The Two Margin Problem in Insurance Markets*

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Abstract

Insurance markets often feature consumer sorting along both an extensive margin (whether to buy) and an intensive margin (which plan to buy). We present a new graphical theoretical framework that extends a workhorse model to incorporate both selection margins simultaneously. A key insight from our framework is that policies aimed at addressing one margin of selection often involve an economically meaningful trade-off on the other margin in terms of prices, enrollment, and welfare. Using data from Massachusetts, we illustrate these trade-offs in an empirical sufficient statistics approach that is tightly linked to the graphical framework we develop.

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1 Introduction

Some of the most important problems in health insurance markets stem from adverse selection, or the tendency of sicker consumers to exhibit higher demand for insurance. Concerns about adverse selection have motivated a variety of regulatory interventions in the U.S. and around the world, including insurance mandates, penalties for being uninsured, subsidies for purchasing insurance, risk adjustment transfers, benefit regulation, and reinsurance. Policy discussions about how to address adverse selection have become salient in the U.S. as many public programs have shifted toward providing health insurance via regulated markets (Gruber, 2017).

But, a deeper look reveals that not all policies combating adverse selection are targeted at the same problem. Policies such as mandates and subsidies combat selection on the *extensive margin* (or "against the market"). This type of selection is characterized by sicker people being more likely to buy insurance. It leads to higher insurer costs and higher consumer prices and causes some healthy people to opt out. Policies such as risk adjustment and benefit regulation, on the other hand, combat selection on the *intensive margin* (or "within the market"). This type of selection is characterized by sicker people being more likely to purchase more generous plans within the market. Intensive margin selection drives up the price of generous plans relative to skimpy ones and results in too many consumers choosing skimpy plans. In some cases, selection within the market may be so strong that generous contracts cannot be sustained, and the market for them unravels entirely (Cutler and Reber, 1998).

Prior work has recognized these two problems and has studied policies targeted at each. However, this literature has largely considered these two forms of selection in isolation—either assuming all consumers buy insurance and focusing on the intensive margin (e.g., Handel, Hendel and Whinston, 2015), or assuming all contracts within the market are identical and focusing on the extensive margin (e.g., Hackmann, Kolstad and Kowalski, 2015). By ignoring one margin or the other, the selection problem is usefully simplified. In empirical work, it becomes amenable to a sufficient statistics approach based on demand and cost curves defined in reference to a single price—either the price of insurance or the price difference between a generous vs. a skimpy plan (Einav, Finkelstein and Cullen, 2010). However, this simplification does not allow for potential *interactions* between these two margins of selection.

In this paper, we generalize the canonical insurance market framework to address both margins simultaneously. The benefit of doing so is not merely a technical curiosity. It has first-order policy importance in settings like the ACA Marketplaces where both the generosity of coverage and rates of uninsurance are serious concerns. To see why, consider an insurance mandate—a policy that aims to correct extensive margin selection by bringing healthy marginal consumers into the market. Our framework shows how a mandate that succeeds in increasing rates of insurance coverage will likely *worsen* selection on the intensive margin. Intuitively, the mandate brings more healthy/low-cost consumers into the market. Because these new consumers tend to select the lower-price (and lower-quality) plans, the risk pools of those plans will get even healthier. In equilibrium, these plans will further reduce prices, siphoning additional consumers away from higher-quality plans on the intensive margin, causing prices for high-quality coverage to spiral upwards. These two offsetting effects (improving take-up and inducing within-market unraveling) represent a clear example of the intensive/extensive margin interactions that are the focus of our paper.[1]

One of our main contributions is to provide a *graphical* demand-cost framework that lets economists visualize (and teach) the two-margin selection problem in a transparent way. To do so, we build on the influential work of Einav, Finkelstein and Cullen (2010) and Einav and Finkelstein (2011), who show how to visualize selection markets in terms of demand, average cost, and marginal cost curves. We generalize their model to allow for two plans—a more generous H plan and a less generous L plan—plus an outside option of uninsurance (U). Although stylized, our vertical model captures the core intuition of the two selection margins: an intensive margin difference in generosity (H vs. L) and an extensive margin option to exit the market (by choosing U). It also captures the key feature of adverse selection: that higher-risk consumers have greater willingness to pay for generous coverage—both for H relative to L, and for L relative to U. Our vertical model is the simplest framework that captures these features, and is useful for developing intuition around a potentially multi-dimensional problem by allowing the market to be represented in standard two-dimensional graphs with familiar demand and cost curves. Equilibrium prices, market shares, and social surplus can all be easily visualized. We also show the extent to which the core

[1] Recent theoretical insights from Azevedo and Gottlieb (2017) and empirical findings from Saltzman (2017) indicate that this is an important omission in contexts like the ACA Marketplaces. We similarly find that these interactions are first-order for plan choices and welfare.

intuitions hold as various assumptions on the model are relaxed, including, for example, allowing for horizontal differentiation across plans.

As in Einav, Finkelstein and Cullen (2010), there is a tight link between our model and the estimation of sufficient statistics used to characterize equilibrium and welfare. Econometric identification is analogous, though exogenous price variation along two margins is required—for example, independent variation in the price of a skimpy plan and in the price of a generous plan.[2]

After developing the graphical framework, we use it to show how policies and regulatory actions that counteract selection on one margin can interact with the other. The relevance of these "cross-margin" interactions is the key conceptual take-away of our paper. We show that a mandate's impact on plan generosity is, in fact, an instance of a broader phenomenon that encapsulates many relevant policy interventions currently in place in insurance markets. These include plan benefits requirements, network adequacy rules, risk adjustment, reinsurance, subsidies, and behavioral interventions like plan choice architectures or auto-enrollment. Each involves a potential trade-off. Policies that aim to address intensive margin selection tend to worsen extensive margin selection, and vice-versa.

The graphical model helps show why these cross-margin interactions occur. The key insight is that for each plan, either its demand or average cost curve is not a price-invariant model primitive (as is true in a two-option model) but an *equilibrium object* that depends on the other plan's price. Policies that target one selection margin typically influence market prices (e.g., the mandate lowers P_L relative to P_H), which in turn shifts demand or cost curves that determine the other margin (e.g., the lower P_L reduces demand for H). This cross-plan dependence of demand and average costs is the key missing piece when the two margins are analyzed separately. We show how the geometry of the demand/cost curves generates this dependence. We also develop a more general non-graphical version of our model that allows for horizontal differentiation and use it to show that many of the key intuitions will hold with a modest amount of horizontal differentiation (i.e. consumers on the margin between H and U).

With the intuition and price theory in place, we analyze the model's insights empirically using demand and cost estimates from Massachusetts' CommCare program, a subsidized insurance exchange that was

[2] Or alternatively, variation in a market-wide subsidy for selecting any plan and independent variation in the price difference between bare bones and generous plans.

a precursor to the state's ACA health insurance Marketplace. We draw on demand and cost estimates from Finkelstein, Hendren and Shepard (2019) to simulate equilibrium in counterfactuals where we vary benefit design rules, mandate penalties, and risk adjustment strength.[3] Beyond demonstrating how our framework can be used, the empirical exercise generates several policy insights. The size of the unintended cross margin effects can be quite large. We find that a strong mandate sufficient to move all consumers into insurance—increasing enrollment by around 25 percentage points—can reduce the market share of generous plans by more than 15 percentage points, or 35% of baseline market share. In the other direction, strengthening risk adjustment transfers until the market "upravels" to include only generous coverage can substantially reduce market-level consumer participation—in our setting by as much as 15 percentage points or 60% of the baseline uninsurance rate. With the additional assumption that consumer choices reveal plan valuations, we find that the cross-margin welfare impacts can be similarly large (and often first-order).

Further, we show that in some settings, cross-margin interactions are critical for determining optimal policy. When intensive margin policies (such as risk adjustment) are weak, it can be optimal to also have weak extensive margin policies (such as an uninsurance penalty). But when intensive margin policies are strong, on the other hand, it can be optimal to also have strong extensive margin policies. These results show that in these markets, regulators are operating in a world of the second-best and must consider interactions between the two margins of selection in order to determine constrained optimal policy. This is true whether optimality is viewed from a formal social surplus perspective or reflects a political preference over rates of insurance coverage on the one hand and insurance quality on the other. While we stop short of prescribing *the* optimal policy in a given market, our results indicate that when extensive margin policies become stronger, intensive margin policies should often strengthen (and vice versa).

Our paper contributes to a growing literature on adverse selection in health insurance markets. Our main contribution is to provide a graphical model that unites two key strands of this literature. The first strand focuses on extensive margin selection and stems from the seminal work of Akerlof (1970).[4] The

[3] Finkelstein, Hendren and Shepard (2019) use a regression discountinuity design to document significant adverse selection both into the market and within the market between a narrow-network, lower-quality option and a set of wider-network, higher-quality plans.

[4] Recent theoretical advances in this strand include Hendren (2013) and Mahoney and Weyl (2017) and empirical applica-

second strand focuses on intensive margin selection, studying either consumer sorting across a fixed set of contracts within a market[5] or how consumer selection is endogenously reflected in the characteristics of the contracts offered.[6]

The most directly connected work is a prior theoretical contribution by Azevedo and Gottlieb (2017) that points out the potential cross-margin effects of a mandate in a setting with vertically differentiated contracts that differ in their coinsurance rates. Our framework maintains the vertical assumption of Azevedo and Gottlieb (2017) while allowing differentiation to be more flexible (i.e. based on factors other than cost-sharing) in a two-contract setting. Similar to Azevedo and Gottlieb (2017), our paper also takes a step toward bridging the gap between the Akerlof (1970) and Einav, Finkelstein and Cullen (2010) fixed-contracts approach and the Rothschild and Stiglitz (1976) endogenous-contracts approach to modeling adverse selection in insurance markets by allowing some contracts to death spiral out of existence in equilibrium while others remain available. This possibility that policies can affect which contracts are ultimately offered in equilibrium is a key feature of our model that was originally highlighted by Rothschild and Stiglitz (1976) but that is generally overlooked by the Einav, Finkelstein and Cullen (2010) workhorse model. Finally, Saltzman (2017) provides a complementary analysis (concurrent with ours) that investigates cross-margin effects using a structural model estimated with ACA data from California.

Our insights about cross-margin interactions are relevant for active policy debates in the ACA and other insurance settings. For example, recently states have been given increasing flexibility to weaken ACA Essential Health Benefits or risk adjustment transfers (intensive margin policies)—with the stated goal being to lower plan prices and reduce uninsurance (a cross-margin effect). On the other hand, state efforts to simplify enrollment (Domurat, Menashe and Yin, 2018) or enact mandate penalties (all extensive margin policies) may create unintended consequences on the intensive margin. More broadly, our model is also relevant to other settings with two selection margins, including the Medicare program (with its Medicare Advantage option), employer programs with a plan choice decision and a participation decision

tions by Bundorf, Levin and Mahoney (2012), Hackmann, Kolstad and Kowalski (2015), Tebaldi (2017), and others.

[5]See e.g., Handel, Hendel and Whinston (2015); Shepard (2016)

[6]See e.g., Glazer and McGuire (2000); Veiga and Weyl (2016); Carey (2017); Lavetti and Simon (2018); Geruso, Layton and Prinz (2019). Geruso and Layton (2017) provides an overview comparing the fixed- and endogenous-contracts approaches to modeling intensive margin selection.

(e.g., CalPERS), national health insurance systems with an opt-out (e.g., Germany), and other selection markets with both an extensive and intensive margin choice.

The rest of the paper is organized as follows. Section 2 presents the graphical vertical model. Section 3 applies the model to show two-margin impacts of various policies. Sections 4-6 apply the model with simulations: section 4 discusses methods; section 5 shows price and enrollment results; and section 6 shows welfare results. Section 7 concludes.

2 Model

Our goal in this section is to develop a theoretical and graphical model that depicts insurance market equilibrium and welfare in the spirit of Einav, Finkelstein and Cullen (2010) ("EFC"), while allowing for the possibility that interventions affecting selection on one margin may affect selection on another. This requires an insurance plan choice set with at least three options. Consider two fixed contracts, $j = \{H, L\}$, where H is more generous than L on some metric, and an outside option, U. In the focal application of our model to the ACA's individual markets, U represents uninsurance.

Each plan $j \in \{H, L\}$ sets a single community-rated price P_j that (along with any risk adjustment transfers—see below) must cover its costs. Consumers make choices based on these prices and on the price of the outside option, $P_U = M$.[7] In our focal example, M is a mandate penalty. The distinguishing feature of U is that its price is exogenously determined; it does not adjust based on the consumers who select into it. This is natural for the case where U is uninsurance or a public plan like Traditional Medicare.[8] $P = \{P_H, P_L, P_U\}$ is the vector of prices in the market.

In the most general formulation, demand in this market cannot be easily depicted in two-dimensional figures. To make the cross-margin effects of interest clearer, we impose a *vertical model* of demand, which assumes contracts are identically preference-ranked across consumers. Although the strict vertical assumption is not necessary for many of our main insights to hold, it captures the key features of the issues raised by simultaneous selection on two margins in a simple way that allows for graphical representation. In

[7] Below, we allow that consumers may receive a subsidy, S, so that choices are based on post-subsidy prices, $P_j^{cons} = P_j - S$.
[8] We adapt the model to the case of Medicare in Appendix B.2.

the next subsections, we present the vertical model, then add the cost curves, and finally show how to find equilibrium and welfare. Throughout the paper, we discuss the implications of relaxing the vertical demand assumption for our findings.

2.1 Demand

The model's demand primitives are consumers' willingness-to-pay (WTP) for each plan. Let $W_{i,H}$ be WTP of consumer i for plan H, and $W_{i,L}$ be WTP for L, both defined as WTP relative to U ($W_{i,U} \equiv 0$). We make the following two assumptions on demand:

Assumption 1. *Vertical ranking:* $W_{i,H} > W_{i,L}$ *for all* i

Assumption 2. *Single dimension of WTP heterogeneity: There is a single index* $s \sim U[0,1]$ *that orders consumers based on declining WTP, such that* $W'_L(s) < 0$ *and* $W'_H(s) - W'_L(s) < 0$ *for all* s.

These assumptions, which are a slight generalization of the textbook vertical model,[9] involve two substantive restrictions on the nature of demand. First, the products are vertically ranked: all consumers would choose H over L if their prices were equal and would similarly prefer L to U if their prices were equal.[10] This is a statement about the *type of setting* to which our model applies. The vertical model applies best when plan rankings are clear—e.g., a low- vs. high-deductible plan, or a narrow vs. complete provider network plan. Importantly, these are precisely the settings where intensive margin risk selection is most relevant. When plans are horizontally differentiated (such as in the Covered California market; see Tebaldi, 2017), it is less likely that high-risk consumers will heavily select into a single plan or type of plan. In such cases, the existing EFC framework can capture the main way risk selection matters: in vs. out of the market (the extensive margin). Our model is designed to study the additional issues that arise when *both* intensive and extensive margins matter simultaneously. [11]

[9] Our vertical model follows the format of Finkelstein, Hendren and Shepard (2019). It is a generalization of the textbook vertical model in which products differ on quality (Q_j) and consumers differ on taste for quality (β_i), so that WTP equals: $W_{i,j} = \beta_i Q_j$ and utility equals $U_{i,j} = W_{i,j} - P_j = \beta_i Q_j - P_j$.

[10] See Appendix B.2 for an alternative case where the outside option is preferred to H and L.

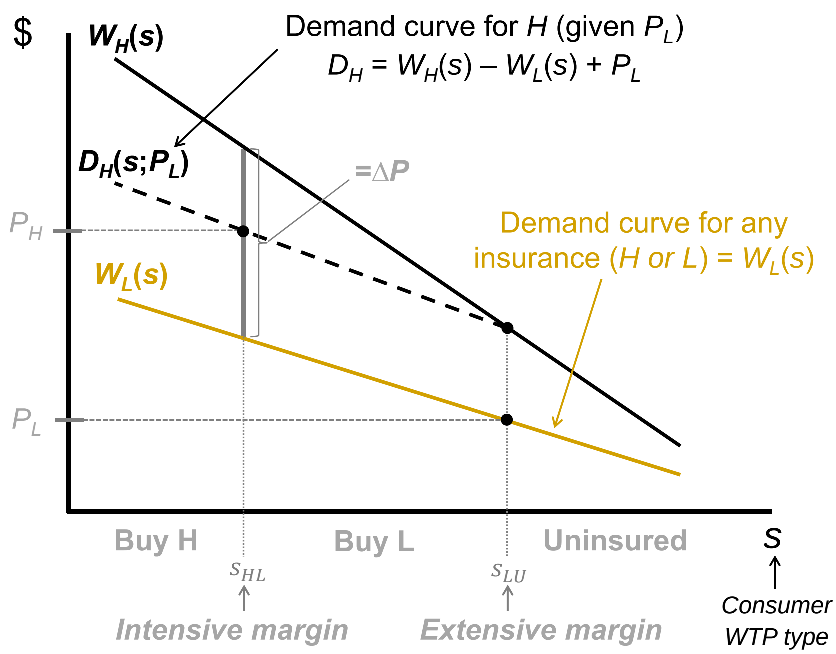
[11] Even in settings without apparent vertical differentiation across plans within the market, our model can be useful in assessing counterfactual policies that might generate this type of differentiation. In particular, our examples below imply that a regulator encouraging vertically differentiated entrants may generate unintended cross-margin effects on the rates of uninsurance.Further, an apparent lack of vertical differentiation may itself be an equilibrium outcome in a vertical model, reflecting a situation where generous coverage has already unraveled.

Second, consumers' WTP for H and L—which in general could vary arbitrarily over two dimensions—are assumed to collapse to a single-dimensional index, $s \in [0, 1]$. Higher s types have both lower W_L *and* a smaller gap between W_H and W_L. Lower s types both care more about having insurance (L vs. U) and more about the generosity of coverage (H vs. L). This assumption is a natural approximation that captures the primary pattern of selection in many cases; indeed it holds exactly in a model where plans differ purely in their coinsurance rate (see, e.g., Azevedo and Gottlieb, 2017). Substantively, Assumption 2 restricts consumer *sorting and substitution patterns* among options when prices change. The primary consequence of this assumption is that consumers are only on the margin between adjacent-generosity options–between H and L or between L and U. No consumer is on the margin between H and U, so if the price of U (the mandate penalty) increases modestly, the newly insured all buy L (the cheaper plan), not H. This restriction captures in a strong way the general (and testable) idea that these are the *main* ways consumers substitute in response to price changes. With this restriction in place (and under a price vector at which all options are chosen), consumers sort into plans with the highest-WTP types choosing H, intermediate types choosing L, and low types choosing U. We show that weakening this assumption—allowing an H-U margin—does not change the key implications of the model as long as most consumers exhibit vertical preferences. We describe a more general (non-graphical) model in Appendix A that allows for both horizontal and vertical differentiation. As we describe below, horizontal differentiation tends to dampen the cross-margin effects we study. Throughout, we provide supplementary (theoretical and empirical) results that show the extent to which the relative degree of horizontal differentiation impacts our main results.

Figure 1 plots a simple linear example of $W_H(s)$ and $W_L(s)$ curves that satisfy these assumptions. The x-axis is the WTP index s, so WTP declines from left to right as usual. Let $s_{LU}(P)$ be the extensive-marginal type who is indifferent between L and U at a given set of prices P. Assuming for now that $P_U \equiv M = 0$, this cutoff type is defined by the intersection of L's WTP curve W_L and L's price, where $W_L(s_{LU}) = P_L$. Consumers to the right of s_{LU} go uninsured. Those to the left buy insurance. Therefore, $W_L(s)$ represents the *(inverse) demand curve for any formal insurance* (H or L). [12]

[12] In the more general case where consumers receive subsidies for purchasing insurance or pay a penalty when choosing U, $W_L(s)$ and the (inverse) demand curve for insurance will diverge. Specifically, $D_L(s) = W_L(s) + S + M$. For simplicity,

Figure 1: Demand and Consumer Sorting under Vertical Model



Notes: The graph shows demand and consumer sorting under the vertical model. $W_H(s)$ and $W_L(s)$ are willingness to pay for the H and L plans. $D_H(s; P_L)$ is the demand curve for H (as a function of P_H), which depends on the value of P_L. See the body text for additional description.

Let $s_{HL}(P)$ be the intensive-marginal type who is just indifferent between H and L. This cutoff type is defined by:

$$\Delta W_{HL}(s_{HL}) \equiv W_H(s_{HL}) - W_L(s_{HL}) = P_H - P_L \tag{1}$$

Consumers to the left of s_{HL} buy H because their incremental WTP for H over L—which we label ΔW_{HL}—exceeds the incremental price. With demand for H and for $H + L$ thus determined by these cutoffs, demand for L equals the difference between the two.[13]

Rearranging equation (1) yields the (inverse) demand for H, given a fixed P_L:

$$D_H(s; P_L) \equiv W_H(s) - W_L(s) + P_L \tag{2}$$

we ignore the subsidy and penalty terms here but fully incorporate consumer subsidies when we use the model to study the effects of common policies (Section 3) as well as in the empirical exercise (Section 5).

[13]Formally, the demand functions for the general case where $M \neq 0$ are defined by the following equations, where $\Delta P \equiv P_H - P_L$: $D_H(P) = s_{HL}(\Delta P)$; $D_L(P) = s_{LU}(P_L - M) - s_{HL}(\Delta P)$; $D_U(P) = 1 - s_{LU}(P_L - M)$.

Figure 1 shows $D_H(s; P_L)$ with a dashed line. One can draw D_H by noting that it intersects the W_H curve at the cutoff type s_{LU} (since $W_L(s_{LU}) = P_L$).[14] It then proceeds leftward at a slope equal to that of ΔW_{HL}, and its intersection with P_H determines s_{HL}. $D_H(s; P_L)$ is flatter than W_H because its slope equals that of $\Delta W_{HL}(s)$.

Most importantly, $D_H(s; P_L)$ is not a pure primitive that could be identified off of exogenous price variation, but instead depends on both WTP primitives (W_H, W_L) and, critically, on P_L. Because demand for H depends on the price of L, policies targeted at altering the allocation of consumers on the extensive margin of insurance/uninsurance can affect the sorting of consumers across the intensive H/L margin if these policies affect the price of L. The dependency of demand for H on the price of L generates an interaction between the intensive and extensive margins, a key theme of this paper.

2.2 Costs

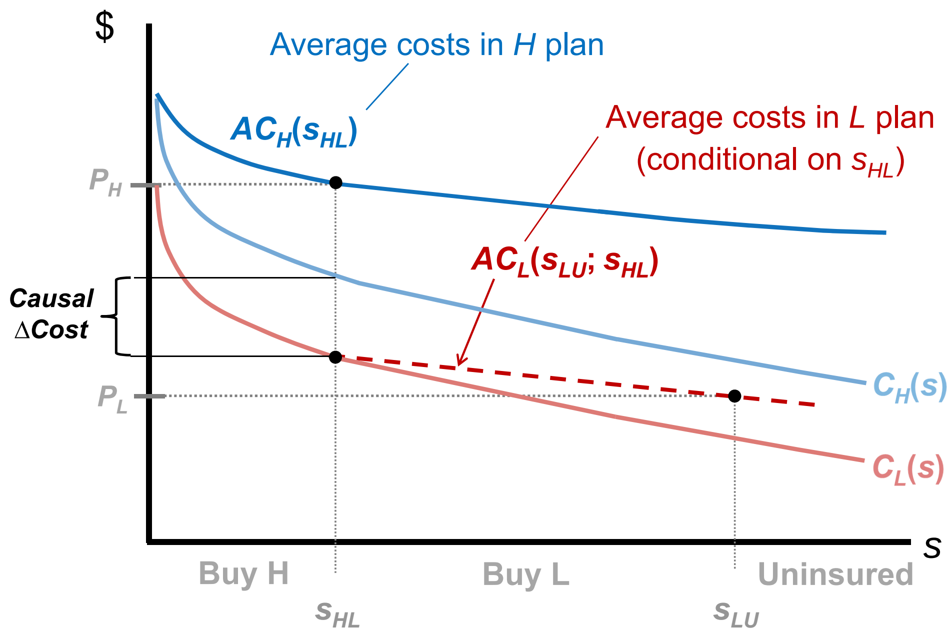
The model's cost primitives are expected insurer costs for consumers of type s in each plan j.[15] These "type-specific costs" are defined as: $C_j(s) = E[C_{ij} \mid s_i = s]$. $C_j(s)$ is analogous to "marginal cost" in the EFC model—so called because it refers to consumers on the margin of purchasing at a given price. However, to avoid confusion in our model where there are two purchasing margins, we refer to $C_j(s)$ as type-specific costs, or simply costs. In addition, we define $C_U(s)$ as the expected costs of uncompensated care of type-s consumers if they were uninsured. Along with adverse selection, external uncompensated care costs motivate subsidy and mandate policies.

Plan-specific average costs are defined as the average of $C_j(s)$ for all types who buy plan j at a given set of prices: $AC_j(P) = \frac{1}{D_j(P)} \int_{s \in D_j(P)} C_j(s) ds$, where (abusing notation slightly) $s \in D_j(P)$ refers to s-types who buy plan j at prices P.

[14] D_H is not defined to the right of s_{LU}, since if P_H falls further than its level at this point, nobody buys L. As a result, the demand curve for H thereafter equals $W_H(s)$.

[15] A key insight of the EFC model is that—while costs may vary widely across consumers of a given WTP type—it is sufficient for welfare to consider the cost of the *typical* consumer of each type. The reason is that with community rated pricing, consumers sort into plans based only on WTP. There is no way to segregate consumers more finely than WTP type, and since insurers are risk-neutral, only the expected cost within type matters. We note, however, that this argument breaks down when leaving the world of community rated prices, as pointed out by Bundorf, Levin and Mahoney (2012), Geruso (2017), and Layton et al. (2017). Our model (like the model of EFC) thus cannot be used to assess the welfare consequences of policies that allow for consumer risk-rating.

Figure 2: Cost Curves under Vertical Model



Notes: The graph shows the cost curves for H and L plans under the vertical model. $C_H(s)$ and $C_L(s)$ are the consumer type-s specific costs. $AC_H(s_{HL})$ and $AC_L(s_{LU}; s_{HL})$ are the average cost curves for H and L given that the intensive margin type is s_{HL} and the extensive margin type is s_{LU}. Adverse selection makes the price difference $P_H - P_L$ larger than the causal cost difference.

We illustrate the construction of these cost curves in Figure 2. We show a case where cost curves C_H and C_L are downward sloping, indicating adverse selection. The gap between the two curves for a given s-type equals the difference in plan spending if the s-type consumer enrolls in H vs. L. We refer to this as the "causal" plan effect, since it reflects the true difference in insurer spending for a given set of people.[16]

We start by deriving $AC_H(P)$, the average cost curve for the H plan. To avoid ambiguity later, it is helpful to redefine the argument of AC_H as the marginal type that buys H at price P, $s_{HL}(P)$. We use this notation in Figure 2. AC_H integrates over individual costs (C_H) from the left: For $s_{HL} = 0$, the only consumers enrolled in H are the very sickest consumers. For these consumers, $s = 0$, implying that $AC_H(s_{HL} = 0) = C_H(s = 0)$. Then, as s_{HL} increases, moving right along the horizontal axis, H includes more relatively healthy consumers, resulting in a downward sloping average cost curve. Eventu-

[16] As in EFC, the causal plan effect reflects both a difference in coverage (e.g., lower cost sharing) conditional on behavior, and any behavioral effect (or moral hazard) of the plans.

ally, when $s_{HL} = 1$ and all consumers are enrolled in H, $AC_H(s_{HL} = 1)$ is equal to the average cost in H across *all* consumers. Because H only has one marginal consumer type (the intensive margin), the derivation of $AC_H(s_{HL})$ is identical to that of the average cost curve in EFC. For each value of s_{HL}, there is only one possible value of AC_H. This implies that the curve can be calculated directly from a market primitive (by integrating over $C_H(s)$) and is not an equilibrium object.

The average cost curve for L, on the other hand, is more complicated because it is an average over a range of consumers, $s \in [s_{HL}, s_{LU}]$, with two endogenous margins. For each value of s_{LU} that defines sorting between U and L, there are many possible values of AC_L, depending on consumer sorting between H and L. This fact makes it impossible to plot a single fixed AC_L curve as we did with AC_H. Nonetheless, it is possible to plot $AC_L(s_{LU})$ *conditional* on $s_{HL}(P)$. We denote this curve $AC_L(s_{LU}; s_{HL})$ and illustrate it with a dashed line in Figure 2. There are many such iso-s_{HL} plots of AC_L (not pictured) that hold P_H fixed at various levels. The leftmost point of the AC_L curve depends on the s_{HL} cutoff type determined by P_H. Higher values of s_{HL} imply that $AC_L(s_{LU}; s_{HL})$ starts from a higher point. Just as AC_H equals C_H at $s = 0$, AC_L equals C_L at $s = s_{HL}$. Moving rightward from $s = s_{HL}$, plan L adds more relatively healthy consumers, resulting in a downward sloping average cost curve.

In summary, while AC_H is fixed and does not depend on the price of L, AC_L is an equilibrium object in that it changes as P_H, and therefore s_{HL}, changes. This implies that the average cost of L and thus the price of L in equilibrium depends on the price of H. Recognizing such dependencies is critical for analyzing policy interventions. For example, a subsidy targeted to H that results in a lower (net) P_H and a larger H enrollment (a rightward-shifted s_{HL}) would cause the leftmost point on AC_L to shift down and rightward and would cause the curve to have a less-steep slope. In a competitive market, this would likely result in a lower P_L, causing additional consumers to enter the market.

2.3 Competitive Equilibrium

We consider competitive equilibria where plan prices, P, exactly equal their average costs:

$$P_H = AC_H(P) \qquad \text{and} \qquad P_L = AC_L(P) \tag{3}$$

In some settings, there will be multiple price vectors that satisfy this definition of equilibrium, including vectors that result in no enrollment in one of the plans or no enrollment in either plan. Because of this, we follow Handel, Hendel and Whinston (2015) and limit attention to equilibria that meet the requirements of the Riley Equilibrium (RE) notion. A policy satisfies the Riley equilibrium refinement if there exists no "Riley Deviation policy," a competing policy that if offered, would earn a profit, render the old policy unprofitable, and for which there is no "safe response" that would render the Riley Deviation unprofitable. A safe response is a policy offering that does not incur a loss when offered with the other existing policies in the market and renders the potential Riley Deviation unprofitable. When we apply these requirements in our simulations, we find a unique equilibrium for all empirical settings that we simulate.[17]

Perfect competition is of course an approximation that will be imperfect in many relevant markets. We maintain this assumption, consistent with much prior work, to simplify the problem and provide a benchmark for thinking about cross-margin interactions.[18]

With the outside option of uninsurance, the equilibration process for the prices of H and L differs somewhat from the more familiar settings explored by EFC and Handel, Hendel and Whinston (2015). In those settings, it is assumed that all consumers choose either H or L. Assuming full insurance conveniently simplifies the equilibrium condition from two expressions to one: Namely, that the differential average cost must be set equal to the differential price.

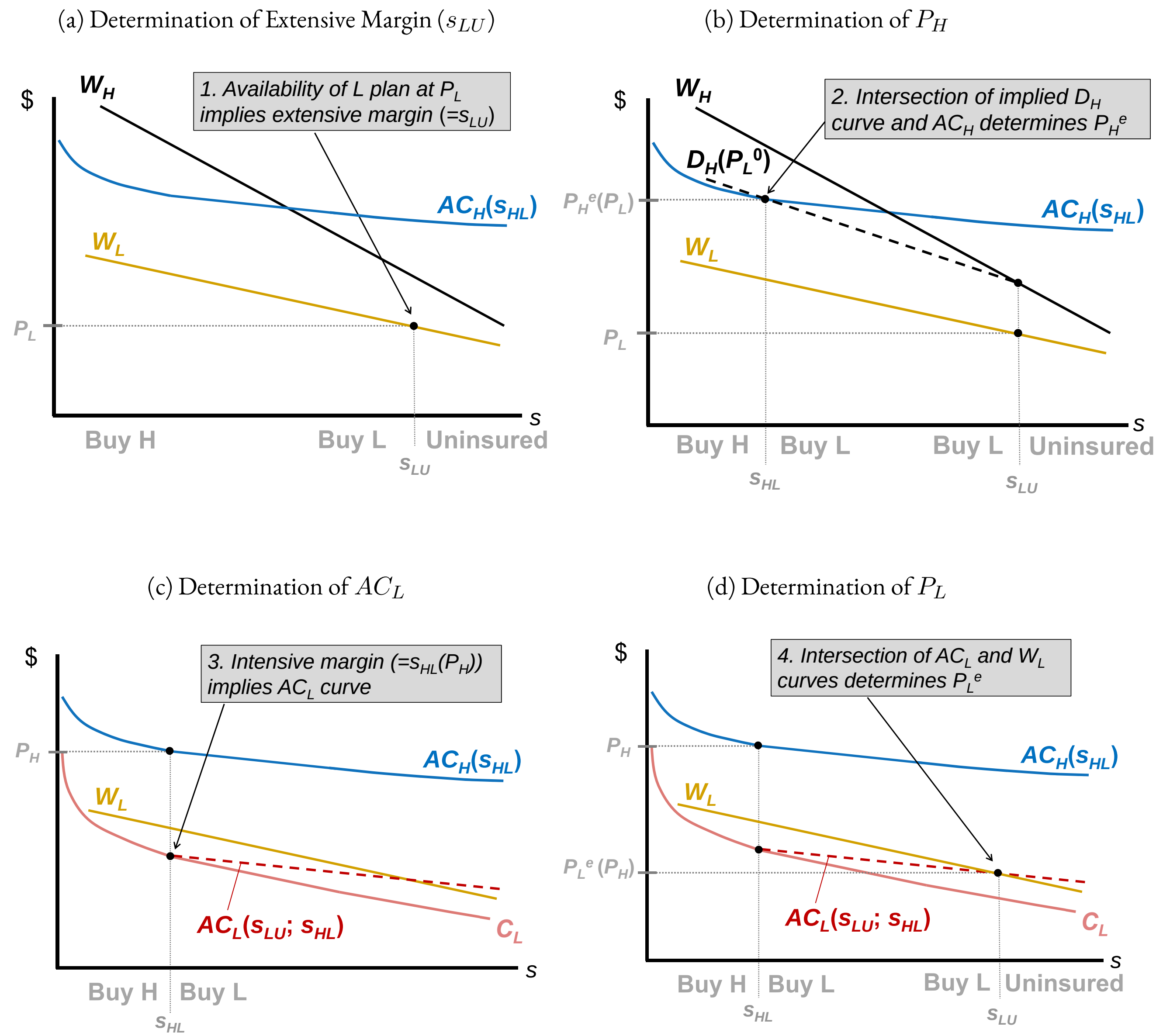
To provide intuition for equilibrium in our setting, we build up from the classic case in EFC, which includes only H and U as plan options.[19] The EFC equilibrium can be seen in Panel (a) of Figure 3, if one ignores the W_L curve. It is defined by the intersection of W_H and AC_H, which determines the competitive equilibrium price. Absent an L plan, any s-type whose WTP for H exceeds the price of H will buy H and all other s-types will opt to remain uninsured.

[17] A detailed discussion of these requirements and an algorithm for empirically identifying the RE are provided in Appendices C.3 and C.4, respectively.

[18] If there is free entry into *both* the H and the L contracts, prices will equal average costs in equilibrium, and there will be no cross-subsidization across the H and L contracts within a single firm. See proofs in Appendix A of Handel, Hendel and Whinston (2015) and Azevedo and Gottlieb (2017). The intuition is that in such a setting, if one firm tried to cross-subsidize the adversely selected H contract with the L contract, another firm would enter the market and provide only the L contract at a lower price, with no need to cross-subsidize. This intuition would work less well in settings with a single fixed cost of firm entry, regardless of how many plans are offered.

[19] The correct analogy from EFC to our framework is a choice between H and U (rather than H and L) because the key feature of U is that its price is exogenously determined, like the lower coverage option in the EFC setting.

Figure 3: Determination of Equilibrium with H, L, and Outside Option



Notes: Figures show how competitive equilibrium is determined in the vertical model with H and L plans and an outside option (uninsured). Panels (a) and (b) show the determination of $P_H(P_L)$: a value of P_L implies the extensive margin (s_{LU}), which in turn implies the demand curve for H and the equilibrium P_H. Panels (c) and (d) show the determination of $P_L(P_H)$: a value of P_H implies the intensive margin (s_{HL}), which implies AC_L and the equilibrium value of P_L.

We next add L to the EFC choice set. To illustrate the equilibrium, we proceed in four steps, corresponding to the four panels in Figure 3. Panels (a) and (b) show how P_H is determined, given a fixed price of L. Panel (a) shows that the fixed P_L implies a given extensive margin cutoff, s_{LU}. Panel (b) shows that this in turn implies an H plan demand curve, $D_H(P_L)$ (in dashed black). The intersection of $D_H(P_L)$

with H's average cost curve determines P_H and the intensive margin cutoff s_{HL}. This process determines the reaction function $P_H^e(P_L)$, which is the break-even price of H for a given price of L.

Panels (c)-(d) of Figure 3 show how P_L is determined, given a fixed P_H. Panel (c) shows that the fixed P_H implies a given intensive margin cutoff (s_{HL}), which in turn fixes the AC_L curve. Panel (d) shows how the intersection of AC_L with W_L determines P_L and the extensive margin cutoff s_{LU}. This process determines the reaction function $P_L^e(P_H)$, which gives the break-even price of L for a given fixed price of H.

In equilibrium, the reaction functions must equal each other: $P_H = P_H^e(P_L)$ and $P_L = P_L^e(P_H)$. Figure 4 depicts the equilibrium, including the AC_L and D_H curves as dashed lines. These dashed lines are themselves equilibrium outcomes, even holding fixed consumer preferences and costs. In other words, there were many possible "iso-s_{HL}" AC_L curves and many possible "iso-P_L" D_H curves. The equilibrium vector of prices are the prices at which demand for L generates the equilibrium $D_H(P_L^e)$ *and* this demand for H simultaneously implies the equilibrium $AC_L(s_{HL})$ curve.

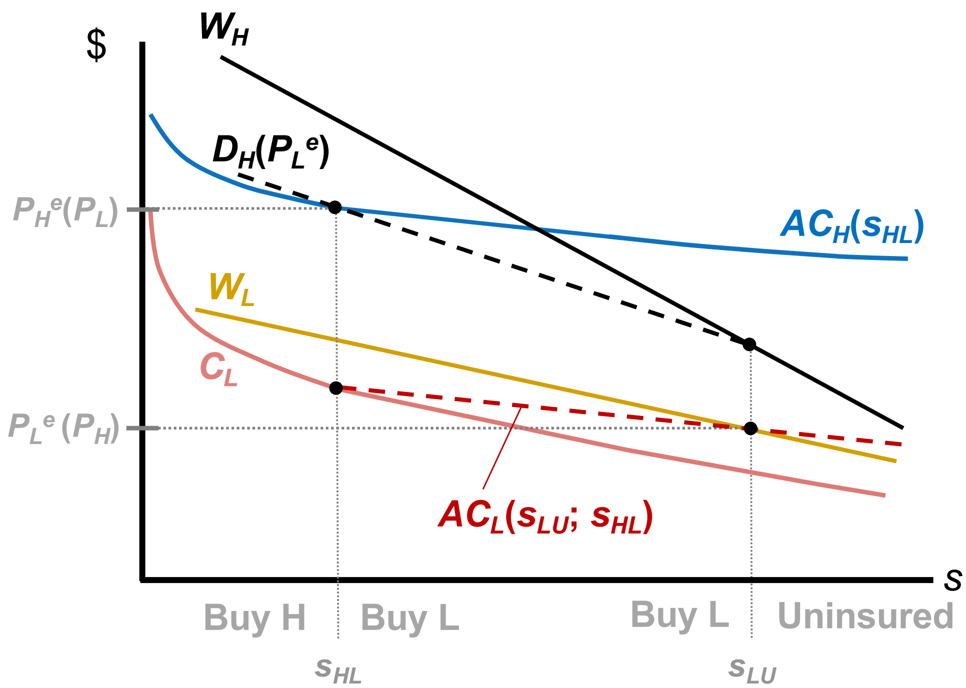
2.4 Social Welfare

We now show how our framework can be used to assess the welfare consequences of different policies. We define social welfare in the conventional way, as total social surplus (willingness-to-pay minus social resource cost). In order to make the figures simpler and more intuitive, we set C_U, the social cost of uninsurance, equal to zero. We nonetheless allow for a positive social cost of uninsurance in our empirical application below.

To build intuition, we start in Panel (a) of Figure 5 by illustrating the case where L is a pure cream-skimmer. That is, L has low average costs because it attracts low-cost individuals, but it has no causal effect on costs, so $C_L = C_H$ for any individual. For this case, given W_H, W_L, and $C_L = C_H$ we can find total social surplus for any allocation of consumers across plans described by the equilibrium cutoff values s_{HL}^e and s_{LU}^e.

Panel (a) of Figure 5 shows that social surplus consists of two pieces. The first piece ($ABHG$) is the social surplus for consumers purchasing H, given by the area between W_H and $C_L = C_H$ for consumers

Figure 4: Final Equilibrium



Notes: The graph shows the final equilibrium under the vertical model with two plans (H and L) and an outside option (U). The black dots mark the key intersections defining equilibrium prices and sorting. The intersection of AC_L and W_L determines P_L and the extensive margin type (s_{LU}). The D_H curve starts at this extensive margin (where it equals W_H), and its intersection with AC_H determines P_H and the intensive margin type (s_{HL}). This s_{HL} type marks the start of the AC_L curve (where it equals C_L).

with $s < s_{HL}$. The second piece ($EFIH$) is the social surplus for consumers purchasing L, given by the area between W_L and $C_L = C_H$ for consumers with $s \in [s_{HL}, s_{LU}]$. Panel (a) of Figure 5 also illustrates foregone surplus for the allocation of consumers across plans. Here, the foregone surplus consists of three components. The first is the foregone surplus due to the fact that consumers with $s \in [s_{HL}, s_{LU}]$ purchased L when they would have generated more surplus by purchasing H, and it is described by the area between W_H and W_L for these consumers ($BCFE$). The second component is the foregone surplus due to the fact that consumers with $s > s_{LU}$ did not purchase insurance when they would have generated positive surplus by purchasing H, and it is described by the area between W_H and $\max\{W_L, C_L\}$ ($CDJF$). We refer to these two components as "intensive margin loss". The third component is the foregone surplus due to the fact that consumers with $s \in [s_{LU}, s^*_{LU}]$ did not purchase insurance when they would have generated positive surplus by purchasing L, and it is described by the area between W_L

and C_L for those consumers.

The figure thus shows how our graphical framework can be used to estimate welfare for any allocation of consumers across H, L, and U. Further, the framework makes it easy to determine the optimal allocation of consumers between insurance and uninsurance and between H and L. In the case of the particular demand and cost primitives drawn in Panel (a), the optimal allocation of consumers across plans is for all consumers to be in H. If H were not available, however, the optimal allocation of consumers across L and U would consist of all consumers with $s < s^*_{LU}$ purchasing L and all other consumers remaining uninsured.

In Panel (b) of Figure 5, we apply our framework to the case where it is efficient for some consumers to be in L rather than in H and for others to remain uninsured. To do this, we change the assumption that L is a pure cream-skimmer and instead assume that costs in H are higher than in L for each consumer and that the cost gap is constant across consumers: $\Delta C_{HL}(s) \equiv C_H(s) - C_L(s) = \delta > 0$. Intuitively, in this scenario consumers prefer H because it provides more or better services—at a higher cost to the insurer. It is convenient to define a new curve $W_H^{Net}(s) = W_H(s) - \Delta C_{HL}(s)$, or WTP for H net of the incremental cost of H vs. L. Under the assumption that δ is constant, $W_H^{Net}(s)$ will be parallel to and below W_H. This is shown in Panel (b) of Figure 5: As L's cost advantage over H increases, W_H^{Net} shifts further down.[20]

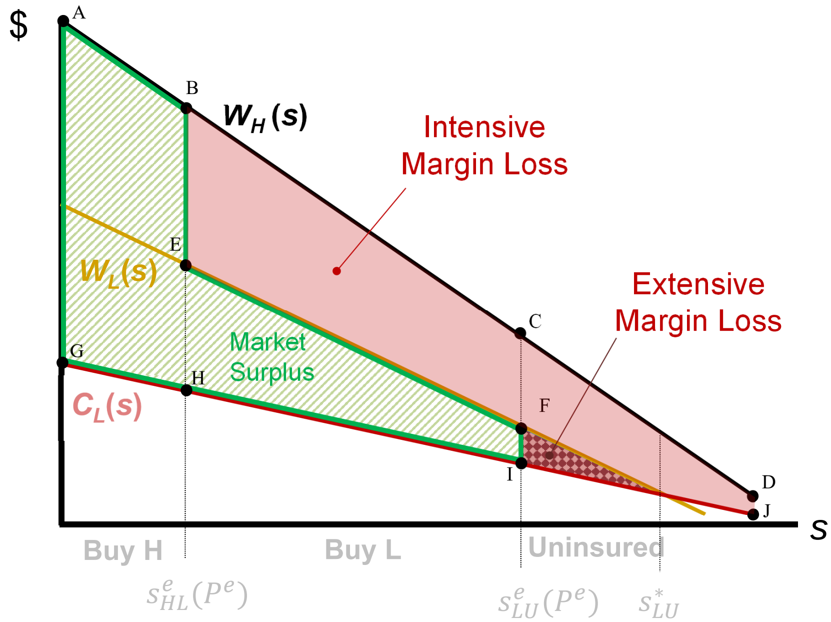
Given this new W_H^{Net} curve, social welfare is still fully characterized by the three curves, W_H^{Net}, W_L, and C_L, and social surplus and foregone surplus are defined in a similar manner to Panel (a). Social surplus still consists of two components. The first is the surplus generated by the consumers enrolled in H, and it is characterized by $ABHG$, the area between W_H^{Net} and C_L for consumers with $s < s_{HL}$.[21] This component is smaller than it was in Panel (a) due to the fact that now H has higher costs than L. In Panel (b) it is thus less socially advantageous for these consumers to be enrolled in H vs. L. The second component is the surplus generated by the consumers enrolled in L, and it is characterized exactly as before by $EFIH$, the area between W_L and C_L for consumers with $s^e_{HL} < s < s^e_{LU}$. Foregone surplus is illustrated in the

[20] Heterogeneity in L's cost advantage across s types could also be accommodated and would result in W_H^{Net} not being parallel to W_H.

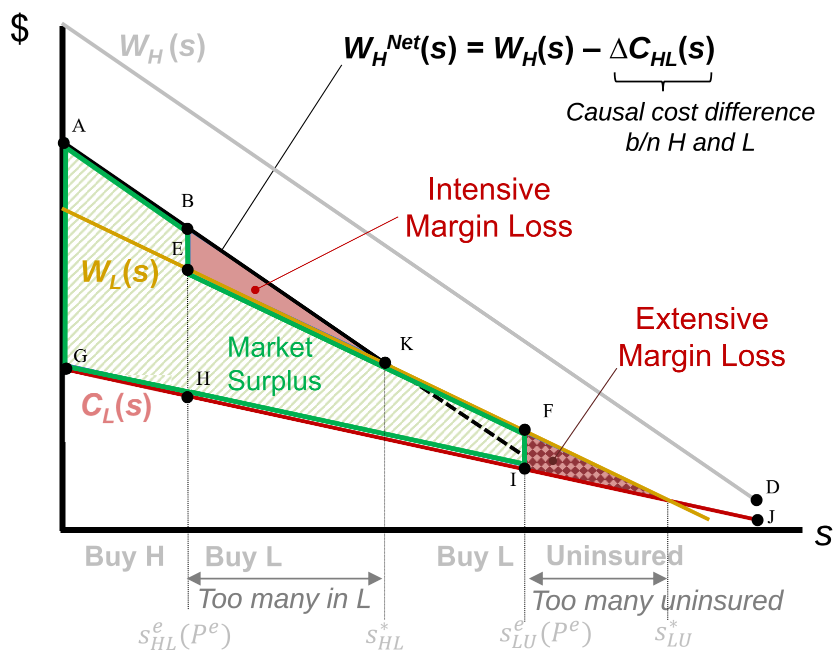
[21] To see this, note that this gap is equal to $W_H^{Net}(s) - C_L(s) = W_H(s) - (C_H(s) - C_L(s)) - C_L(s) = W_H(s) - C_H(s)$.

Figure 5: Welfare

(a) Welfare when L Is a Pure Cream-Skimmer



(b) Welfare when L Has a Cost Advantage



Notes: The graphs show welfare given equilibrium prices P^e and implied consumer sorting between H, L, and uninsured. Panel (a) shows the case where the L plan is a pure cream-skimmer ($\Delta C_{HL} = C_H(s) - C_L(s) = 0$), while panel (b) shows the case where L has a causal cost advantage ($\Delta C_{HL} > 0$). The market surplus is shaded in green; the loss due to intensive margin misallocation (between H and L) is shaded in red; and the loss due to extensive margin misallocation (between L and U) is shaded in thatched red.

figure in Panel (b) similar to the illustration in Panel (a).[22] In summary, Figure 5 shows how our model can accommodate settings in which it is not socially efficient for all consumers to be enrolled in H or even in L, such as settings where there is moral hazard, administrative costs, etc.

Appendix B.3 derives a formal expression for welfare, allowing for cases where C_U is non-zero—e.g., if the outside option involves social costs like uncompensated care. This derivation formalizes what is shown graphically in Figure 5.

3 Two-Margin Impacts of Risk Selection Policies

In this section, we use our model to assess the consequences of three policies commonly used to combat adverse selection in insurance markets: benefit regulation, the mandate penalty on uninsurance, and risk adjustment transfers. Each of these policies is targeted at one margin of adverse selection, but our model shows how they affect the other. We discuss each policy in turn and provide graphical illustrations for their consequences. We conclude with a discussion of other policies where cross-margin impacts on selection may be relevant, including behavioral interventions targeting take-up.

3.1 Benefit Regulation

We start by examining benefit regulation. In Figure 6, we consider a rule that eliminates L plans from the market. This thought experiment captures a variety of policies that set a binding floor on plan quality—e.g., network adequacy rules, caps on out-of-pocket limits, and the ACA's "essential health benefits." These policies seek to address *intensive margin* adverse selection problems by eliminating low-quality, cream-skimming plans. But, as we show, they can also have unintended *extensive margin* consequences.

Panel (a) of Figure 6 shows the baseline equilibrium with both H and L plans, while Panel (b) shows equilibrium with L plans eliminated, which reduces to the classic EFC equilibrium. Panel (c) shows the welfare impact of benefit regulation. This involves two competing effects: Some consumers formerly in

[22] Here, forgone surplus again consists of two components. The first is the foregone intensive margin surplus due to the fact that consumers with $s \in [s^e_{HL}, s^*_{HL}]$ are enrolled in L but would generate more surplus if they were enrolled in H. It is characterized by the area between W_H^{Net} and W_L for these consumers (BKE). (Unlike in Panel (a), with H's higher costs it is now inefficient for any consumer with $s > s^*_{HL}$ to enroll in H.) The second component represents the extensive margin foregone surplus, and it is identical to the extensive margin foregone surplus in Panel (a).

L shift to H (the intended consequence), and some consumers formerly in L become uninsured (the unintended consequence).

In the textbook cream-skimming case, where H is the socially efficient plan for everyone (though most consumers still generate more social surplus in L vs. U), these two effects have opposing welfare consequences. The first (intended) effect *increases social surplus* by shifting people out of L—an inefficient plan that exists only by cream-skimming—and into H. The second (unintended) effect, however, *lowers social surplus* by shifting some L consumers into uninsurance. Thus, even in this textbook case where the L plan is an inefficient cream-skimmer, banning it has ambiguous welfare consequences.[23]

What explains this counter-intuitive result? This can be thought of as an example of "theory of the second best"-style interactions that emerge with two margins of selection. Regulation that bans a pure cream-skimming L plan addresses an intensive margin selection problem. But it has the unintended side effect of worsening the extensive margin selection problem of too much uninsurance. Put differently, a pure cream-skimming L plan adds no social value *within* the market, but by segmenting the healthiest people into a low-price plan, it can improve welfare by bringing new consumers *into* the market.[24]

3.2 Mandate Penalty on Uninsurance

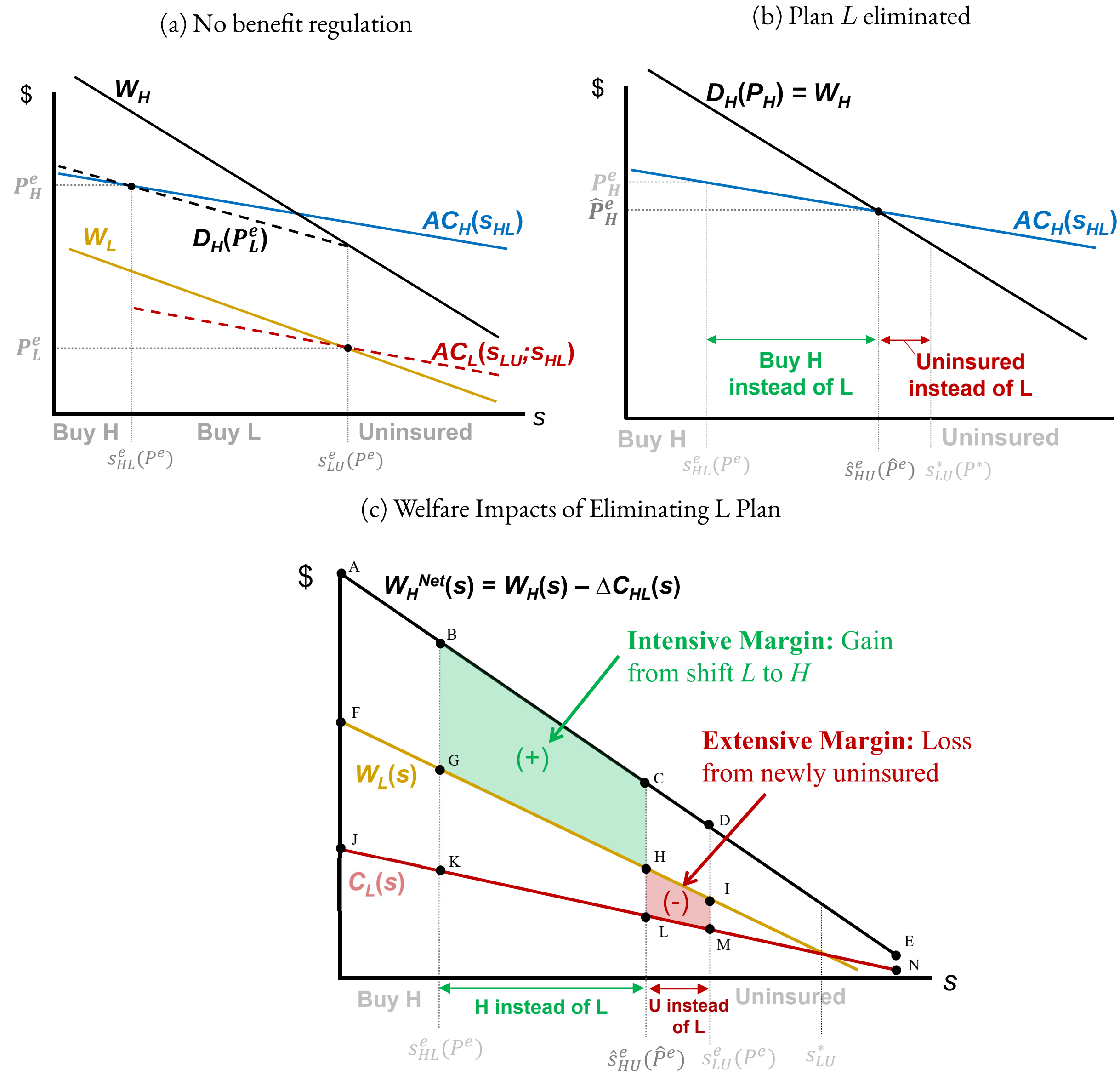
Next we consider the consequences of a mandate penalty for remaining uninsured (choosing U). The analysis is also applicable for analyzing the effect of providing larger insurance subsidies, which likewise reduce consumers' net price of buying insurance relative to remaining uninsured.

The mandate penalty has both a direct effect and an indirect effect through equilibrium price adjustments. The direct effect of a mandate penalty is to increase the demand for insurance. Panel (a) of Figure 7 shows this via an upward shift in W_L and W_H by $\$M$, reflecting that both become cheaper relative to U (whose utility and price are normalized to zero). As a result of this shift, some people who were previously

[23]The net welfare impact depends on the market primitives (W_H, W_L, C_H, C_L) and the social cost of uninsurance, C_U. Section 2 presents the framework for how these can be measured and the net welfare impact quantified.

[24]Of course, this reasoning depends on the market stabilizing to a separating equilibrium where both H and L survive. If the market unravels to the L plan, insurance coverage will typically not be higher: the price of L will not be low (since it attracts all consumers), and because the quality of L is lower, uninsurance will typically be higher than in an H-only equilibrium where L is banned. Whether the market stabilizes to a separating equilibrium or unravels to L/upravels to H depends on the market primitives.

Figure 6: Impact of Benefit Regulation



Notes: The figure shows the impact on equilibrium (panels a and b) and welfare (panel c) of a benefit regulation that eliminates the L plan. This thought experiment captures a variety of policies that set a binding floor on plan quality, thus eliminating low-quality plans. For welfare impacts, we show the textbook case where H is the efficient plan for all consumers and L is more efficient than U.

uninsured buy insurance in the L plan. This is the intended effect of the penalty.

Panel (b) depicts the unintended, equilibrium effects of the penalty. By definition under extensive margin adverse selection, the newly insured individuals are relatively healthy. Because they buy the low-price L plan, they lower L's average costs (i.e., a movement down the AC_L curve, not a shift in the AC_L

curve) and therefore its price. The lower P_L leads some consumers to shift on the *intensive margin* from H to L—as captured by the downward shift in H's demand curve, $D_H(P_L)$. This is the main unintended effect of the penalty: although it is intended to reduce uninsurance, the penalty also shifts people toward lower-quality plans on the intensive margin.[25]

There is a second equilibrium effect from this shift in consumers from H to L. The consumers who shift are high-cost relative to L's previous customers, pushing up L's average costs. In panel (b), this is depicted via an upward shift in the $AC_L(P_H)$ curve, which has to occur because of the higher P_H and the leftward shift in the marginal s_{HL} type. The higher average costs in L partly offset the fall in P_L due to the mandate and dampen the impact of the mandate on the price of L. Thus our model shows how and why cross-margin effects may make a mandate less effective than one would predict from its direct effects alone: The penalty induces healthy people to enter the market but also induces relatively sick people to move from H to L. Nonetheless, as long as the original equilibrium is stable, one can show that on net, a larger penalty decreases P_L and uninsurance (see Appendix A for a formal derivation).

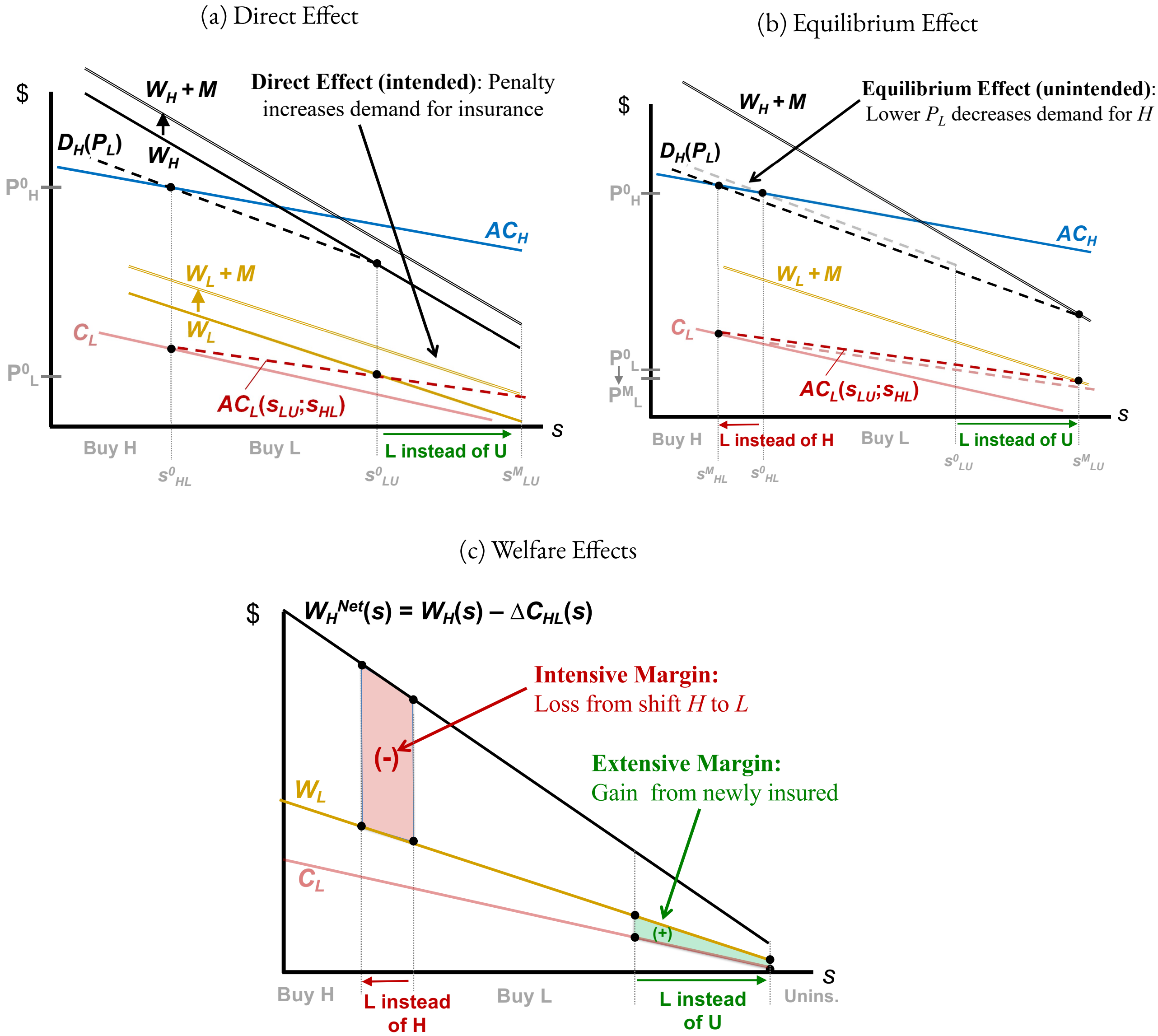
Panel (c) of Figure 7 shows the welfare effects in the textbook case where H is the efficient plan for all consumers. There are again competing effects: (intended) welfare gains from newly insured consumers and (unintended) welfare losses from consumers moving from H to the lower-quality L plan. Thus, the interaction of the two margins of selection makes the welfare impact of a mandate ambiguous even in this textbook case. In the extreme, a penalty could even lead to a market where high-quality contracts are unavailable to consumers (i.e., market unraveling to L).

3.3 Risk Adjustment Transfers

Next we consider the impact of implementing risk adjustment, including the effects of strengthening or weakening risk adjustment transfers relative to the status quo. Of the three policies we consider, risk adjustment is the most difficult to illustrate graphically because the policy adds new risk-adjusted cost curves (for both L and H) that crowd the figure. (See Figure A2 in the appendix.)

[25] We show in our simulations and in Appendix A that this prediction is largely robust to relaxing the vertical model. It is driven by two properties: (1) that the newly uninsured are relatively healthy (extensive margin adverse selection), and (2) that the newly insured mostly choose the low-priced L plan.

Figure 7: Impact of Mandate Penalty on Uninsurance



Notes: The figure shows the impact of a mandate penalty in our framework. Panel (a) shows the direct effect: higher demand for insurance. Panel (b) shows the unintended equilibrium effect: an intensive margin shift from H to L. Panel (c) shows the welfare effects in the textbook case where H is the efficient plan for all consumers and L is more efficient than U.

In the ACA Marketplaces, the per-enrollee transfer to plan j is determined by a formula of the form:[26]

$$T_j(P) = \left(\frac{\overline{R}_j(P)}{\overline{R}(P)} - 1 \right) \cdot \overline{P}(P) \tag{4}$$

[26] The actual formula used in the Marketplaces is a more complicated version of this formula that adjusts for geography, actuarial value, age, and other factors. Our insights hold with or without these adjustments, so we omit them for simplicity.

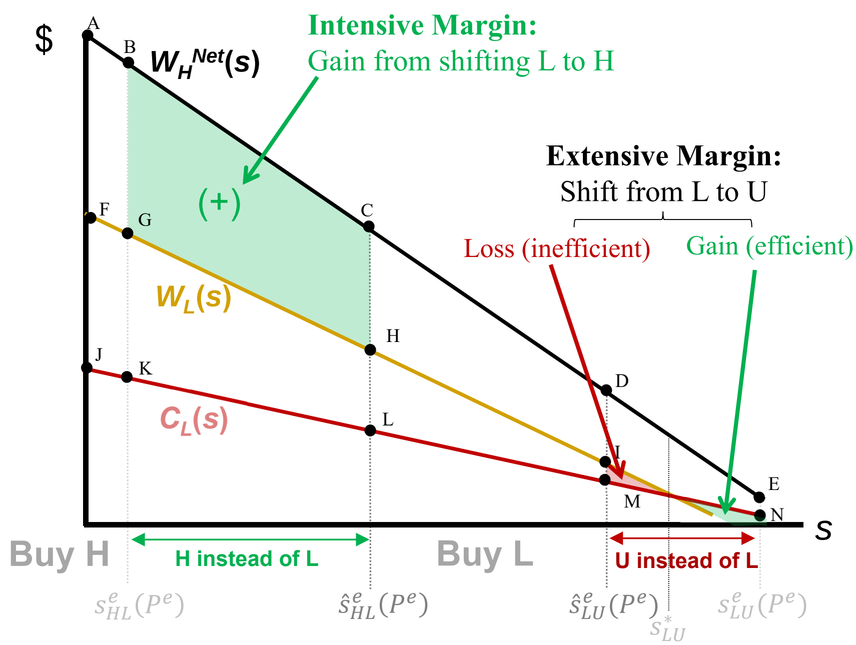
where $\overline{R}_j(P)$ is the average risk score of the consumers enrolling in plan j given price vector P, $\overline{R}(P)$ is the (share-weighted) average risk score among all consumers purchasing insurance, and $\overline{P}(P)$ is the (share-weighted) average price in the market. The transfer is positive as long as j's average risk score is larger than $-j$'s average risk score. The sum of H's and L's transfers is always zero, making the transfer system budget neutral. Note that risk adjustment here is imperfect in the sense of not necessarily eliminating all variation in net enrollee costs.[27] This is consistent with our empirical findings below.

To understand the impact of risk adjustment on the two margin problem, we tune its strength by introducing a parameter α. We define the transfer from L to H as $\alpha \cdot T(P)$. With $\alpha = 0$, there is no risk adjustment. With $\alpha = 1$, there is ACA-level risk adjustment. Other values magnify or attenuate these transfers. For example, if a risk adjustment transfer were \$500 under $\alpha = 1$ it would be \$600 under $\alpha = 1.2$. Importantly changes to α not imply changes to the underlying risk scores (which are determined by enrollee diagnoses). Adjusting α corresponds to ongoing policy activity, as we discuss below.

In Appendix A, we derive comparative statics describing the effect of an increase in α (i.e., a magnification of the imperfect transfers) on P_H and P_L. These comparative statics mimic the simulations we perform in the empirical section where we simulate equilibria under no risk adjustment and with increasingly large risk adjustment transfers (i.e., increasingly large values for α). Larger values of α unambiguously lower the price of H. The effect of an increase in α on the price of L, however, is ambiguous. In addition to risk adjustment's direct effect to push up L's average costs by transferring money from L to H, there is a second, indirect effect. The consumers who shift from L to H tend to be L's most expensive enrollees, even net of imperfect risk adjustment transfers. This lowers L's risk-adjusted average costs, pushing the price of L downward. This indirect effect will be larger when intensive margin adverse selection is severe (even after risk adjustment) and when consumers are highly price elastic on the intensive margin. Indeed, we find in some of our simulations that the indirect effect is large, and risk adjustment has minimal effects or even decreases P_L. We defer further discussion of the comparative statics to the results section.

[27] Perfect risk adjustment, where transfers exactly capture all variation in C_L across consumer types, is a useful thought experiment. But in practice markets include an imperfect form of risk adjustment, where transfers are based on individual risk scores computed from diagnoses appearing in health insurance claims. See Geruso and Layton (2018) for an overview. And See Appendix for more discussion of the case of perfect risk adjustment.

Figure 8: Welfare Effects of Risk Adjustment



Notes: The figure shows the welfare effects of a risk adjustment policy that shifts consumers on the intensive margin from L to H (by lowering $P_H - P_L$) and on the extensive margin from L to U (by raising P_L). We show a case where H is globally more efficient than L, so the intensive margin shift is welfare improving, but where U is sometimes more efficient than L. Optimal sorting across the extensive margin occurs when $s_{LU} = s^*_{LU}$.

Figure 8 depicts the welfare effects of a risk adjustment policy where the direct effect dominates such that the policy shifts consumers from H to L and also has some effect on the extensive margin, shifting consumers from L to U. Again, we illustrate welfare for the textbook case where H is the efficient plan for all. As with benefit regulation and the mandate penalty, there are opposing effects: a welfare gain from the intensive margin shift from L to H and a welfare loss from the extensive margin shift from L to uninsurance. (There is also a welfare gain on the extensive margin due to the fact that some of the people induced to choose uninsurance instead of L generate negative social surplus when enrolled in L.) This suggests that, like the other policies, the welfare effects of risk adjustment are theoretically ambiguous.

3.4 Other Policies

The same price theory can be applied to other policies not explicitly discussed above, such as reinsurance. The key insight is that *anything* that affects selection on one margin has the potential to affect selection on the other margin, as firms adjust prices in equilibrium to compensate for the changing consumer risk pools.

Further, cross margin effects are relevant not only for policies that *aim* to address selection, but also for policies for which selection impacts are incidental or a nuisance. Handel (2013), for example, shows how addressing inertia through "nudging" can exacerbate intensive margin selection in an employer-sponsored plan setting. Our model implies that in other market settings, where uninsurance is a more empirically-relevant concern, there is a further effect of nudging: Worsening risk selection on the intensive margin (i.e., increasing the market segmentation of healthy enrollees into L and sick enrollees into H) through behavioral nudges may improve risk selection on the extensive margin by pushing down the equilibrium price of L. This may counterbalance the welfare harm documented in Handel (2013). Similar insights apply to any behavioral intervention that even incidentally affects the sorting of consumer risks (expected costs) across plans.[28] Similarly, behavioral interventions intended to increase take-up of insurance, such as information interventions or simplified enrollment pathways, may have important intensive margin consequences similar to the effects of a mandate.

4 Simulations: Methods

To demonstrate how our model can be applied empirically, we draw on previously estimated model primitives from two separate Massachusetts pre-ACA individual health insurance exchanges to simulate a hypothetical post-ACA market. Demand and cost curves from a low-income population are drawn from the subsidized health insurance exchange, known as Commonwealth Care or "CommCare" as estimated by Finkelstein, Hendren and Shepard (2019), which we abbreviate "FHS." A demand curve for higher income individuals is drawn from the un-subsidized individual market "CommChoice" as estimated in Hackmann, Kolstad and Kowalski (2015), which we abbreviate "HKK."[29] Our inclusion of both the

[28] This is relevant not only as it relates to inertia (Polyakova, 2016), but also to misinformation (Kling et al., 2012; Handel and Kolstad, 2015), complexity (Ericson and Starc, 2016), and other behavioral concerns. It is also relevant for non-behavioral policy changes in other markets, including Medicare. For example, Decarolis, Guglielmo and Luscombe (2020) document that intensive margin risk selection was affected by a Medicare policy change that allowed mid-year plan switching across Medicare Advantage plans. This could have extensive margin impacts on who chooses Medicare Advantage versus Traditional Medicare.

[29] We import the HKK estimates to generate a demand curve for the high income population, though in principle, simulating high income demand as an ad-hoc shift or rotation to the estimated demand curve for the low income population could

low-income and high-income populations is motivated by the design of subsidies under the ACA. Low-income households receive subsidies that are *linked* to the price of insurance, a policy that limits cross-margin effects by fixing the extensive margin price of insurance. Higher-income households do not receive subsidies, meaning that cross-margin effects may be relevant. In order to capture these dynamics, we include both groups in our analysis. We apply the FHS cost curve to both populations. That is, people of a given s-type in either population would have the same expected cost conditional on plan.[30]

We make two key modifications to the baseline FHS and HKK estimates. First, to allow for broader policy counterfactuals, we extrapolate the curves over the full range of s-types. Second, we combine the two sets of estimates to form one set of aggregated demand and cost curves, reflecting ACA markets that include subsidized (low-income) and unsubsidized (high-income) enrollees. Given these modifications, readers should consider these simulations illustrative of mechanisms rather than exact predictions for any specific market. The co-mingling of the subsidized and unsubsidized group in the same market in our simulations is a choice aimed at illustrating the mechanisms we wish to highlight rather than as an accurate description of the Massachusetts market. Details on the construction of these demand and cost curves, as well as figures showing the final curves, are in Appendix C.1.

Given these demand and cost curves, it is straightforward to estimate equilibrium prices and allocations of consumers across H, L, and U under a given set of policies. Our method for finding equilibrium is based on the approach described in Figure 3. We characterize equilibrium as a price vector P_H, P_L at which any plan that has nonzero enrollment breaks even. We then use a Riley equilibrium concept to choose which break-even price vector is the equilibrium price vector.[31] This method results in a unique equilibrium for each policy environment we consider.

We then simulate market equilibrium under different specifications of two policies: a mandate penalty (ranging from $0 to $60 per month) and risk adjustment transfers (ranging from zero to 3 times the size of ACA transfers). We study the effects of these policies in a 2×2 matrix of market environments. The first

have also served the purpose of illustrating the tradeoffs in our model.

[30]Both sets of demand and cost curves are well-identified using exogenous variation in net consumer prices. FHS use a regression discontinuity design based on three household income cutoffs that generate discrete changes in consumer subsidies. HKK use a difference-in-differences design leveraging the introduction of an uninsurance penalty in Massachusetts.

[31]See Appendix C.4 for additional details.

dimension of the environment we vary is subsidy design, with two regimes: (1) "ACA-like" subsidies that are *linked* to the price of the cheapest plan and (2) "fixed" subsidies set at an exogenous dollar amount.[32] In both cases, low-income consumers receive subsidies only if they purchase H or L, and the subsidy is identical for both plans. High-income consumers do not receive subsidies.

The second dimension we vary is whether L is a pure cream-skimmer (i.e. $C_L(s) = C_H(s)$ for all s) or has a cost advantage. FHS find no evidence that L has lower costs than H in CommCare, motivating our cream-skimmer case. To illustrate another possibility, we simulate the case where L has a 15% cost advantage (i.e. $C_L(s) = 0.85C_H(s)$). Of particular interest is how the welfare consequences of risk adjustment and the uninsurance penalty vary across these two cases. We explore these in Section 6.

5 Simulation Results: Prices and Enrollment

In this section, we present results on how prices and market shares change under (1) stronger mandate penalties and (2) stronger risk adjustment. In Appendix D.2 we also present results on how prices and market shares change under benefit regulation, where we implement benefit regulation by eliminating L from the consumers' choice set. In Appendices D.4.1 and D.4.2 we explore the sensitivity of our results to relaxing the vertical model and modifying the primitives (specifically, consumers' incremental WTP for H vs. L), finding that the key results are quite robust. In presenting results, we vary consumer characteristics (demand and costs/selection), supply-side features (horizontal differentiation among plans), and policy interventions (mandate/subsidies, risk adjustment) to generate a catalogue of findings that provide guidance on how these features interact to affect equilibrium prices and enrollment.

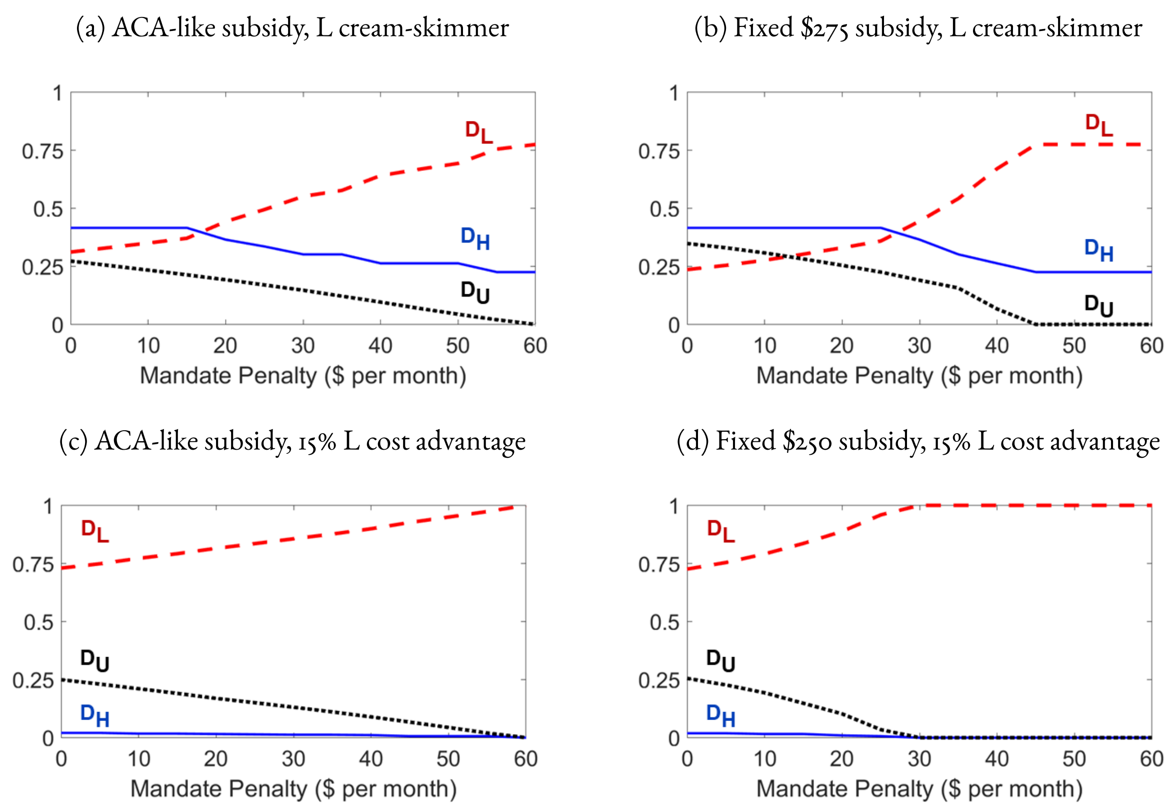
5.1 Mandate/Uninsurance Penalties

Figure 9 presents equilibrium market shares for each option, H, L, and U, under different levels of a mandate penalty for remaining uninsured ($P_U \equiv M$). We consider penalties in increments from \$0 to

[32]For (1) we follow the ACA rules by setting the subsidy such that the net-of-subsidy price of the index plan equals 4% of income for consumers at 150% of the federal poverty line (FPL) in 2011 (or \$55 per month), the year on which our estimated demand and cost curves are based. The ACA subsidy rules actually link the subsidy to the price of the second-lowest cost silver plan. Our subsidy rule mimics this rule in spirit (in a way that is compatible with our CommCare setting) by linking the subsidy to the price of L.

$60, applied equally to both the subsidized and unsubsidized populations.[33] In all cases we include ACA-style risk adjustment (described in detail in Section 5.2 below). The top two panels of Figure 9 contain the results for the case where L is a pure cream-skimmer. The bottom two panels contain results for the case where L has a 15% cost advantage. The cases with ACA-like price-linked subsidies are shown in the left panels and the cases with a fixed subsidy are in the right panels.[34] All results are also reported in Appendix Table A1.

Figure 9: Market Shares with Varying Mandate Penalty (M)



Notes: The figures show market shares for H, L, and uninsurance (U) from our simulations with varying sizes of the mandate penalty (x-axis, in $ per month). The panels represent different subsidy designs and specifications for the L plan's causal cost advantage vs. H (i.e., ΔC_{HL}). In panels (a) and (b), L is a pure cream-skimmer ($\Delta C_{HL} = 0$), while in panels (c) and (d) L has a 15% cost advantage. Panels (a) and (c) have "ACA-like subsidies" linked to the price of L, while panels (b) and (d) have fixed subsidies of the indicated dollar amounts.

[33] We find that in all cases studied here, $P_U = 60$ is sufficient to drive the uninsurance rate to 0 in the presence of ACA risk adjustment transfers.

[34] Fixed subsidies are equal to $275 in the case where L is a pure cream-skimmer and $250 in the case where L has a 15% cost advantage. These values were chosen in order to ensure that risk adjustment and the uninsurance penalty have some effect on market shares. With subsidies that are "too large" no consumers opt to be uninsured and with subsidies that are "too small" no consumers opt to purchase insurance, making the simulated policy modifications uninformative.

For the two ACA-like subsidy cases (left), the patterns are qualitatively similar regardless of modeling L as a cream skimmer (top) or as having a cost advantage (bottom). When there is no mandate penalty, some consumers choose each of the three options, H, L, and U, though the share in H is extremely low in the cost advantage case. As the penalty increases, the uninsurance rate decreases, with no consumers remaining uninsured at a penalty of $60/month. However, there are also intensive margin consequences: As the penalty increases, there is a shift of consumers from H to L. In the case where L is a pure cream-skimmer, H's market share decreases from 42% with no penalty to 23% with a penalty of $60/month. This represents a significant decline in H's market share and a significant deterioration of the average generosity of coverage among the insured. When L has a 15% cost advantage (bottom), the patterns are similar, though H's initial market share with no penalty is much lower ($\approx$ 2%).

The two fixed subsidy cases are presented in the right panels of Figure 9. When L is a pure cream-skimmer (top), with zero penalty consumers are split across H, L, and U. As the penalty increases from zero, consumers move from U to L, the intended effect of the policy. At a penalty of just under $30/month the influx of inexpensive consumers into L causes P_L to get low enough that some consumers switch from H to L. As the penalty continues to increase, consumers move into L from both U and H until the mandate reaches just over $40/month and all consumers are insured. At this point 23% of the market is enrolled in H and 77% of the market is enrolled in L. This represents an intended decline in the uninsurance rate from 35% to 0% but also an unintended decline in H's market share from 42% to 23%.[35]

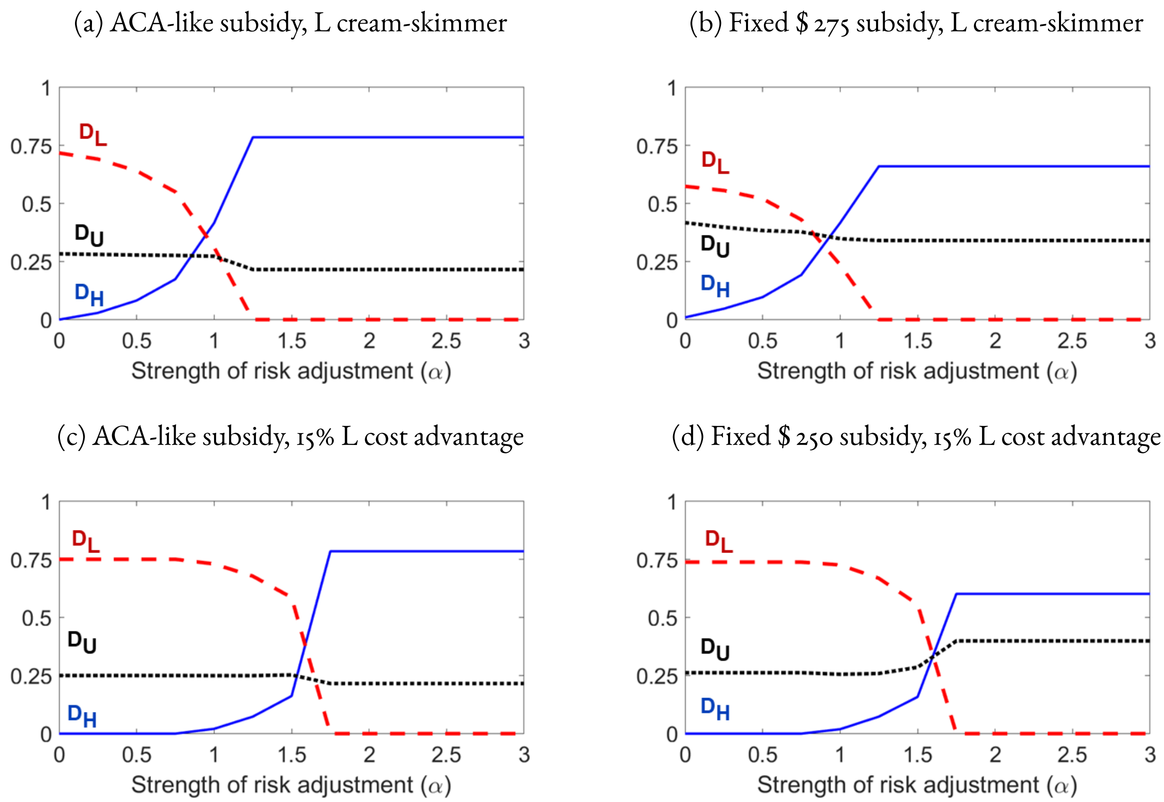
In each of the cases in Figure 9, a larger mandate penalty has the intended consequence of decreasing uninsurance *and* the unintended consequence of shifting consumers from H to L.[36] This is consistent with implications of our graphical model as well as the comparative statics we outline in Sections 2 and 3. The unintended intensive margin effect is starkest when L is a perfect cream-skimmer, highlighting how market primitives can amplify the cross-margin impacts of policy changes.[37]

[35] In the case where L has a 15% cost advantage, the penalty again decreases both the uninsurance rate (intended) and H's market share (unintended), but H's market share with a $0 penalty is so low (around 3.5%) that the decline in H's market share (to zero) is relatively insignificant.

[36] This finding also holds when we relax the vertical assumptions of the model, as we explore further in Appendix D.4.1 and show in Appendix Figure A10. In addition, in Appendix D.4.2 we show that these results are robust to varying the incremental WTP for H vs. L.

[37] To see why the effect is larger for the cream-skimmer case, note that for fixed preferences, it is more difficult to achieve high enrollment in H when L has an actual cost advantage versus when L has similar costs to H. This leads to lower enrollment in

Figure 10: Market Shares with Varying Strength of Risk Adjustment (α)



Notes: The figures show market shares for H, L, and uninsurance (U) from our simulations with varying strength of risk adjustment α (on the x-axis). As described in text, α is a multiplier on the risk adjustment transfer: $\alpha = 0$ implies no risk adjustment; $\alpha = 1$ is baseline risk adjustment using the ACA formula; and $\alpha > 1$ is over-adjustment. The panels represent different subsidy designs and specifications for the L plan's causal cost advantage vs. H (i.e., ΔC_{HL}). In panels (a) and (b), L is a pure cream-skimmer ($\Delta C_{HL} = 0$), while in panels (c) and (d) L has a 15% cost advantage. Panels (a) and (c) have "ACA-like subsidies" linked to the price of L, while panels (b) and (d) have fixed subsidies of the indicated dollar amounts.

5.2 Risk Adjustment

We now consider the effects of risk adjustment. We start with risk adjustment transfers implied by the ACA risk adjustment transfer formula (see Eq. 4). We first calculate risk scores for each individual using the HHS-HCC risk adjustment model used in the ACA Marketplaces. (This is a straightforward mechanical application of the regulator's algorithm to our individual-level claims data.) We then use those scores plus the FHS regression discontinuity design to estimate a "risk score curve" $RA(s)$ describing the average risk score across consumers of a given s-type. Because this curve is novel to this paper and not

H even with a small penalty and less opportunity for a reduction in H's market share.

estimated by FHS, we describe the estimation of it in Appendix C.2. We plot this curve alongside the cost curve in Appendix Figure A5. It is apparent that while risk scores explain part of the correlation between willingness-to-pay and costs, they do so only imperfectly. Specifically, we find that risk scores account for about one-third of the correlation between willingness-to-pay and costs, implying substantial selection on costs net of the ACA's imperfect risk adjustment policy. (Although incidental to our aims here, this is a novel finding.)

We use the risk score curve to determine the average risk scores for H and L for any given allocation of consumers across H, L, and U. This is similar to constructing average cost curves from marginal costs. We then enter these average risk scores into the risk adjustment transfer formula (Eq. 9) to determine the transfer from L to H for a given price vector $T(P)$, the statutory transfer under ACA risk-adjustment. Finally, we find the equilibrium prices. Under the benchmark risk adjustment, these prices satisfy $P_H = AC_H(p) - T(P)$ and $P_L = AC_L(P) + T(P)$ when L and H have non-zero enrollment.

To vary the strength of risk adjustment transfers we maintain the original risk scores and structure of the transfer formula, but we multiply transfers by a scalar α (as in the discussion in section 3.3 and comparative statics in Appendix A) so that transfers from L to H are some multiple of the transfers implied by the ACA formula (i.e. $P_H = AC_H(p) - \alpha T(P)$ and $P_L = AC_L(P) + \alpha T(P)$). We allow α to vary from 0 (no risk adjustment) to 3 (risk adjustment transfers 3 times the size of ACA transfers). The case of ACA transfers occurs where $\alpha = 1$. In these risk adjustment simulations, we are not modifying the fit of risk adjustment nor changing the scores in any way. Instead, we are enhancing the transfer implied by the same scores so that if a plan's risk adjustment transfer was $500 under $\alpha = 1$, it is $600 under $\alpha = 1.2$. This approach to evaluating strengthening or weakening risk adjustment reflects real-world policy experimentation: The federal government recently reduced α from 1 to 0.85 in the ACA Marketplaces and gave states the ability to further reduce α.[38] Our approach thus maps to feasible policy interventions, rather than assuming that the regulator can increase the predictive power of risk scores.

Equilibrium market shares for different levels of α in the cases without and with a cost advantage for L are found in the top and bottom panels of Figure 10, respectively. Market shares under ACA-like

[38] The reduction of α from 1 to 0.85 occurred when the federal government decided to "remove administrative costs" from the benchmark premium that multiplies insurer risk scores to determine transfers in the transfer formula described by Eq. 4.

subsidies are presented in the left panels and market shares under fixed subsidies are found in the right panels. Results are also found in Appendix Table A2. With ACA-like subsidies, patterns are qualitatively similar when L is a pure cream-skimmer and when L has a 15% cost advantage. In both cases, when there is no risk adjustment ($\alpha = 0$), the market unravels to L: No consumers choose H, and the market is split between L and uninsurance. As the strength of risk adjustment transfers increases, consumers shift from L to H. This is the intended consequence of risk adjustment. When L is a pure cream-skimmer, transfers about 1.25 times the size of ACA transfers are sufficient to cause the market to "upravel" to H. When L has a 15% cost advantage transfers need to be 1.6 times the size of ACA transfers to generate the same outcome. In both cases, there is no extensive margin effect except at the level of α where the market initially upravels to H. At that point, there is a small reduction in the uninsurance rate. This reduction is due to the fact that there the subsidy becomes linked to the (higher) price of H instead of the (lower) price of L due to the exit of L from the market. With the larger subsidy, more consumers purchase insurance.[39]

The right column of Figure 10 presents market shares under fixed subsidies with different levels of α. Here, we again see that stronger risk adjustment transfers have the intended effect: Higher levels of α result in more consumers choosing H instead of L. In the case where L is a pure cream-skimmer, we see only a small extensive margin effect, with a small decrease in the uninsurance rate as α increases. This is consistent with our comparative statics from Section 3: The direct effect of increasing the transfer from L to H is more than fully offset by the indirect effect of the costliest (net of imperfect risk adjustment) L enrollees leaving L and joining H, resulting in a decrease in P_L and a corresponding decrease in the uninsurance rate. (See Section 3 and Appendix A for a fuller discussion of this result.)

On the other hand, in the case where L has a 15% cost advantage we see a different unintended extensive margin consequence of stronger risk adjustment transfers: More consumers opt to remain uninsured. In this case, with no risk adjustment ($\alpha = 0$) all insured consumers opt for L, with no consumers choosing H and the market split between L and U. ACA risk adjustment transfers ($\alpha = 1$) barely alter these

[39] This reduction seemingly goes against the intuition we present in Section 3 where we showed that in many cases risk adjustment may *increase* the uninsurance rate rather than decrease it as we see here. Note, however, that in the cases here the subsidy is linked to the extensive margin price. This results in risk adjustment having no effect on the net-of-subsidy extensive margin price faced by the low-income consumers (except where L exits the market), limiting (and in this case eliminating) any unintended extensive margin consequence.

market shares. As transfers are strengthened above ACA levels, consumers begin to opt for H instead of L. At the higher levels of α, extensive margin consequences also start to appear with some consumers exiting the market and opting for uninsurance. When transfers are strengthened to two times the size of ACA transfers, the market upravels to H with all insured consumers opting for H instead of L. At $\alpha = 2$ the uninsurance rate reaches almost 50%, an increase of 15 percentage points (60%) compared to the case with no risk adjustment. This indicates that this shift of consumers to more generous coverage on the intensive margin had a substantial extensive margin impact. We show that the same result holds when we relax the vertical model assumptions in Appendix Figure A10.[40]

These results provide important lessons for where the unintended extensive margin effects of risk adjustment will matter most. First, ACA-like price-linked subsidies protect against the unintended extensive margin effects of risk adjustment, even when those subsidies are only targeted to the low-income consumers making up 60% of the market (though there may be important effects on the size of the subsidies themselves, and thus government costs). Second, the unintended extensive margin effects are more likely to occur when L has a larger cost advantage. In cases where L and H have similar costs, extensive margin effects are likely to be small. But when L has a large cost advantage, stronger risk adjustment can have significant effects on the portion of consumers who opt to be uninsured.

6 Simulation Results: Welfare

We next analyze the changes in social surplus associated with the policy simulations of Section 5. We characterize welfare at a baseline equilibrium, then trace the gains and losses associated with illustrative policy changes, and finally determine optimal policy. Importantly, we show that the optimal mandate penalty depends on the strength of risk adjustment and vice versa. One straightforward implication is that if mandate penalties were altered by legislative action or court outcomes, a constrained optimal response from a regulator would be to adjust risk adjustment strength in concert. (Unlike mandate penalties, regulators typically have authority to tune risk adjustment without legal changes.)

[40] In Appendix D.4.1 we explore the sensitivity of these results to the vertical model assumption, finding that the results are robust to modest relaxation of the assumption. See Figure A10. Also, in Appendix D.4.2 we show that these results are largely robust to varying the incremental WTP for H vs. L.

We begin by noting the possibility that in many settings, social surplus may not be increased by policies that raise insurance take-up or move consumers from less generous to more generous coverage. This is because some consumers may not value insurance (or more generous coverage) more than its incremental cost. Further, policies may have opposing effects on the intensive and extensive margins, increasing enrollment in more generous coverage while simultaneously decreasing overall insurance take-up, or vice versa. For these reasons, it is important to understand the effects of policies not just on market allocations (which Section 5 presents), but also on welfare.

As discussed in Section 2, it is straightforward to estimate overall social surplus associated with some equilibrium market outcome (enrollment shares), given the $W_H^{Net} = W_H - (C_H - C_L)$; W_L; and $C_L^{Net} = C_L - C_U$ curves. From Section 4, we have all necessary primitives except C_U. From Section 5, we have equilibrium market shares under a variety of policy environments, which we can contrast to the social optimum defined by the primitives. Therefore, the only missing piece for estimating welfare is the social cost of uninsurance. In Section 2 we assumed $C_U = 0$ for simplicity. However, this assumption ignores uncompensated care, care paid for by other state programs, or more difficult-to-measure parameters like a social preference against others being uninsured. Because we do not have any way to directly measure the social cost of uninsurance, we specify it as linked to the observed type-specific cost of enrolling in H. We write the social cost of uninsurance for type s as:

$$C_U(s) = \frac{(1-d)C_H(s)}{1+\phi} + \omega \tag{5}$$

where d is the share of total uninsured healthcare costs that the uninsured pay out of pocket, ϕ is the assumed moral hazard from insurance, and ω is some fixed cost of uninsurance. For d and ϕ, we use the values as derived from Finkelstein, Hendren and Shepard (2019) and assume that $d = 0.2$ and $\phi = 0.25$.[41] We set the fixed cost $\omega = -\$97$ per month, which is the ω value consistent with 95% of the population being optimally insured when L has a 15% cost advantage.

Before analyzing welfare, we provide an important caution: as is standard in the literature, welfare

[41] We note that without this assumption (i.e. if we assume $C_U = 0$), it is inefficient for any consumer to purchase insurance, as no consumer values either H or L more than the cost of enrolling them in H or L. This fact plus a full discussion of the derivation of the assumed values of d and ϕ can be found in Finkelstein, Hendren and Shepard (2019).

estimation depends on inferring consumer value from observed demand responses. In other words, our welfare estimates are accurate only to the extent that demand accurately reflects true valuations. Behavioral frictions might cause consumer demand to deviate from valuations (Handel, Kolstad and Spinnewijn, 2019). Liquidity constraints could also cause valuation and demand to diverge (Casaburi and Willis, 2018). A separate issue is that our specification of C_U is *ad hoc* and may not reflect the actual social costs of uninsurance. Indeed, many of our welfare conclusions will necessarily be sensitive to assumptions about C_U. (See results with alternative assumptions on C_U in Appendix D.3.2.) We present this analysis to illustrate how to apply our framework but are cautious about drawing strong normative conclusions.[42]

6.1 Welfare and Changes to Risk Adjustment

We now show how to estimate welfare with our graphical model. For parsimony, we focus on the case of strengthening risk adjustment transfers. In Appendix D.3 we show the case of an uninsurance penalty. Figure 11 plots the empirical analogs to our welfare figures from Section 2. Panel (a) depicts foregone surplus relative to the social optimum under a baseline case with ACA risk adjustment ($\alpha = 1$), no mandate penalty, and a fixed subsidy equal to \$250. Panel (b) depicts the difference in social surplus between the baseline case and a similar case where risk adjustment is strengthened ($\alpha = 2$), reflecting the simulation reported in the bottom-right panel of Figure 10. Instead of plotting C_L, we plot $C_L^{Net} = C_L - C_U$, as in Eq. (18) to account for the fact that $C_U \neq 0$. We also plot $W_H^{Net} = W_H - (C_H - C_L)$ as in Section 2.

In Panel (a), we indicate the equilibrium s cutoffs for $\alpha = 1$. The intensive margin equilibrium cutoff is s^e_{HL} and the extensive margin cutoff is s^e_{LU}. Thus, consumers with $s < s^e_{HL}$ enroll in H, consumers with $s^e_{HL} < s < s^e_{LU}$ enroll in L, and consumers with $s > s^e_{LU}$ remain uninsured.

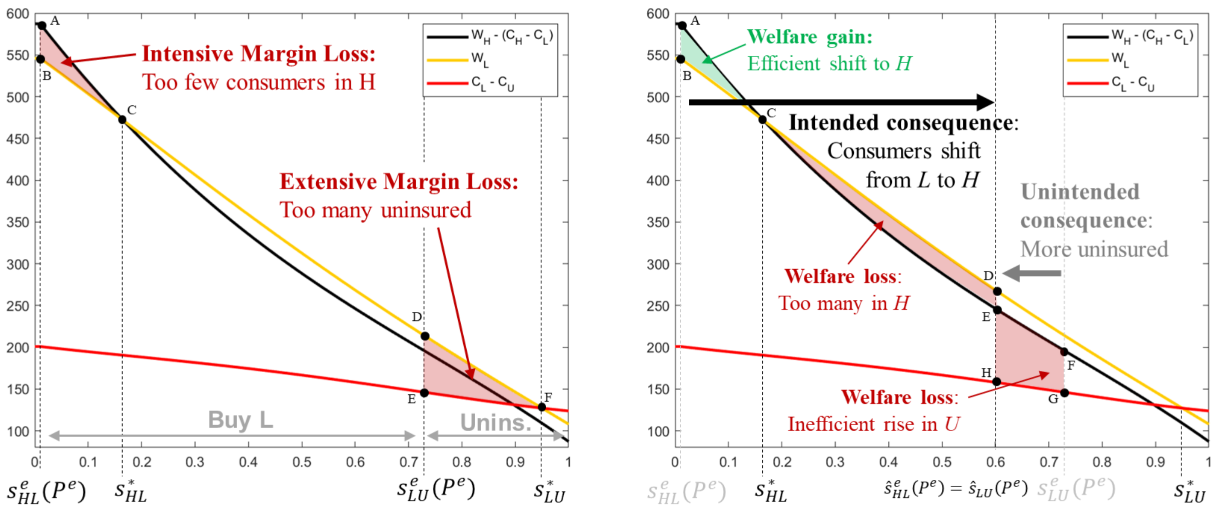
Efficient sorting of consumers across options is indicated by s^* cutoff types. Consumers with $s < s^*_{HL}$ should be in H, consumers with $s^*_{HL} < s < s^*_{LU}$ should be in L, and the few consumers with $s > s^*_{LU}$ should be uninsured to maximize social surplus. In panel (a) of Figure 11, we depict the foregone surplus in the baseline ACA setting with shaded areas. Intensive margin foregone surplus (lost surplus due

[42] Importantly, considerations about choice frictions or about the difficulty of measuring C_U do not threaten the use of our model for the positive analysis of Section 5, which consists of predictions of prices and market shares under different counterfactual mandate penalties and risk adjustment. Such predictions do not rely on assumptions about C_U or about demand reflecting underlying consumer valuation.

Figure 11: Empirical Welfare Effects from Simulations

(a) Baseline Sorting and Welfare Loss

(b) Welfare Effects of Stronger Risk Adjustment



Notes: In both panels (a) and (b), we assume that there is a fixed subsidy equal to \$250 and L has a 15% cost advantage over H. Further, 60% of the population is low-income and 40% of the population is high-income, so WTP curves are weighted sums of both types. Panel (a) shows welfare losses in this setting under no mandate and $\alpha = 1$, relative to efficient sorting. Efficient cutoffs are indicated with a * while equilibrium outcomes are denoted with an e superscript. Panel (b) shows welfare changes under a risk adjustment policy where $\alpha = 2$, relative to the baseline risk adjustment policy where $\alpha = 1$.

to consumers choosing L instead of H) is indicated by the welfare triangle ABC, representing a welfare loss of \$19.71.[43] Extensive margin foregone surplus is represented by the welfare triangle DEF. Welfare loss on this margin amounts to \$33.47. Combining these, the (average per consumer) foregone surplus in the baseline setting in panel (a) of Figure 11 is thus \$53.18.

Panel (b) of Figure 11 shows the welfare consequences of strengthening risk adjustment. To show the effects of strengthening risk adjustment, we increase α from 1 to 2, so that risk adjustment transfers are increased to two-times the ACA transfers. We hold all other policy parameters fixed. Recall from the bottom-right panel of Figure 10 that moving from $\alpha = 1$ to $\alpha = 2$ in this setting shifts nearly 60% of consumers in the market from L to H but also shifts 13% of consumers in the market from L to U. Overall, no consumers remain in L when $\alpha = 2$.

The first effect of increasing α is the intended consequence of risk adjustment, and here it implies both welfare gains and losses. Welfare gains occur when consumers whose incremental valuation for H

[43] These shapes are more triangle-ish than triangular.

vs. L exceeds the incremental cost of H vs. L (i.e. those with $W_H^{Net}(s) > W_L(s)$) enroll in H instead of L. These gains are represented by the green welfare triangle ABC, and they amount to \$19.71. Welfare losses occur when consumers whose incremental valuation for H vs. L is less than the incremental cost of H vs. L (i.e. those with $W_H^{Net}(s) < W_L(s)$) enroll in H instead of L as L unravels. These offsetting welfare losses occur when "too many" consumers enroll in H, and they are represented by the red welfare triangle CDE and amount to \$19.24. In other settings, where it is always more efficient for consumers to be enrolled in H instead of L (such as the pure cream-skimming case), there will only be welfare gains on this margin. In the case of panel (b) of Figure 11, the two effects nearly cancel each other out so that the net welfare gain due to the intended consequence of shifting consumers from L to H amounts to just \$0.47.

The second effect of increasing α is the unintended consequence of risk adjustment, and here it implies welfare losses. Because risk adjustment leads to a higher price of L, some consumers exit the market, increasing the uninsurance rate. In this case, all consumers who exit the market value insurance more than the (net) cost of insuring them, $C_L^{Net} = C_L - C_U$, causing the welfare consequences of this shift of consumers out of the market to be unambiguously negative. The size of the welfare loss is represented by the area of $EFGH$, which we estimate to be \$68.30. Combining the intended and unintended consequences of risk adjustment, we estimate that in this setting doubling risk adjustment transfers by shifting from $\alpha = 1$ to $\alpha = 2$ would decrease welfare by \$67.83, on average per consumer.

Welfare results for all settings studied in Figures 9 and 10, for the full range of levels of α, and under different assumptions about C_U are found in Appendix D.3.2. These results indicate that under our baseline assumption of C_U (Equation 5), with ACA-like subsidies, increasing the strength of risk adjustment transfers always improves welfare when L is a pure cream-skimmer. In this case, there is no effect of risk adjustment on the extensive margin due to the linkage of the subsidy to the price, leaving only intensive margin consequences. The intensive margin effects of moving consumers from L to H are also unambiguously positive, as it is inefficient for any consumer to be enrolled in L vs. H. When L has a cost advantage, increasing the strength of risk adjustment transfers improves welfare given low initial levels of α but decreases welfare given higher initial levels of α, with the welfare-maximizing risk adjustment policy having an α around 1.25, or 1.25 times the strength of ACA risk adjustment transfers. This non-monotonic result is due to the fact that increases in α from low initial levels of α induce only those consumers who value H highest relative to L to enroll in H, with consumers whose incremental WTP does not exceed their incremental cost remaining enrolled in L.

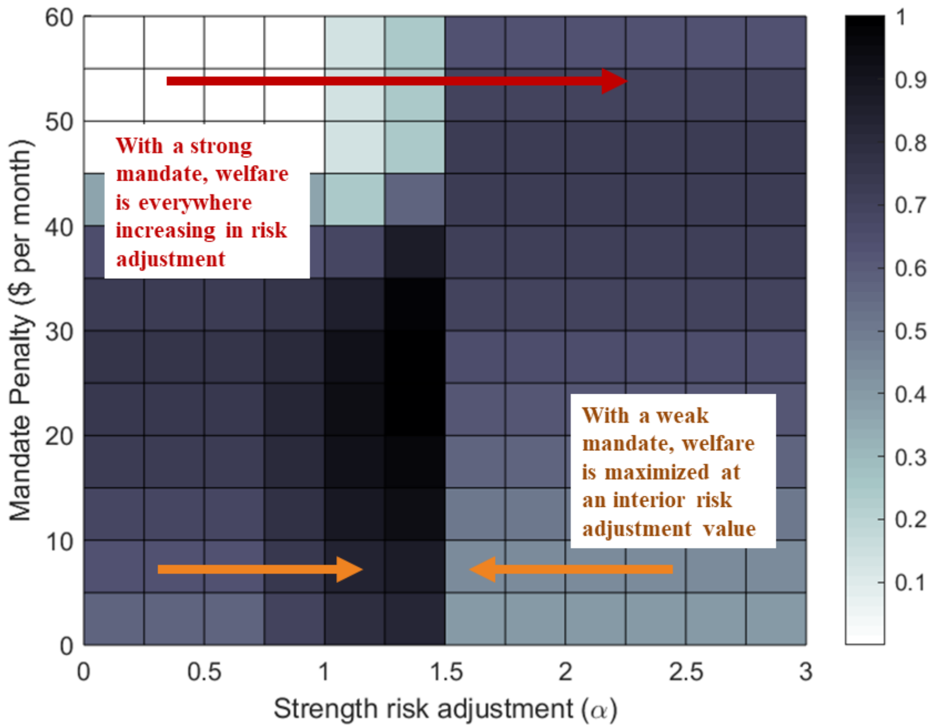
With fixed subsidies, the welfare consequences again depend on whether L has a cost advantage. Recall that when L is a pure cream-skimmer, extensive margin consequences of risk adjustment are limited. It is inefficient for any consumers to be enrolled in L vs. H in the cream-skimmer case, implying that the intensive margin effects of moving consumers from L to H are unambiguously positive. When L has a cost advantage, patterns in the fixed subsidy case are similar to the ACA-like subsidy case, with welfare increasing with the strength of risk adjustment at low initial levels of α and decreasing at higher levels. Here, in addition to moving some consumers who should not be in H into H, stronger risk adjustment also pushes consumers out of the market, further worsening the negative effects of risk adjustment. Overall, risk adjustment is most likely to improve welfare in a setting with ACA-like subsidies and when L plans do not have a cost advantage. However, policymakers should be cautious when strengthening risk adjustment in settings where subsidies are fixed and/or plans are heterogeneous in their cost structures.

6.2 Optimality under Interacting Policies

The findings above suggest the necessity of a second-best approach to policy: optimal extensive margin policy (penalties and subsidies) will often depend on the intensive margin policies (risk adjustment and benefit regulation) currently in use in a market. Here we show how our model can be used to assess optimal policy, allowing for these interactions.

We again consider uninsurance penalties and risk adjustment. We compute social welfare over a grid of uninsurance penalties and levels of α. We do this for the case in which L has a 10% cost advantage and low-income consumers (who comprise 60% of the market) receive a fixed subsidy equal to $250 when purchasing insurance. The social cost of uninsurance is once again set to $C_U(s) = 0.25C_H(s) - 97$ as in the previous section. We "cherry-pick" this case because the two policies interact in interesting ways. For completeness, we perform similar analyses for all other settings studied in Figures 9 and 10. Results are reported in Appendix D.3.

Figure 12: Welfare under Interacting Extensive and Intensive Margin Policies



Notes: The figure shows social welfare outcomes (darker = higher welfare) from the model simulations under different parameters for the strength of risk adjustment (α, x-axis) and for the size of the uninsurance mandate penalty ($ per month, y-axis). The key point is that the optimum for one policy depends on the other: with weak risk adjustment a weaker mandate is optimal, while with strong risk adjustment a strong mandate is optimal.

Figure 12 presents the welfare estimates graphically as a heat map, where darker areas represent higher values of social surplus.[44] Under a 10% cost advantage, the socially efficient allocation is for 33% of the population to be in H, 60% of the population to be in L, and the remainder to be uninsured. We can examine how the optimal level of risk adjustment changes with different values of the mandate penalty. The figure shows that in this setting, when the mandate penalty is high, welfare is increasing in the strength of risk adjustment (i.e. higher α). At these high values of the mandate penalty, all consumers purchase insurance, eliminating any potential unintended extensive margin consequences. Under such high market enrollment, it is optimal to use strong risk adjustment to sort more people into H instead of L. With low levels of the mandate penalty, however, risk adjustment has important unintended extensive margin

[44]Consider a given α, mandate combination that generates a level of welfare $W(\alpha, \text{mandate})$. We scale/normalize the heat map shading as follows: $W^{\text{norm}}(\alpha, \text{mandate}) = \frac{W(\alpha,\text{mandate})-\min(W)}{\max(W)-\min(W)}$, where the maximum and minimum are taken over all possible α, mandate combinations for the setting.

consequences. Thus, the benefits of shifting consumers from L to H must be traded off against the costs of shifting consumers out of the market and into U. The results in Figure 12 indicate that with a small penalty, social surplus is maximized at $1.25 < \alpha < 1.5$, somewhat stronger than ACA risk adjustment but weaker than the optimal level of α under a strong penalty, which is > 1.5.

We can also use Figure 12 to consider the optimal mandate penalty for each level of α. With weak risk adjustment, starting from low levels of the mandate penalty, social surplus is increasing in the size of the penalty. However, starting from high levels of the penalty, the sign is opposite, with social surplus *increasing* rapidly as the penalty is *reduced*. This occurs because while a strong mandate penalty increases social surplus by inducing consumers to enroll in insurance, it also has the first-order offsetting effect of shifting consumers from H to L. Ultimately, an intermediate penalty level (around \$30) maximizes social surplus, though any level of the penalty below \$40 achieves much higher levels of social surplus than the level achieved by a penalty exceeding \$40. When risk adjustment is strong, social surplus is increasing in the mandate penalty. Here, strong risk adjustment causes the market to "upravel" to H, eliminating any potential unintended intensive margin consequences of increasing the level of the penalty. With strong risk adjustment, a stronger mandate thus only induces consumers to move from U to H, generating higher levels of social surplus.

In terms of optimal policy, Figure 12 reveals that social surplus is highest for an intermediate level of both the uninsurance penalty and risk adjustment. Given such a combination of policies, consumers sort themselves to each of H, L, and U, which is the socially efficient outcome in this particular setting. Note that the lowest-surplus combinations are a strong mandate with weak risk adjustment or a weak mandate with strong risk adjustment.

In Appendix D.3 we show that other settings have different optimal policies. In the case where L is a pure cream-skimmer and subsidies are linked to prices (ACA-like subsidies), optimal policy is to have strong risk adjustment (high α) and a weak mandate. In the case where L has a cost advantage, a weak mandate with weak to moderate risk adjustment is the optimal policy. In all cases, it is clear that these two policies interact with each other, implying that evaluating one policy in isolation from the other can be misleading. Specifically, market designers should not only consider consumer preferences for high- vs.

low-quality coverage and consumer valuation of insurance but also the interaction between intensive and extensive margin selection when determining the optimal combination of policies.

7 Conclusion

Adverse selection in insurance markets can occur on either the extensive (insurance vs. uninsurance) or intensive (more vs. less generous coverage) margin. While this possibility has long been recognized, most prior treatments of adverse selection focus on only one margin or the other. This focus misses important cross-margin trade-offs inherent to many selection policies.

In this paper, we develop a simple graphical framework that generalizes the framework of Einav, Finkelstein and Cullen (2010) by adding the option to remain uninsured. Our setup allows for and highlights simultaneous selection on both margins. We use this framework to build intuition for the unintended intensive margin consequences of extensive margin policies and vice versa. We show that the extent to which these cross margin effects occur depends on the primitives of the market.

We also show that it is straightforward to take the graphical framework to data with variation that identifies two sets of demand and cost curves. We do this with estimates from Massachusetts and find that the extensive/intensive margin trade-off is empirically relevant for evaluating the consequences of various policies. Specifically, (1) strengthening uninsurance penalties can increase insurance take-up while shifting some consumers from higher- to lower-quality coverage, and (2) strengthening risk adjustment transfers can shift enrollment toward higher-quality coverage while also increasing uninsurance. Additionally, price-linked subsidies for low-income consumers tend to weaken some of these trade-offs (i.e. effects of risk adjustment and benefit regulation) but not others (i.e. mandates/uninsurance penalties). Finally, we show that trade-offs related to risk adjustment are more pronounced when the lower-quality plan has a cost advantage.

Because many policies lead to coverage gains on one margin and coverage losses on the other, in some cases the unintended effects of policies are first-order with respect to welfare. We show cases in which the welfare losses from coverage losses on the unintended margin exceed welfare gains from coverage gains on the intended margin. This happens most often with a penalty for choosing to be uninsured.

The simplicity of our approach is not without some costs. The assumption of perfect vertical ordering of demand is required to maintain simplicity in our graphs, though we show in both theory and empirics that our results are largely robust relaxing this assumption. What matters is that the *primary* form of plan differentiation is vertical. Conclusions may differ in more complex cases, which are an important area for future research.

The issues we highlight are relevant for future reform of individual health insurance markets in the U.S. Many have observed that the quality of coverage available in these settings is low, with most plans having tight provider networks, high deductibles, and strict utilization controls. Additionally, others have observed that take-up is far from complete, with many young and healthy consumers remaining uninsured (Domurat, Menashe and Yin, 2018). These two observations are consistent with adverse selection on the intensive and extensive margins, respectively. Our framework highlights the unfortunate but important point that budget-neutral policies targeting one of these problems tend to exacerbate the other due to the trade-off between extensive and intensive margin selection. This point is often absent from reform discussions, and our intention is to correct this potentially costly omission.

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Online Appendix for: The Two Margin Problem in Insurance Markets

A Analysis in a General Model (Relaxing Vertical Assumptions)

In this appendix, we present a formal mathematical analysis of the equilibrium impacts of tuning the parameters governing the two main policies discussed in Section 3: the mandate penalty and risk adjustment. We implement this analysis in a general model that does not invoke the vertical assumptions used for our graphical approach. This lets us show how the vertical assumptions interact with the model's main predictions.

Horizontal differentiation allows for an additional margin of substitution, between H and U, that the vertical model shuts down. As we show below, this adds additional terms to the comparative statics defining the policy effects on prices and market shares. But as long as these H-U substitution terms are not too large—e.g., as long as when M increases, most of the newly insured buy the cheaper L plan, not H—then they do not reverse the sign of the vertical model predictions. Thus, our results are not a knife-edge case driven by the assumption of pure vertical differentiation. Rather, as long as vertical differentiation is the "main" way that H and L compete, the model provides a useful approximation. This is consistent with the findings of our empirical robustness check that allows for horizontal differentiation in Appendix D.4.1.

A.1 Model Setup

The setup is identical to that of Section 2, with two plans H and L and $P = \{P_H, P_L\}$ denoting insurer prices. Let $G = \{S_H, S_L, M\}$ denote plan-specific government subsidies (S_j) and the mandate penalty (M). Throughout this section (as in Section 2), we assume $S_H = S_L = S$, though the framework would generalize if this were not true. Nominal consumer prices equal $P_j^{cons} = P_j - S$ for $j = \{L, H\}$ and $P_U^{cons} = M$.

Unlike in the vertical model, we will not assume that W_H and W_L are perfectly correlated. Instead, we allow consumers to vary along both willingness to pay dimensions. Each consumer type is characterized by an ordered pair $s = (s_H, s_L)$, where s_H indexes WTP for H and s_L indexes WTP for L. We once again normalize $W_U \equiv 0$. Note that a single s-index is no longer sufficient to characterize consumer willingness-to-pay. Without loss of generality, the s index takes a bivariate uniform distribution, so it represents an index of the percentile of the WTP distribution for H and L.

The set of consumers who choose a given option $j \in \{H, L, U\}$ is defined as $A_j(P, G) = \{s : W_j(s) - P_j^{cons} \geq W_k(s) - P_k^{cons} \ \forall k\}$. Demand is defined as the size of this group: $D_j(P, G) = \int_{A_j(P,G)} ds$.

For each "WTP-type," we once again have a plan-specific expected cost $C_j(s)$. We again make the adverse selection assumption that costs in a given plan are increasing in WTP for that plan. Hence $\partial C_j(s_H, s_L)/\partial s_j < 0$ for plan j. Average costs for plan $j \in \{L, H\}$ equal the average of $C_j(s)$ over the enrolling set of consumers:

$$AC_j(P; G) = \frac{1}{D_j(P; G)} \int_{A_j(P,G)} C_j(s) ds \quad (6)$$

Similarly, we can define the average risk score functions:

$$\overline{R}_j(P;G) = \frac{1}{D_j(P;G)} \int_{A_j(P,G)} R(s)ds \tag{7}$$

where $R(s)$ is the average risk score among type-s consumers. The baseline per-enrollee risk adjustment transfer from L to H is a function of these average risk scores, the (share-weighted) average risk score in the market ($\equiv \overline{R}(P;G)$) and the (share-weighted) average price in the market ($\equiv \overline{P}(P;G)$):

$$T(P;G) = \left(\frac{\overline{R}_H(P;G)}{\overline{R}(P;G)} - 1 \right) \overline{P}(P;G). \tag{8}$$

Finally we introduce a parameter $\alpha \in (0,1)$ that multiplies the transfer, $\alpha \cdot T(P;G)$, allowing us to vary the strength of risk adjustment by scaling the transfers up or down such that $\alpha = 0$ represents no risk adjustment, $\alpha \in (0,1)$ is partial risk adjustment, $\alpha = 1$ is full-strength risk adjustment, and $\alpha > 1$ is over-adjustment.

We define equilibrium as prices equal average costs net of risk adjustment transfers:

$$\begin{aligned} P_H &= AC_H\left(P;G\right) - \alpha T(P;G) \equiv AC_H^{RA}(P;G,\alpha) \\ P_L &= AC_L\left(P;G\right) + \alpha T(P;G) \equiv AC_L^{RA}(P;G,\alpha) \end{aligned} \tag{9}$$

where $AC_j^{RA}(P;G,\alpha)$ are risk-adjusted costs for plan $j = \{L,H\}$.

A.2 Approach and Assumptions on Signs of Demand/Cost Curve Slopes

We now consider the equilibrium response to an increase in the uninsurance penalty M and an increase in α, i.e. the strength of the risk adjustment transfers. Our goal is to understand the cross-margin interactions—the effect of M on demand for H and the effect of risk adjustment on the share uninsured. To do so, we use the equilibrium conditions to derive the relevant comparative statics, $\frac{dD_H}{dM}$ and $\frac{dD_U}{d\alpha}$. The comparative statics take account of both direct effects—denoted with partial derivatives below (e.g., $\frac{\partial AC_H}{\partial P_H}$)—and equilibrium effects on market prices—denoted with total derivatives (e.g., $\frac{dP_H}{dM}$). These comparative statics allow us to show the features of demand and cost that determine the sign and magnitude of the cross-margin effects.

In analyzing these comparative statics, we will assume a *stable equilibrium* that is characterized by *adverse selection*. These assumptions let us sign the slopes of several demand/cost curves that enter the equations. In particular, we assume:

- Equilibrium stability, which requires that $1 - \frac{\partial AC_j}{\partial P_j} > 0$ for $j = \{H,L\}$ locally to the equilibrium point.
- Adverse selection, which requires that (on average) the highest-cost types buy H, middle-cost types buy L, and the lowest-cost choose U. More specifically, we assume:
    1. The marginal H consumer is lower-cost than the average H consumer and higher-cost than the average L consumer—which implies that $\frac{\partial AC_H}{\partial P_H} > 0$ and $\frac{\partial AC_L}{\partial P_H} > 0$.

2. The consumer on the margin of H and L is lower-cost than the average H consumer—so $\frac{\partial AC_H}{\partial P_L} < 0$
3. The marginal uninsured consumers are lower-cost than the average consumer of H or L, so $\frac{\partial AC_H}{\partial M} \leq 0$ and $\frac{\partial AC_L}{\partial M} \leq 0$.

For the analysis of risk adjustment, we also assume that the analogous stability and adverse selection conditions hold for *risk-adjusted* average costs AC_H^{RA} and AC_L^{RA}. This is true in our empirical simulations, where we find that risk adjustment is imperfect, so risk-adjusted cost curves are characterized by adverse selection.

Further, while we do not impose the vertical model, it is useful to note its implications for several relevant partial derivatives:

- Vertical model assumes that no consumers are on the H-U margin, which implies that $\frac{\partial D_H}{\partial M} = \frac{\partial AC_H}{\partial M} = \frac{\partial D_U}{\partial P_H} = 0$.

In the analysis below, we color in red the terms that are zero under the vertical model. This lets readers see where relaxing the vertical assumptions adds additional terms to the comparative statics.

A.3 Increase in Uninsurance Penalty (M)

We derive comparative statics for enrollment in H in response to a change in the uninsurance penalty M. Throughout this section, we assume that there is no risk adjustment in place, which simplifies the math.

We start by analyzing $\frac{dD_H}{dM}$, the cross-margin effect of a mandate penalty on enrollment in H. This comparative static is comprised of two parts. First, in red is the direct enrollment change in H for a change in M, holding fixed P_H and P_L. In the vertical model, this $\frac{\partial D_H}{\partial M}$ term would be zero. The second term is the indirect effect on D_H through the change in relative prices of H and L. Formally:

$$\frac{dD_H}{dM} = \underbrace{\frac{\partial D_H}{\partial M}}_{\text{HU margin}} + \underbrace{\underbrace{\frac{\partial D_H}{\partial \Delta P_{HL}}}_{(-)} \cdot \left(\frac{dP_H}{dM} - \frac{dP_L}{dM} \right)}_{\text{HL margin}}. \tag{10}$$

In the vertical model, $\frac{\partial D_H}{\partial M} = 0$, so under the vertical assumption the sign of $\frac{\partial D_H}{\partial M}$ would be fully determined by the change in the incremental price of H vs. L caused by an increase in M. If an increase in M leads to an increase in $\Delta P_{HL} = P_H - P_L$, then an increase in M will lead to lower demand for H. This positive relationship between M and ΔP_{HL} would occur under our assumptions about adverse selection because an increase in M would induce a fall in P_L as the consumers on the margin between L and U who are induced to purchase L are relatively healthy. If the vertical model does not hold, $\frac{\partial D_H}{\partial M} > 0$, which would partly offset the decrease in D_H but not fully do so as long as it is small in magnitude.

Thus, to sign the cross-margin effect, we need to show that $\frac{dP_H}{dM} - \frac{dP_L}{dM} > 0$. We now fully differentiate P_H and P_L with respect to M to characterize this relationship more explicitly.

$$\begin{aligned} \frac{dP_H}{dM} &= \frac{\partial AC_H}{\partial M} + \frac{\partial AC_H}{\partial P_H}\frac{dP_H}{dM} + \frac{\partial AC_H}{\partial P_L}\frac{dP_L}{dM} \\ \frac{dP_L}{dM} &= \frac{\partial AC_L}{\partial M} + \frac{\partial AC_L}{\partial P_H}\frac{dP_H}{dM} + \frac{\partial AC_L}{\partial P_L}\frac{dP_L}{dM} \end{aligned} \tag{11}$$

Notice, that unlike under the purely vertical model, a change in M impacts direct costs for both H and L. Solving this system of equations again for $\frac{dP_H}{dM}$, we get the expression below.

$$\frac{dP_H}{dM} = \left[\frac{\partial AC_H}{\partial M} + \frac{\partial AC_L}{\partial M}\frac{\partial AC_H}{\partial P_L}(1 - \frac{\partial AC_L}{\partial P_L})^{-1}\right] \times \Phi_H^{-1} \tag{12}$$

where $\Phi_H = \{1 - \frac{\partial AC_H}{dP_H} - \frac{\partial AC_H}{\partial P_L}\frac{\partial AC_L}{\partial P_H}(1 - \frac{\partial AC_L}{\partial P_L})^{-1}\}$.

We now can sign $\frac{dP_H}{dM}$ as follows:

$$\frac{dP_H}{dM} = \left[\underbrace{\frac{\partial AC_H}{\partial M}}_{\text{Ext. Margin Selection}(\leq 0)} + \underbrace{\underbrace{\frac{\partial AC_L}{\partial M}}_{(-)} \cdot \underbrace{\frac{\partial AC_H}{\partial P_L}}_{(-)} \underbrace{\left(1 - \frac{\partial AC_L}{\partial P_L}\right)^{-1}}_{(+)}}_{\text{Substitution to } L\ (+)}\right] \times \underbrace{\Phi_H^{-1}}_{(+)} \tag{13}$$

and $\Phi_H = \underbrace{(1 - \frac{\partial AC_H}{dP_H})}_{(+)} - \underbrace{\frac{\partial AC_H}{\partial P_L}\frac{\partial AC_L}{\partial P_H}}_{(-)}\underbrace{(1 - \frac{\partial AC_L}{\partial P_L})^{-1}}_{(+)} > 0$, where all signs are determined by the adverse selection and stability assumptions laid out above.

Therefore, we can sign $\frac{dP_H}{dM} > 0$ under the vertical model. The intuition is as we have already described: the mandate penalty lowers P_L, leading relatively healthy H consumers to leave H and substitute to L, which raises AC_H and therefore P_H. When the vertical model does not hold, extensive margin selection of consumers on the HU margin into H ($\frac{\partial AC_H}{\partial M} < 0$) pushes in the other direction. But as long as extensive margin substitution is not too large, the main effect of substitution to L will dominate.

We derive the expression for $\frac{dP_L}{dM}$ in a similar way:

$$\frac{dP_L}{dM} = \left[\underbrace{\frac{\partial AC_L}{\partial M}}_{\text{Ext. Margin Selection}(-)} + \underbrace{\underbrace{\frac{\partial AC_H}{\partial M}}_{(\leq 0)} \cdot \underbrace{\frac{\partial AC_L}{\partial P_H}}_{(+)} \underbrace{\left(1 - \frac{\partial AC_H}{\partial P_H}\right)^{-1}}_{(+)}}_{\text{Substitution to } H (\leq 0)}\right] \times \underbrace{\Phi_L^{-1}}_{(+)} \tag{14}$$

where $\Phi_L = \{1 - \frac{\partial AC_L}{dP_L} - \frac{\partial AC_L}{\partial P_H}\frac{\partial AC_H}{\partial P_L}(1 - \frac{\partial AC_H}{\partial P_H})^{-1}\} > 0$ as with Φ_H above.

Thus, under the vertical model where $\frac{\partial AC_H}{\partial M} = 0$, we can unambiguously say that P_L falls with a higher mandate penalty ($\frac{dP_L}{dM} < 0$). This conclusion also holds when we relax the vertical model (as shown by the negative substitution term), as any extensive margin substitution into H acts to lower the price of H, drawing the sickest consumers away from L and pushing L's costs and price even further down.

Returning now to $\frac{dD_H}{dM}$, we observe under the vertical model that $\left(\frac{dP_H}{dM} - \frac{dP_L}{dM}\right) < 0$, which implies that $\frac{dD_H}{dM} > 0$. In other words, the "unintended consequence" of decreasing enrollment in H should always occur under the vertical model. When we relax the vertical model, this result will also hold as long substitution on the HU margin is not too large.

A.4 Increasing the Strength of Risk Adjustment (α)

We now consider in our more general model the effect of a small increase in the α parameter on the share of the population that is uninsured. As in the previous section, we color in red the terms that are zero under the vertical model. This lets readers see where relaxing the vertical assumptions adds additional terms to the comparative statics.

The change in the share of the uninsured population given a change in α is comprised of two parts: changes in enrollment from the HU margin (in red) and LU margin (in black). Under the vertical model assumptions, the HU margin is not present.

$$\frac{dD_U}{d\alpha} = \underbrace{\underbrace{\frac{\partial D_U}{\partial \Delta P_{HU}}}_{\geq 0} \frac{d\Delta P_{HU}}{d\alpha}}_{\text{HU margin}} + \underbrace{\underbrace{\frac{\partial D_U}{\partial \Delta P_{LU}}}_{(+)} \frac{d\Delta P_{LU}}{d\alpha}}_{\text{LU margin}} \tag{15}$$

where $\Delta P_{HU} = P_H - S - M$ and $\Delta P_{LU} = P_L - S - M$ are the net prices of H and L relative to uninsurance.

By the law of demand, $\frac{\partial D_U}{\partial P_H} \geq 0$, $\frac{\partial D_U}{\partial P_L} > 0$. Under the vertical model, $\frac{\partial D_U}{\partial P_H} = 0$, so the cross-margin effect of risk adjustment on uninsurance is entirely determined by the sign of the LU margin. We now consider the impact of a change in α on ΔP_{HU} and ΔP_{LU}. The change in prices depends on the nature of subsidies. With subsidies linked to the price of L, ΔP_{LU} $(= P_L - S - M)$ is fixed by construction. Therefore, the LU margin of substitution is shut down. In the vertical model, we will have $\frac{dD_U}{d\alpha} = 0$.

Let us now consider the case where there is a fixed subsidy and therefore prices can be affected by the level of transfers. We fully differentiate (9) and rearrange to get a system of equations. These are identical under both the horizontal and vertical model.

$$\frac{dP_H}{d\alpha} = \underbrace{T(.)}_{(+)} \times \left[\underbrace{-1}_{\text{Direct}(-)} + \underbrace{\frac{\partial AC_H^{RA}}{\partial P_L} \left(1 - \frac{\partial AC_L^{RA}}{\partial P_L}\right)^{-1}}_{\text{Substitution from L }(-)} \right] \times (\Phi_H^{RA})^{-1} < 0$$

where $\Phi_H^{RA} \equiv 1 - \frac{\partial AC_H^{RA}}{\partial P_H} - \frac{\partial AC_L^{RA}}{\partial P_H} \frac{\partial AC_H^{RA}}{\partial P_L} (1 - \frac{\partial AC_L^{RA}}{\partial P_L})^{-1}$. As in the mandate section above, this Φ_H^{RA} term must be positive under the assumptions on stability and adverse selection we have made.

The term in brackets is composed of two effects. First, there is a direct effect of stronger risk adjustment transferring money to H, which tends to lower P_H. Second, there is an indirect substitution effect, arising from substitution of relatively healthy consumers on the margin between H and L opting for H and lowering H's average cost and thus its price. Thus, $\frac{dP_H}{d\alpha} < 0$ because both the direct and indirect effects push P_H down.

Doing the same for $\frac{dP_L}{d\alpha}$ gives

$$\frac{dP_L}{d\alpha} = \underbrace{T(.)}_{(+)} \times \left[\underbrace{1}_{\text{Direct}(+)} + \underbrace{\left(-\frac{\partial AC_L^{RA}}{\partial P_H}\right)\left(1 - \frac{\partial AC_H^{RA}}{\partial P_H}\right)^{-1}}_{\text{Substitution to H }(-)} \right] \times \underbrace{(\Phi_L^{RA})^{-1}}_{(+)}$$

where $\Phi_L^{RA} \equiv 1 - \frac{\partial AC_L^{RA}}{\partial P_L} - \frac{\partial AC_H^{RA}}{\partial P_L}\frac{\partial AC_L^{RA}}{\partial P_H}(1 - \frac{\partial AC_H^{RA}}{\partial P_H})^{-1}$, which must be positive under the stability and adverse selection assumptions.

Here, the direct effect is positive because larger transfers take money from L, driving up the price of L. However, the indirect substitution effect is negative—since $\frac{\partial AC_L^{RA}}{\partial P_H} > 0$ by adverse selection. Intuitively, stronger risk adjustment transfers increase the price of L, causing consumers on the H-L margin to opt for H instead of L. These consumers are the highest-cost L enrollees, implying that their exit from L will lower L's average cost and thus its price. Therefore, the indirect substitution effects will mute (or even fully offset) the direct effect of risk adjustment on P_L. Because of this direct and indirect effect, it is ambiguous whether P_L will increase or decrease, and in general, any change in P_L will be smaller than one would expect from the direct effect alone.

Further, the question of whether the direct or indirect effect dominates depends on whether the substitution term is greater than or less than 1 in absolute value. If it is greater than 1, then the substitution term will dominate. This will occur if $\frac{\partial AC_L^{RA}}{\partial P_H} > 1 - \frac{\partial AC_H^{RA}}{\partial P_H}$. This will tend to occur when intensive margin adverse selection is very strong (even after risk adjustment) so that both $\frac{\partial AC_L^{RA}}{\partial P_H}$ and $\frac{\partial AC_H^{RA}}{\partial P_H}$ are large. Conversely, if adverse selection is weak, the direct effect will dominate.

This expression also tells us how the size of any cost advantage for L may affect the effects of increasing α. When L has no cost advantage over H (the cream-skimmer case), the only reason L gets any demand is intensive margin adverse selection. When adverse selection is strong in the cream-skimmer case, L exists but the substitution effect is also large, muting the direct effect of risk adjustment. When adverse selection is weak in the cream-skimmer case, L fails to exist. Thus, it is more likely that increasing α will have little or no (or possibly negative) effect on P_L in the case where L has no cost advantage than in the case where L has a cost advantage.

To summarize the case with fixed subsidies, $\frac{dD_U}{d\alpha}$ is ambiguous even under the vertical model because we cannot theoretically sign the change in P_L when when α increases. If the direct effect dominates, then P_L will increase with α and uninsurance will rise under the vertical model. If the substitution to H dominates, then P_L will fall and uninsurance will also fall.

When we relax the vertical assumptions, the potential for stronger risk adjustment to increase uninsurance is further mitigated by the presence of the HU extensive margin. The term $\frac{\partial D_U}{\partial P_H}\frac{dP_H}{d\alpha}$ in equation (15) will be positive. Because $\frac{dP_H}{d\alpha} < 0$, consumers on the HU margin will tend to become insured (in H) when risk adjustment is strengthened. This may offset any rise in uninsurance along the LU margin if P_L rises, as more consumers leave uninsurance to buy H.

B Appendix: Extensions to the Graphical Model

B.1 Graphical Analysis of Perfect Risk Adjustment

In this section, we illustrate how our graphical model can be used to show the effects of perfect risk adjustment on equilibrium prices and market shares. Under *perfect* risk adjustment, transfers perfectly capture all variation in C_L across consumer types. The graphical representation of the role of risk adjustment in the two margin problem is complicated by the fact that risk adjustment transfers cause RAC_H (the risk-adjusted cost curve) to become an equilibrium object rather than a stable market primitive (like AC_H), as any effects of selection into the market are at least partially shared between L and H due to the risk-based transfers.

To simplify exposition, we assume that the causal cost difference between H and L equals a constant value of δ for all consumer types s. We define perfect risk adjustment as transfers such that the average cost in H net of risk adjustment always equals the average cost in L net of risk adjustment plus δ: $RAC_H(P) = RAC_L(P) + \delta$. Under perfect risk adjustment, the average risk-adjusted cost in H and L does not depend on consumer sorting between H and L. Instead, the average cost of both plans depends only on consumer sorting between insurance and uninsurance. If new healthy consumers join the market (buying the L plan), the risk transfers share the improved risk pool equally between H and L, maintaining the δ difference between their average costs. The important simplifying feature of *perfect* risk adjustment is that when it comes to average costs, there is only one relevant margin of adjustment: the extensive margin. With *imperfect* risk adjustment, residual intensive margin selection that is not compensated by risk adjustment remains relevant, complicating the graphical analysis.

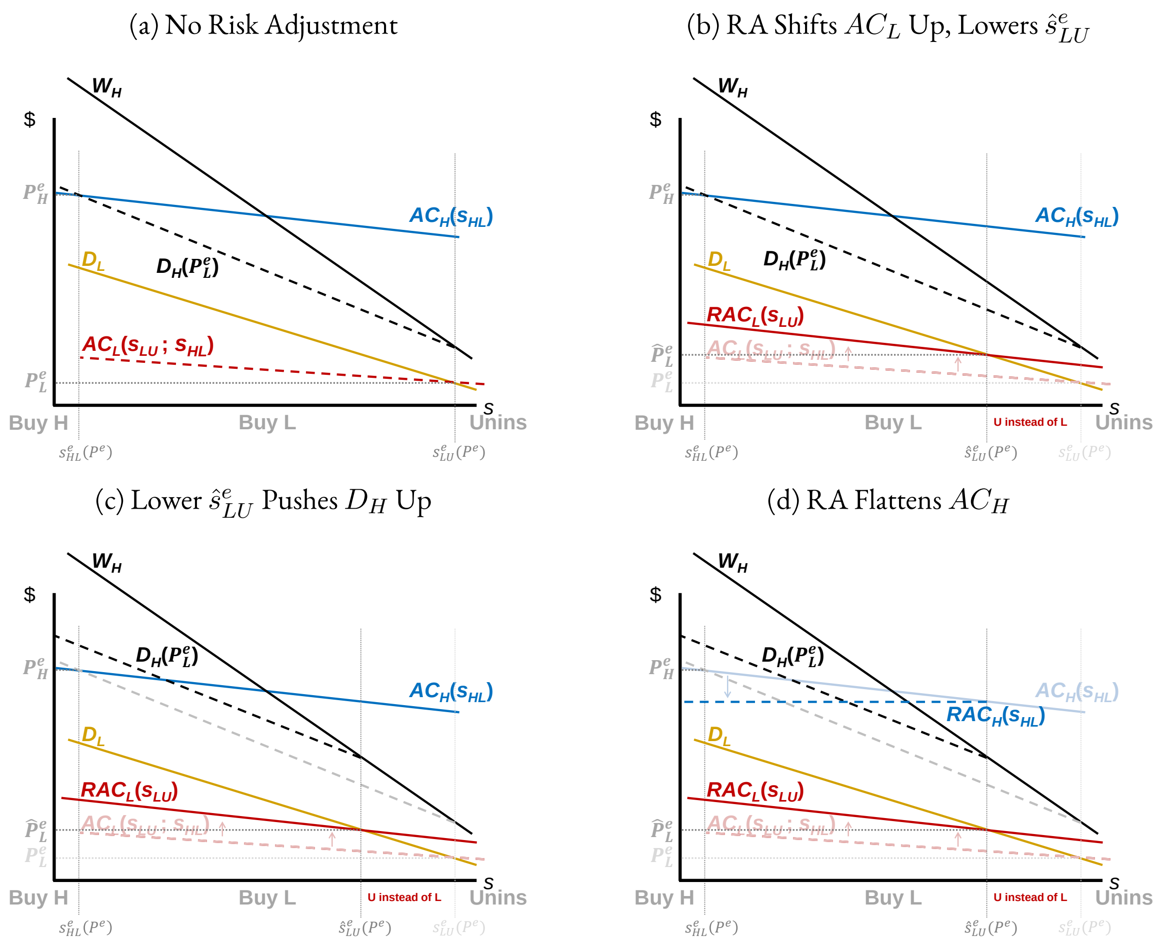
We depict the perfect risk adjustment case in Figure A1. Note that here we do not assume that L is a pure cream-skimmer but instead that L has a cost advantage equal to δ. Risk adjustment affects the curves in a number of ways. First, as depicted in panel (b), risk adjustment causes the average cost curve for L to shift upward and rotate slightly to make it parallel with the original, unadjusted average cost curve for H. This shift reflects the risk transfer away from L (and to H) that raises L's effective costs. $RAC_L(s_{LU})$ still slopes down because of extensive margin adverse selection, but it is now a fixed curve that does not depend on the price of H or sorting between H and L.[45] The new, higher average cost curve for L, RAC_L implies a new, higher equilibrium price for L, $\hat{P}^e_L$. This higher price of L implies a new demand curve for H, shifted upward from the previous demand curve and depicted in panel (c) of Figure A1. This higher demand curve for H reflects the fact that the higher price of L makes L less attractive relative to H.

Panel (d) of Figure A1 illustrates the second direct effect of risk adjustment. For the H plan, risk adjustment causes the average cost curve, $RAC_H(s_{HL})$, to be *rotated downward* relative to the unadjusted curve, $AC_H(s_{HL})$. RAC_H is now a flat line, since sorting between plans (i.e., the value of s_{HL}) does not affect average costs. The level of RAC_H equals $AC_H(s_{LU})$—the average cost if the entire population up to the extensive margin type s_{LU} were to enroll in H.

Figure A2 shows how this shift in H's average cost curve combines with the shift in H's demand curve to produce a new lower equilibrium price of H, $\hat{P}^e_H$ and a higher quantity of consumers enrolling in H.

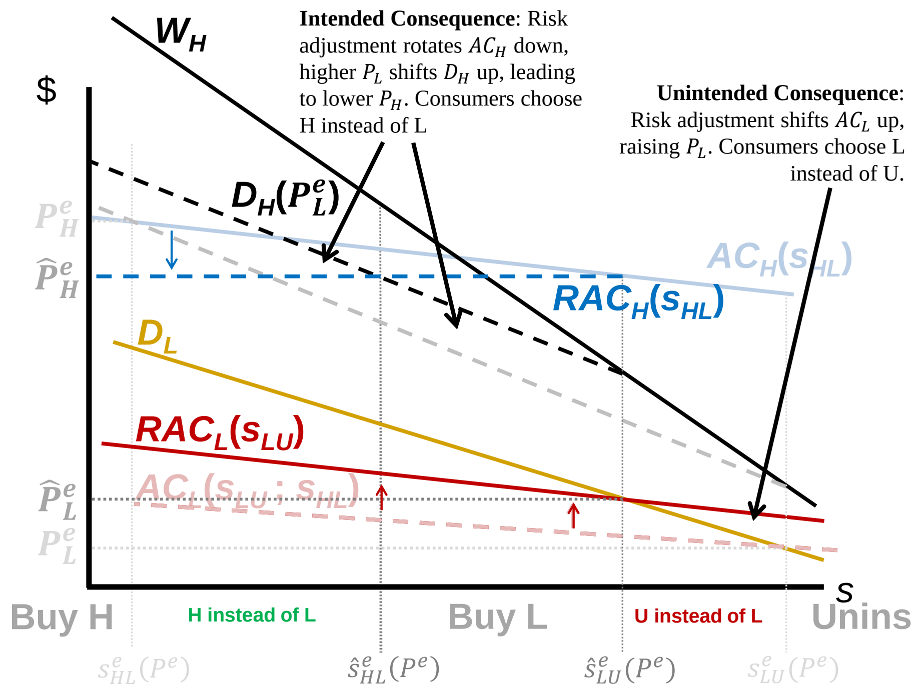
[45] One can show that RAC_L is parallel to the old AC_H since it is capturing the overall average costs of everyone from $s = 0$ up to a given s_{LU} cutoff.

Figure A1: Equilibrium under Perfect Risk Adjustment



Notes: Starting from equilibrium in panel (a) and introducing perfect risk adjustment in panel (c), perfect risk adjustment shifts up the average cost of L from $AC_L(s_{LU})$ to $RAC_L(s_{LU})$, reflecting the transfer away from L to H. Unlike AC_L, the risk adjusted RAC_L only depends on the extensive margin S_{LU}, not on the allocation across plans (s_{HL}). The risk adjusted curve $RAC_L(s_{LU})$ intersects D_L at a lower point, shifting out the extensive margin from s^e_{LU} to $\hat{s}^e_{LU}$. Next, in panel (c) we see that this lower extensive margin-type $\hat{s}^e_{LU}$ shifts up D_H. Finally, in panel (d) we see that risk adjustment flattens the risk adjusted average cost of H, RAC_H, which like RAC_L no longer varies depending on sorting between the two plans, s_{HL}.

Figure A2: Equilibrium under Perfect Risk Adjustment



Notes: Under perfect risk adjustment, the risk-adjusted average cost curve for H is completely flat for a given s_{LU}. Equilibrium occurs at s_{HL} and s_{LU} values such that RAC_H intersects D_H and RAC_L intersects D_L.

In summary, perfect risk adjustment has two effects. First, it causes the average cost curve for H to rotate downward until it is flat. This rotation of the cost curve causes s_{HL} to shift right, indicating a shift of consumers from L to H. This is the intended effect of risk adjustment, and it is caused by a transfer from L to H to compensate H for the externality imposed on it by intensive margin selection from L. Second, it causes the average cost curve for L to both rotate and shift up.[46] This change in AC_L causes s_{LU} to shift left, indicating a shift of consumers from L to U, increasing uninsurance. This is the unintended effect of risk adjustment. It occurs because the transfer to H comes from L, resulting in an increase in L's costs and price, forcing some consumers out of the market. In Section 3 we also provide a graphical description of the welfare consequences of risk adjustment, both perfect and imperfect.

In Appendix A and Appendix D.4.1 we also explore (both theoretically and empirically) how the effects of risk adjustment are affected by the relaxation of our vertical model assumption, finding that the presence of consumers with non-vertical preferences can act to weaken the unintended effects of risk adjustment on the extensive margin.

Finally we note that if risk adjustment is perfect—as assumed in this subsection—it will often lead to countervailing effects with some consumers opting for H instead of L and other consumers opting for U instead of L. With imperfect risk adjustment, in contrast, the unintended extensive margin effect may or may not occur, depending on the relative sizes of the direct and indirect effects.

[46] The curve remains downward-sloping because perfect risk adjustment only addresses intensive margin selection, leaving selection on the extensive margin in place.

B.2 Extension: Medicare Advantage + Traditional Medicare

Our graphical model can be extended to other cases beyond the baseline $H/L/U$ setup modeled on the ACA Marketplaces. One setting of particular policy interest is the Medicare Advantage (MA) market, in which plans of varying quality compete with an outside option of Traditional Medicare (TM). A key difference for the MA-TM setting is that the inside-option plans are *advantageously* selected relative to the outside option. Unlike the ACA case where the outside option of uninsurance attracts the lowest-cost consumers, TM has historically attracted the sickest and highest-cost enrollees.[47] We show in this section how our graphical model can capture the MA-TM case under the maintained assumption of vertical differentiation. (For non-vertical differentiation, a 2-D graphical approach is not feasible, but see the math in Appendix A that captures the general case.)

The MA-TM extension works as follows. We start by setting up a model with three vertically ranked plans: (1) TM, the most preferred option; (2) H, a high-quality MA plan (middle option); and (3) L, a lower-quality MA plan (least preferred). We think of TM as representing Traditional Medicare bundled with a generous Medigap plan so that it is the most generous option for both cost sharing and provider network. H could be a broad-network MA plan (e.g., a PPO), while L could be a narrow-network MA plan (e.g., an HMO). Importantly, we assume that TM is the outside option whose price is set *exogenously* by policymakers (e.g., via the Part B premium and rules for MA subsidies/benchmarks), while the prices of H and L are determined in equilibrium. We note, of course, that the real-world MA-TM market is much more complicated than this setup and that vertical differentiation is an approximation. Our model should be seen as an approximation, and the caveats discussed for our baseline model also apply here.

To capture advantageous selection with respect to TM, we *reorder the plan sorting* along our maintained "*s* type" x-axis. Rather than have the lowest-WTP types choose the outside option (of uninsurance) as in our baseline model, the highest-WTP types now choose the outside option of TM. Middle-WTP types choose the H MA plan, and the lowest-WTP types choose the L MA plan. We will continue to assume that WTP correlates with sickness (cost), so the sickest types choose TM, middle types choose H, and the healthiest types choose L. This reordering lets us define demand and costs curves and competitive equilibrium in a similar manner as in our baseline H/L/U model. We note that this reordering is different from the EFC-graph approach to advantageous selection, which instead uses upward sloping curves corresponding to a market where consumer preference for more generous coverage itself is negatively correlated with costs.

Formally, we maintain the vertical model assumptions of Section 2 with labeling changes. We normalize $W_{i,L} \equiv 0$ and make the following two assumptions:

Assumption 3. *Vertical ranking:* $W_{i,TM} > W_{i,H} > W_{i,L} \equiv 0$ *for all* i

Assumption 4. *Single dimension of WTP heterogeneity: There is a single index* $s \sim U[0,1]$ *that orders consumers based on declining WTP, such that* $W'_H(s) < 0$ *and* $W'_{TM}(s) - W'_H(s) < 0$ *for all* s.

We assume that the consumer price of TM, P_{TM}, is set exogenously. The prices of the H and L MA plans are set competitively to equal their average costs:

$$P_H = AC_H(P) \qquad \text{and} \qquad P_L = AC_L(P) \tag{16}$$

[47]There is evidence that in recent years, improved risk adjustment has offset some of these differences. The model in this section should be seen as illustrative of the traditional case where MA was still advantageously selected.

As in the baseline model, there could be non-uniqueness, and we limit attention to equilibria that meet the requirements of the Riley Equilibrium (RE) notion (see Appendix C.3). For the graphical presentation, we focus on the case of monotonic adverse selection in which higher-WTP correlates with higher costs. For graphical simplicity, we also focus on the pure cream-skimming case where $C_H(s) = C_L(s)$ for all s. The more general case would be similar but would involve plotting two separate type-specific cost curves. Finally, we depict the case with positive demand for all contracts, though in principle the model allows one more contracts to unravel.

Figure A3 shows equilibrium in the MA-TM case under these assumptions. The graph is similar to equilibrium in the baseline H/L/U case (see Figure 4) but with a few differences. First, the price of *TM* is exogenous and there is therefore no need to show the average cost of *TM*. Second, all demand and average cost curves are now equilibrium objects that depend on P_H or P_L; it is no longer possible to define AC_H and D_L based on primitives alone. This makes the setup slightly more complex to describe, but the basic concepts and cross-margin policy effects are similar.

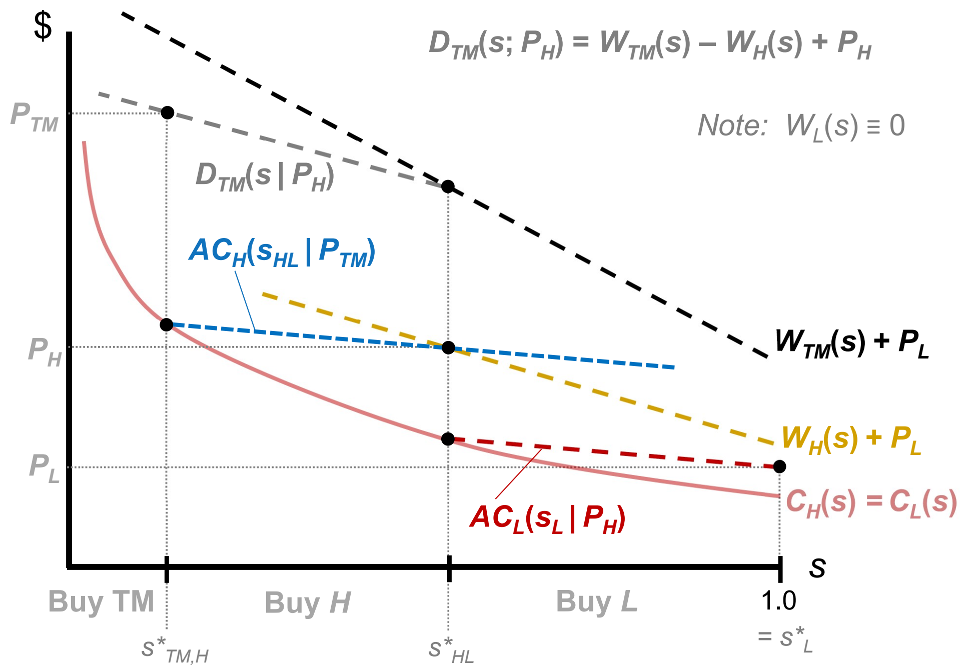
Walking through Figure A3, suppose we start with an exogenous P_{TM} (set by policymakers) and an initial guess for P_H and P_L. The demand curve that determines sorting between TM and H is $D_{TM}(s) = W_{TM}(s) - W_H(s) + P_H$. The type indifferent between these two options is $s^*_{TM,H}$, defined by $D_{TM}(s^*_{TM,H}) = P_{TM}$. Types to the left of this point ($D_{TM}(s) > P_{TM}$) choose TM, while types to the right of this point choose H or L. Sorting between H vs. L is determined by the yellow curve $D_H(s) \equiv W_H(s) + P_L$, with indifferent type $s^*_{H,L}$ defined by $W_H(s^*_{H,L}) + P_L = P_H$. Types to the left of $s^*_{H,L}$ choose H (since $D_H(s) > P_H$), while types to the right choose L (since $D_H(s) < P_H$). Notice that both the dashed black and yellow curves equal WTP (for TM and H) shifted upward by P_L. This is similar to the way that the mandate penalty (price of the lowest-quality option) shifted upward WTP for insurance plans in our baseline H/L/U model, but in this case the price of L is endogenous.

Turning to costs, the pink curve is the type-specific cost curve, $C_H(s) = C_L(s)$, for this pure cream-skimming case (though this would be easy to generalize). The average cost curve for H starts at $s^*_{TM,H}$ and slopes downward to the right (lying above the $C_H(s)$ curve), capturing the average costs of all individuals choosing H (i.e., $s \in [s^*_{TM,H}, s_{HL}]$). In equilibrium, $AC_H(s)$ intersects $D_H(s)$ at $s = s^*_{H,L}$ so that $AC_H(s^*_{H,L}) = P_H$. For the L plan, the average cost curve starts at this $s^*_{H,L}$ type and slopes downward to the right (lying above the $C_L(s)$ curve). Since all $s \in [s^*_{H,L}, 1]$ choose L, the final average costs of L equals the value of $AC_L(s)$ at $s = 1$. In equilibrium, $AC_L(1) = P_L$.

This model can also be used to think about cross-margin policy effects. For instance, suppose the government decreases the price of *TM*, intending to get more consumers to choose the higher-quality *TM* option. Some consumers then shift from H into *TM* at the $s^*_{TM,H}$ margin, captured by a movement along the D_{TM} curve. These people leaving H are its highest-cost consumers, so the AC_H curve shifts downward, resulting in a lower P_H and a shift from L to H on the intensive margin. Therefore, a change in the extensive margin price (P_{TM}) results in a demand shift on the intensive margin from the L to the H plan. Notice, however, that unlike the H/L/U case, the cross-margin effects *reinforce* the original policy's goal of getting consumers into higher-quality plans. In addition to the intended shift from H to TM (higher quality), there is a cross-margin shift from L to H (also higher quality). In words, lowering the price of TM results in more MA enrollees choosing higher-quality MA options.[48]

[48] Similar analysis could also be applied to study the cross-margin impact of a risk adjustment transfer from L to H, which might lower the price of H and draw consumers into H from TM. In reality in the MA-TM market, risk adjustment applies across all three options, making the analysis somewhat different.

Figure A3: Equilibrium in Medicare Advantage + Traditional Medicare Case



Notes: The graph shows equilibrium in the Medicare Advantage (MA) + Traditional Medicare (TM) case, as described in the appendix text. Assumptions, curve setups, and equilibrium are similar to our baseline H/L/U model, but with sorting reordered so that the highest-WTP (furthest left) types choose the outside option of *TM*, middle-WTP types choose the higher-quality MA plan (H), and the lowest-WTP types choose the lower-quality MA plan (L).

B.3 Formal Social Welfare Function

In this appendix, we derive a formal expression for welfare, building on the graphical presentation in the body text. We allow for cases where C_U is non-zero—e.g., if the outside option involves social costs like uncompensated care.

We define social welfare as:

$$\widehat{SW}(P) = \int_{0}^{s_{HL}(P)} (W_H(s) - C_H(s))\, ds + \int_{s_{HL}(P)}^{s_{LU}(P)} (W_L(s) - C_L(s))\, ds - \int_{s_{LU}(P)}^{1} C_U(s)\, ds \quad (17)$$

Recall that the level of utility was normalized above by setting $W_U = 0$. As in the figures, we can express welfare in terms of three curves and two areas (integrals) if we make the following transformations. First, add a constant equal to total potential cost of U, defining $SW = \widehat{SW} + \int_0^1 C_U(s)\, ds$. Second, define "net costs" of L (in excess of C_U) as $C_L^{Net}(s) \equiv C_L(s) - C_U(s)$. Rearranging and simplifying, this yields the following expression for social welfare:

$$SW = \underbrace{\int_0^{s_{HL}(P)} \left(W_H^{Net}(s) - W_L(s)\right) ds}_{\text{Intensive Margin Surplus from } H \text{ vs. } L} + \underbrace{\int_0^{s_{LU}P)} \left(W_L(s) - C_L^{Net}(s)\right) ds}_{\text{Extensive Margin Surplus from } L \text{ vs. } U} \quad (18)$$

The first term is the intensive margin surplus (H vs. L) for consumers who buy H, $s \in [0, s_{HL}]$. Notice that $W_H^{Net}(s) - W_L(s) = \Delta W_{HL} - \Delta C_{HL}$, so this is indeed capturing the intensive margin surplus. The second term is the extensive margin surplus from insurance (in L) relative to uninsurance, which applies to everyone who buys insurance, $s \in [0, s_{LU}]$. Equation (18) shows that it is straightforward to calculate welfare even when $C_U \neq 0$, as long as the researcher has information about C_U.

C Appendix: Simulation Method Details

C.1 Constructing Demand and Cost Curves

As discussed in section 4, we draw on separate demand and cost estimates for both low-income subsidized consumers from Finkelstein, Hendren and Shepard (2019) (abbreviated "FHS") and high-income unsubsidized consumers from Hackmann, Kolstad and Kowalski (2015) (abbreviated "HKK"). We describe how each respective paper produced its primitives as well as our modifications below.

C.1.1 Low-Income Demand and Costs: FHS (2019)

FHS Primitives

- Population: FHS estimate insurance demand in Massachusetts' pre-ACA subsidized health insurance exchange, known as "CommCare." CommCare was an insurance exchange created under the state's 2006 "Romneycare" reform to offer subsidized coverage to low-income non-elderly adults (below 300% of poverty) without access to other health insurance (from an employer, Medicare, Medicaid, or another public program). This population was similar, though somewhat poorer, than the subsidy-eligible population under the ACA.

- Market structure: CommCare participation was voluntary: consumers could choose to remain uninsured and pay a (small) penalty. As FHS show, a large portion of consumers (about 37% overall) choose the outside option of uninsurance, despite the penalty and large subsidies. The CommCare market featured competing insurers, which offered plans with standardized (state-specified) cost sharing rules but which differed on their provider networks. In 2011, the main year that FHS estimate demand, the market featured a convenient vertical structure among the competing plans. Four insurers had relatively broad provider networks and charged nearly identical prices just below a binding price ceiling imposed by the exchange. One insurer (CeltiCare) had a smaller provider network and charged a lower price. FHS pool the four high-price, broad network plans into a single "H option"—technically defined as each consumer's preferred choice among the four plans—and treat CeltiCare as a vertically lower-ranked "L option." FHS present evidence that this vertical ranking is a reasonable characterization of the CommCare market in 2011.

- FHS Estimation: To estimate demand and costs, FHS use a regression discontinuity design leveraging discontinuous cutoffs in subsidy amounts based on household income. Because subsidies vary across income thresholds, there is exogenous net price variation that can transparently identify demand and cost curves with minimal parametric assumptions. FHS leverage discontinuous changes in net-of-subsidy premiums at 150% FPL, 200% FPL, and 250% FPL arising from CommCare's subsidy rules. They estimate consumer willingness-to-pay for the lowest-cost plan (L) and incremental consumer willingness-to-pay for the other plans (H) relative to that plan.[49] This method provides estimates of the demand curve for particular ranges of s. The same variation is used to estimate $AC_H(s)$ and $C_H(s)$, the average and marginal cost curves for H. Our goal is not to innovate on these estimates but rather to apply them as primitives in our policy simulations to understand the empirical relevance of our conceptual framework.

Our Modifications to FHS Primitives

- Extrapolating to extremes of s distribution: The FHS strategy provides four points of the $W_L(s)$ curve and four points of the $W_{HL}(s) = W_H(s) - W_L(s)$ curve. As shown in Figure 10 from FHS, for the W_L curve these points span from $s = 0.36$ to $s = 0.94$ and for the W_{HL} curve these points span from $s = 0.31$ to $s = 0.80$. Because our model allows for the possibility of zero enrollment in either L or H or both, we need to modify the curves, extrapolating to the full range of consumers, $s \in [0, 1]$. We start by extrapolating linearly, and then we "enhance" demand for H among the highest WTP consumers, as we view this as more realistic than a linear extrapolation. (We explore the sensitivity of our empirical results to alternative assumptions about this WTP enhancement in Appendix D.4.2) We then smooth the enhanced demand curves to eliminate artificial kinks produced by the estimation and extrapolation.

  (1) Linear demand: For the linear demand curves, we extrapolate the curves linearly to $s = 0$ and $s = 1.0$. Call these curves $W_L^{lin}(s)$ and $W_H^{lin}(s)$, with incremental WTP defined as $W_{HL}^{lin} = W_H^{lin} - W_L^{lin}(s)$.

  (2) Enhanced demand: For the enhanced demand curves $\left(W_L^{enh}(s) \text{ and } W_H^{enh}(s)\right)$, we inflate consumers' relative demand for H vs. L in the extrapolated region, relative to a linear extrapolation. We implement enhanced demand in an *ad hoc* but transparent way: We first generate $W_L^{enh}(s) = W_L^{lin}(s)$ for all s. For all $s >= 0.31$ (the boundary of the "in-sample" region of $W_{HL}(s)$), we likewise set $W_{HL}^{enh}(s) = W_{HL}^{lin}(s)$. For $s = 0$, we set $W_{HL}^{enh}(s = 0) = 3W_{HL}^{lin}(s = 0)$, so that the maximum enhanced incremental willingness-to-pay is three times the value suggested by the primitives. We then linearly connect the incremental willingness to pay between s=0 and s=0.31, setting $W_{HL}^{enh}(s < 0.31) = W_{HL}^{lin}(s) + 3 \times \frac{(0.31-s)}{0.31} \times W_{HL}^{lin}(0)$ so that the enhanced curve is equal to the linear curve for $s >= 0.31$, equal to three times the linear curve at $s = 0$, and linear between $s = 0.31$ and $s = 0$. This approach assumes that there exists a group of (relatively sick) consumers who exhibit very strong demand for H relative to L, which seems likely to be true in the real world. Thus,

$$W_{HL}^{enh}(s) = \begin{cases} W_{HL}^{lin}(s) & \text{for } s \in [0.31, 1] \\ W_{HL}^{lin}(s) + 3 \times \frac{(0.31-s)}{0.31} \times W_{HL}^{lin}(0) & \text{for } s \in [0, 0.31) \end{cases} \tag{19}$$

[49] Because the base subsidy for L and the incremental subsidy for H change discontinuously at the income cutoffs, there is exogenous variation in both the price of L and the incremental price of H.

and

$$W_H^{enh}(s) = W_L^{lin}(s) + W_{HL}^{enh}(s). \tag{20}$$

Both the linear and the enhanced WTP curves are shown in the top panel of Figure A4.

- Cost of L plan: We need to produce estimates of $C_L(s)$ to complete the model. FHS provide suggestive evidence that $C_L(s)$ is quite similar to $C_H(s)$—i.e., that for a given enrollee, L does not save money relative to H. We conducted further analyses to provide additional evidence on this question (leveraging entry of the L plan in some areas but not others, leveraging additional price variation for L vs. H, etc.), consistently finding a lack of evidence of any cost advantage for L among the enrollees marginal to these sources of variation. While L may indeed be a pure cream-skimmer in this setting, the assumption that $C_H(s) = C_L(s)$ for all s seems unlikely to hold in many other settings. Thus, we consider both the setting where L has a 15% cost advantage so that $C_L(s) = 0.85C_H(s)$ and the setting where, consistent with the empirical evidence, L is a pure cream-skimmer, i.e. $C_L(s) = C_H(s)$.

- Smoothing primitives: Because they were estimated using a regression discontinuity design, the primitives above all have discrete "kink points" at which the slope of the curve with respect to the share of the population enrolled changes discretely. In these regions, equilibrium allocations are extremely sensitive to small changes in policy parameters. To avoid this unrealistic sensitivity, we smooth the cost curves as well as the enhanced demand curves using a fourth degree polynomial. Specifically, for primitive $Y(s)$, we run the following regression.

  $$Y = \hat{\beta}_0 + \hat{\beta}_1 s + \hat{\beta}_2 s^2 + \hat{\beta}_3 s^3 + \hat{\beta}_4 s^4 + \epsilon$$

  Using the fitted coefficients, we then use the predicted value $\hat{Y}$,

  $$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 s + \hat{\beta}_2 s^2 + \hat{\beta}_3 s^3 + \hat{\beta}_4 s^4$$

  This "smoothing" process was done on both the WTP curves as well as the cost curve primitives.

C.1.2 High-Income Demand and Costs: HKK (2015)

For our simulations, we also consider demand of higher-income groups, which allows us to simulate policies closer to the ACA. Under the ACA, low-income households receive subsidies to purchase insurance while high-income households do not. We construct WTP curves for high-income households using estimates of the demand curve for individual-market health insurance coverage in Massachusetts from Hackmann, Kolstad and Kowalski (2015) ("HKK").

HKK Primitives

- Population: HKK estimate demand in the unsubsidized pre-ACA individual health insurance market in Massachusetts, which is for individuals with incomes above 300% of poverty (too high to qualify for CommCare).

- Estimation: HKK use the introduction of the state's individual mandate in 2007-08 as a source of exogenous variation to identify the insurance demand and cost curves. HKK only estimate demand for a single L plan.

Our Modifications to HKK Primitives

- Constructing $W_L^{HI}(s)$: We start by constructing $W_L^{HI}(s)$, based on the estimates from Hackmann, Kolstad and Kowalski (2015). The superscript HI refers to high income. The HKK demand curve takes the following form:

$$W_{HKK}(s) = -\$9,276.81 * s + \$12,498.68 \tag{21}$$

  This demand curve is "in-sample" in the range of $0.70 < s < 0.97$. As with the low-income, subsidized consumers, we linearly extrapolate $W_{HKK}(s)$ out-of-sample to construct $W_L^{HI,lin}(s)$. Specifically, we let $W_L^{HI,lin}(s) = W_{HKK}(s)$ for all s.

- Constructing $W_H^{HI,lin}(s)$ and $W_H^{HI,enh}(s)$: HKK only estimate demand for a single L plan. Similar to FHS, we start by estimating a linearly extrapolated WTP for H, $W_H^{HI,lin}(s)$, and then "enhance" demand for H among the highest WTP types, $W_H^{HI,enh}(s)$, using the W_{HL}^{lin} and W_{HL}^{enh} as constructed for the low-income population above (i.e. we assume that extensive margin WTP for insurance is different between the high-income and low-income groups, but intensive margin WTP for H vs. L is the same):

$$W_H^{HI,lin}(s) = W_L^{HI} + W_{HL}^{lin}(s)$$
$$W_H^{HI,enh}(s) = W_L^{HI} + W_{HL}^{enh}(s)$$

- Constructing $C_L^{HI}(s), C_H^{HI}(s)$: We assume that the cost curves for this group are equivalent to the cost curves of the subsidized population, Thus,

$$C_H^{HI}(s) = C_H(s)$$
$$C_L^{HI}(s) = C_L(s)$$

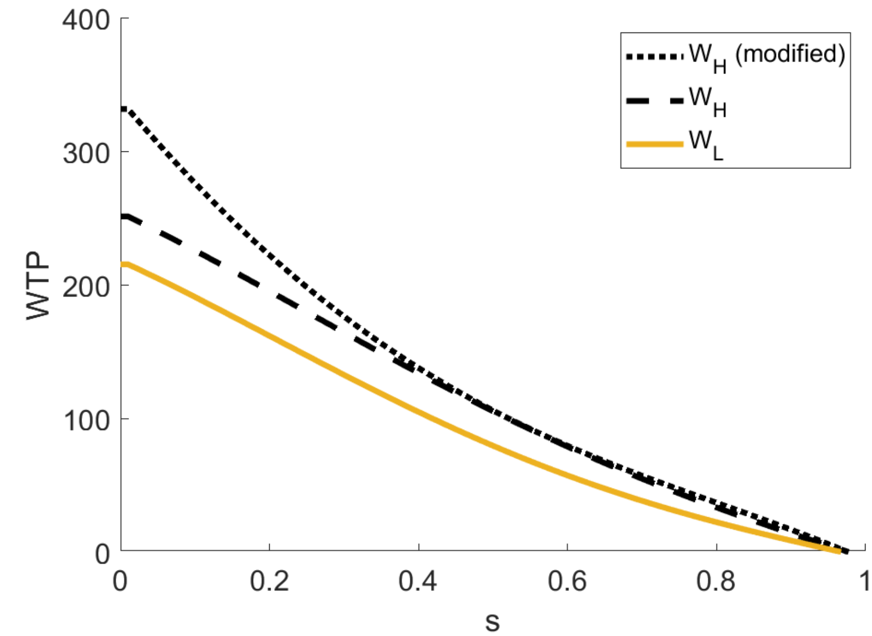
  where $C_H(s)$ is drawn from FHS and $C_L(s)$ is the curve as constructed in the previous section. We note that these assumptions imply that the high-income consumers have a level shift in WTP with no difference in the extent of intensive or extensive margin selection from the low-income consumers.

- Smoothing primitives: Similar to above, we also smooth primitives.

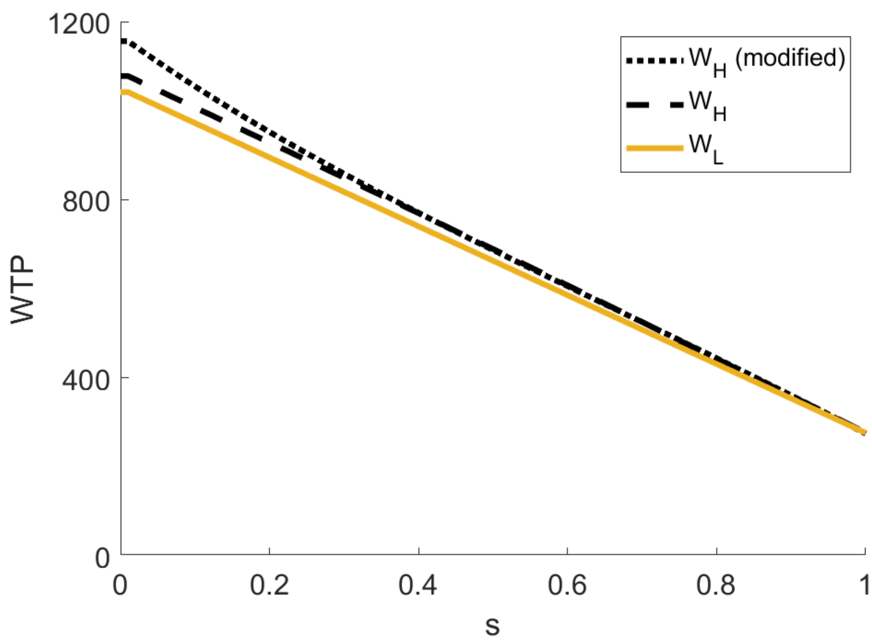
We thus have two demand systems: one for low-income consumers and one for high-income consumers. Both exhibit WTP for H that is "enhanced" for the highest WTP types beyond what a simple linear extrapolation would imply. We combine these systems to form one set of demand and cost curves, by assuming that 60% of the market is low-income and 40% of the market is high-income, consistent with the population in the ACA Health Insurance Marketplaces.

Figure A4: WTP Curves for H and L

(a) Low-Income



(b) High-Income



Notes: Figure shows WTP Curves for H and L, $W_H(s)$ and $W_L(s)$. The top panel shows curves for low-income group which come from (Finkelstein, Hendren and Shepard, 2019). The bottom panel shows curves for high-income group which come from (Hackmann, Kolstad and Kowalski, 2015). Linear curves extrapolate linearly over the out-of-sample range [0,0.31]. Modified (i.e. "enhanced") curves assume that the lowest s-types have very high incremental WTP for H.

C.2 Estimation of Risk Score Curve

Like WTP and costs, we use FHS's regression discontinuity approach to estimate a risk adjustment function for each s-type, $R(s)$. This function characterizes the *expected* cost of each s-type, as predicted by the actual risk scores of each enrollee, RA_i^{HCC}. To calculate this, we first compute these scores for each individual in our data, based on diagnosis codes present in the individual-level claims. All risk scores are computed using the Hierarchical Condition Categories (HCC), a risk adjustment model used by the Centers for Medicare and Medicaid Services for the ACA Marketplaces.[50]

Once we have a risk score for each individual in the data A_i^{HCC}, the risk score curve $R(s)$ was identified off of the same premium discontinuities as used to identify the demand curve in FHS. We then connect and smooth segments in a similar fashion to our construction of the cost and WTP curves to generate the $R(s)$ we use in our analysis. Similar to our assumption that the cost curve $C_H(s)$ estimated on the subsidized population applies to the un-subsidized population, we assume that this $R(s)$ curve estimated on the un-subsidized population also applies to the subsidized population.

Figure A5 shows a measure of risk-adjusted costs for the H plan in comparison to raw costs $C_H(s)$. It plots $C_H(s)$ and $C_H(s)/R(s)$; the latter would be constant in s under perfect risk adjustment. Consistent with risk adjustment being meaningful but imperfect, the risk-adjusted cost curve is much flatter than raw costs but still downward sloping. Over the $s \in [0, 1]$ interval, the risk-adjusted cost curve falls by about $130, compared to a fall of $367 in raw costs. Thus, by this measure, risk scores net out about 35% of the cost variation along the marginal cost curve for H. Since this simulation exclusively uses cost and risk score primitives from the subsidized population of pre-ACA Massachusetts, this finding should not necessarily be seen as generalizable to the entire ACA exchange population.

C.3 Riley Equilibrium Concept

We consider equilibria that meet the requirements of the Riley Equilibrium (RE) notion. In words, a price vector of $P = (P_H, P_L)$ is a Riley Equilibrium if there is no profitable deviation for which there is no "safe" (i.e. weakly profitable) reaction that would make the deviating firm incur losses. We slightly modify the definition presented in Handel, Hendel and Whinston (2015) below

DEFINITION 1: A *Riley Equilibrium* is a set of break-even price offers $P \in \mathcal{P}^{BE}$ for which there exists no Riley Deviation P'. A Riley Deviation (P') is a set of offers such that $P' \cup P$ is closed and $P' \cap P = \emptyset$. This P' is a Riley deviation if the following criteria are satisfied.

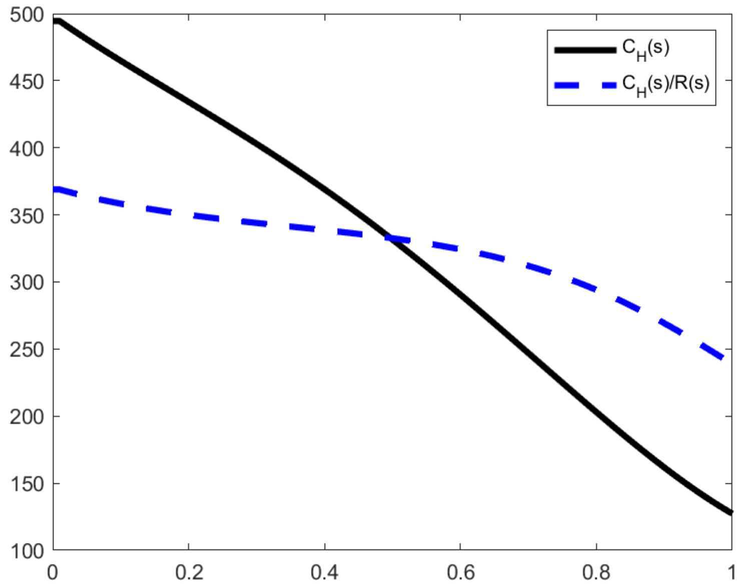
1. The Riley Deviation plan P' is weakly profitable and garners non-zero enrollment when the original prices are also offered: $P'_j \geq AC_j(P'_j)$ when $P \cup P'$ is offered and $P'_j \neq P_j$ (Note that this deviates from Handel, Hendel and Whinston (2015), which requires that the Riley Deviation is *strictly* profitable)

2. No "Safe Response" (P'') exists

We define a safe response as a set of price offers P'' such that $P \cup P' \cup P''$ is closed and P'' is disjoint from $P \cup P' \cup P''$ such that

[50] In practice, the methodology involves grouping diagnoses into different conditions, such as diabetes, etc. Individuals are then assigned risk scores based on the weighted value of all of their conditions. CMS publishes its weights annually on its website (https://www.cms.gov/medicare/health-plans/medicareadvtgspecratestats/risk-adjustors.html)

Figure A5: Raw Costs (C_H) versus Risk-Adjusted Costs



Notes: Figure shows raw C_H (black, continuous line) and risk-score normalized C_H (blue, dashed). While the risk score is able to flatten out the cost curve somewhat, not all risk is captured by the score, leaving some slope.

1. P' incurs losses when $P \cup P' \cup P''$ is offered
2. P'' does not incur losses when any market offering $\hat{P}$ containing $P \cup P' \cup P''$ is offered

It is straightforward to show that in our setting no price vector that earns positive profits for either L or H is a RE (see Handel, Hendel and Whinston, 2015 for a proof). This limits potential REs to the price vectors that cause L and H to earn zero profits. We refer to these price vectors as "breakeven" vectors. This set consists of the following potential vectors:

1. No Plan Enrollment: Prices are so high that no consumer enrolls in H or L
2. L-only: P_H is high enough that no consumer enrolls in H while P_L is set such that P_L equals the average cost of the consumers who choose L.
3. H-only: P_L is high enough that no consumer enrolls in L while P_H is set such that P_H equals the average cost of the consumers who choose H.
4. H and L: P_L and P_H are set such that both L and H have positive enrollment and P_L is equal to the average cost of the consumers who choose L and P_H is equal to the average cost of the consumers who choose H.

To simplify exposition, in Section 2 we assume that there is a unique RE such that there is positive enrollment in both H and L. However, we note that under certain conditions the competitive equilibrium will instead consist of positive enrollment in only one of the two plan options. We allow for these possibilities in the empirical portion of the paper and are able to find an unique RE where at least one plan has non-zero enrollment for every setting tested. See Appendix C.4 for details on the algorithm.

C.4 Reaction Function Approach to Finding Equilibrium

Evaluating demand, profits: For each uninsurance penalty, risk adjustment strength, L-plan cost advantage, and subsidy type setting, we find the equilibrium price configuration (P_H, P_L) using the following grid-search method. We construct a grid of P_H, P_L price combinations, with H on the vertical axis and L on the horizontal axis. For most simulations, we use a coarse grid with $1 units. For each pair, we evaluate H and L profits using the demand, cost, and risk-adjustment equations as detailed in the body of the paper. For insurance types H, L and uninsurance U we evaluate demand by finding the "indifference points"–the first and the last points in the s distribution such that each type of insurance's enrollment conditions are satisfied. Because of the vertical model, we can attribute all intermediate points of the s distribution between these indifference points to a given plan. If no points on the s vector satisfy the plan's enrollment conditions, the plan has zero enrollment. We have indifference points s_{HL}, s_{LU} if both H and L have non-zero enrollment and s_{HU}, s_{LU} if L or H has zero enrollment, respectively. If there is non-zero demand for both H and L, we calculate the average risk of those enrolled in each plan and construct transfers from the less risky plan to the more risky plan, per the ACA risk adjustment formula (see equation 4). In some counterfactual policy simulations, the transfer is multiplied by α. Finally, average costs are calculated for each plan with non-zero enrollment. The function returns the H, L profit grids Π^H, Π^L with which we can then evaluate equilibrium.

Finding equilibrium: For a given grid coarseness, we set a tolerance value T equal to the increment between grid points. A plan is considered to have zero profits if its profits are between $-T$ and T. Potential equilibria are all price pairs where (1) only H has non-zero enrollment and is making zero profits (2) only L has non-zero enrollment and is making zero profits (3) both H and L have non-zero enrollment and are both making zero profits. Given the coarseness of the grid, there are usually multiple potential equilibria of each type. We use the following process to refine this set down to the final equilibrium point according to our concept of the Riley Equilibrium.

- Single plan equilibria: First, we refine our $L-$only and $H-$only equilibria. For the remainder of this paragraph, we will refer to the potential $L-$only equilibria, but an analagous methodology also applies to refining potential $H-$only equilibria. Let $\mathcal{P}^{L-only}$ be the set of potential $L - only$ equilibria. Price vector $(P_H, P_L) \in \mathcal{P}^{L-only}$ iff. at (P_H, P_L)

  1. $\Pi^L(P_H, P_L) \in [-T, T]$
  2. L has nonzero enrollment
  3. H has zero enrollment.

  Given the curved nature of the primitives, for some settings, especially those where L has a large cost advantage, there are multiple unique P_L that are potential L-only equilibrium vectors.

  Further, for each potential L-only P_L, $\exists\ P_H^{min}\ s.t.\ \forall\ P_H > P_H^{min}(P_H, P_L) \in \mathcal{P}^{L-only}$[51] For each potential L-only equilibrium price P_L, we evaluate whether the conditions of a Riley Equilibrium are satisfied at (P_H^{min}, P_L). We need only evaluate P_H^{min} since any potential deviations from

[51] If at (P_H, P_L), L has non-zero enrollment and earns zero profits and H gets zero enrollment, then if H increases its price to $P_H' > P_H$, enrollment allocations will remain exactly the same and L will continue to make zero-profits.

(P_H^{min}, P_L) would also be deviations from (P_H, P_L), $P_H > P_H^{min}$.

To test an L-only equilibrium for an H-deviation, the process is as follows: Starting with the lowest $P_L \in \mathcal{P}^{L-only}$, the Riley Equilibrium refinement algorithm evaluates whether a Riley Deviation exists for a given potential L-only P_L using three nested loops. For L-only equilibria (P_L, P_H^{min}), we consider H-only Riley Deviations (P'_H, P_L) where $P'_H < P_H^{min}$.

1. *Find Potential Riley Deviations:* The outer loop evaluates each $P'_H < P_H^{min}$ to identify whether $\Pi^H(P'_H, P_L) > T$ (i.e. H makes positive profits). If no such potential H-deviations are found, (P_H^{min}, P_L) is considered a RE. If a potential H-deviation is found, the second loop is called.
2. *Find Potential Retaliations:* This loop evaluates each grid point (P'_H, P'_L), $P'_L < P_L$ to identify potential L-retaliations where $\Pi^L(P'_H, P'_L) > -T, \Pi^H(P'_H, P'_L) < -T$ (i.e. L makes weakly positive profits and H makes negative profits. If no such potential retaliations are found for a given potential H-deviation, then (P_H^{min}, P_L) is not a Riley Equilibrium (since there exists a Riley Deviation with no retaliation).
3. *Determine if Retaliation is "Safe":* If a potential retaliation is found, a third loop is activated to evaluate if there is any point (P''_H, P'_L), $P''_H < P'_H$ that makes a given retaliation "unsafe" where unsafe is defined as $\Pi^L < -T$ (i.e. L makes negative profits). If no such "unsafe" point exists, then the retaliation point is safe and the potential deviation would not succeed.

If no retaliation-proof deviation exists for a given (P_L, P_H^{min}), then the point is a RE. If a deviation does exist, the next larger $(P'_L, P_H min') \in \mathcal{P}^{L-only}$ is tested.

- H-L equilibria: Because of the coarseness of the grid, there are usually multiple connected points where both H and L have enrollees and are making zero profits. We pick the point with the lowest P_L to evaluate. For each potential HL equilibrium, we test if any single-plan deviations exist. This consists of checking whether any Riley Deviations that change P_H holding fixed P_L or change P_L holding fixed P_H exist, using the same set of RE loops described in the previous paragraph. If either type of deviation is found, the HL equilibrium is not an RE.

We apply this algorithm to every cost, risk adjustment, mandate penalty, and subsiyd type setting and in every case are able to find an unique equilibrium that satisfies our Riley Equilibrium conditions.

D Appendix: Additional Simulation Results

D.1 Simulation Results for Mandate/Uninsurance Penalty

Tables A1 and A2 Show additional outcomes for the mandate/uninsurance penalty simulations discussed in Section 5 and shown in Figure 9. In all cases, the welfare measure represents the social surplus under the particular policy setting as a percent of the difference between minimum possible social surplus and maximum possible social surplus achieved.

Table A1: Varying Mandate Penalty

(a) ACA-like subsidy, L cream-skimmer

mandate	0	15	30	45	60
price H	382	374	371	360	349
price L	352	344	337	325	313
share H	.42	.42	.3	.26	.23
share L	.31	.37	.55	.67	.77
share U	.27	.21	.15	.069	0
subsidy	297	289	282	270	258
welfare	.91	.76	.49	.24	0

(b) Fixed $275, L cream-skimmer

mandate	0	15	30	45	60
price H	387	381	373	349	349
price L	357	351	341	313	313
share H	.42	.42	.37	.23	.23
share L	.24	.3	.44	.77	.77
share U	.35	.28	.19	0	0
subsidy	275	275	275	275	275
welfare	.93	.79	.56	0	0

(c) ACA-like subsidy, L cost advantage

mandate	0	15	30	45	60
price H	414	409	404	399	.
price L	307	300	292	283	273
share H	.021	.017	.013	.0065	0
share L	.73	.79	.86	.93	1
share U	.25	.19	.13	.067	0
subsidy	252	245	237	228	218
welfare	.95	.75	.52	.27	0

(d) Fixed $250 , L cost advantage

mandate	0	15	30	45	60
price H	415	404	.	.	.
price L	307	294	273	273	273
share H	.019	.016	0	0	0
share L	.73	.84	1	1	1
share U	.26	.15	0	0	0
subsidy	250	250	250	250	250
welfare	.27	.16	0	0	0

Notes: Table A1 contains equilibrium prices, market shares, subsidy levels and relative welfare under varying levels of mandate penalties. Panels (a) and (b) are results for when L is a cream-skimmer ($\Delta C_{HL} = 0$) while panels (c) and (d) are for when L has a 15% cost advantage. In panels (a) and (c), the market has a price-linked subsidy while in panels (b) and (d), the market has a fixed subsidy. Relative welfare is calculated as $\frac{welfare-min(welfare)}{max(welfare)-min(welfare)}$ where max and min are taken over integer mandate penalty values 0 to 60 under the panel's same L cost advantage, subsidy scheme.

D.2 Simulations of Benefit Regulation

Tables A3 and A4 characterize equilibrium results with and without an L-plan offered when the L-plan is a pure cream-skimmer and when L has a 15% cost advantage. For a given setting, the welfare loss is reported in dollars and represents loss relative to welfare under the optimal allocation.

The results indicate that for the ACA-like price-linked subsidies, removing L from the choice set always (weakly) improves welfare. This is because removing L results in a higher subsidy and more people entering the market. In the fixed subsidy cases, we find that removing L often causes both an increase in H's market share and an increase in the uninsurance rate (especially when L has a 15% cost advantage). However, we find that in all cases, benefit regulation improves welfare, implying that the welfare losses from more people being uninsured are more than offset by welfare gains from more people enrolling in H.

Table A2: Varying Risk Adjustment (α)

(a) ACA-like subsidy, L cream-skimmer

α	0	.5	1	1.5	2
price H	.	437	382	362	362
price L	372	362	352	.	.
share H	0	.082	.42	.78	.78
share L	.72	.64	.31	0	0
share U	.28	.28	.27	.22	.22
subsidy	317	307	297	307	307
welfare	.46	.59	.91	.91	.91

(b) Fixed $275, L cream-skimmer

α	0	.5	1	1.5	2
price H	495	438	387	377	377
price L	381	369	357	.	.
share H	.0095	.097	.42	.66	.66
share L	.57	.52	.24	0	0
share U	.42	.38	.35	.34	.34
subsidy	275	275	275	275	275
welfare	.68	.73	.93	1	1

(c) ACA-like subsidy, L cost advantage

α	0	.5	1	1.5	2
price H	.	.	414	361	362
price L	308	308	307	313	.
share H	0	0	.021	.16	.78
share L	.75	.75	.73	.59	0
share U	.25	.25	.25	.25	.22
subsidy	253	253	252	258	307
welfare	.93	.93	.95	.99	.58

(d) Fixed $250, L cost advantage

α	0	.5	1	1.5	2
price H	.	.	415	365	381
price L	309	309	307	316	.
share H	0	0	.019	.16	.6
share L	.74	.74	.73	.56	0
share U	.26	.26	.26	.29	.4
subsidy	250	250	250	250	250
welfare	.24	.24	.27	.48	1

Notes: Table A2 contains equilibrium prices, market shares, subsidy levels and relative welfare under varying strengths of risk adjustment α. Panels (a) and (b) are results for when L is a cream-skimmer ($\Delta C = 0$) while panels (c) and (d) are for when L has a 15% cost advantage. In panels (a) and (c), the market has a price-linked subsidy while in panels (b) and (d), the market has a fixed subsidy. relative welfare is reported as $\frac{welfare - min(welfare)}{max(welfare) - min(welfare)}$ where max and min are taken over integer mandate penalty values 0 to 60 under the panel's same L cost advantage, subsidy scheme.

D.3 Additional Welfare Results from Simulations

D.3.1 Graphical Illustration of Welfare Consequences of an Uninsurance Penalty

In this appendix we show how to estimate the welfare consequences of an uninsurance penalty with our graphical model. This exercise corresponds to the similar exercise analyzing the welfare consequences of risk adjustment in the main text. Panel (a) of Figure A6 plots the empirical analogs to our welfare figure from Section 2 for the case where L is a pure cream-skimmer. Instead of plotting C_L, we plot $C_L^{Net} = C_L - C_U$, as in Eq. (18) to account for the fact that $C_U \neq 0$. We indicate the equilibrium s cutoffs for the baseline ACA setting, where subsidies are linked to the price of the lowest-priced plan, $\alpha = 1$, and there is no uninsurance penalty. The intensive margin equilibrium cutoff is s^e_{HL} and the extensive margin cutoff is s^e_{LU}. Thus, consumers with $s < s^e_{HL}$ enroll in H, consumers with $s^e_{HL} < s < s^e_{LU}$ enroll in L, and consumers with $s > s^e_{LU}$ remain uninsured.

It is apparent that, from a social surplus perspective, no consumer should be in L because $W_H - (C_H - C_L)$ is everywhere above W_L. This is because L is a pure cream-skimmer: All consumers value H more than L and L has no cost advantage over H. In addition, in this setting some consumers (those with

Table A3: Benefit Regulation : L-plan Cream Skimmer

	ACA-like all sub		Fixed = Avg. Cost		Fixed = 300		Fixed = 275		Fixed =2 50	
	L offered	No L	L offered	No L	L offered	No L	L offered	No L	L offered	No L
price H	382	362	353	390	429	429	448	448	461	461
price L	352	.	308	.	.	.	.	.	.	.
share H	.42	.78	.29	.65	.43	.43	.31	.31	.22	.22
share L	.31	0	.71	0	0	0	0	0	0	0
share U	.27	.22	0	.35	.57	.57	.69	.69	.78	.78
subsidy	297	307	322	322	300	300	275	275	250	250
welfare	-229	-225	-266	-213	-211	-211	-219	-219	-228	-228

Notes: Table A3 contains equilibrium prices, market shares, subsidy levels and welfare for various subsidy settings with and without the L plan offered. All results are for a setting where L is a cream-skimmer ($\Delta C_{HL} = 0$). The first two columns contain results for ACA-like price-linked subsidies. The following columns are for various fixed subsidies. Welfare is calculated under the baseline assumption, $C_U(s) = 0.64C_H(s) - 97$.

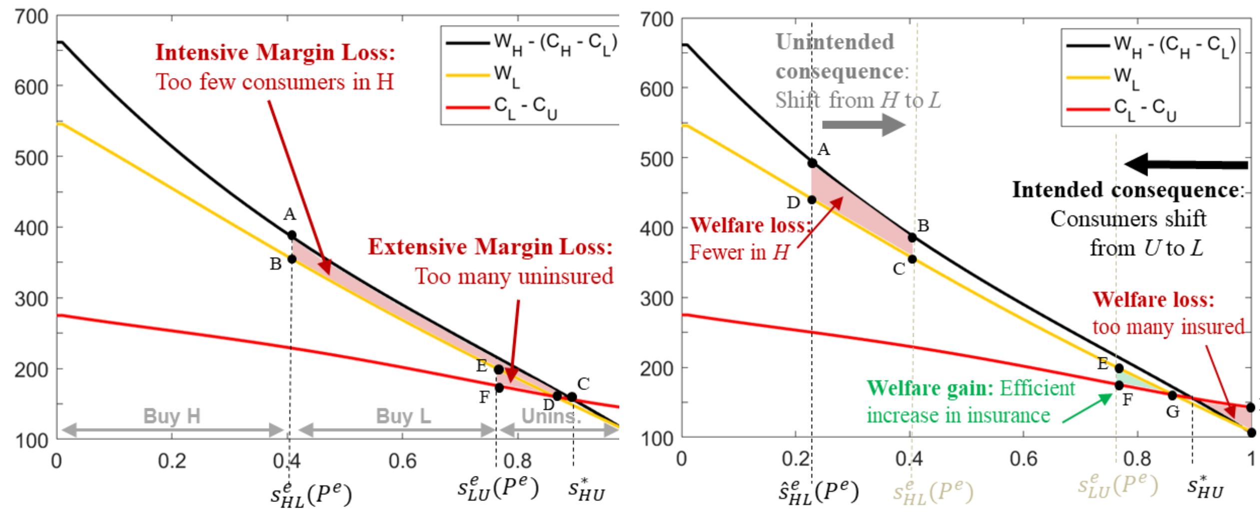
Table A4: Benefit Regulation : L-plan 15% cost advantage

	ACA-like all sub		Fixed = Avg. Cost		Fixed = 300		Fixed = 275		Fixed =2 50	
	L offered	No L	L offered	No L	L offered	No L	L offered	No L	L offered	No L
price H	414	362	.	390	.	429	441	448	462	461
price L	307	.	273	.	273	.	345	.	373	.
share H	.021	.78	0	.65	0	.43	.066	.31	.088	.22
share L	.73	0	1	0	1	0	.47	0	.25	0
share U	.25	.22	0	.35	0	.57	.46	.69	.67	.78
subsidy	252	307	322	322	300	300	275	275	250	250
welfare	-406	-236	-469	-224	-469	-222	-345	-230	-298	-239

Notes: Table A4 contains equilibrium prices, market shares, subsidy levels and welfare for various subsidy settings with and without the L plan offered. All results are for a setting where L has a 15% cost advantage. The first two columns contain results for ACA-like price-linked subsidies. The following columns are for various fixed subsidies. Welfare is calculated under the baseline assumption, $C_U(s) = 0.64C_H(s) - 97$.

Figure A6: Empirical Estimates of Foregone Surplus

(a) Baseline Foregone Surplus (b) Impose $60 Penalty



Notes: Panels (a) and (b) show welfare losses under ACA-like subsidies relative to efficient sorting, when L is a cream-skimmer and when L has a 15% cost advantage over H, respectively. In both settings, 60% of the population is low-income and 40% of the population is high-income, so WTP curves are weighted sums of both types. Efficient cutoffs are indicated with a * while equilibrium outcomes are denoted with an e superscript. For both panel (a) and (b), we assume $C_U(s) = 0.64C_H(s) - 97$.

$s > s^*_{HU}$) should not be insured at all. These consumers do not value either H or L more than the (net) cost of enrolling them, making it inefficient for them to be insured. In the figure, we depict the foregone surplus in the baseline ACA setting with shaded areas. The foregone intensive margin surplus in panel (a) (lost surplus due to consumers choosing L instead of H) is described by the area between W_H^{Net} and W_L for the consumers not enrolled in H, $ACDB$. This area represents a welfare loss of $41.92. The foregone extensive margin surplus (lost surplus due to consumers choosing U instead of L) is given by the area between W_L and C_L^{Net} for the consumers who are not enrolled in insurance but should be, EDF. This area represents a welfare loss of $16.58. The total foregone surplus in the baseline ACA setting in panel (a) of Figure A6 is $58.50.

Panel (b) of Figure A6 shows how we estimate the welfare consequences of adding an uninsurance penalty of $60 per month to the baseline case from Panel (a). Recall from the top-left panel of Figure 9 that the imposition of a $60 mandate (1) induces all previously uninsured consumers to purchase insurance and (2) causes a shift of 19% of the market from H to L. Effect (1) is the intended consequence of the penalty, and it implies both welfare gains and losses. Welfare gains occur among those consumers who value L more than $C_L^{Net} = C_L - C_U$ and who newly enroll in L (green welfare triangle EFG). Welfare losses occur among those consumers who value L less than C_L^{Net} and who newly enroll in L (red welfare triangle GHI). Together, the intended consequence of the penalty, inducing all consumers to purchase insurance, implies a net welfare gain of $16.59. Effect (2) is the unintended consequence of the penalty, shifting consumers from H to L. Here, it implies a welfare loss of $57.83, which arises because H and L have similar costs but all consumers value H more than L. Overall a $60 uninsurance penalty leads to a welfare loss of $41.25 in this setting.

We report welfare impacts of a mandate in other market settings in Appendix D.3.2. Those results, which correspond to the cases in Figures 9, show that it is common for an uninsurance penalty to negatively affect welfare. Given the demand and cost primitives we consider, the unintended consequence of shifting consumers from H to L often more than offsets welfare gains from inducing some consumers who value insurance more than its cost to become insured. This is true both when L is a cream-skimmer and when L has a cost advantage. However, it is not clear that this result would generalize to other settings with different consumer willingness-to-pay for H vs. L.

D.3.2 Additional Welfare Estimates Corresponding to Market Share Simulations

Figures A7 and A8 present welfare results corresponding to the market shares in Figures 9 and 10. For a given parameter setting k, we report here welfare normalized as follows: $W_k = \frac{welfare - min(welfare)}{max(welfare) - min(welfare)}$. We characterize welfare under three different assumptions of the cost of uninsured individuals. The first baseline assumption is the same as in the body of the text:

$$C_U(s) = \frac{(1-d)C_H(s)}{1+\phi} + \omega,$$

where the share of total uninsured health care costs that the uninsured pay out of pocket is $d = 0.2$, the assumed moral hazard from insurance is $\phi = 0.25$, and the fixed cost of uninsurance is $\omega = -97$. In addition to this baseline specification, we also show welfare results where we assume uninsured individuals to have the same cost as they would in H ($C_U = C_H$) and where uninsured individuals have no cost $C_U = 0$.

When the cost of the uninsured is high ($C_U = C_H$), a stronger mandate is generally optimal in all settings. When the uninsured are less costly, however, lower mandates and higher risk adjustment are generally optimal.

D.3.3 Optimality under Interacting Policies, Further Results

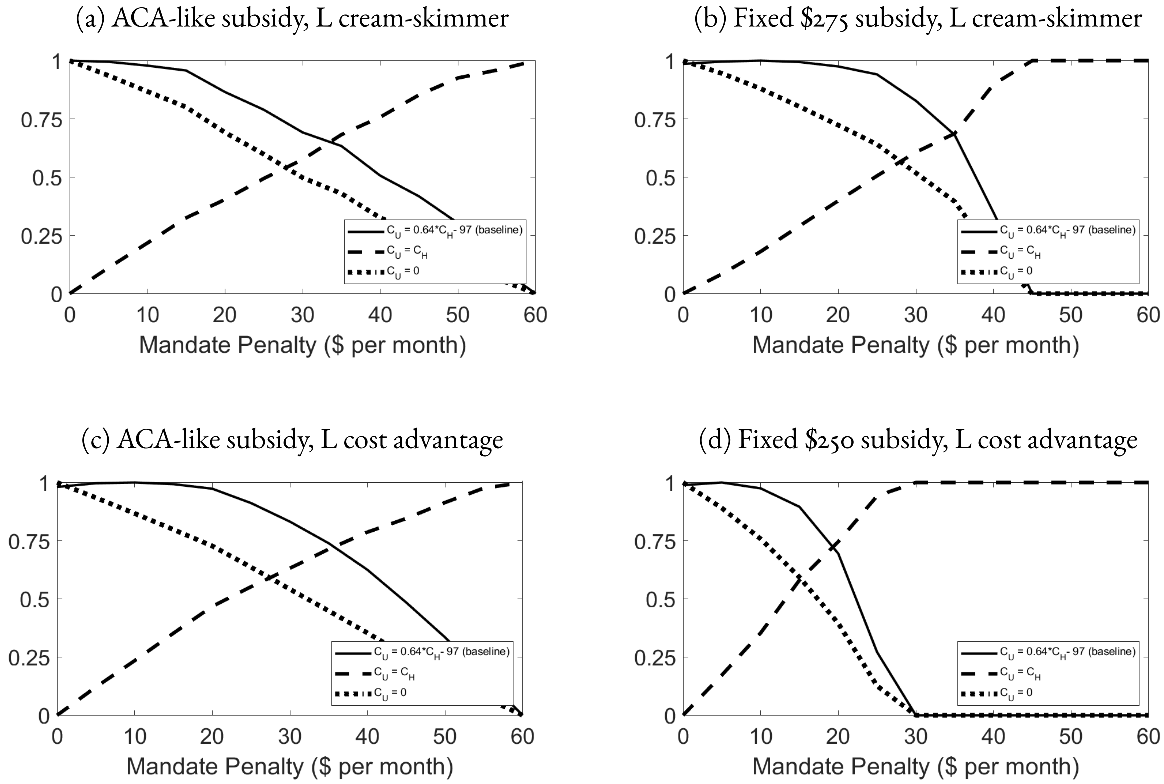
In Figure A9, we present welfare results under interacting extensive margin (mandate) and intensive margin (risk adjustment α parameter) policies for all settings studied in Figures 9 and 10 in the main text. These results are similar to the results we report in Section 6 but correspond to different market and policy settings. We see that the optimal mandate and risk adjustment combination depends on both the subsidy as well as the cost structure. When the L plan is a cream-skimmer, moderate to strong risk adjustment is preferable in order to induce more consumers to enroll in H vs. L. When L has a cost advantage, however, weaker risk adjustment is preferable. Further, when L is a cream-skimmer, the optimal mandate for a given level of risk adjustment also varies, with ACA-like subsidies warranting a lower mandate compared to the fixed subsidy case.

D.4 Empirical Robustness: Varying Simulation Model Assumptions

D.4.1 Empirical Robustness: Relaxing the Vertical Model

The demand primitives from Finkelstein, Hendren and Shepard (2019) were estimated in a setting where insurance options could be clearly ranked from most to least desirable for all consumers and where WTP was assumed to vary along a single dimension of heterogeneity. As a result, these primitives are consistent

Figure A7: Welfare with Varying Mandate Penalty (M)



Notes: Figure A7 depicts equilibrium relative welfare under varying levels of the mandate penalty. The simulations are the same as in figure 9. Panels (a) and (b) are results for when L is a cream-skimmer ($\Delta C_{HL} = 0$) while panels (c) and (d) are for when L has a 15% cost advantage. In panels (a) and (c), the market has a price-linked subsidy while in panels (b) and (d), the market has a fixed subsidy. For each set of simulations, we present relative welfare under three different assumptions about the social cost of uninsurance. Relative welfare is calculated as $\frac{welfare - min(welfare)}{max(welfare) - min(welfare)}$ where max and min are taken over the possible mandate penalties within a set of simulations and C_U assumptions.

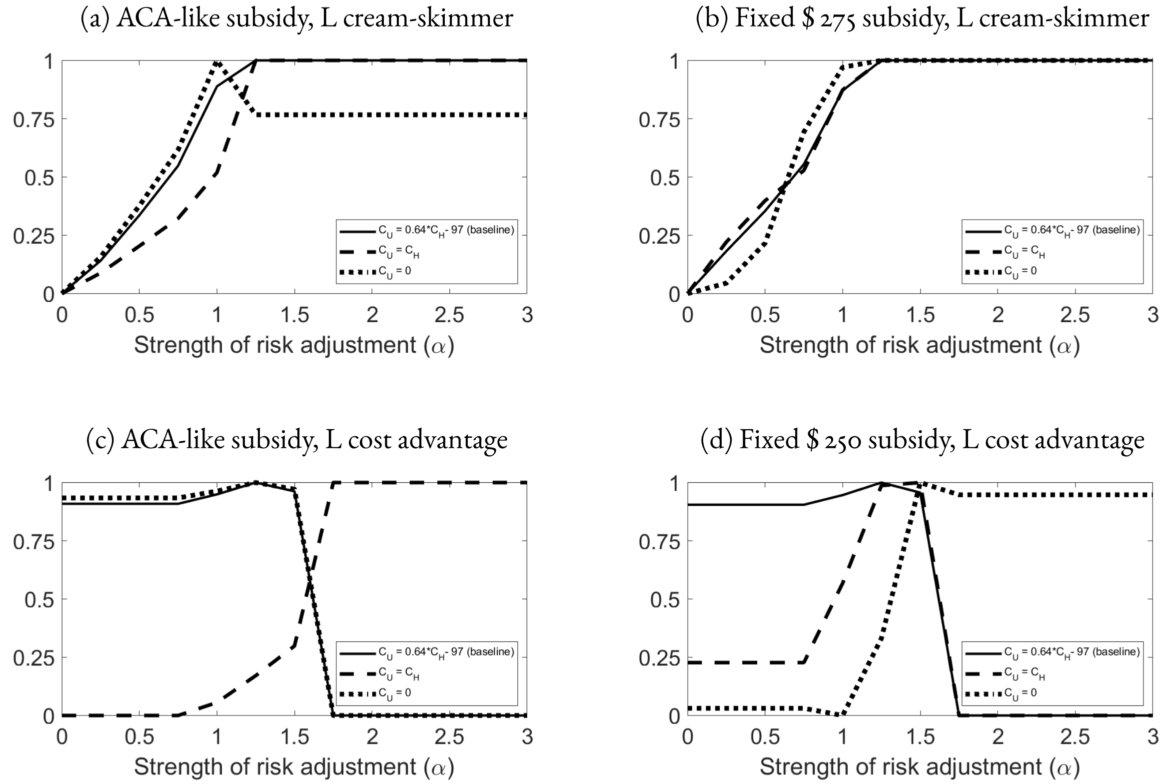
with a vertical demand structure. In effect, this means that throughout our main simulations, individuals are only on the margin between H and L or L and U, never on the margin between H and U (except in cases where the market "upravels" and nobody chooses L). As the theoretical analysis in Appendix A shows, allowing for an HU substitution margin that would be present with horizontal differentiation adds additional terms to the comparative statics defining cross-margin policy effects.

We can investigate how robust our empirical results are to the vertical model by assuming some portion of the population does not value L at all and is thus solely on the margin between H and U. To do this, we perform the following exercise:

Simulation modifications

- From our standard population comprising 60% subsidized low income types and 40% unsubsidized high income types, we assume γ percent of each type do not value L so that they may only choose between H and U

Figure A8: Welfare with Varying Strength of Risk Adjustment (α)



Notes: Figure A7 depicts equilibrium relative welfare under varying strengths of risk adjustment α. The simulations are the same as in figure 10. Panels (a) and (b) are results for when L is a cream-skimmer ($\Delta C_{HL} = 0$) while panels (c) and (d) are for when L has a 15% cost advantage. In panels (a) and (c), the market has a price-linked subsidy while in panels (b) and (d), the market has a fixed subsidy. For each set of simulations, we present relative welfare under three different assumptions about the social cost of uninsurance. Relative welfare is calculated as $\frac{welfare - min(welfare)}{max(welfare) - min(welfare)}$ where max and min are taken over the possible α values within a set of simulations and C_U assumptions.

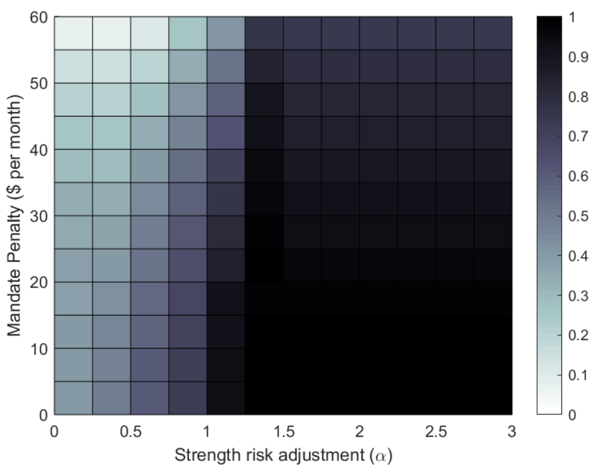
- We assume that this γ portion has the standard $W_H(s)$ and $W_H^{HI}(s)$ curves and same s distribution as in our baseline simulations
- The remaining $1-\gamma$ portion of the population has the standard demand primitives and may choose between H, L, and U as normal
- For a given price bid, P_H and P_L, and subsidy, we allow both types to choose plans, estimating profits and equilibrium in the typical way

Impact of HU margin types on mandate results

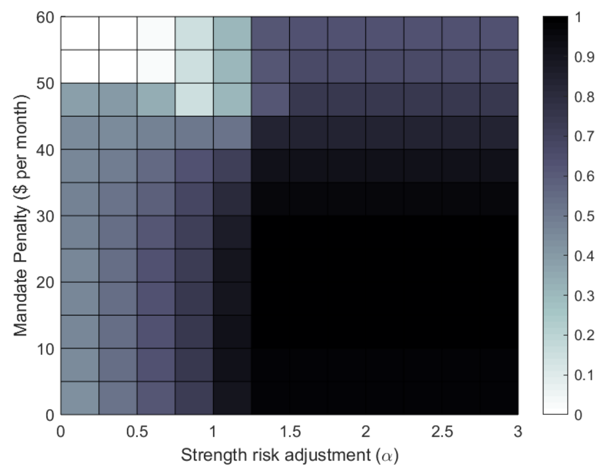
In panel (a) of Figure A10 we estimate demand shares with ACA-like subsidies where the L plan is a pure cream-skimmer and with increasingly larger values of γ (i.e., increasing proportions of HU margin types) from 0% up to 20%. For every mandate penalty level, the market allocation to H is everywhere higher with larger shares of HU margin types. As the uninsurance penalty increases, consumers move from U to L *and* from U to H. There is still an unintended shifting of consumers from H to L as

Figure A9: Welfare under Interacting Extensive and Intensive Margin Policies

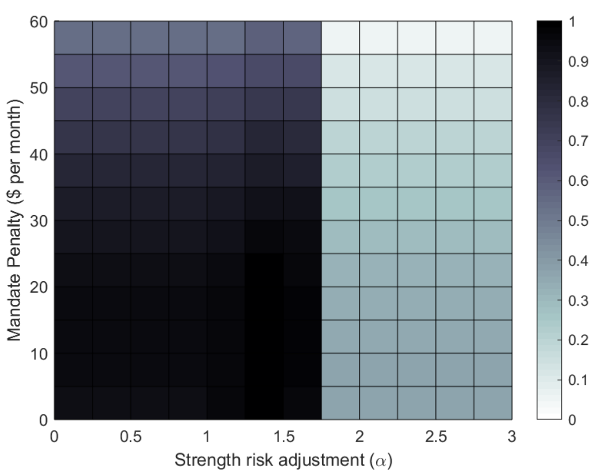
(a) ACA-like subsidy, L cream-skimmer



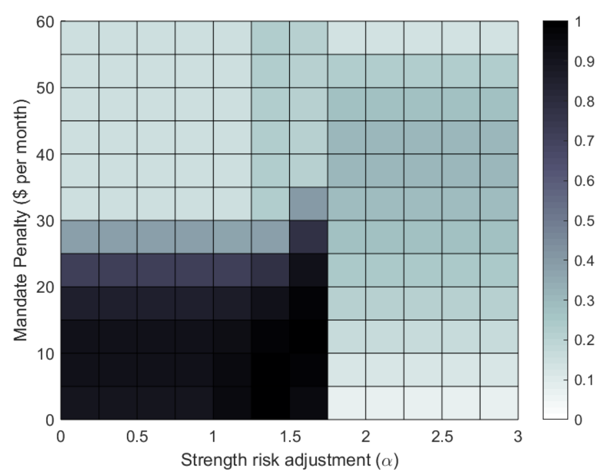
(b) Fixed 275 subsidy, L cream-skimmer



(c) ACA-like subsidy, 15% L cost advantage



(d) Fixed 250 subsidy, 15% L cost advantage



Notes: Figure A9 depicts equilibrium relative welfare under varying levels of the mandate penalty and strength of risk adjustment α. Panels (a) and (b) are results for when L is a cream-skimmer ($\Delta C_{HL} = 0$) while panels (c) and (d) are for when L has a 15% cost advantage. In panels (a) and (c), the market has a price-linked subsidy while in panels (b) and (d), the market has a fixed subsidy. Relative welfare is calculated as $\frac{welfare - min(welfare)}{max(welfare) - min(welfare)}$ where max and min are taken over all the possible mandate penalties and risk adjustment strengths within a subsidy and cost setting. For all simulations, we use our baseline assumption of the social cost of uninsurance, $C_U = 0.64 C_H - 97$.

highlighted in Section 5 of the paper, but there are countervailing forces, composed of (1) the shifting of consumers from U to H, and (2) the fact that the presence of some lower-cost HU margin types in H lowers the price of H and the price differential between H and L.

On net, D_H still declines with a stronger mandate with a γ of 10% or 20%. This shows that the empirical "unintended" effect of the mandate on D_H is robust to some horizontal differentiation. However, the net decline is increasingly muted as γ increases, and a level of γ much larger than 20% would eventually result in D_H being flat or increasing with the mandate penalty.

Impact of HU margin types on risk adjustment results

Next, in panel (b) of Figure A10 we estimate demand shares as we vary risk adjustment strength for the case of fixed subsidies when L has a 15% cost advantage. Recall that this is the risk adjustment simulation where we saw a trade-off between extensive and intensive margin selection: Stronger risk adjustment induced consumers to move from L to H but it also induced some consumers to exit the market and opt for U.

Similar to our mandate simulations allowing for some consumers to be on the HU margin, we see that the initial allocations to H absent risk adjustment are higher when we have more HU margin types compared to our baseline setting. Because lower cost HU margin types will enroll in H compared to our baseline types, the cost differential between the two plans is lower with larger shares of HU margin types. Consequently, the size of risk adjustment transfers for a given α are lower. However, the level of α that causes the market to "upravel" to H is the same for all levels of γ. Further, the uninsurance rate also depends very little on γ, with the U market share at any given level of α being similar across levels of γ. This indicates that our result that under certain conditions risk adjustment can unintentionally increase the uninsurance rate while simultaneously shifting consumers from L to H is largely robust to our vertical model assumption for the market primitives we examine.

D.4.2 Empirical Robustness: Varying ΔW_{HL}

Demand for H critically depends on the incremental willingness to pay for H relative to L, $\Delta W_{HL} = W_H(s) - W_L(s)$. Below, we see how sensitive our results are to variations in this incremental willingness to pay. Specifically, we estimate equilibrium under simulations where we hold fixed $W_L(s)$ at baseline but scale $\Delta W_{HL}(s)$ by a multiplier $\rho \in [0.25, 4]$:

$$\Delta W_{HL}^{adj}(s) = \Delta W_{HL}(s)^{raw} * \rho$$

$$W_H^{adj}(s) = W_L(s) + \Delta W_{HL}^{adj}(s)$$

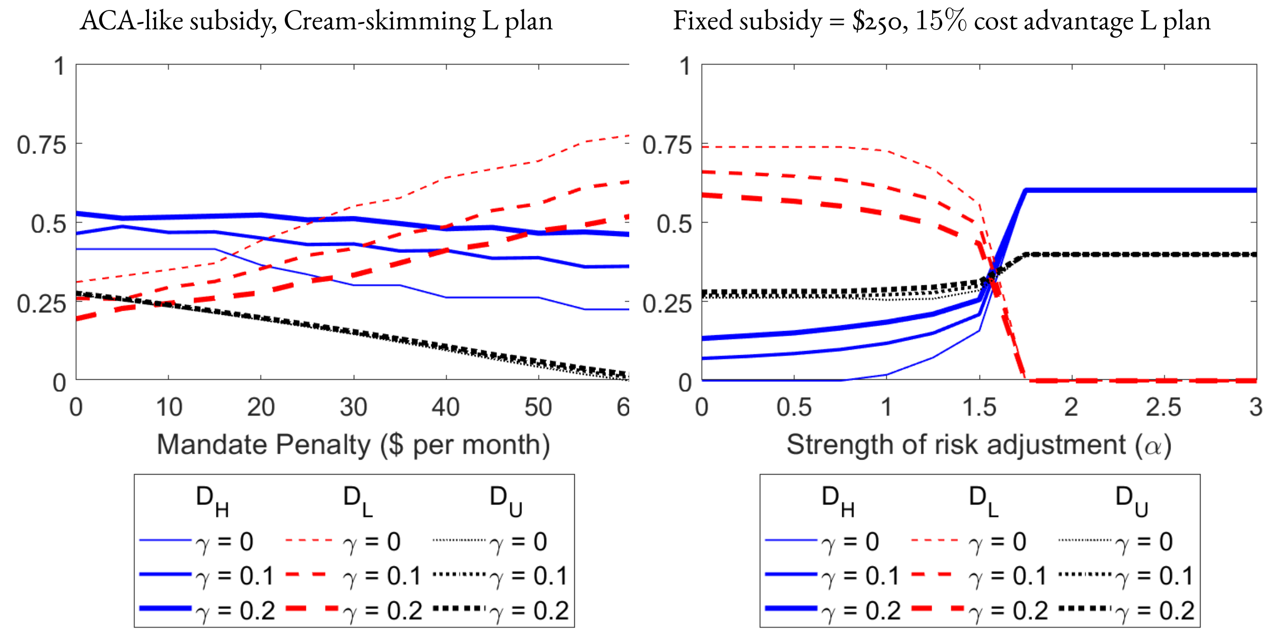
This scaling changes both the level and slope of $W_H(s)$, as seen in Figure A11.

Using our typical counterfactual process, we estimate equilibrium market shares under these modified primitives for varying levels of the mandate penalty and risk adjustment strength. Simulation results are presented in Figure A12. We find that under both increased and decreased incremental willingness to pay (i.e. higher and lower ρ), the general patterns of our counterfactual exercises do not change.

Panel (a) shows that demand for H declines with a larger mandate penalty, except at the very high scalar $\rho = 4$. When $\rho = 4$, the marginal willingness to pay for H relative to L is sufficiently high that an incrementally higher mandate penalty induces individuals to enter the market and then choose H over L. As a result, demand for H is weakly increasing in the mandate penalty throughout the range of penalties

Figure A10: Relaxing vertical model

(a) Mandate penalty (b) Risk adjustment



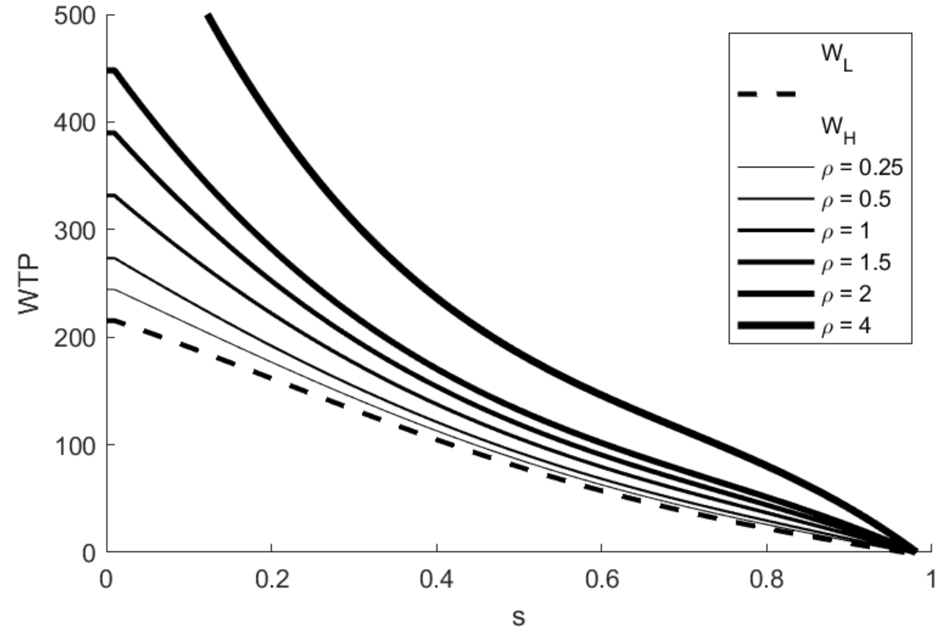
Notes: Panels (a) and (b) of Figure A10 depicts equilibrium market shares of H,L, and uninsurance under varying levels of the mandate penalty and risk adjustment strength (α), respectively. Three separate simulations are presented. The thinnest line is our baseline simulation where no individuals are on the margin between H and uninsurance ($\gamma = 0$) while the thickest lines correspond to when 20% of individuals do not consider L and are thus on the margin between H and U ($\gamma = 0.2$). All simulations in panel (a) are for a cream-skimming L plan and ACA-like price linked subsidy and all simulations in panel (b) are for an L plan with a 15% cost advantage and fixed subsidy of $250 for both plans.

tested while demand for L only rises for high levels of the mandate. The rise in L only occurs in the range of mandate penalties where the individuals induced to enter the market are of sufficiently low marginal willingness to pay that some choose L instead of H. Because this is a relatively small group, the cost differential between H and L remains small.

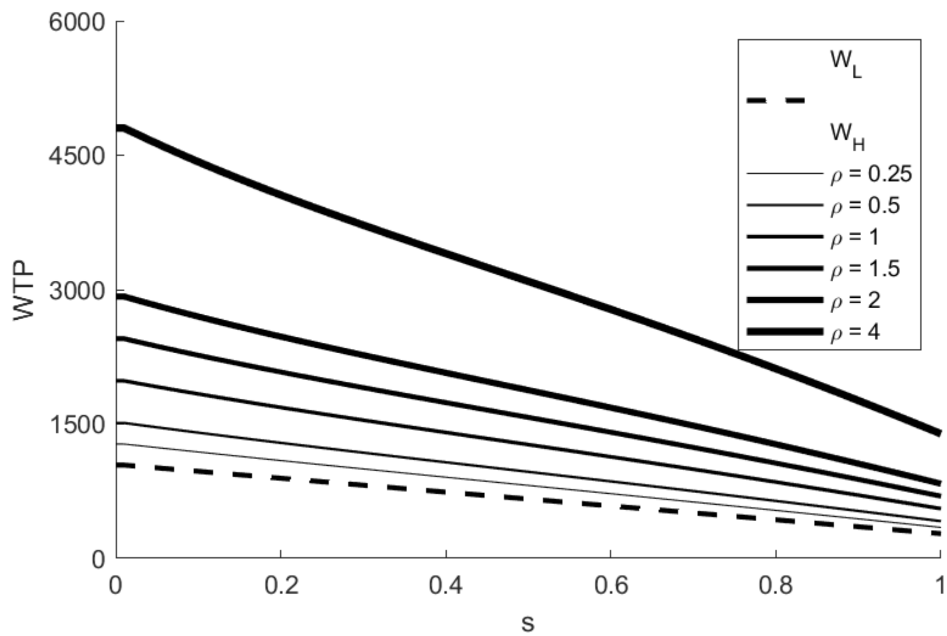
Panel (b) shows that increasing the strength of risk adjustment has similar effects at all levels of ρ. Initially, stronger risk adjustment induces consumers to choose H instead of L. But in all cases, there is also eventually an unintended increase in the uninsurance rate. The effect of modifying ρ is that the shifts in market share (both from L to H and from L to U) occur at different levels of α with shifts occurring at lower levels of α for higher levels of ρ. That is, when marginal willingness to pay for H relative to L is higher, a lower level of risk adjustment is needed to induce changes in market shares.

Figure A11: Scaled WTP_H

(a) Low income demand



(b) High income demand

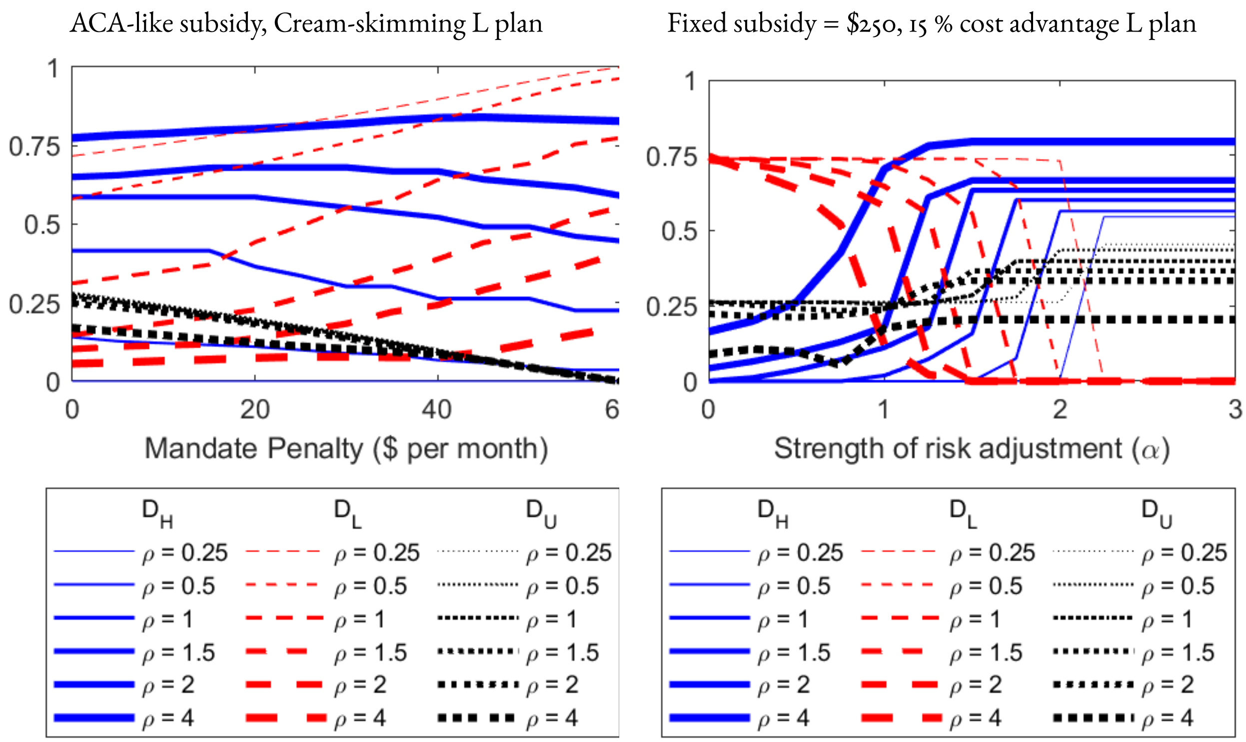


Notes: Panels (a) and (b) of A11 depicts willingness to pay curves for high and low-income consumers, respectively, under various scaling factors ρ of $\Delta W_{HL}^{adj} = \rho \Delta W_{HL}$. The thickest lines are for high marginal WTP for H relative to L. Baseline is for $\rho = 1$. Willingness to pay for L is the dashed line and remains unmodified.

Figure A12: Scaling ΔWTP

(a) Mandate penalty

(b) Risk adjustment



Notes: Figure A12 shows market shares for H,L, and uninsurance under the different scaled ΔWTP curves depicted in figure A11. Panel (a) depicts shares for different mandate penalties under an ACA-like price-linked subsidy and cream-skimming L plan ($\Delta C_{HL} = 0$). Panel (b) depicts shares for different strengths of risk adjustment (α) under a fixed subsidy and a 15% L plan cost advantage. As in figure A11, thicker lines correspond to market shares when marginal willingness to pay for H relative to L is set higher (higher ρ).