics from some previous efforts by individual states to reform their health insurance systems. Section 4 discusses the important role of the construction of the fine that is levied on consumers who do not purchase health insurance. Section 5 considers the setting where insurers set premiums strategically. Section 6 concludes.

2 Model with Price-Taking Insurers

For the sake of expositional simplicity, we start by considering a simple insurance model that incorporates many of the key features highlighted in Akerlof (1970), Wilson (1980), Einav et al. (2010) and Einav and Finkelstein (2011). Our most parsimonious model assumes a continuum of risk types, that risk is the only source of consumer heterogeneity, and losses are binary. In Appendix B, we demonstrate that our key results extend to a model setting with discrete risk types, richer forms of heterogeneity and multiple loss sizes.

2.1 Consumers

A unit measure of consumers have wealth $w > 0$ and face a potential loss of size $0 < l < w$ in the presence of limited liability. Consumers only differ in the probability $\pi \in [0, 1]$ of the loss occurring, which is distributed throughout the population by the continuous cumulative distribution function $H(\pi)$ with support $[0, 1]$.[7] Let the random variable Π be H-distributed, and denote a realization of Π by π. Agents are risk-averse with a concave Bernoulli utility function $u(c)$ over consumption, so the expected utility of type π is given by

$$\pi u(w - l) + (1 - \pi)u(w)$$

when there is no insurance.

We assume that individuals can choose from exactly two available insurance contracts that differ exogenously in how much of the loss l they cover. Following Einav et al. (2010), and without loss of generality, we normalize the low coverage contract to be no insurance at a zero premium, and the high coverage contract to be full insurance at some endogenous premium p. Abstracting from moral hazard, we take l and each individual's

[7] The full support assumption can be viewed as a limiting case where, as in Hendren (2012), even the most extreme risk types, for whom the loss never or always occurs, exist with arbitrarily small but positive density. None of our substantive results depend on this assumption. Appendix B relaxes this and other assumptions, as noted earlier.

risk π as exogenous and, therefore, independent of the insurance choice. The demand for insurance, therefore, is only a function of the price p.

The assumption of fixed coverage levels places our analysis in the spirit of Akerlof (1970) rather than Rothschild and Stiglitz (1976), who endogenize coverage levels as well.[8] As discussed in Einav et al. (2010) and Einav and Finkelstein (2011), this assumption is a reasonable characterization of many insurance markets. It becomes an even more appropriate assumption for the ACA health exchanges which place regulatory bounds on minimum coverage, despite allowing for a range of plans that differ in copayments made by consumers (see Handel et al., 2013, for a model of insurance markets with two fixed (non-zero) coverage levels, covering 90% and 60% of an individual's cost, respectively). This modeling decision is also most natural to analyze one of the main policy interventions of the ACA, namely the penalty for not having insurance, which affects the demand for health insurance on the extensive margin and which we consider in Section 4.

2.2 Insurers

There are many identical, risk-neutral insurers that maximize their respective expected profits. In this section, we assume that insurers act as price-takers, as in Akerlof (1970). In Section 5, we demonstrate how the results change when insurers set premiums strategically in a model of Bertrand competition.

We assume throughout that an individual's risk type π is private information, so insurers cannot offer different premiums to different individuals. Even if insurers could observe risk types, the ACA does not permit pricing based on pre-existing conditions. One can, therefore, think of our analysis as applying to a set of individuals who are otherwise identical in terms of characteristics that insurers are allowed to price, such as smoking status.

2.3 Competitive Equilibria

The following definition of a competitive equilibrium is consistent with the informational assumptions outlined above:

Definition 1. *With unobservable risk types π, a competitive equilibrium is a premium p^* and a critical type π^* such that*

$$u(w - p^*) \geq \pi u(w - l) + (1 - \pi)u(w) \quad \forall \pi \geq \pi^*, \tag{1}$$

[8] See e.g. Netzer and Scheuer (2014) for a recent treatment.

$$u(w - p^*) < \pi u(w - l) + (1 - \pi)u(w) \quad \forall \pi < \pi^* \tag{2}$$

and

$$(1 - H(\pi^*))p^* = \int_{\pi^*}^{1} \pi dH(\pi) l. \tag{3}$$

The first two conditions characterize consumers' demand for insurance, given the equilibrium premium p^*. At that premium, individuals of risk type $\pi \geq \pi^*$ are just indifferent or strictly prefer to buy insurance, whereas all other types $\pi < \pi^*$ prefer to stay uninsured. The third condition then requires insurers to make zero profits at the policy premium p^* on the pool of risk types who demand insurance when the premium is p^*, which includes all types $\pi \geq \pi^*$. In particular, the left-hand side of (3) equals the total premium revenue collected from these agents while the right-hand side is equal to their expected losses. This zero profit condition can be simply rewritten as $p^* = \mathbb{E}[\Pi | \Pi \geq \pi^*] l$, i.e. the equilibrium premium must equal the expected loss of the pool of insurance buyers induced to buy the policy.

To characterize the set of competitive equilibria, a graphical representation following Einav and Finkelstein (2011) is useful. For any critical buyer $\pi \in [0, 1]$, the *average cost* of insuring everyone with risk equal to or greater than π is

$$\Gamma(\pi) \equiv \mathbb{E}[\Pi | \Pi \geq \pi] l. \tag{4}$$

Our assumptions ensure that $\Gamma(\pi)$ is continuous, increasing in π, and satisfies $\Gamma(0) = \mathbb{E}[\Pi] l$ and $\Gamma(1) = l$. In words, when $\pi = 0$ is the critical type, the average cost of the entire population is just the unconditional expected loss. On the other hand, with critical type $\pi = 1$, their losses are certain, and so their expected loss is simply l.

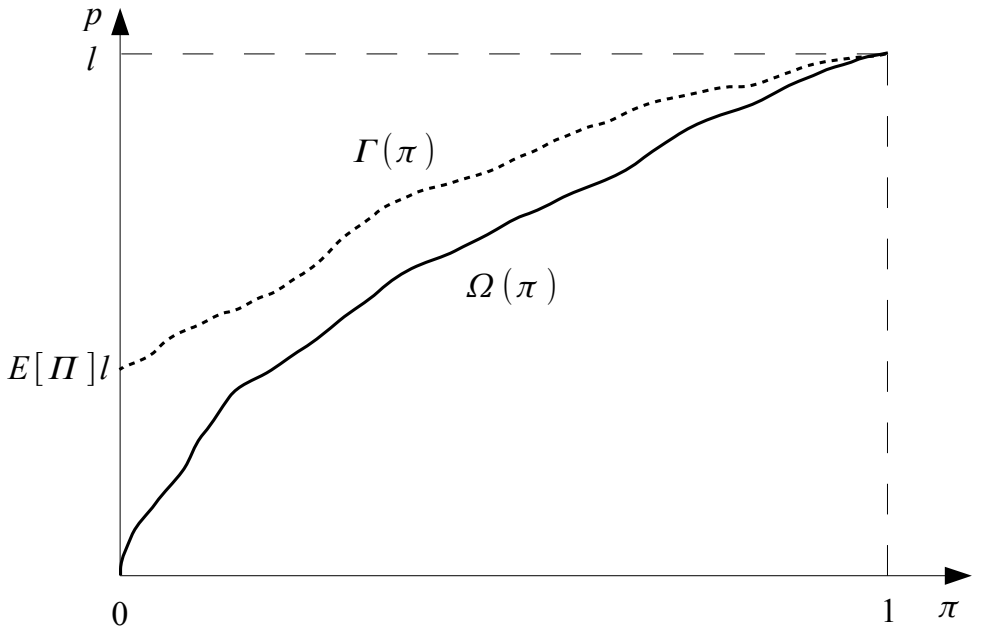
On the demand side, we can define the *willingness to pay* $\Omega(\pi)$ for insurance of each type π implicitly by solving

$$u(w - \Omega) \equiv \pi u(w - l) + (1 - \pi)u(w). \tag{5}$$

Since the right-hand side is decreasing in π, there is a unique solution $\Omega(\pi)$ for each π, which is also continuous, increasing in π, and satisfies $\Omega(0) = 0$, $\Omega(1) = l$.[9] In words, the lowest risk type $\pi = 0$ never experiences a loss and, therefore, has no willingness to pay for insurance. In contrast, the highest risk type $\pi = 1$ experiences the loss l for sure and is, therefore, willing to pay a premium up to l. We can also interpret $\Omega(\pi)$ as an

[9] As is standard, we are assuming that the loss size l does not exceed available wealth w. As discussed more below in our calibration exercise, in the presence of limited liability, it is possible for actual losses to exceed wealth for some types, and so $\Omega(\pi)$ is only weakly increasing in π and $\Omega(1) < l$.

Figure 1: Unique Competitive Equilibrium with Complete Unraveling

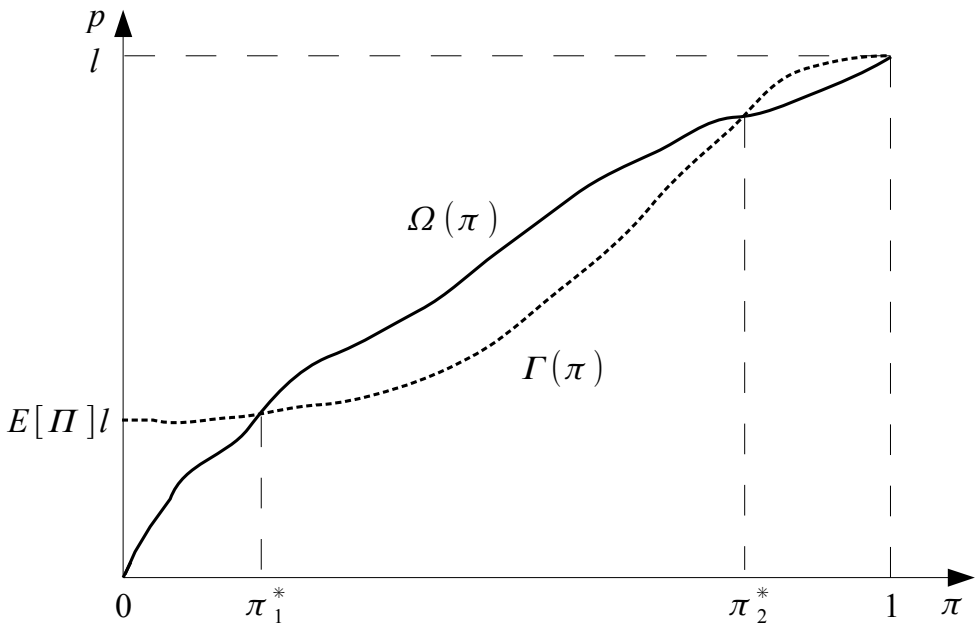


inverse demand curve: with a premium $p = \Omega(\pi)$, insurance will demanded by all types higher than π (so that the inverse function $\Omega^{-1}(p)$ identifies the marginal buyer when the premium is p).

A competitive equilibrium, therefore, is any π^* such that $\Gamma(\pi^*) = \Omega(\pi^*)$, so that the average cost and willingness to pay curves intersect. For the remainder of the paper, we confine attention to the generic case where all intersections are proper intersections rather than tangency points of the two curves. A simple illustration is provided in Figure 1. Note that, by risk aversion, $\Omega(\pi) \geq \pi l$, so the inverse demand curve must always lie above the diagonal line $p = \pi l$. Obviously, we have $\Gamma(1) = \Omega(1)$, so there always exists a competitive equilibrium. Here, it is such that nobody buys insurance except for the very highest risk types with $\pi = 1$, who are just indifferent between buying or not buying when faced with the fair premium $p^* = l$ for this pool. In the situation depicted in Figure 1, this outcome is, in fact, the only equilibrium, corresponding to the case of complete unraveling emphasized in Akerlof (1970). Specifically, for any $\pi < 1$, the average cost curve is above the demand curve, so insurers would make losses at any premium $p < l$.

The fact that condition $\Omega(1) = l = \Gamma(1)$ holds in this baseline model is not required for an equilibrium to always exist. Below, we consider the role of limited liability where the willingness to pay at the very highest risk ($\pi = 1$) is lower than the average cost. There always exist a "corner" equilibrium where $p = \Gamma(1)$ and nobody buys insurance. Conversely, as in the model extension in the Appendix, if we had $\Omega(1) > \Gamma(1)$, then there

Figure 2: Multiple Competitive Equilibria



would always exist an (interior) equilibrium, due to the continuity of Γ and Ω and the fact that $\Omega(0) < \Gamma(0)$.

3 Equilibrium Multiplicity and Initial Conditions

Since most of the insurance literature has implicitly focused on either linear demand or cost curves (see, e.g., Cutler and Reber, 1998, and Einav and Finkelstein, 2011) or strategic insurers (see Section 5 and Einav et al., 2010), the possibility of multiple competitive equilibria has not received much attention in this context.[10] As a result, there is no real role for the type of "initial conditions" discussed in Section 1.

Equilibrium multiplicity, however, can arise naturally in our framework because the average cost and demand curves are upward sloping, but their shapes are otherwise unrestricted. A simple example is depicted in Figure 3. There are three competitive equilibria in total, namely the one with unraveling located at $\pi^* = 1$ as well as two additional equilibria with critical buyers π_1^* and π_2^*.

As is well known in other contexts (see e.g. Wilson, 1980, for a lemons goods market and Mas-Colell et al., 1995, for a labor market model with unobservable productivities),

[10] See also Hackmann et al. (2013), Handel et al. (2013) and Mahoney and Weyl (2013) for recent studies of health exchanges in models with a unique equilibrium.

whenever there are multiple equilibria, they are Pareto ranked: The equilibrium at π_1^* is Pareto better than the equilibrium at π_2^*, which is Pareto better than the equilibrium with complete unraveling at $\pi^* = 1$. For example, compare π_1^* against π_2^*. In the equilibrium at π_1^*, all types $\pi \geq \pi_2^*$ are better off than in the equilibrium at π_2^* because they pay a lower premium for their insurance (i.e., $\Gamma(\pi_1^*) < \Gamma(\pi_2^*)$). Moreover, the types $\pi \in [\pi_1^*, \pi_2^*)$ prefer to buy insurance at π_1^* rather than staying with their endowment, which would be their choice at π_2^*. So, they are also better off. The types $\pi < \pi_1^*$ are indifferent because they do not buy insurance in either case. Moreover, insurers earn zero profits in all equilibria.

Indeed, the "good" equilibrium π_1^* — which offers the lowest premium and entices the most consumers to buy insurance — Pareto dominates all the others.[11] The other equilibria arise because of a *coordination failure*: When only a few individuals purchase insurance, they will be the highest risk types, and so the premium that breaks even for this pool will also be high. At the same time, only the riskiest types find it worthwhile to sign up for insurance because the premium is so high.

3.1 Introducing Dynamics

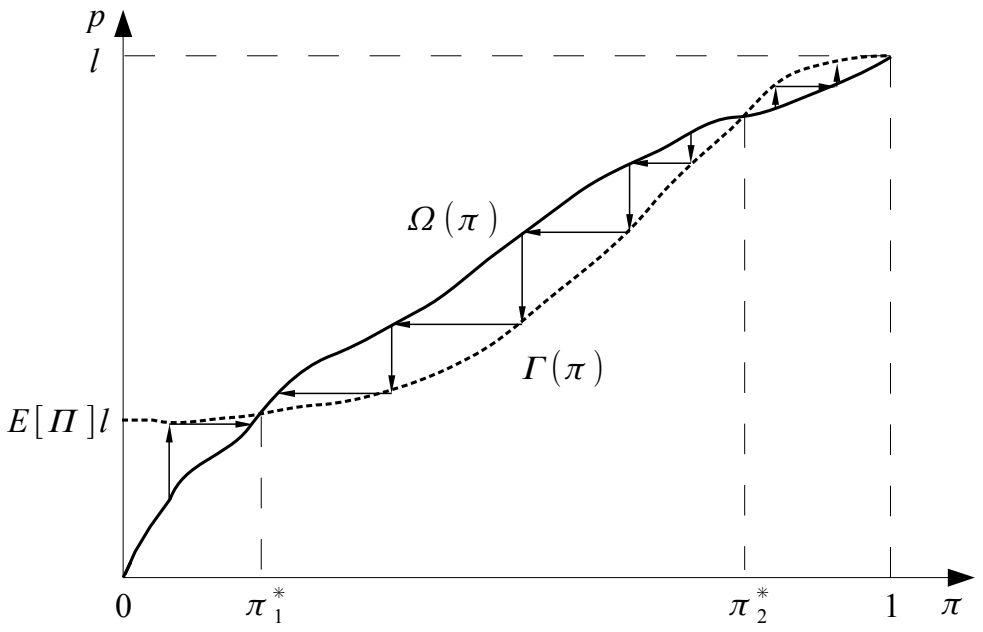
The previous literature examining multiple equilibria has not explicitly distinguished between stable and unstable equilibria. For policy purposes, only stable equilibria are material. Moreover, initial conditions do not matter with multiple equilibria unless at least two are stable. As we now show, generating two stable equilibria requires having at least three equilibria in total. Initial conditions do not matter if there are only two equilibria.

To study the circumstances under which initial conditions could affect which competitive equilibrium is reached, a dynamic version of this static model is required. The most straightforward way to introduce dynamics is to assume that, in each period, premiums reflect the average cost of the pool of individuals who purchase insurance, thereby allowing insurers to always break even. But, given this premium, consumers decide whether to enroll for insurance the next period. Cutler and Reber (1998), Monheit et al. (2004) and Clemens (2014) provide evidence for this pattern of price and demand adjustments.

These dynamics can be conveniently illustrated graphically using the same type of diagram as before. Recall that, for any critical type π_t in period t, we can read the premium from the average cost curve by setting $p_t = \Gamma(\pi_t)$. The consumers' reaction in $t+1$, therefore, can then be read off the demand curve to obtain a new marginal buyer

[11] In fact, the good equilibrium is constrained Pareto efficient under the restriction to full insurance contracts.

Figure 3: Dynamics and Equilibrium Stability



$\pi_{t+1} = \Omega^{-1}(p_t)$, and so forth. This leads to the recursion $\pi_{t+1} = \Omega^{-1}(\Gamma(\pi_t))$ for the evolution of marginal buyers, as illustrated in Figure 3. It immediately implies that π increases (i.e. there is unraveling where the premium increases and fewer consumers sign up for insurance) whenever $\Gamma(\pi) > \Omega(\pi)$ while π falls otherwise (more consumers demand insurance, so the premium falls).

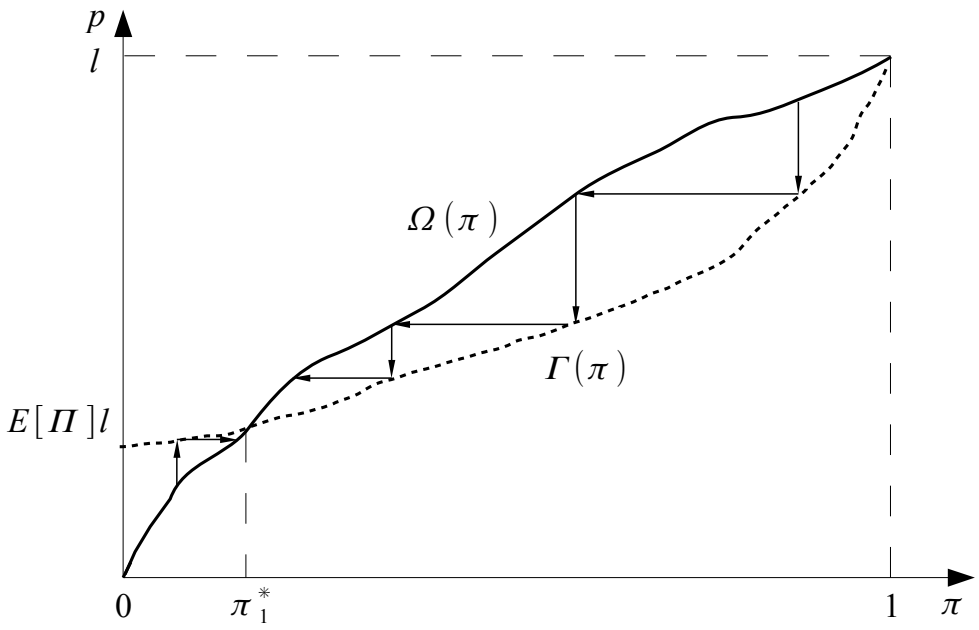
We can see that, of the three competitive equilibria here, only two are stable, whereas the intermediate one with the marginal buyer π_2^* is unstable. Which competitive equilibrium is eventually reached depends on the initial value of π, as formalized in the following proposition:

Proposition 1. *(i) Initial conditions $\pi \in [0,1)$ matter for which competitive equilibrium is reached only if there exist at least three competitive equilibria.*
(ii) When there are exactly three equilibria with critical types $\pi_1^* < \pi_2^* < 1$, the intermediate equilibrium with marginal buyer π_2^* is generically unstable while the other two are stable.
(iii) In this case, π_2^* is the critical threshold for initial conditions: for any initial $\pi > \pi_2^*$, there is unraveling to the "bad" stable equilibrium where $\pi^* = 1$. For any $\pi < \pi_2^*$, the "good" stable equilibrium with critical type π_1^* is reached.

Proof. See Appendix. ∎

While the possibility of equilibrium multiplicity per se is not surprising in this model,

Figure 4: Globally Stable Equilibrium with Two Equilibria



Proposition 1 formalizes the non-obvious result that at least three competitive equilibria are required to obtain at least two *stable* equilibria, which are the only type of equilibria that are relevant for policy purposes. Figure 4 illustrates why the existence of just two equilibria is not enough for initial conditions to matter. In this case, the best equilibrium is always the (unique) globally stable equilibrium and so convergence to the bad equilibrium, which is *unstable*, cannot occur. As discussed earlier, Proposition 1 (i) does not depend on the fact that the condition $\Omega(1) = \Gamma(1)$ implies that $\pi = 1$ is always an equilibrium. In particular, we would have a "corner" equilibrium at $\pi = 1$ if $\Omega(1) < \Gamma(1)$, or an interior equilibrium when $\Omega(1) > \Gamma(1)$. Instead, at least one intermediate, unstable equilibrium is always required in order to produce two stable equilibria and, hence, for initial conditions to matter.

With exactly three equilibria as depicted in Figure 3, unraveling occurs starting from initial conditions to the left of π_1^* (a partial unraveling) and to the right of π_2^* (a full unraveling), whereas the dynamics imply falling premiums and more individuals enrolling otherwise. Evidence for such dynamics have been documented in states which, before the ACA, placed restrictions on adjusting premiums based on age and preexisting conditions. Writing about the New Jersey Individual Health Coverage Program (IHCP) the began in 1993, Monheit et al. (2004) found dynamics similar to those shown in Figure 3 for values of $\pi > \pi_2^*$ (or $\pi < \pi_1^*$). In particular, between the end of 1995 and the end of 2001, enroll-

ment fell from 186,130 individuals to just 84,968, with premiums rising by 200% to 300%. Three other states — Kentucky, New York and Vermont — tried health care reforms with similar consequences (Cohn, 2012). Clemens (2014) provides a comprehensive analysis of the effect of the introduction of community rating regulations in these states and finds that the fraction of uninsured gradually increased by around 70%, from 18% to 31%, in the three years following the reforms. Cutler and Reber (1998) provide evidence for gradual unraveling of high coverage plans in a setting with employer provided insurance.

As widely reported in the popular media reports, the initial conditions described in Section 1 would quite reasonably discourage lower-risk consumers from enrolling in the health exchanges relative to higher-risk consumers. In the context of our model in this section, we would expect consumers with large values of π to be the first to enroll, potentially trapping the system in the bad stable equilibrium. Of course, by Proposition 1, these mechanics only matter if multiple equilibria actually exist in the first place, a topic to which we now turn.

3.2 A Calibration based on the Medical Expenditure Panel Survey

To examine the potential for the type of multiple equilibria shown in Figure 3, we now present a simple quantification of the model. This subsection provides calculations corresponding to our model developed above, where household types differ in their probability of an identical loss. Appendix B presents a calibration based on the case where household types face the same loss probability across different loss amounts. The key lessons are the same in both sets of calculations. Moreover, the generalization provided in Appendix B demonstrates that similar quantitative exercises could be performed allowing for richer forms of heterogeneity.

We use data from the Medical Expenditure Panel Survey (MEPS) for the pre-Medicare population (ages 18 - 64) provided to us by Cohen and Uberoi (2013) to calibrate the average cost (AC) and demand curves.[12] This data allows us to construct a distribution of health expenditures per person. Figure 5 shows the average cost curve as well as the willingness-to-pay curves at different levels of risk aversion. The horizontal axis corresponds to the top X% percent of spenders, where X (the "rank") is the shown value.[13]

[12] We are grateful to both of these authors for providing some additional data related to the pre-Medicare (ages 18 - 64) population that are not shown in their paper.

[13] Notice that the horizontal axis in Figure 5, denoted in X%, has the same ordering as the horizontal axis in the previous figures, denoted in π. Rightward movements in both imply greater risk. However, the support itself is now bounded above zero. In particular, the left-most point of 100% in Figure 5 now corresponds to a willingness to pay that is greater than zero since the average person in the bottom 50% of spenders now faces a chance of loss greater than zero. In contrast, in the previous figures, the left-most

The vertical axis is denominated in dollars. The average cost curve simply sorts medical spenders by percentile. For example, the mean health expenditure per person in the top 100% of the population (i.e., the entire population mean) is equal to $3,844, increasing to $7,476 for population in the top 50%, and climbing to $38,147 for the top 5%.

Of course, an important question is how much of this (ex-post) heterogeneity corresponds to (ex-ante) private information of individuals. On one extreme, the cost distribution could entirely result from ex-post risk, where all individuals have the same expected costs and, therefore, no private information. In this case, the AC curve would be flat and there would be no adverse selection. On the other extreme, all of the distribution could be driven by heterogeneous individuals with private information about their (deterministic) health expenditures. Instead, we take an intermediate stance that is closest to our formal model. In particular, we distinguish quantiles including the top $X\%$ of spenders, with $X \in \{5, 10, 20, 25, 30, 50, 100\}$ and assume that individuals only have private information about which of these bins they belong to.[14]

We calibrate the marginal willingness to pay for insurance for each of the shown percentiles as follows. First, we assume throughout a constant relative risk aversion utility function $u(c) = c^{1-\alpha}/(1-\alpha)$, where α is the level of risk aversion. Second, for this calibration, the constant loss value l is derived from equation (4) by using the average cost of the top 5% of the population from the MEPS and setting with $\pi_{5\%} = 1$ for them. Third, given this fixed loss value, the (marginal) value of π is then calculated recursively (from the top) at each value of $X\%$ by solving equation (4) for π.[15] (Hence, the value of π increases as the shown value of $X\%$ decreases.) Finally, for a given value of α, the demand curve is then calculated by solving equation (5) for the value of Ω for each value of π, and hence $X\%$. The value of wealth w in equation (5) is initially set equal to the median net worth found in the 2010 Survey of Consumer Finances (Board of Governors 2012) , which assumes that the probability of a loss is independent of the household's wealth.

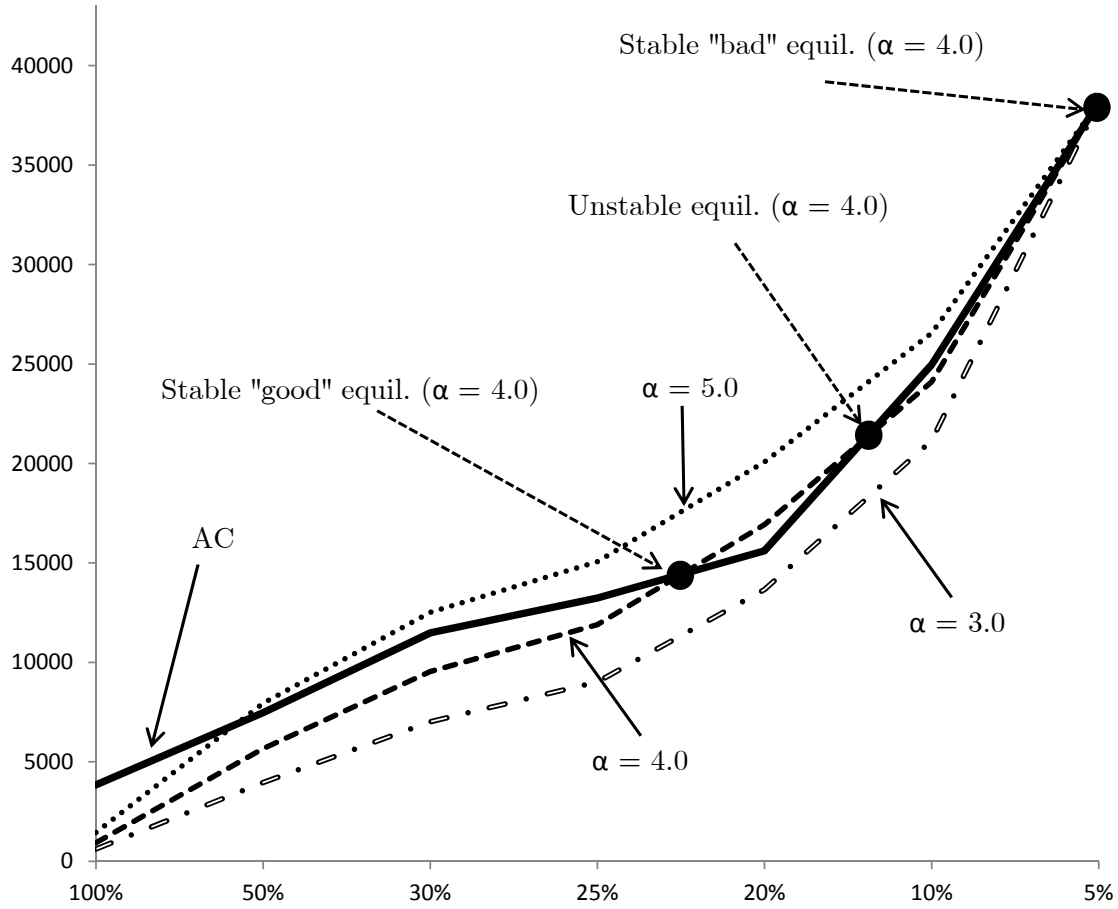
Consider first the case of $\alpha = 3$. Notice that the willingness-to-pay curve is always smaller than the AC curve (i.e., $\Omega(X\%) < \Gamma(X\%)$ except at the top rank (the smallest shown value of $X\%$) where both curves join). This outcome corresponds to the full unraveling case shown previously in Figure 1. Intuitively, at this comparatively small level of risk aversion, agents with a smaller loss probability π (located at *larger* values of $X\%$ on the horizontal axis) are willing to forgo insurance, pushing up its average cost, thereby

point of $\pi = 0$ corresponded to a person who faced no chance of loss.

[14] We have performed robustness checks with even fewer bins and similar results.

[15] For instance, to compute the probability $\pi_{10\%}$ of the loss for the top 10-5% of spenders, we solve $(0.5\pi_{10\%} + 0.5\pi_{5\%})l = AC_{10\%}$, where we take the average costs $AC_{10\%}$ and $l = AC_{5\%}$ from the MEPS data and set $\pi_{5\%} = 1$. $\pi_{20\%}$ is then obtained from solving $(0.5\pi_{20\%} + 0.25\pi_{10\%} + 0.25\pi_{5\%})l = AC_{20\%}$, etc.

Figure 5: Willingness to Pay and Average Costs: Median Net Worth

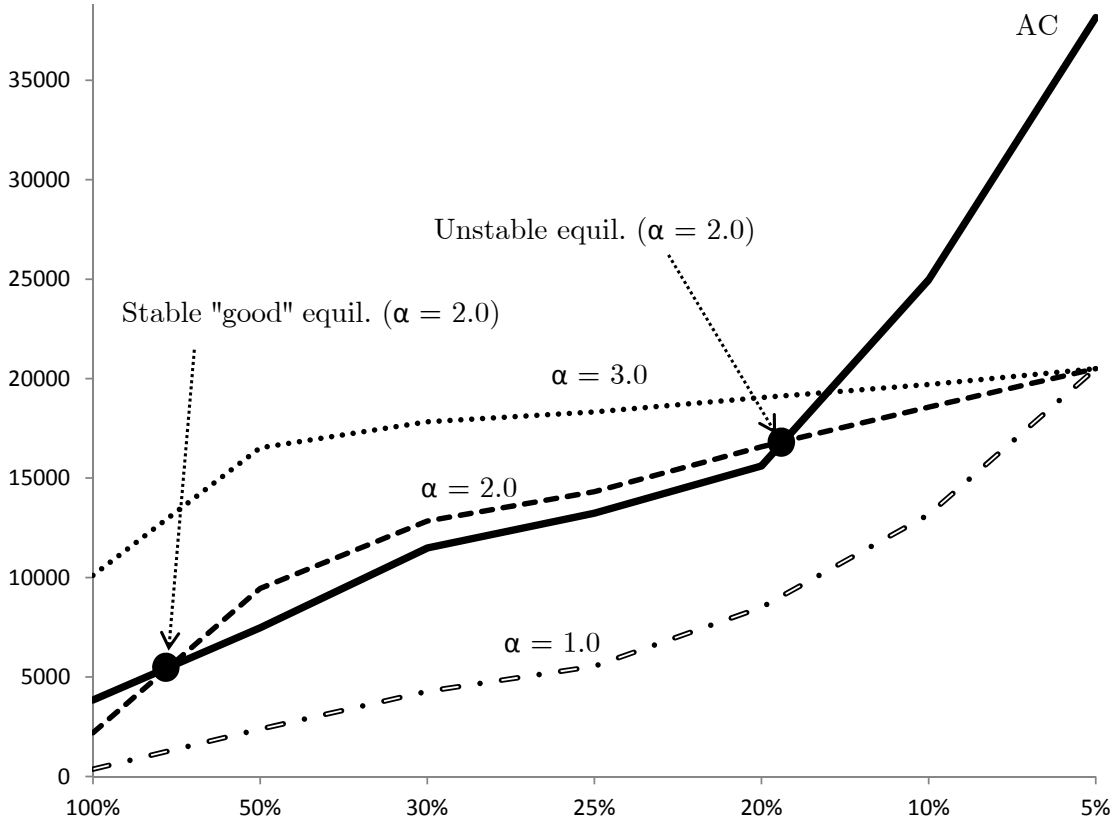


Source: Medical Expenditure Panel Survey (Cohen and Uberoi 2013).
Explanation: Wealth equals net worth (assets less liabilities), including net housing wealth.

leading to unraveling as the value of $X\%$ gets smaller. Now, consider the case of $\alpha = 5$. In this case, the willingness-to-pay curve intersects the AC curve just once before again joining the AC curve at the smallest value of $X\%$. Since at the the good equilibrium (close to the top 50% of spenders), the demand curve intersects the cost curve from below, we know from Section 3 that it is stable, whereas the equilibrium at the top 5% is unstable. Starting from any initial condition, the dynamics will bring the market to the stable equilibrium located at the larger rank, with more than half of the population being covered, consistent with a comparatively large level of risk aversion.

Finally, consider the in-between case where $\alpha = 4$. Notice that the willingness-to-pay and AC curves now intersect at three places, at the shown stable "good" and "bad" equilibria and an unstable intermediate equilibrium. Notice that the sharply rising AC curve as rank $X\%$ grows smaller plays a critical role in causing these multiple intersections.

Figure 6: Willingness to Pay with Median Liquid Assets



Source: Medical Expenditure Panel Survey (Cohen and Uberoi 2013).
Explanation: Wealth equals liquid assets only.

More generally, multiple equilibria are more likely to be produced as losses become more concentrated.[16] Indeed, health costs are much more concentrated than most other types of insurable losses. By Proposition 1, initial conditions matter here: if we start from a situation to the right of the unstable equilibrium (covering somewhere between the top 10 and 20% of the population in terms of spending), the dynamics converge to the worst equilibrium with only the top 5% covered. Otherwise, we eventually reach the best equilibrium with the critical quantile between the top 20 and 25%.

To check the robustness of our results to various assumptions, Figure 6 repeats the same calculations assuming that wealth w is now set equal to the median *liquid assets* reported in the 2010 Survey of Consumer Finances. (Hence, the AC curve remains unchanged.) Liquid assets are a potentially more accurate measure of the relevant amount

[16]Of course, as cost become more concentrated, the willingness-to-pay Ω curve must also increase faster at small values of $X\%$ so that $\Omega(1) = \Gamma(1)$. But at large values of α, the value of Ω will rise faster than Γ, thereby preventing multiple equilibria.

of wealth when illiquid assets, mainly housing, cannot be legally confiscated to pay for medical bills. Because the value of liquid assets is smaller than the median net worth, we can consider relatively smaller values of α in our comparisons.

The reason why the highest willingness to pay no longer also joins the AC curve at its highest point is due to *limited liability*. The calibrated loss amount l now exceeds the wealth level w, and so the maximum potential loss is capped at w.[17] The presence of limited liability generally enhances the likelihood of equilibrium multiplicity by reducing the slope of the willingness-to-pay curve in the same neighborhood where the slope of the AC curve is increasing.

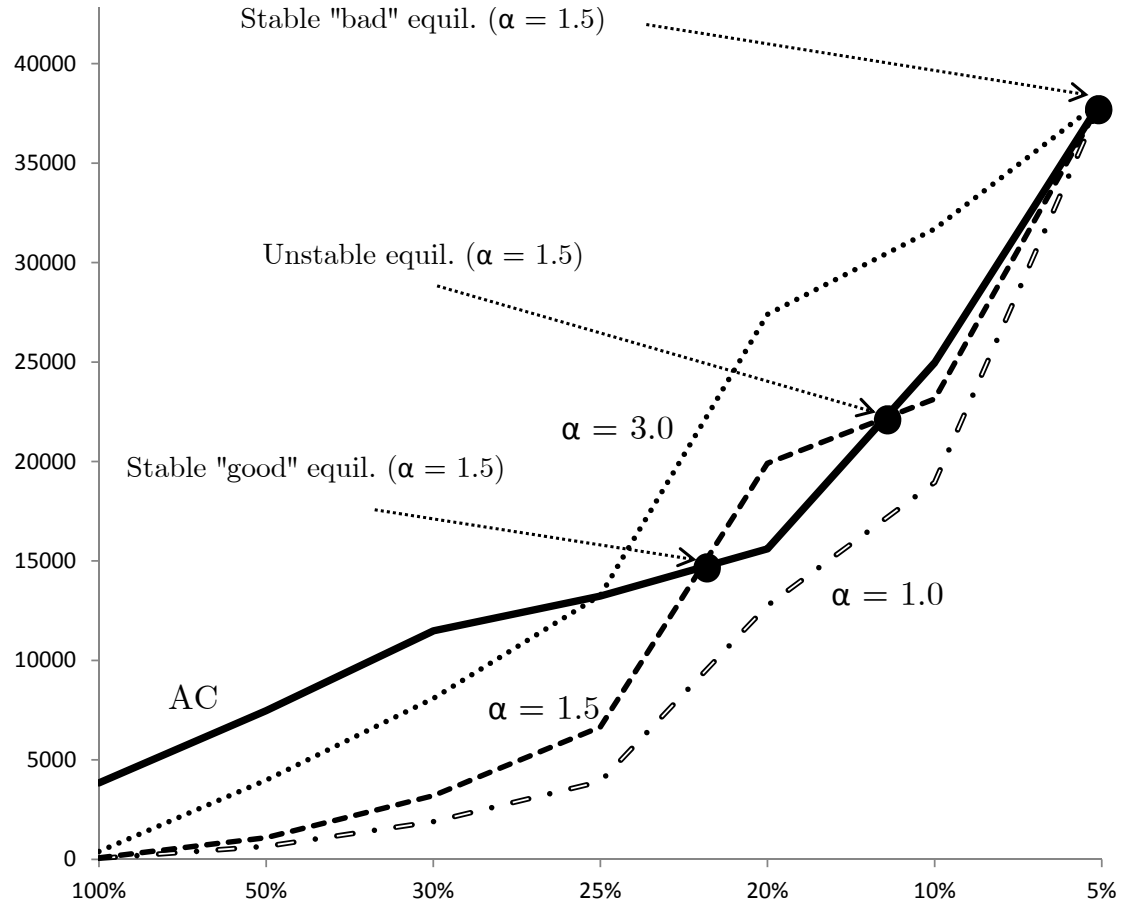
Notice that the smallest value of α, now set equal to 1, produces a willingness-to-pay curve that is always below the AC curve, corresponding to the case of a single (corner) equilibrium with full unraveling at 0% (not shown). But we get three equilibria for the other two values of α. In particular, the largest value of α, now set equal to 3, produces just one intersection, corresponding to an unstable equilibrium. But this unstable equilibrium falls in-between two *corner* stable equilibria: a stable corner equilibrium at 100% where everyone buys insurance (where the willingness to pay exceeds the average cost of the entire population) and another stable corner equilibria at 0% (not shown) where nobody buys insurance. For the in-between value of α, now set equal to 2, we have a stable interior equilibrium, followed by an unstable equilibrium at a larger value of X%, followed by a corner stable equilibria at 0% (not shown) where nobody buys insurance.

By focusing on median wealth for all cost quantiles, our estimates, however, have not accounted for the fact that both the size of wealth and the probability of loss tend to increase in age. For additional robustness, Figure 7 shows the effect of assuming that rank now grows linearly in age, where 18-year olds are now effectively located at the 100% mark on the horizontal axis while 64-year olds are located at the 5% mark. We can now also use the median values of liquid assets at each age from the 2010 Survey of Consumer Finances. Notice that allowing for this relationship has very little impact on our results. Relative to Figure 6, the effects of limited liability are now absent because older people tend to have both more assets and a higher probability of loss.

Appendix B presents additional estimates that relax the assumption that the size of loss is fixed across different risk types. In particular, the probability of loss is now held fixed across households, and a risk type is now defined in terms of the heterogenous size of loss. As before, a low level of risk aversion α leads to unraveling. Moreover, the in-between level of risk aversion produces multiple stable equilibria. However, unlike

[17] In the actual simulations, we cap the loss at w less \$1,000. Not only does this threshold avoid "almost" infinite marginal utility states, it roughly corresponds with Medicaid qualifications as well.

Figure 7: Willingness to Pay with Median Liquid Assets and Risk Increasing by Age



Source: Medical Expenditure Panel Survey (Cohen and Uberoi 2013).
Explanation: Wealth equals liquid assets only.

before, even large values of risk aversion now produce multiple stable equilibria. Overall, therefore, the empirical evidence is consistent with the potential for multiple equilibria, especially for moderate values of risk aversion and when loss sizes are not fixed.

Of course, we view these calibrations as merely a first step towards exploring the possibility of multiple equilibria in insurance markets. In a more complete exercise, which is beyond the scope of the current paper, heterogeneity in both risk and risk-aversion could be accounted for, and both dimensions could be backed out from richer data sources. Moreover, we have considered data from the entire population aged 18-65 rather than just the subset of individuals most likely to demand insurance in the ACA health exchanges. Finally, our calculations have abstracted from the various fines and subsidies in place, to which we turn in the next section.

4 Mandate Enforcement through Fines

Given the previous experience in the states, the mandate—in reality, the associated *fine* that gives the mandate its force—is widely viewed as critical to the success of the ACA. Indeed, the mandate was the focus of the challenge to the ACA heard by the Supreme Court in *National Federation of Independent Business v. Sebelius*. Chandra et al. (2011) present evidence that the phase-in of the mandate in the Massachusetts plan encouraged healthier consumers to enroll, and Hackmann et al. (2013) estimate the socially optimal level of the penalty that enforces the mandate in a model with linear cost and demand curves.

In this section, we show that the actual *form* of the fine, and not just its level, plays an important role in the presence of equilibrium multiplicity. The ACA imposes an absolute fine — a fixed dollar amount or a percentage of income, whichever is greater — whereas the Massachusetts reform in 2006 created a *relative* fine that was a function of market premium prices. In addition to the fine, the ACA also makes subsidies available to households with lower income.

We begin by demonstrating how the introduction of an *absolute* fine f for not having insurance as well as a subsidy s for having insurance can be captured in our graphical framework. Of course, neither the fine nor the subsidy affects the average cost curve $\Gamma(\pi)$. However, it affects the construction of the willingness to pay for insurance, now denoted as $\hat{\Omega}(\pi)$, through the modified indifference condition

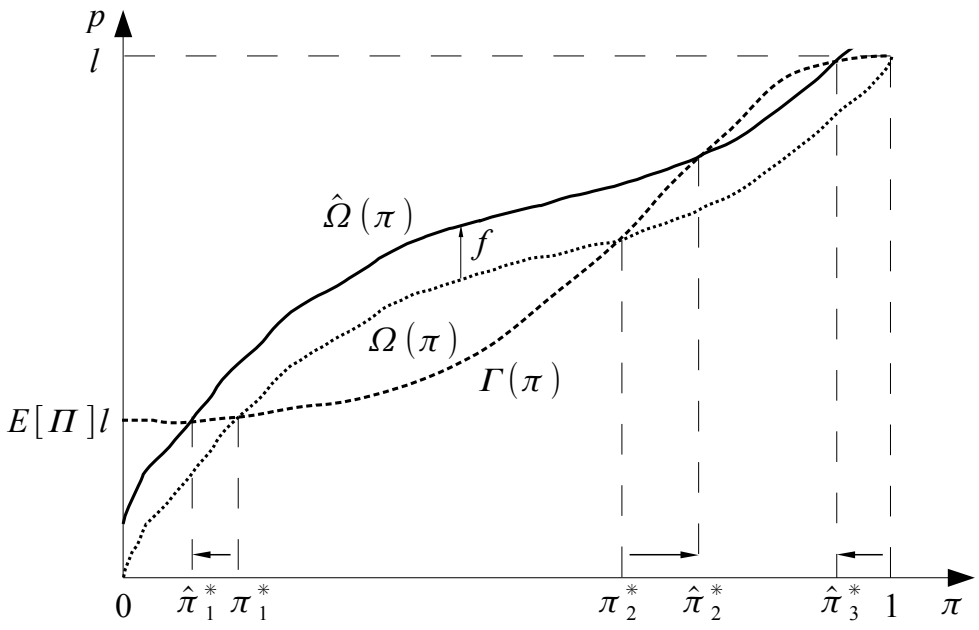
$$u(w - \hat{\Omega} + s) = \pi u(w - f - l) + (1 - \pi)u(w - f). \tag{6}$$

Notice that the subsidy s and the fine f both *shift up* the inverse demand curve $\hat{\Omega}(\pi)$, in fact, in a parallel manner in the case of a subsidy. We now focus on the construction of the fine f given its greater importance in the recent debate.

Unsurprisingly, an absolute fine can give rise to better equilibria with more individuals insured. In the example shown in Figure 1 where only the complete unraveling equilibrium exists, shifting up the $\hat{\Omega}$-curve will induce the emergence of equilibria with a positive mass of individuals getting coverage. In fact, this upward shift could induce multiple equilibria where previously there was only one. For the example shown in Figure 3 with three equilibria, Figure 8 illustrates how shifting up the $\hat{\Omega}$-curve can shrink the range of initial values $(\hat{\pi}_2^*, 1]$ for which unraveling to the bad stable equilibrium π_3^* occurs. At the same time, it also shifts both the good stable equilibrium π_1^* and the bad stable equilibrium π_3^* to the left and, hence, leads to a greater number of individuals being covered at a lower premium.

Of course, we can always set the fine to be large enough such that there exists a unique

Figure 8: Enforcement of a Mandate through a Fine f



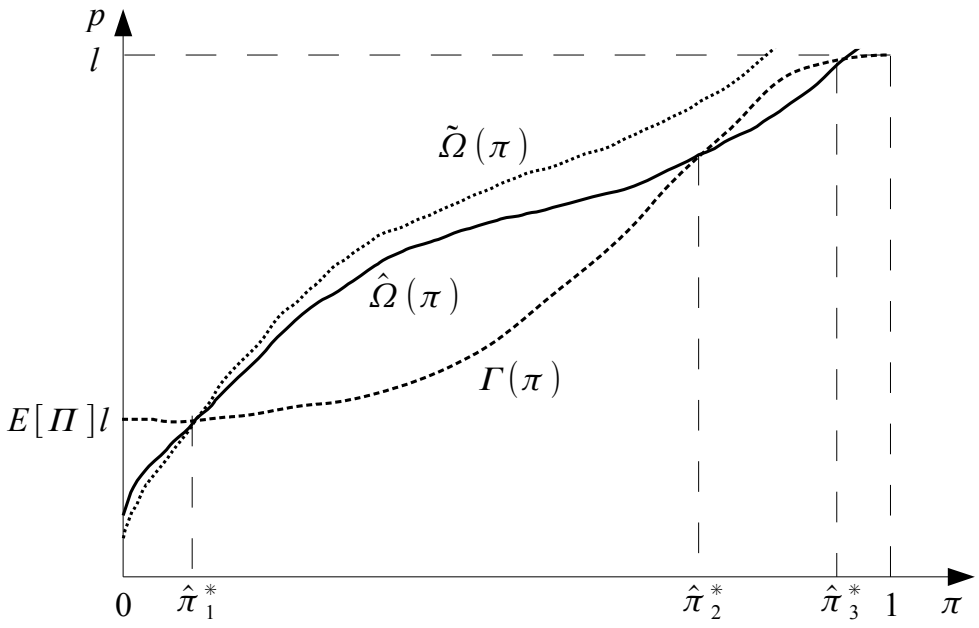
equilibrium where everyone buys insurance and there is no risk of unraveling. However, this outcome may be both inefficient and politically challenging. Indeed, the peculiar nature of the fine's construction under the ACA — namely, its assessment only on tax filers who are owed a refund — reflects the sensitivity that Congress felt it faced in creating a fine that causes too much hardship.

A more interesting question is whether there exists another fine mechanism that eliminates the possibility of equilibrium multiplicity *without* imposing a higher fine *in the best equilibrium* π_1^*. As Figure 8 makes clear, it is actually not necessary to impose a higher fine *everywhere* in order to eliminate the bad stable equilibria. A large fine value is only necessary in situations where few individuals enroll for insurance, that is, where the critical value of π and, hence, the premium are both large.

A *relative* fine that is tied to the actual equilibrium premium in the market achieves exactly this outcome. Using the dynamics developed in Section 3, suppose that in each period t, the fine that must be paid by uninsured consumers is set equal to kp_t, where $k > 0$ is some constant that can be interpreted as the percentage of the current premium p_t.[18] Since $p_t = \Gamma(\pi_t)$, the resulting willingness to pay for insurance, now denoted as

[18] In the case of Massachusetts, the corresponding value of k would roughly equal $1/2$.

Figure 9: Relative versus absolute fine with $k\Gamma(\hat{\pi}_1^*) = f$



$\tilde{\Omega}(\pi)$, for each risk level π is then defined implicitly by

$$u(w - \tilde{\Omega}) = \pi u(w - l - k\Gamma(\pi)) + (1 - \pi)u(w - k\Gamma(\pi)).^{19} \tag{7}$$

The benefit of the relative fine is that the fine value — and, hence, consumers' demand for insurance — automatically increase as the market unravels towards a bad stable equilibrium. This outcome occurs *even if* we choose k such that $k\Gamma(\hat{\pi}_1^*) = f$, so the relative and the absolute fines take exactly the same value in the best equilibrium $\hat{\pi}_1^*$. This is illustrated in Figure 9, which shows how the inverse demand curve under the relative fine $\tilde{\Omega}(\pi)$ is a counter-clockwise rotation at point $\hat{\pi}_1^*$ relative to the inverse demand curve under the absolute fine $\hat{\Omega}(\pi)$. Proposition 2 formalizes the advantages of a relative fine compared to an absolute fine with this normalization.

Proposition 2. *Let $\hat{\pi}_1^* < 1$ be the best equilibrium under an absolute fine $f > 0$, and set the relative fine such that $k\Gamma(\hat{\pi}_1^*) = f$ (i.e., equal fine values at the best equilibrium). Then:*
(i) for any number $N \geq 1$ of equilibria, the worst equilibrium $\tilde{\pi}_N^*$ under the relative fine is Pareto better (more coverage at a lower price) than the worst equilibrium under the absolute fine $\hat{\pi}_N^*$, i.e. $\tilde{\pi}_N^* \leq \hat{\pi}_N^*$.

[19] Notice that, since $\Gamma(\pi)$ is increasing, the right-hand side of (7) is still decreasing in π, and so $\tilde{\Omega}(\pi)$ remains well-defined and increasing.

(ii) The best equilibrium under the absolute and relative fine are identical, i.e. $\hat{\pi}_1^* = \tilde{\pi}_1^*$.
(iii) The interval of initial conditions $[0, \tilde{\tilde{\pi}}_1)$ *from which we converge to the best equilibrium* $\tilde{\pi}_1^*$ *under the relative fine is larger than the range of initial conditions* $[0, \hat{\tilde{\pi}}_1)$ *from which we converge to the best equilibrium* $\hat{\pi}_1^* = \tilde{\pi}_1^*$ *under the absolute fine, i.e.* $\tilde{\tilde{\pi}}_1 \geq \hat{\tilde{\pi}}_1$.

Proof. See Appendix. ∎

In sum, a re-construction of the fine toward a relative basis is more likely to expand coverage, by moving the market to the good stable equilibrium, without costing non-insured consumers anything more in the good equilibrium. However, even if the bad stable equilibrium does emerge (which may still be possible under a small enough relative fine), its "badness" is also reduced (more coverage at a lower price).

It is also worth pointing out that, in the context of this model, introducing a fine for non-participation (or other forms of enforcing a mandate) can never lead to a Pareto improvement. This is because there are always individuals with sufficiently low π who, in any equilibrium without a fine, prefer to demand no insurance. With a fine in place, they will either remain uninsured and pay the fine or, if the fine is high enough, buy insurance at a premium that is higher than their original willingness to pay. In either case, they will be worse off. Hence, a fine or mandate can increase coverage but not in a Pareto improving way.[20]

Even when relaxing the assumption that π has full support on $[0, 1]$, as in Appendix B (as well as in the model calibrated to the MEPS data considered earlier), a Pareto improvement from introducing a fine is possible only in the presence of multiple equilibria, when the fine induces a shift from a bad equilibrium with low coverage to a good equilibrium where in fact *everyone* gets covered, and everyone being covered is an equilibrium *even without the fine*. Only this outcome guarantees that nobody ends up paying the fine and even the lowest risk types actually prefer buying insurance when everyone does so, so they are better off compared to the bad equilibrium (see e.g. Figure 12 in Appendix B). Explicitly accounting for equilibrium multiplicity, therefore, crucially underlies standard arguments for Pareto improving mandates or fines in the context of adverse selection.

5 Strategic Insurers

So far, we have focused on the notion of competitive equilibrium where insurers act as price-takers, as in Akerlof (1970). A natural question is whether equilibrium multiplic-

[20] This argument goes through unaffected when the revenue from the fine is returned lump-sum to all individuals, or when the fine on non-participants is replaced by a subsidy for participation that is financed by a lump-sum tax.

ity and, hence, the role of initial conditions also extend to situations in which insurers strategically set premiums rather than taking them as given.

Following Einav et al. (2010) in the insurance market and Mas-Colell et al. (1995) in a labor market setting, suppose there are at least two insurers who set premiums in a two-stage Bertrand game. In the first stage, insurers simultaneously announce their premiums. In the second stage, individuals decide whether to purchase insurance and, if so, from which insurer.[21] Of course, each consumer's risk level π is still private information. But we now assume that there is common knowledge of the distribution $H(\pi)$, consumer wealth w, the loss amount l, and the form of utility $u(c)$. Hence, the shapes of $\Gamma(\pi)$ (the average cost curve) and $\Omega(\pi)$ (the willingness to pay curve) are common knowledge.

Returning to the setting without any fines, the following proposition, which is easily adapted from Mas-Colell et al. (1995) and Einav et al. (2010), shows that equilibrium multiplicity disappears.

Proposition 3. *With strategic insurers, the unique subgame perfect equilibrium outcome of the above two-stage game involves the critical type*

$$\pi_1^* = \min \{\pi \in [0,1] \,|\Omega(\pi) = \Gamma(\pi)\}.$$

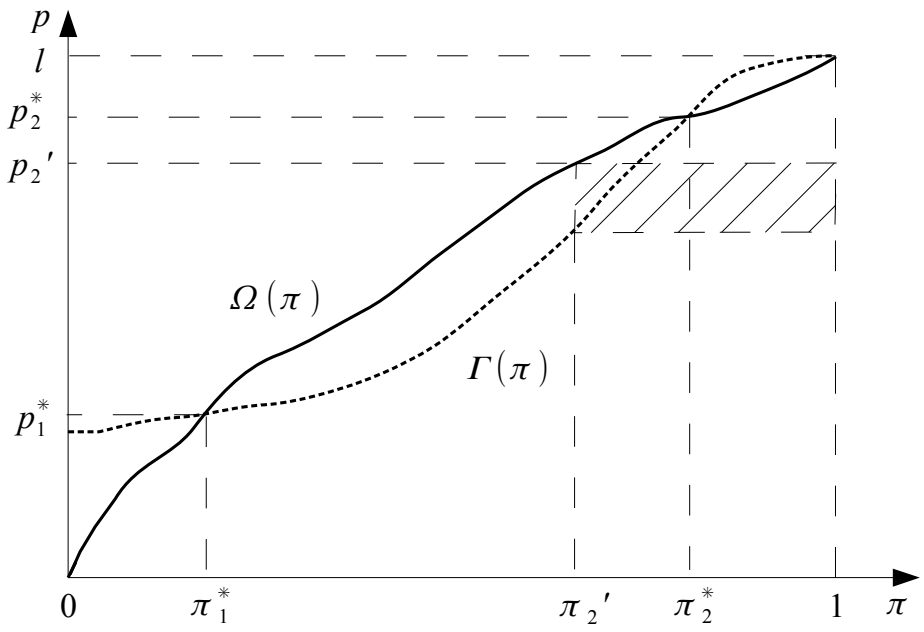
In words, when insurers set premiums strategically, only the best competitive equilibrium (with the lowest premium and the most people covered) survives. This result holds even if there is more than one *competitive* equilibrium, that is, multiple equilibria in the price-taking model.

Intuitively, consider again the setting shown earlier in Figure 3 with exactly three competitive equilibria. Figure 10 illustrates the mechanics when firms now behave strategically. Suppose we are in the worst equilibrium with critical type $\pi = 1$ and premium $p = l$.[22] *If* all insurers set premium $p = l$, only types $\pi = 1$ demand insurance, and the average cost of this pool is $\Gamma(1) = l$, and so all insurers make zero profits. Hence, this outcome is a *competitive* equilibrium in the sense of Definition 1. But it also emits a profitable deviation by any strategic insurer. In particular, suppose that an insurer deviates and sets a premium $p_2' < p_2^*$. As drawn in Figure 10, this insurer will capture the entire market with demand from all types $\pi \geq \pi_2'$ (and observe $\pi_2' < \pi_2^*$). Moreover, at π_2', the average cost curve is below the demand curve, so $\Gamma(\pi_2') < p_2'$. Hence, offering the premium p_2' will result in strictly positive profits for the deviating insurer corresponding

[21] As usual, to break a tie (since actual currency denominations are technically a countable set to the penny level), if multiple insurers announce exactly the same premium levels, individuals then randomize among them with equal probabilities.

[22] The same argument could be made about the intermediate equilibrium with π_2^* and p_2^*.

Figure 10: Equilibrium Uniqueness with Strategic Insurers

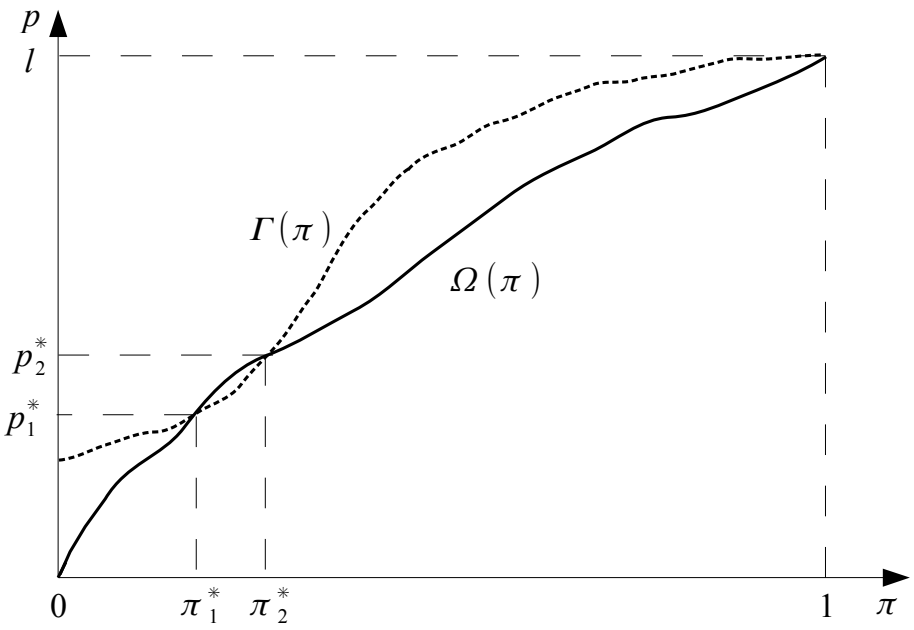


to the dashed area in Figure 10. The only competitive equilibrium from where there is no such profitable deviation is the good equilibrium with marginal buyer π_1^* and the lowest premium p_1^*.

Strategic premium setting in a framework of Bertrand-like competition may seem like the more relevant case than price-taking for insurance markets, since many insurers are not atomistic and do actively set premiums taking into account their competitors' and customers' responses to their actions. However, as e.g. Mas-Colell et al. (1995) emphasize in the setting of labor markets with adverse selection, the outcome in Proposition 3 relies on the assumption that firms have common knowledge about all market fundamentals, including the *global* shape of the demand and cost curves Ω and Γ. In contrast, in the competitive equilibria with price-taking considered in Sections 2 to 4, insurers only need to know the average cost of those who buy insurance *at the going premium*; they do not need to know anything about the preferences or risk distribution underlying this equilibrium or have non-localized knowledge *away* from current conditions.

In the strategic setting, a *mistaken* attempt at a profitable deviation could lead to substantial losses. For instance, suppose again we start from the worst equilibrium $\pi^* = 1$ in Figure 10. If an insurer deviates by offering a marginally lower premium $p = l - \varepsilon$, this will lead to losses since $\Gamma(\pi) > \Omega(\pi)$ for π close to one. To make profits, a deviating insurer would have to offer a discretely lower premium $p < p_2^* < l$, but also not too low,

Figure 11: Small and Distant Interval of Profitable Premium Deviations



since losses would be incurred again if $p < p_1^*$. In Figure 10, the demand and cost curves are drawn such that the interval of profitable premium deviations (p_1^*, p_2^*) is still relatively large. However, this need not be the case. Figure 11 depicts market fundamentals where this interval is very small and far away from the going premium $p = l$. In this case, insurers would actually incur losses for large range of premium cuts in (p_2^*, l), and only make profits if they reduce premiums by a very large (and just the right) amount until $p \in (p_1^*, p_2^*)$. In other words, Proposition 3 requires that insurers have precise knowledge about market conditions potentially far away from the current situation. In contrast, the competitive equilibrium and the dynamics in Section 3 only require knowledge about local market conditions around the current situation.

Strategic insurers could potentially limit their losses if they could rapidly change prices to try to discover the global shapes of the willingness-to-pay and average cost curves. However, as noted in Section 1, transitory losses from pricing experimentation are magnified by the fact that regulations prevent insurers from changing prices frequently. Once set, ACA plan premiums are generally viewed as locked until the next open enrollment period (Kaiser 2013) .

Moreover, the ability to sharply increasing premiums after a pricing mistake is challenging. Under the McCarran-Ferguson Act of 1945, individual states typically regulate the business of insurance, and most states already require some steps before rates can

be increased (National Conference of State Legislatures 2013).[23] However, because rules vary between states, Title I (Subtitle A, Sec. 1003) of the ACA creates a more uniform standard around rate increases. These rules include requiring states to collect premium information and determine if plans should be excluded from the health exchange based on unjustified premium increases.[24] If an insurer requests a premium increase above 10%, a more detailed explanation must be provided and posted on their and the HHS website. The ACA also makes $250 million available to states to take action against insurers requesting unreasonable rate increases. According to the Centers for Medicare and Medicaid Services (2010) , "[t]his funding will help assure consumers in every state that any premium increases requested by their insurance company, regardless of size, is justified."

In the absence of perfect information about the market structure, insurers, therefore, may simply prefer local adjustments to premiums in a backward looking manner, as documented in Cutler and Reber (1998). Such behavior would effectively make them price-takers again.[25] Consumer-protection laws intended to protect consumers from frequent and large price increases could undermine experimentation and essentially force insurers into price-taking behavior that includes the potential of getting stuck in a bad equilibrium with low coverage and high prices.

6 Conclusion

This paper characterizes when the "initial conditions" of a new insurance market — like a website failure at launch — could have permanent consequences. We show that initial conditions can be material if (i) insurers are competitive price-takers, and if (ii) there exist at least three competitive equilibria. In the case of exactly three equilibria, one equilibrium is unstable while the other two are stable. A "good" stable equilibrium is Pareto superior — by offering more coverage at a lower price — to a "bad" stable equilibrium. While some older papers have noted the possibility of multiple equilibria, this paper appears to be first to formalize the conditions required to have multiple *stable* equilibria, which are the only equilibria that are relevant for policy purposes. For example, a model with just two competitive equilibria has only one stable equilibria, rendering initial conditions

[23] At least two dozen states require that the insurer receives prior approval from the state insurance commissioner or department before increasing health insurance premiums (National Conference of State Legislatures 2013).

[24] For a few states — Alabama, Louisiana, Missouri, Oklahoma, Texas, and Wyoming — these determinations will be made by the federal government since these states do not have effective review processes in place.

[25] See also Rothschild (1974) for the classic model on experimentation to learn about demand conditions. These two-armed bandit models also have the typical feature that multiple equilibria can arise.

irrelevant. Three or more equilibria are required to produce two or more stable equilibria.

We provide some suggestive empirical evidence using the Medical Expenditure Panel Survey that the presence of three equilibria is indeed consistent with moderate levels of risk aversion. Multiple equilibria are more likely to emerge when losses are very concentrated (as in the case of health care) and in the presence of limited liability. Future work can provide a more detailed empirical analysis using a wider range of data sets.

As is well known, the Affordable Care Act (ACA) levies a fine on non-participants in order to try to prevent unraveling. Without the presence of multiple equilibria, a fine cannot expand coverage in a Pareto improving manner, but it effectively redistributes from low to high risk types. Equilibrium multiplicity is a necessary (but not sufficient) condition for a fine to achieve a Pareto improvement. The ACA's fine, however, is constructed as an absolute amount, equal to the greater of a fixed dollar amount or a fixed fraction of income. In contrast, the 2006 Massachusetts plan, on which the ACA is modeled, levied a fine on a relative basis, equal to a fraction of the equilibrium premium. The relative fine, therefore, grows with the amount of adverse selection. We show that changing the fine from an absolute to a relative amount — normalized to be equal in the desired, good equilibrium — increases the range of initial conditions consistent with reaching the good equilibrium, while also reducing the severity of the bad equilibrium, if it still exists.

If insurers price strategically, rather than acting like price takers, only the good equilibrium emerges. In particular, any attempt to price at the bad equilibrium emits profitable deviations. However, strategic pricing also requires insurers to have global knowledge of the distribution of risk types and participant characteristics (preferences, loss amounts, and wealth). Incorrect deviations can be costly across a wide range of guesses: If an insurer reduces prices too little, they will continue to be stuck with high-risk types who are now paying below the fair rate required for zero profits. But if the firm reduces prices too much, it still can lose money even if it favorably changes the risk pool. In contrast, competitive pricing only requires localized knowledge of average costs.

Existing evidence from previous health care reforms at the state level and from some employer-based plans suggest that insurers instead update their prices more consistently with the price-taking model. While there could be good reasons for limitations to the frequency of price changes and the amount of increases, such as consumer protection, an unintended consequence could be that they further discourage price discovery, thereby increasing the potential for reaching a Pareto dominated equilibrium.

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A Appendix: Proofs

A.1 Proof of Proposition 1

(i). We show that initial conditions cannot matter when there are only one or two competitive equilibria. If $\pi^* = 1$ is the only equilibrium, we must have $\Gamma(\pi) > \Omega(\pi)$ for all $\pi < 1$. Otherwise, by continuity of Γ and Ω and since $\Gamma(0) = \mathbb{E}[\Pi]l > \Omega(0) = 0$, there would have to exist at least one intersection of Γ and Ω at some $\pi < 1$ and hence another equilibrium. Since $\Gamma(\pi) > \Omega(\pi)$ for all $\pi < 1$, the dynamics imply unraveling to $\pi^* = 1$ for any initial π and therefore initial conditions do not matter.

If there are two equilibria with $\pi^* = 1$ and some $\pi_1^* < 1$, it must hold that $\Gamma(\pi) > \Omega(\pi)$ for all $\pi \in [0, \pi_1^*)$ and $\Gamma(\pi) < \Omega(\pi)$ for all $\pi \in (\pi_1^*, 1)$ by an analogous argument as above. Hence, for any $\pi \in [0, 1)$, we converge to the constrained efficient equilibrium $\pi_1^* < 1$. As a result, initial conditions again do not matter for the equilibrium that is eventually reached except in the non-generic case where the initial $\pi = 1$.

(ii) and *(iii).* Note first that, for any number N of equilibria $\pi_1^* < ... < \pi_{N-1}^* < 1$, the best equilibrium π_1^* must be stable generically. This is because $\Gamma(\pi) > \Omega(\pi)$ for all $\pi \in [0, \pi_1^*)$ and, since there is a proper intersection of Γ and Ω generically, $\Gamma(\pi) < \Omega(\pi)$ for all $\pi \in (\pi_1^*, \overline{\pi}_1)$ and $\overline{\pi}_1 > \pi_1^*$ sufficiently close to π_1^*. With exactly 3 competitive equilibria $\pi_1^* < \pi_2^* < 1$, this implies that in fact $\overline{\pi}_1 = \pi_2^*$, and since again there is a proper intersection of Γ and Ω at π_2^* generically, $\Gamma(\pi) > \Omega(\pi)$ for all $(\pi_2^*, 1)$, as illustrated in Figure 3. Hence, the intermediate equilibrium π_2^* is unstable and the other two are stable. Moreover, we converge to π_1^* for any initial $\pi < \pi_2^*$ and to $\pi^* = 1$ for any $\pi > \pi_2^*$.

A.2 Proof of Proposition 2

Note first that, for any absolute fine $f > 0$, $\hat{\Omega}(1) = l + f > \Gamma(1) = l$, so for any number N of equilibria, both the best equilibrium $\hat{\pi}_1^*$ and the worst equilibrium $\hat{\pi}_N^*$ under f must satisfy $\hat{\pi}_1^* \leq \hat{\pi}_N^* < 1$. We next observe that, comparing the definitions (6) and (7) and using the normalization that $k\Gamma(\hat{\pi}_1^*) = f$ and the fact that $\Gamma(\pi)$ is increasing in π, $\tilde{\Omega}(\pi) < \hat{\Omega}(\pi)$ for all $\pi < \hat{\pi}_1^*$ and $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi)$ for all $\pi > \hat{\pi}_1^*$. We use this repeatedly to prove claims *(i)* to *(iii)* in the proposition.

(i). Since $\hat{\Omega}(1) > \Gamma(1)$ under $f > 0$, the worst equilibrium $\hat{\pi}_N^* < 1$ must be such that $\hat{\Omega}(\pi) > \Gamma(\pi)$ for all $\pi > \hat{\pi}_N^*$. Since $\hat{\pi}_N^* \geq \hat{\pi}_1^*$, the above result that $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi)$ for all $\pi > \hat{\pi}_1^*$ a fortiori implies $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi) > \Gamma(\pi)$ for all $\pi > \hat{\pi}_N^*$. This immediately rules out $\tilde{\pi}_N^* > \hat{\pi}_N^*$.

(ii) and (iii). Note first that the best equilibrium $\hat{\pi}_1^*$ is always such that $\hat{\Omega}(\pi) < \Gamma(\pi)$

for all $\pi < \hat{\pi}_1^*$. Moreover, since we observed that $\tilde{\Omega}(\pi) < \hat{\Omega}(\pi)$ for all $\pi < \hat{\pi}_1^*$, we also have $\tilde{\Omega}(\pi) < \Gamma(\pi)$ for all $\pi < \hat{\pi}_1^* \leq \tilde{\pi}_1^*$. Hence, the range of initial values from which we converge to the best equilibrium always takes the form of an interval with lower bound zero and upper bound $\overline{\pi}_1 \geq \hat{\pi}_1^*$. Since $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi)$ for all $\pi > \hat{\pi}_1^*$ and $\tilde{\Omega}(\hat{\pi}_1^*) = \hat{\Omega}(\hat{\pi}_1^*)$, we also have $\tilde{\pi}_1^* = \hat{\pi}_1^*$, as claimed in *(ii)*.

Suppose first that the best equilibrium $\hat{\pi}_1^* < 1$ is the unique equilibrium under the absolute fine f, so $\hat{\Omega}(\pi) > \Gamma(\pi)$ for all $\pi > \hat{\pi}_1^*$ and vice versa. Then by the above observation that $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi)$ for all $\pi > \hat{\pi}_1^*$ and vice versa, this immediately implies that $\tilde{\pi}_1^* = \hat{\pi}_1^*$ is also the unique equilibrium under the relative fine. It also implies that, in both cases, the best equilibrium is globally stable, so we converge to it for any initial conditions and thus $\bar{\tilde{\pi}}_1 = \bar{\hat{\pi}}_1 = 1$.

Otherwise, since the best equilibrium $\hat{\pi}_1^*$ generically corresponds to a proper intersection of $\hat{\Omega}(\pi)$ and $\Gamma(\pi)$ and $\hat{\Omega}(\pi) < \Gamma(\pi)$ for all $\pi < \hat{\pi}_1^*$, me must have $\hat{\Omega}(\pi) > \Gamma(\pi)$ for some interval $(\hat{\pi}_1^*, \bar{\hat{\pi}}_1)$ with $\bar{\hat{\pi}}_1 > \hat{\pi}_1^*$. Hence, under the absolute fine, we converge to $\hat{\pi}_1^*$ for any initial π in the interval $[0, \bar{\hat{\pi}}_1)$. Then the above observation that $\tilde{\Omega}(\pi) > \hat{\Omega}(\pi)$ for all $\pi > \hat{\pi}_1^*$ immediately implies $\tilde{\Omega}(\pi) > \Gamma(\pi)$ for some interval $(\hat{\pi}_1^* = \tilde{\pi}_1^*, \bar{\tilde{\pi}}_1)$ with $\bar{\tilde{\pi}}_1 > \bar{\hat{\pi}}_1$. The range of initial values for π for which we converge to the best equilibrium under the relative fine is therefore $[0, \bar{\tilde{\pi}}_1)$ with $\bar{\tilde{\pi}}_1 > \bar{\hat{\pi}}_1$.

B Appendix: Generalizing the Price-Taking Model

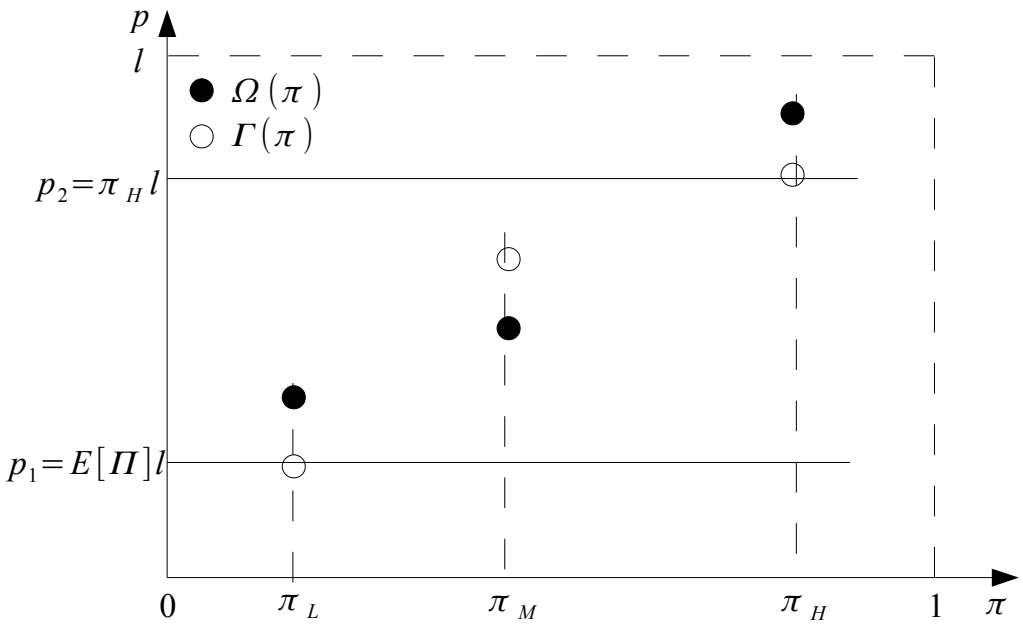
This Appendix generalizes the model of Section 2 to allow for the presence of discrete risk types, a richer amount of heterogeneity between consumers and more general variation in the size of losses.

B.1 Allowing for Discrete Risk Types

We now show multiple equilibria can emerge even when we relax the assumption that the distribution of types $H(\pi)$ is continuous with full support on $[0, 1]$. For example, consider a case with three risk types, $0 < \pi_L < \pi_M < \pi_H < 1$, of low ($L$), medium ($M$) and high ($H$) risk, respectively. Their willingness to pay for insurance $\Omega(\pi)$ is depicted as black dots in Figure 12. The empty circles represent the average costs of insuring the corresponding pools, and so $\Gamma(\pi_H)$ is the cost of only insuring the high risk type H, $\Gamma(\pi_M)$ is the average cost of insuring both the medium M and high risk H types, and $\Gamma(\pi_L) = \mathbb{E}[\Pi]l$ is the average cost of insuring all three risk types.

We have chosen these values such that there are two competitive equilibria: one good

Figure 12: Equilibrium Multiplicity with Three Types

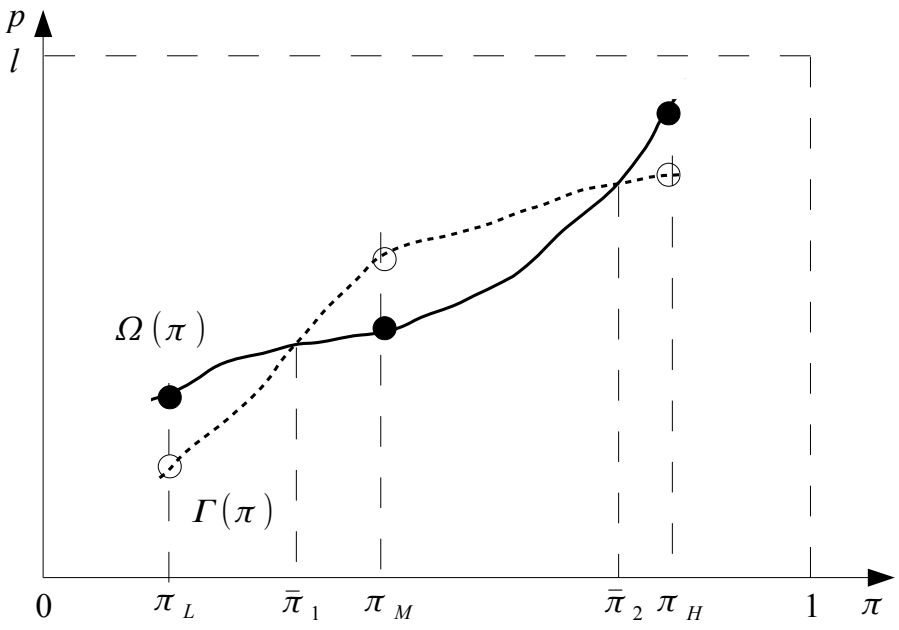


equilibrium in which everyone is insured at premium $p_1 = \mathbb{E}[\Pi]l$, and another bad equilibrium in which only the high risk type is insured at a higher premium $p_2 = \pi_H l > p_1$.[26] There is no equilibrium where only the medium and high types π_M and π_H are insured, because the average cost $\Gamma(\pi_M)$ for that pool is higher than the willingness to pay of the medium type $\Omega(\pi_M)$, so the medium risk type would not buy insurance at premium $\Gamma(\pi_M)$ and the dynamics would unravel to the bad equilibrium.

Let us connect Figure 12 to the corresponding figures that we drew for the case of a continuum of types in Sections 2 and 3. Filling up the space between the three discrete types naturally leads to Figure 13. We see that, with continuous types and this pattern of curves, there are in fact three equilibria: a stable bad equilibrium, where only types $\pi \geq \overline{\pi}_2$ are insured (with $\pi_M < \overline{\pi}_2 < \pi_H$), an unstable interior equilibrium with critical type $\overline{\pi}_1$ between π_L and π_H, and a stable corner equilibrium where everyone with $\pi \geq \pi_L$ is insured. Notice that Figure 13 is very similar to Figure 3 shown in Section 3. In particular, for initial conditions to matter, the existence of an unstable equilibrium is still required, and the average cost and willingness to pay curves need to intersect at least twice in the interior. Moreover, the marginal buyer $\overline{\pi}_1$ in the unstable equilibrium represents the

[26] With discrete types, competitive equilibria involve points with $\Omega(\pi) \geq \Gamma(\pi)$ rather than necessarily $\Omega(\pi) = \Gamma(\pi)$. However, Definition 1 still applies. For instance, in the competitive equilibrium with premium p_2, we have $\Omega(\pi_L) < \Omega(\pi_M) < p_2 < \Omega(\pi_H)$, so that only the highest type π_H demands insurance. Moreover, $p_2 = \Gamma(\pi_H) = \pi_H l$, and insurers make zero profits.

Figure 13: Connection between continuous and discrete type model



critical value of initial conditions that determines whether the good or bad equilibrium is reached eventually. The only difference between the discrete and the continuous cases is that the highest risk type in the discrete case may lay within the support shown for the continuous case.

B.2 Richer Forms of Consumer Heterogeneity and Multiple Loss Sizes

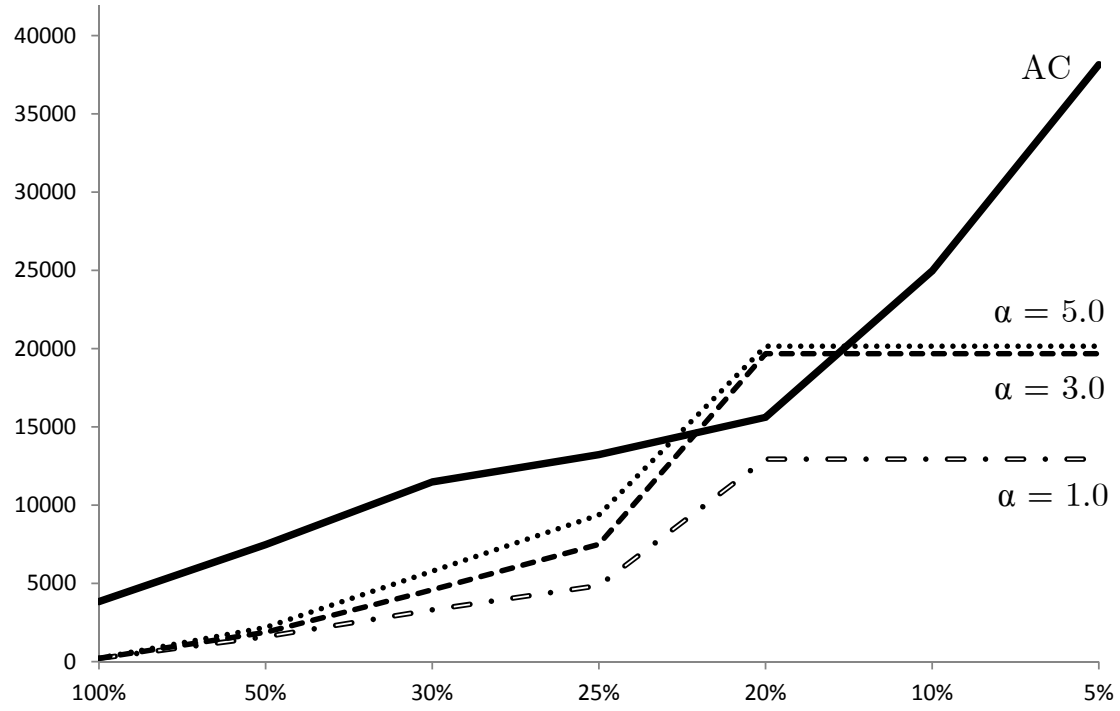
It is also straightforward to extend our analysis in Section 2 to allow for richer forms of consumer heterogeneity and multiple sizes of losses. Let the population be indexed by the continuous variable $\theta \in [0,1]$ with distribution $F(\theta)$. Suppose there are S possible loss levels $l_s(\theta)$ indexed by s, which may differ across θ. The probability that type θ suffers a loss of size s is denoted by $\pi_s(\theta)$, where, of course, $\sum_{s=1}^{S} \pi_s(\theta) = 1 \; \forall \theta$. The expected loss for type θ is, therefore,

$$\sum_{s=1}^{S} \pi_s(\theta) l_s(\theta).$$

We can normalize the population type index θ so that the expected costs are increasing in θ. In particular, let us take θ as the *quantiles* of the average cost distribution, so that

$$\Gamma(\theta) = \int_{\theta}^{1} \sum_{s=1}^{S} \pi_s(\theta') l_s(\theta') dF(\theta') \Big/ (1 - F(\theta))$$

Figure 14: Willingness to Pay with Median Liquid Assets and Constant Loss Probability



Source: Medical Expenditure Panel Survey (Cohen and Uberoi 2013).
Explanation: Wealth equals net worth (assets less liabilities), including net housing wealth.

is the average cost of the most costly $1-\theta$ share of the population, and $F(\theta) = \theta$. Clearly, $\Gamma(\theta)$ is still increasing in θ as before.

Correspondingly, we can capture the consumers' willingness to pay for insurance for those individuals who are located at the θ-quantile of the cost distribution. Formally, for each quantile θ, let $\Omega(\theta)$ be given by the highest value of Ω such that

$$u(w(\theta) - \Omega; \theta) = \sum_{s=1}^{S} \pi_s(\theta) u(w(\theta) - l_s(\theta); \theta).$$

Note that we can allow for both wealth levels $w(\theta)$ and preferences (notably risk-aversion) $u(c;\theta)$ to vary across quantiles of the cost distribution; for instance, higher expected cost individuals may on average be wealthier (since older) or more risk-averse (they see the doctor more often).

As long as $\Omega(\theta)$ remains increasing — and, hence, higher expected cost individuals on average have a higher willingness to pay for insurance — our entire analysis from before is maintained: a competitive equilibrium corresponds to a quantile θ where $\Gamma(\theta) = \Omega(\theta)$.

We can also employ the same graphical approach as before, the only difference being that the π-axis turns into an θ-axis of quantiles of the cost distribution. At an equilibrium with critical quantile θ^*, the share of the population purchasing insurance is given by $1-\theta^*$, and so $1-\theta$ can also be interpreted as quantity of insurance as in Einav et al. (2010).

Figure 14 shows the empirical evidence from the Medical Expenditure Survey Panel and the Survey of Consumer finances where the probability of loss π is fixed (at 0.3) but the size of loss $l_s(\theta)$ is now allowed to vary across the types. As before, the horizontal axis corresponds to the top X% percent of spenders, where X (the "rank") is the shown value. Now, however, the variation in spending comes from differences in loss amounts rather than probabilities. (Given the fixed value of π, a recursive algorithm parallel to that discussed in the text is used to impute the losses across the different values of X%.) As before, the relatively small value of $\alpha = 1$ leads to unraveling. However, both the in-between and large values of α lead to multiple stable equilibria: one at first intersection of willingness-to-pay and average cost lines and a second at the corner case where $X = 5$, where the willingness-to-pay is below the average cost. The driving force is, again, limited liability. As X% gets small, the value of losses must grow in order to match spending levels in the MEPS. As a result, the willingness to pay is capped for a wider range of types at smaller values of X% corresponding to larger losses. Increasing the level of risk aversion, therefore, has very little impact on the demand for insurance in this range.