Heterogeneity, Demand for Insurance and Adverse Selection

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Abstract

Recent evidence underlines the importance of demand frictions distorting insurance choices. Heterogeneous frictions cause the willingness to pay for insurance to be biased upward (relative to value) for those purchasing insurance, but downward for those who remain uninsured. The paper integrates this finding with standard methods for evaluating welfare in insurance markets and demonstrates how welfare conclusions regarding adversely selected markets are affected. The demand frictions framework also makes qualitatively different predictions about the desirability of policies like insurance subsidies and mandates, commonly used to tackle adverse selection.

Keywords: Heterogeneity, Adverse Selection, Demand Frictions, Insurance Market Interventions

JEL-codes: D60, D82, D83, G28

1 Introduction

Adverse selection due to heterogeneity in risks has been considered a prime reason for governments to intervene in insurance markets. The classic argument is that the presence of higher risk types increases insurance premia and drives lower risk types out of the market (Akerlof 1970). However, empirical work has found surprisingly little evidence supporting the importance of adverse selection in insurance markets. An individual's risk type often plays a limited role in explaining his or her demand for

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insurance, which raises the important question what type of heterogeneity is actually driving the variation in insurance demand. Recent work attributes the unexplained variation to heterogeneity in preferences (Cohen and Einav 2007, Einav, Finkelstein and Cullen 2010a, Einav, Finkelstein and Schrimpf 2010b) and finds that the estimated welfare cost of inefficient pricing due to adverse selection is small. Since the foregone value of insurance for the uninsured is estimated to be low, heterogeneity in preferences tends to reduce the scope for policy interventions in insurance markets.

A parallel and growing empirical literature, however, shows the importance of various types of frictions driving the demand for insurance. Examples are limited cognitive ability (Fang, Keane and Silverman 2008), biased risk perceptions (Abaluck and Gruber 2011), inertia (Handel 2013) and information frictions (Handel and Kolstad 2015).[1] These demand frictions provide an alternative explanation for why risks do not explain the variation in the demand for insurance, but, in contrast with preferences, drive a wedge between the *true* value of insurance and the value of insurance as *revealed* by an individual's demand. The presence of demand frictions thus affects the earlier welfare estimates and policy recommendations assuming preference heterogeneity.

This paper presents a stylized framework with demand frictions to analyze policy and welfare in insurance markets. Heterogeneous frictions, just like heterogeneous risks, affect the sorting of individuals along the demand curve. Under reasonable and testable assumptions, this causes the demand curve to overstate the true insurance value for those with high willingness to pay and vice versa. The paper integrates this insight with now standard methods for welfare analysis in insurance markets that have ignored demand frictions (see Einav, Finkelstein and Cullen, 2010a). A key contribution of this novel approach is that it allows to draw data-based welfare conclusions that deviate from revealed preferences, without relying on specific assumptions on the structural wedge between revealed and true value or on individual-level analysis of frictions like in Bernheim and Rangel (2009).

The paper starts by establishing the systematic relationship between the true and revealed value of insurance in the presence of frictions. At the heart of the analysis is a simple selection effect. Consider the case where some individuals underestimate the risk to which they are exposed, while others overestimate this. Or, alternatively, some individuals underestimate the coverage provided by an insurance contract, while others overestimate this. The underestimation tends to discourage individuals from buying insurance, which implies that those who decided not to buy insurance are more likely to underestimate its value and vice versa.[2] This selection effect does not depend on the specific nature of the underlying frictions. The demand curve, which reveals indi-

[1] In addition to 'behavioral' frictions, there are also examples of 'economic' constraints distorting the insurance demand, like liquidity constraints (Cole et al. 2012, Gruber 2005), price distortions due the presence of publicly provided programs (Brown and Finkelstein 2008).

[2] The selection effect when considering an expected value conditional on a particular choice or outcome is structurally similar to the mechanisms underlying for example the winner's curse, regression towards to the mean, and choice-driven optimism (Van Den Steen 2004).

viduals' willingness-to-pay for insurance, overstates the insurance value for the insured individuals and understates the (potential) insurance value for the uninsured individuals. I analyze the robustness of this selection effect and provide testable conditions under which frictions indeed reduce the gradient of insurance value with respect to willingness-to-pay.

The policy implications of this selection effect are immediate. The evaluation of policy interventions which have either *all* insured or *all* uninsured as targets will be unambiguously biased in opposite directions when this evaluation relies on individuals' revealed preferences. In particular, the welfare gain of a universal mandate to buy insurance is unambiguously higher than the demand for insurance would suggest. While the described selection effect is not particular to the demand for insurance, demand frictions are shown to be empirically important in insurance markets and insurance mandates are omnipresent as well.

The second part of the paper integrates the systematic relationship between revealed and true value driven by demand frictions into the standard welfare analysis of adversely selected insurance markets — the central issue in the recent insurance literature.[3] In particular, in the absence of demand frictions, the welfare cost of adverse selection depends only on the relation between the demand and its corresponding cost curves, as shown by Einav et al. (2010a).[4] I extend their sufficient statistics approach for demand frictions, which cause the welfare-relevant *value curve* to be a counter-clockwise rotation of the demand curve, and I show that their impact is accounted for by one additional statistic, namely the share of the residual variation in insurance demand - left unexplained by heterogeneity in risks - that is driven by frictions rather than by preferences.

To estimate the exact share of frictions extra information would be required in addition to the information used to estimate the demand and cost curves. Other than that, the welfare analysis can simply build on existing empirical estimates of the demand and cost curves. The framework thus provides a simple, yet robust approach to evaluate the robustness of standard welfare conclusions, even when the relevant demand frictions are not exactly known. I illustrate this in a numerical example based on the empirical analysis of employer-provided health insurance in Einav et al. (2010a). I find that for plausible values of the friction share the market inefficiency is in fact substantially higher and would justify government interventions. The estimated welfare cost due to inefficient pricing doubles when twenty-five percent of the residual variation in demand is driven by frictions.

The final part of the paper uses the framework with demand frictions to revisit the

[3]See Einav, Finkelstein and Levin (2010c), Chetty and Finkelstein (2013) for recent reviews.

[4]See also Hackmann, Kolstad and Kowalski (2015) for a recent implementation of this approach in the context of the Massachusetts health reform. The stylized model in Einav et al. (2010a) has been extended to imperfect competition (Mahoney and Weyl, 2014), for endogenous contract characteristics (Veiga and Weyl, 2015) and multiple contracts (Azevedo and Gottlieb, 2015).

desirability of various policy interventions in insurance markets and finds qualitatively different predictions about which policies are preferred. I further illustrate these qualitative differences using some numerical examples. A first key finding is that frictions reduce the effectiveness of insurance subsidies relative to insurance mandates. While price policies are constrained by the individuals' willingness to insure, the welfare impact depends on the true insurance value. When frictions reduce the willingness to insure of individuals who should be buying insurance, larger subsidies are required to encourage them to actually buy insurance. Relatedly, frictions also reduce the effectiveness of risk-rated premiums. Compared to uniform price subsidies, risk-rating adjusts the insurance price to reflect individual-specific risks and aims to correct an individual's insurance decision for the cost externality she imposes on insurers. The potential efficiency gain may be high (see Bundord, Levin and Manhoney 2012), but the realization of this gain crucially depends on the individual-specific risks being perceived accurately and not being neutralized by other demand frictions. Otherwise, risk-rating introduces the inefficiency it is supposed to correct.

The fact that people over- or underinsure due to demand frictions naturally calls for alternative policy interventions that directly address these frictions.[5] Examples are the provision of information or the standardization of contracts through government-run insurance exchanges. Such interventions make individuals better off at a given price, but the equilibrium price may change as the selection of individuals into insurance is affected.[6] I illustrate the potentially opposite effects on welfare within the framework with demand frictions by contrasting two policies that provide individual-specific information to individuals about their mean expenses and the variance of their expenses respectively.

Related Literature Starting with the work by Chiappori and Salanié (1997, 2000), several papers have tested for the presence of adverse selection in different insurance markets. The weak relationship between risk and insurance choice, reviewed in Cohen and Siegelman (2010), inspired a new series of studies which estimate the heterogeneity in risk preferences jointly with the heterogeneity in risk types (Cohen and Einav, 2007; Einav et al. 2010a, 2010b). The estimated heterogeneity allows one to move beyond testing for adverse selection and actually analyze the welfare cost of inefficient pricing. This cost is generally found to be small (see Einav et al. 2010c).

While attributing heterogeneity in insurance choices - unexplained by heterogeneity in risks - to heterogeneity in preferences is a natural first step and in line with the revealed preference paradigm, the empirical evidence supporting this approach is limited.[7] Several papers have recently made the case that insurance behavior cannot

[5] See Congdon et al. (2011), Chetty and Finkelstein (2013) for recent discussions

[6] Condon, Kling and Mullainathan (2011) also discuss the potential welfare loss when people are better informed about their risks. Handel (2013) provides an empirical welfare analysis of a similar trade-off for a nudging policy when people's decisions are subject to switching costs or inertia.

[7] A few papers use explicit measures of risk preferences to explain insurance choices (e.g., Cutler,

be adequately explained with standard preferences and beliefs.[8] A large literature in psychology documents more generally how choices under risk are subject to biases and heuristics.[9] In the context of insurance, a growing number of empirical papers analyze deviations from expected utility maximization in explaining insurance choices. For example, Abaluck and Gruber (2011) and Barghava et al. (2015) identify important inconsistencies in insurance choices and document that dominated options are frequently chosen. By complementing insurance data with surveys, Fang et al. (2008) find that heterogeneity in cognitive ability is important (relative to risk aversion) in explaining the choice of elderly to buy Medigap, while Handel and Kolstad (2015) document the importance of information frictions in explaining the choice of health insurance plans. Barseghyan et al. (2012) find that a structural model with distorted probabilities explains the data better than a model with standard risk aversion looking at deductible choices in auto and house insurance.[10] As mentioned before, not only behavioral biases, but also economic constraints can cause the relation between insurance choice and insurance values to be tenuous (e.g., Gruber 2005, Cole et al. 2012).

Accounting for demand frictions when analyzing welfare and policy interventions in insurance markets seems the natural next step in light of the evidence above. This is the step undertaken in this paper. The analysis follows two recent trends in public economics; the first is the inclusion of non-standard decision makers (or demand frictions more generally) in welfare analysis, the second is the expression of optimal policies in terms of sufficient statistics.[11] In a similar spirit, Chetty, Kroft and Looney (2009) extend the sufficient statistics approach to tax policy for tax salience and Spinnewijn (2015) extends the sufficient statistics approach to unemployment policy for biased perceptions of employment prospects. Mullainathan, Schwartzstein and Congdon (2012) propose a unifying framework to examine the implications of behavioral biases for social insurance and optimal taxation. In contrast with previous work, the focus in this paper is on heterogeneity in behavioral frictions and how this underlies the demand for insurance. Using the framework with heterogeneous frictions, Handel, Kolstad and Spinnewijn (2015) study their interaction with pricing inefficiencies in employer-provided health plans and evaluate the positive and normative implications of demand and supply-side interventions.

The remainder of the paper is as follows. Section 2 introduces a simple model

Finkelstein and McGarry 2008), but the estimated role of these preference measures is often minor (e.g., Fang et al. 2008). Heterogeneity in risk preferences should affect an individual's insurance choices across different domains similarly, but recent work finds rather limited evidence for domain-general components (Barseghyan et al., 2011, and Einav et al., 2011).

[8] For example, Chiappori and Salanié (2012) emphasize the importance of understanding risk perceptions to analyze insurance behavior. Cutler and Zeckhauser (2004) argue that distorted risk perceptions are one of the main reasons why some insurance markets do not work efficiently.

[9] See Tversky and Kahneman (1974) and Slovic (2000) for seminal contributions to this literature.

[10] Other examples in this spirit are Bruhin et al. (2010), Snowberg and Wolfers (2010) and Sydnor (2010).

[11] See Chetty (2009), Congdon et al. (2011) and Chetty and Finkelstein (2013) for recent discussions.

of insurance demand with frictions and characterizes the difference between true and revealed insurance values along the demand curve. Section 3 introduces heterogeneity in risk types and preferences to analyze and calibrate the cost of adverse selection depending on the presence of frictions. Section 4 analyzes how frictions affect the effectiveness of the relevant government interventions in insurance markets. Section 5 concludes.

2 Insurance Demand with Frictions

This section introduces a stylized model of insurance demand with demand frictions. The analysis deviates from the revealed preference paradigm by allowing the variation in insurance choices to be also driven by heterogeneous frictions, unrelated to the true insurance value. We establish a systematic difference between the true value of insurance and the value as revealed by an individual's demand. It is this systematic relationship that we exploit to revisit standard welfare and policy analysis in insurance markets in the subsequent sections.

2.1 Stylized Model

Individuals decide whether or not to buy insurance against a risk. All individuals are offered a single contract at price p. Individuals, however, differ in several dimensions. They have different preferences, risk types, perceptions, cognitive ability, wealth, liquidity, etc. For any individual i, these characteristics jointly determine the *true* value of insurance v_i and the *revealed* value of insurance $\hat{v}_i$. The true value v_i refers to the actual insurance value for the individual and is assumed to be relevant for welfare. The revealed value $\hat{v}_i$ equals the maximum price at which the individual buys insurance and thus reflects the individual's insurance demand.[12] That is, individual i buys insurance if and only if $\hat{v}_i \geq p$, but would maximize her utility by buying insurance if and only if $v_i \geq p$.[13] I denote the difference between the true and revealed value by a simple noise term

$$\varepsilon_i \equiv \hat{v}_i - v_i.$$

This difference is driven by individual-specific demand frictions. Hence, both heterogeneity in the true valuations and heterogeneity in the frictions drive the heterogeneity in the demand for insurance across individuals. I denote the cumulative distribution of any variable x by F_x and the mean and variance by μ_x and σ_x^2. The correlation between variables x and y is denoted by $\rho_{x,y}$.

[12] The wedge between the revealed and true values corresonds to the wedge between the 'decision utility' (inferred from an agent's decisions) and 'experienced utility' (referring to the hedonic experience) to the extent that the latter is deemed relevant for evaluating welfare (see Kahneman and Thaler 2006).

[13] The revealed and true values of insurance are expressed as certainty equivalents to be directly comparable to the insurance price.

The share of individuals buying insurance at price p equals $D(p) = 1 - F_{\hat{v}}(p)$. The demand curve reflects the marginal buyers' willingness to pay $D^{-1}(q)$ for any level of market coverage q. This revealed value is different from the true value in the presence of frictions. The expected true value for the marginal buyers at price p equals $E(v|\hat{v} = p)$, which I denote by $MV(p)$.[14] Graphically, one can construct the *value curve*, depicting this marginal true value $MV\left(D^{-1}(q)\right)$ for any level of market coverage q, and compare this to the demand curve. The wedge between the two curves determines the bias in the welfare analysis by a *Revealed Preference* (RP) policy maker, who uses the demand curve rather than the value curve to evaluate welfare.

The following stylized examples illustrate how empirically relevant frictions could fit well in this stylized framework. I will refer back to these examples when interpreting the main results.

Example 1 (Inaccurate Perceptions) *The value of insurance depends on an individual's risk exposure. The individual misperceives the value of an insurance contract when she misperceives either the risk she is exposed to (e.g., Sydnor 2010, Barseghyan et al. 2012) or the coverage provided by the contract (e.g., Harris and Keane 1999, Handel and Kolstad 2015). Consider an insurance contract covering expenses with mean μ_i and variance σ_i^2. For an individual with mean-variance preferences with parameter of risk aversion γ_i, the true value of insurance equals $v_i = \mu_i + \frac{\gamma_i}{2}\sigma_i^2$.[15] The noise term equals $\varepsilon_i = \hat{\mu}_i - \mu_i$ if she misperceives the mean and $\varepsilon_i = \frac{\gamma_i}{2}\left(\hat{\sigma}_i^2 - \sigma_i^2\right)$ if she misperceives the variance.*

Example 2 (Inertia) *An individual's willingness to insure depends on her default option, determined by her own prior choices or her employer's choice on her behalf (e.g., Handel 2013). Consider the individual-specific cost s_i reflecting an individual's inertia to deviate from the default. If the default is to be uninsured, individual i buys insurance if $v_i \geq p + s_i$ and thus $\varepsilon_i = -s_i$. If the default is to be insured, the individual buys insurance if $v_i \geq p - s_i$ and thus $\varepsilon_i = s_i$.*

Example 3 (Bounded Rationality) *Choices under uncertainty are complex and insurance plans are difficult to understand. Different individuals are more or less able to choose the utility-maximizing plan (e.g., Fang et al. 2008, Abaluck and Gruber 2011). Consider a share α of individuals who are 'boundedly rational' and imitate the choice of some (rational) peer j with valuation v_j so that $\varepsilon_i = v_j - v_i$. If the peer's value*

[14] Individuals with the same revealed value may have different true values. Using their unweighted average to evaluate welfare implies that in the absence of frictions, total welfare is captured by the consumer surplus.

[15] The insurance values are exactly equal to the certainty equivalents when individuals have CARA preferences with γ the parameter of absolute risk aversion and when the contract covers a normally distributed risk. The assumption of CARA preferences or additivity of the risk premium in the valuation of a contract is very common in the recent empirical insurance literature (see the review by Einav et al. 2010c).

is uncorrelated to the own value, the correlation between the revealed and true values equals α.

I make two assumptions to focus the analysis. First, I assume that *only* the true value is relevant for welfare and policy analysis. Depending on the policy interventions and the frictions considered, some weight could be given to the revealed value as well. For example, in case of inaccurate perceptions, one could argue that when different insurance valuations are caused only by different perceptions of the underlying risk (and not by different perceptions of the actual coverage provided) they should not be considered as frictions at all.[16] In case of inertia or bounded rationality, switching or processing costs could be relevant for price policies used to encourage individuals to change contracts, but are arguably irrelevant when mandating an insurance plan. While this caveat should be accounted for in practice, using only true values to evaluate welfare in this stylized framework simply sharpens the contrast with standard *Revealed Preference* analysis. Second, the main focus is on the case in which the impact of the frictions on the revealed value cancels out on average. That is, $E(\varepsilon) = 0$ and thus $E(\hat{v}) = E(v)$. In general, frictions affect different people differently, but they may also drive the revealed value in one particular direction relative to the true value. For example, risk perceptions may be noisy, but also optimistically biased on average and thus reduce the demand for insurance. Similarly, frictions driven by liquidity constraints will unambiguously reduce the demand for insurance. This second assumption sharpens the focus on the heterogeneity in frictions, but the analysis naturally extends when frictions introduce an average bias, which would simply increase or decrease the wedge caused by the heterogeneity in frictions depending on its sign.

2.2 Demand vs. Welfare

Demand frictions affect the sorting of individuals with different valuation along the demand curve. We now analyze how individuals' true value relates to their willingness-to-pay or, graphically, how the value curve relates to the demand curve. I establish a systematic relationship between the two starting with strong assumptions, but then show how the results generalize when relaxing these assumptions.

I start by comparing the true and revealed insurance value for two infra-marginal groups: the insured and the uninsured.

Proposition 1 *When frictions are independently distributed and $E(\varepsilon) = 0$, the demand curve overestimates the insurance value for the insured and underestimates the insurance value for the uninsured. That is,*

$$E(\varepsilon|\hat{v} \geq p) \geq 0 \geq E(\varepsilon|\hat{v} < p) \text{ for any } p. \tag{1}$$

[16] See for example the subjective expected utility theory in Savage (1954).

The Proposition implies that the difference between the true and revealed value is unambiguously biased in opposite directions for the insured and uninsured. The robustness of this result does not rely on the independence assumption, as I will show shortly, but on a simple selection effect; frictions that affect the decision to buy insurance will be differently represented among the insured and the uninsured. Even though frictions cancel out over the entire population, they do not conditional on the decision to buy insurance. For example, overly optimistic beliefs about the risk exposure discourage individuals from buying insurance, while overly pessimistic beliefs encourage individuals to buy insurance. Those buying insurance are thus more likely to be too pessimistic, while those who do not buy insurance are more likely to be too optimistic, even when beliefs are unbiased on average.

This simple argument has important policy consequences. The selection effect unambiguously signs the mistake an RP-policy maker who uses the demand curve to evaluate welfare consequences of policy interventions targeting either all the insured or all the uninsured. He overestimates the value generated in the insurance market and underestimates the potential value of insurance for the uninsured. As a consequence, universal insurance mandates, central in the insurance policy debate, are always underappreciated. In contrast, the cost of a policy affecting all insured individuals, like banning the insurance product, is always overestimated.

The selection mechanism suggests that, *on average*, people with a high revealed value are more likely to overestimate the value of insurance than people with a low revealed value. To establish that higher revealed values *always* signal stronger overestimation of the true values, a positive monotone likelihood ratio property is required:

Property MLRP. *For any* $\hat{v}_1 \geq \hat{v}_2$, $\varepsilon_1 \geq \varepsilon_2$, $\frac{f(\hat{v}_1|\varepsilon_1)}{f(\hat{v}_1|\varepsilon_2)} \geq \frac{f(\hat{v}_2|\varepsilon_1)}{f(\hat{v}_2|\varepsilon_2)}$.

The MLRP is satisfied by a large class of distributions including the normal distribution (see Milgrom 1981) and implies the following result:

Proposition 2 *When frictions satisfy MLRP, the demand curve overestimates the true value for the marginal buyers more, the higher the price. That is,*

$$\frac{\partial}{\partial p} E\left(\varepsilon | \hat{v} = p\right) \geq 0. \tag{2}$$

The proposition allows to evaluate more targeted policies (e.g., a price subsidy), which only affect the choice of some agents. The result has again important policy implications: an RP-policy maker is more likely to underestimate (overestimate) the value of extending the market coverage q, the more (less) individuals are already buying insurance. For symmetric distributions and $E\left(\varepsilon\right) = 0$, the RP-policy maker underestimates the marginal value of insurance if and only if the market coverage q exceeds 50 percent.

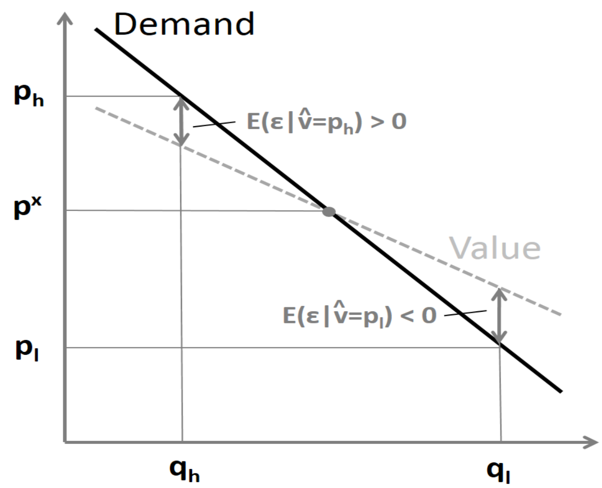

Figure 1: **Demand Curve vs. Value Curve: Counter-Clockwise Rotation**

Graphical representation Proposition 2 implies that the value curve is a counter-clockwise rotation of the demand curve as illustrated in Figure 1.[17] Denote by p^x the price at which the demand curve and value curve intersect (i.e., $p^x = MV(p^x)$). The value curve lies below the demand curve when prices are higher than p^x and above the demand curve when prices are lower than p^x. The difference between the two curves is monotone in the price. The counter-clockwise rotation also implies that the area to the left of any q is larger below the demand curve than below the value curve, while to the right of any q it is smaller. That is, condition (2) implies condition (1) for $E(\varepsilon) = 0$, but the opposite does not necessarily hold.

Best linear predictor The two Propositions provide a sharp characterization of the relation between demand and value curve, but rely on strong assumptions. The result that the value curve tends to be a counter-clockwise rotation of the value curve extends beyond these assumptions.

To see this note that the value curve - plotting the conditional expected true value $E(v|\hat{v} = p)$ for each price - is the best predictor of the true value as a function of the revealed value $\hat{v}$. The best *linear* predictor equals

$$L(v|\hat{v}) = \mu_v + \frac{cov(v, \hat{v})}{var(\hat{v})} (\hat{v} - \mu_{\hat{v}}).$$

This indicates that the ratio of the covariance between true and revealed value relative

[17] Note that Johnson and Myatt (2006) analyze shifts and rotations of the demand curve when marketing and advertizing changes the (unconditional) distribution of the value of insurance. In their analysis, rotations are caused by changes in the variance of the insurance value. In this analysis, the value curve is also a rotation of the demand curve, but coming from the difference between the revealed values and the conditional expectation of the true values, which implies that the correlation between the two distributions matters.

to the variance in revealed value captures the *average* co-movement between value and demand. This ratio depends on the correlation and the relative dispersion of the true and revealed values,

$$\frac{cov\left(v,\hat{v}\right)}{var\left(\hat{v}\right)}=\rho_{v,\hat{v}}\times\frac{\sigma_{v}}{\sigma_{\hat{v}}}.$$

In case of normal heterogeneity, this ratio fully determines the co-movement at *any* revealed value $\hat{v}$ as the conditional expectation equals the best linear predictor, i.e., $E\left(v|\hat{v}\right)=L\left(v|\hat{v}\right)$. We can state the following result:

Corollary 1 *If value and frictions are normally distributed and* $E\left(\varepsilon\right)=0$*, conditions (1) and (2) hold if and only if* $\rho_{v,\hat{v}}\times\frac{\sigma_{v}}{\sigma_{\hat{v}}}\leq 1$.

Heterogeneous frictions, whether they are independent or not, reduce the correlation $\rho_{v,\hat{v}}$ between the true and revealed of insurance below one. For example, with heterogeneous risk perceptions, we expect the correlation $\rho_{v,\hat{v}}$ to be imperfect as long as learning is incomplete.[18] Similarly, with bounded rationality, the share of boundedly rational types would determine how far the correlation $\rho_{v,\hat{v}}$ is below 1. The reduced correlation unambiguously reduces the extent to which the true value co-varies with the revealed value below one-for-one and rotates the value curve counter-clockwise relative to the demand curve. However, heterogeneous frictions also affect the dispersion in true values relative to the dispersion in revealed values. If frictions decrease the relative dispersion $\sigma_{v}/\sigma_{\hat{v}}$, they further decrease the extent to which the true value co-varies with the perceived value. This is the case when frictions are independent of the true values. An increase of this relative dispersion would require a sufficiently large negative correlation between the two. Moreover, to actually reverse the inequalities in the Propositions, the effect through the reduced dispersion would need to dominate the effect through the reduction in the correlation.[19] Building on the insight that frictions reduce the correlation, but can also affect the relative dispersion, I provide an extension of the Propositions for discrete type distributions in the web appendix.

3 Insurance Markets: Welfare Analysis

We use the established relationship between the demand and value curves to revisit now standard welfare analysis in insurance markets. The key inefficiency analyzed in the literature is that individuals sort into insurance plans based on their risks. Firms

[18] John C. Harsanyi (1968) observed that "by the very nature of subjective probabilities, even if two individuals have exactly the same information and are at exactly the same high level of intelligence, they may very well assign different subjective probabilities to the very same events." While rationality may restrict individuals to be Bayesian, it puts no restrictions on the risk priors, which are primitives of the model.

[19] Note that the condition in the Corollary can also be rewritten as $\rho_{v,\varepsilon}\geq-\frac{\sigma_{\varepsilon}}{\sigma_{v}}$, indicating that it is sufficient for the correlation between the noise term and the true value not to take a large negative value.

cannot directly price these risks, but set prices to reflect average costs instead. Einav, Finkelstein and Cullen (2010a), henceforth EFC, recently showed that the relative slope of the cost curve, depicting the average cost of buyers at different prices, to the demand curve captures the degree of adverse selection and is sufficient to estimate the corresponding welfare cost in the absence of demand frictions. Demand frictions, however, cause a different type of selection inefficiency by inducing some individuals with low valuation to buy insurance and vice versa. I build on the sufficient statistics approach in EFC and derive a formula to estimate the actual welfare cost of inefficient selection (based on both risks ánd frictions). The framework provides a robust approach to assess how demand frictions can affect standard welfare analysis, independent of their particular structure.

3.1 Stylized Model

The setup of this insurance model closely follows EFC, but is extended with demand frictions. The model considers a market for a single insurance contract with exogenous characteristics a la Akerlof (1970). This assumption allows me to keep the model tractable despite the multi-dimensional heterogeneity, but makes it impossible to consider the impact of frictions on contract terms.[20]

Individuals decide whether or not to buy the uniform insurance contract offered by risk-neutral insurers. An individual i's risk type determines the expected cost to the insurer, which I denote by π_i. The true value of insurance v_i equals this expected cost π_i plus a risk premium r_i. The risk premium determines the net-value or surplus generated when individual i buys insurance from a risk-neutral insurer. It does not only depend on the individual's (risk) preference, but also on the distribution of the risk that she is facing. For example, with CARA preferences and normal risks, an individual's risk premium is determined by her risk aversion and the variance of her insured expenses. For convenience, I will refer to π_i as the individual's risk type and to r_i as her preference type.

Like before, the revealed value equals the true value plus the noise term, but the true value now consists of a risk and preference term,

$$\hat{v}_i \equiv v_i + \varepsilon_i \equiv \pi_i + r_i + \varepsilon_i.$$

The stylized model thus captures three sources of heterogeneity underlying the demand

[20] The equilibrium characterization of screening contracts for Rotschild-Stiglitz type models with types only differing in risks has been extended for types also differing in risk aversion (e.g., Jullien et al. 2007) or risk perceptions (e.g., Sandroni and Squintani 2007, 2013; Spinnewijn 2013). To keep the analysis tractable, these models consider discrete types, only two dimensions of heterogeneity and a specific correlation between the two dimensions. These three assumptions are relaxed in the stylized model I consider. Most recently, Azevedo and Gottlieb (2015) and Veiga and Weyl (2015) have provided tractable equilibrium characterizations of endogenous contracts in contexts with multi-dimensional heterogeneity, which could be a promising starting point to start exploring the equilibrium impact of demand frictions on contract terms.

for insurance: risk types (determining the insurance cost), preferences (determining the insurance surplus), and frictions (distorting the insurance demand). The sorting of individuals based on their risk types determines the cost to the insurers. The average and marginal cost at price p equal $AC(p) = E(\pi|\hat{v} \geq p)$ and $MC(p) = E(\pi|\hat{v} = p)$ respectively. The sorting of individuals based on surplus determines welfare. That is, the welfare impact of extending market coverage depends on the difference between marginal value $MV(p)$ and marginal cost $MC(p)$ at the market price p.

Graphical representation Figure 2 plots a linear demand curve together with the corresponding marginal and average cost curves, depicting the average cost for the marginal and infra-marginal buyers at each price p. If individuals with higher risks have a higher willingness-to-pay for insurance, the cost to the insurer will be increasing in the price and the market is *adversely selected* from a cost perspective. This results in decreasing cost curves in Figure 2. The average cost curve, which decreases at a lower rate, lies above the marginal cost curve. The less an individual's risk affects his or her insurance choice, the less the marginal cost would depend on the price. This would flatten the average and marginal cost curve and reduce the wedge between the two. With upward-sloping cost curves, the market would be *advantageously selected* from a cost perspective.[21]

3.2 Equilibrium and Welfare

We now characterize the welfare cost of inefficient selection in the equilibrium of this stylized insurance market. We consider a competitive equilibrium in which the equilibrium price p^c equals the average cost of providing insurance (given that price),[22]

$$AC(p^c) = p^c. \tag{3}$$

An individual buys insurance when her revealed value exceeds the equilibrium price. However, it is efficient for an individual to buy insurance if her valuation exceeds the cost of insurance. When constrained by uniform pricing, the efficient price p^* is such that the marginal cost of insurance equals the marginal value of insurance,[23]

$$MC(p^*) = MV(p^*). \tag{4}$$

The price p^* corresponds to the efficient level of market coverage q^*.

[21] In this case, individuals with higher risk are less likely to buy insurance. Both cost functions are increasing and the average cost function will be below rather than above the marginal cost function.

[22] This notion of the competitive equilibrium follows EFC, but the analysis could be naturally extended with market power (see Mahoney and Weyl, 2014).

[23] In the unconstrained efficient allocation an individual buys insurance if and only if $r \geq 0$. Since individuals with the same revealed value cannot be separated, the constrained efficient allocation has individuals with revealed value $\hat{v}$ buying insurance if and only if $E(r|\hat{v} = p) = MV(p) - MC(p) \geq 0$. I compare uniform pricing with risk-adjusted pricing in section 4.2.

Comparing the equilibrium condition (3) and the efficiency condition (4) makes clear how the inefficiency in equilibrium is driven by the wedge between the average and marginal cost on the one hand and the wedge between the true and revealed value on the other hand. The total welfare cost due to inefficient pricing in this market is determined by the difference between the insurance value and cost for the pool of inefficiently uninsured individuals,

$$\Gamma = \left| \int_{p^*}^{p^c} \left[MV(p) - MC(p) \right] dD(p) \right|.$$

We now contrast this with the welfare analysis by a Revealed Preference policy maker. He believes that the inefficiency is completely captured by the wedge between average and marginal cost with the efficient price p^{RP} given by

$$MC\left(p^{\mathrm{RP}}\right) = p^{\mathrm{RP}}.$$

Using revealed values, he estimates the welfare cost to be

$$\Gamma^{\mathrm{RP}} = \int_{p^{\mathrm{RP}}}^{p^c} \left[p - MC(p) \right] dD(p).$$

The RP-policy maker (1) misidentifies the pool of inefficiently uninsured and (2) misestimates the welfare loss of being inefficiently uninsured,[24]

$$\Gamma = \left| \Gamma^{\mathrm{RP}} + \underbrace{\int_{p^*}^{p^{\mathrm{RP}}} \left[MV(p) - MC(p) \right] dD(p)}_{(1)} + \underbrace{\int_{p^{\mathrm{RP}}}^{p^c} \left[MV(p) - p \right] dD(p)}_{(2)} \right|.$$

Graphical representation The demand and average cost curve intersect at the equilibrium price p^c. The efficient price p^* is the price for which the the value curve and the marginal cost curve intersect. The welfare cost Γ equals the triangular area between the value curve and the marginal cost curve in between the competitive and the efficient level of insurance coverage. This is all shown in the right panel of Figure 2. The RP-policy maker mistakenly beliefs that the efficient price p^{RP} is given by the intersection of the demand and marginal cost curve. The estimated cost Γ^{RP} corresponds to the triangle between the demand and marginal cost curve, as shown in the left panel of Figure 2. Only when the revealed and true values coincide, the demand and cost curves are indeed sufficient to determine the cost of adverse selection, as shown in EFC.

[24] Note that Γ^{RP} is always positive. With adverse selection, $p^c > p^{\mathrm{RP}}$ and $p > MC(p)$ for the prices in between. With advantageous selection, $p^c < p^{\mathrm{RP}}$ and $p < MC(p)$ for the prices in between. This is not necessarily the case for the integral determining Γ, which is why I take the absolute value of the integral.

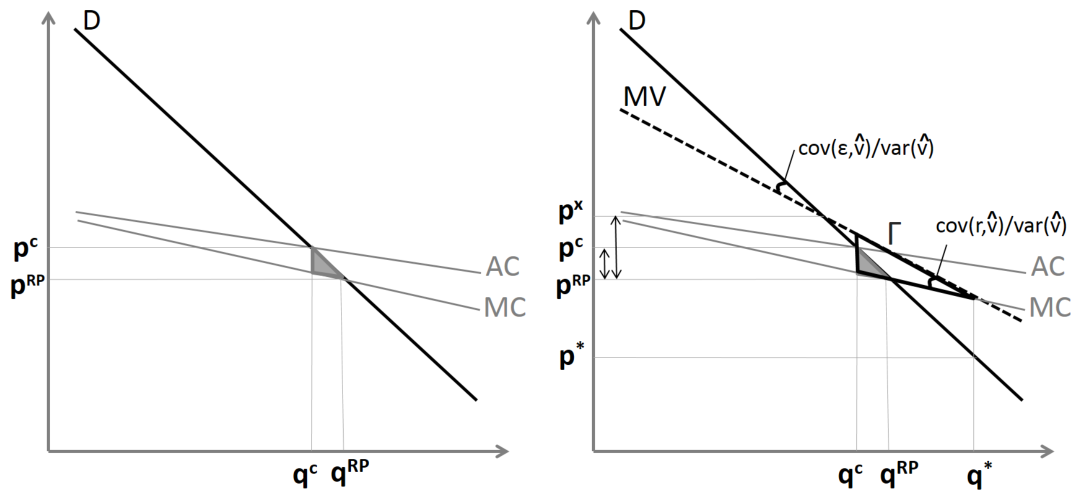

Figure 2: **Welfare Cost of Inefficient Pricing**: The figures contrast the true welfare cost Γ (in the right panel) with the estimated welfare cost $\Gamma^{\text{RP}}$by a revealed-preference policy maker (in the left panel) in an adversely selected market with demand frictions such that $cov\left(\varepsilon,\hat{v}\right)/cov\left(r,\hat{v}\right)>0$ and $\mathcal{P}=\left[p^{x}-p^{\text{RP}}\right]/\left[p^{c}-p^{\text{RP}}\right]>1$.

The wedge between the true welfare cost Γ and the estimate Γ^{RP} depends crucially on whether the revealed values overstate or understate the true values. In an adversely selected market, the equilibrium price tends to be inefficiently high due to average-cost pricing. The RP-policy maker underestimates the implied under-insurance if in addition the uninsured underestimate the value of insurance. This is always the case if the intersection p^{x} exceeds the equilibrium price p^{c}. We can state:

Proposition 3 *In an adversely selected market with $p^{c}\leq p^{x}$ and frictions satisfying MLRP, the true welfare cost Γ exceeds the estimated welfare cost Γ^{RP}.*

This case is illustrated in Figure 2 and also applies to the empirical analysis in EFC, which we will revisit below. The actual welfare cost Γ is higher than Γ^{RP}, both because the extent of under-insurance is worse (i.e., $p^{*}<p^{\text{RP}}$) and because the demand function underestimates the value of insurance for the inefficiently uninsured (i.e., $p<MV\left(p\right)$ for all $p\in\left[p^{*},p^{c}\right]$).

The sign and magnitude of the difference between Γ and Γ^{RP} clearly depend on the wedge between the demand and value curve, and the positioning of the area Γ^{RP} relative to the intersection between the demand and value curve. I turn to this issue next.

3.3 A Sufficient Statistics Formula

This section presents a "sufficient-statistics" expression of the welfare cost of inefficient selection, shedding further light on the interaction between the demand and supply inefficiencies. The formula also provides a simple approach to evaluate the robustness of welfare conclusions in the presence of demand frictions.

The derivation of the sufficient statistics formula relies on normal heterogeneity. As discussed in Section 2.2, the insights are expected to extend to any setting where conditional expectations are well approximated by the best linear predictor. Or put differently, to any setting where the covariance ratio's $cov(\pi, \hat{v})/var(\hat{v})$ and $cov(v, \hat{v})/var(\hat{v})$ capture well how cost and value relate to revealed values. In case of normal heterogeneity, these ratio's equal the slopes of the marginal cost curve and value curve relative to the demand curve.

Corollary 2 *With normal heterogeneity, the ratio of the true and estimated welfare cost equals*

$$\frac{\Gamma}{\Gamma^{\mathrm{RP}}} \cong |\frac{[1+\frac{cov(\varepsilon,\hat{v})}{cov(r,\hat{v})}\mathcal{P}]^2}{1+\frac{cov(\varepsilon,\hat{v})}{cov(r,\hat{v})}}| \text{ with } \mathcal{P} \equiv \left[p^x - p^{\mathrm{RP}}\right] / \left[p^c - p^{\mathrm{RP}}\right]. \tag{5}$$

The approximation relies on a linearization of the demand curve through $\left(p^{\mathrm{RP}}, q^{\mathrm{RP}}\right)$ and (p^c, q^c) and the corresponding value and cost curves.[25] Since the demand and cost curves are sufficient to estimate Γ^{RP}, one appeal of this formula is to identify the additional information that is required to account for frictions.

The actual welfare cost crucially depends on the covariance ratio $cov(\varepsilon, \hat{v})/cov(r, \hat{v})$. This ratio captures the extent to which the variation in demand is driven by frictions rather than by preferences. When all demand components are independent, this equals the relative share of the residual variation in demand - left unexplained by risks - that is driven by frictions. Graphically, this friction share determines how the slope of the value curve relates to the slopes of the demand and marginal cost curve; the value curve rotates counter-clockwise if $cov(\varepsilon, \hat{v})/cov(r, \hat{v})$ increases above zero. It initially coincides with the demand curve (when the residual variation is driven only by preferences) and rotates to a curve parallel to the marginal cost curve (when the residual variation is driven only by frictions).[26]

The impact of the covariance ratio $cov(\varepsilon, \hat{v})/cov(r, \hat{v})$ depends on the price ratio $\mathcal{P} = \left[p^x - p^{\mathrm{RP}}\right] / \left[p^c - p^{\mathrm{RP}}\right]$, which captures the positioning of the value curve relative to the cost curves. This price ratio is illustrated by arrows in Figure 2. The difference

[25] The derivation in the proof shows clearly how I use the linearization. In particular, the linearization turns the welfare costs Γ and Γ^{RP} into triangular areas, for which I can derive exact expressions. In the numerical examples in the web appendix, I show that the error due to the linear approximation in estimating the bias $\Gamma/\Gamma^{\mathrm{RP}}$ is small, especially when $cov(\varepsilon, \hat{v})/cov(r, \hat{v})$ is small.

[26] Relating this to the earlier decomposition of Γ, the ratio affects both the misestimation of the insurance surplus and the misidentification of the pool of inefficiently uninsured;

$$E(\varepsilon|\hat{v}=p) = \frac{cov(\varepsilon,\hat{v})}{cov(r,\hat{v})}\left[E(r|\hat{v}=p) - \mu_r\right] \text{ and } p^{\mathrm{RP}} - p^* = \frac{cov(\varepsilon,\hat{v})}{cov(r+\varepsilon,\hat{v})}\mu_r.$$

$p^c - p^{\mathrm{RP}}$ depends on the nature of selection due to average-cost pricing, while the difference $p^x - p^{\mathrm{RP}}$ determines whether at the price that is deemed to be efficient by an RP-policy maker, the marginal buyer over- or underestimates the value of insurance.[27]

To illustrate the joint role of the covariance ratio and the price ratio, consider a market that is adversely selected from a cost perspective ($p^c > p^{\mathrm{RP}}$). When the value curve intersects with the demand curve at the competitive price ($p^x = p^c$), the price ratio $\mathcal{P}$ equals 1, implying that the welfare cost Γ increases (approximately) linearly with the covariance ratio,

$$\Gamma \cong \Gamma^{\mathrm{RP}} \times |1 + \frac{cov\left(\varepsilon, \hat{v}\right)}{cov\left(r, \hat{v}\right)}|.$$

An RP-policy maker unambiguously underestimates the welfare cost when $cov\left(\varepsilon, \hat{v}\right)/cov\left(r, \hat{v}\right) > 0$, which is in line with Proposition 3. For larger $\mathcal{P} > 1$ (e.g., shifting the value curve up such that $p^x > p^c$), the bias in the welfare evaluation becomes larger and increases at a faster rate when the covariance ratio increases. This is the case illustrated in the right panel of Figure 2. For smaller $\mathcal{P} < 1$ (e.g., shifting the value curve down such that $p^x < p^c$), some of the inefficiently uninsured are overestimating rather than underestimating the value of insurance. As a consequence, an RP-policy maker may now overestimate the welfare cost. For even smaller $\mathcal{P} < -cov\left(r, \hat{v}\right)/cov\left(\varepsilon, \hat{v}\right)$, he wrongly believes that the market equilibrium exhibits under-insurance. The efficient price p^* is above the competitive price p^c, even though an RP-policy maker perceives it to be below and thus mistakenly believes that market coverage should be increased.

3.4 Implementing the Formula

I now illustrate the implementation of the sufficient statistics formula in a particular context and demonstrate how the general impact of demand frictions on welfare estimates can be accounted for. I consider the context of employer-provided health plans, analyzed in EFC, and use their estimates to calculate how the true welfare cost Γ would change for different values of the covariance ratio $cov\left(\varepsilon, \hat{v}\right)/cov\left(r, \hat{v}\right)$. Importantly, this approach to evaluate the robustness of standard welfare analysis does not require the data underlying the estimate of Γ^{RP} (i.e., the demand and cost curves), but allows to gauge whether demand frictions can matter. I also briefly discuss the additional data that would be required to estimate the relevant friction share in this context and provide some back-of-the-envelope calculations of plausible values referring to existing estimates (from different applications). While more rigorous empirical analysis is needed to draw firm conclusions, the numerical exercise indicates that in this particular context the welfare cost of adverse selection is substantially higher when accounting for the plausible role played by demand frictions.

[27] With a friction mean $E\left(\varepsilon\right) = \mu_{\varepsilon}$ underlying the demand function, the intersection price p^x equals $\mu_{\hat{v}} - \mu_{\varepsilon}/\left[cov\left(\varepsilon, \hat{v}\right)/var\left(\hat{v}\right)\right]$. Hence, for zero-mean frictions, the intersection price p^x equals $\mu_{\hat{v}} = \mu_v$.

Numerical Example EFC analyze choices of employer-provided health plans.[28] They find this market to be adverse selected, but estimate the welfare cost of the implied under-insurance to be low (only 3 percent of first best welfare).[29] In their particular context, more than 50 percent of the individuals are predicted to buy insurance at the competitive price, suggesting that they would underestimate the welfare cost under zero-mean frictions.

Table 1 evaluates the robustness of their welfare estimates by showing the *true* welfare cost of inefficient selection Γ for different values of the unknown covariance ratio. The results indicate that the true welfare cost Γ increases rapidly with $cov\left(\varepsilon,\hat{v}\right)/cov\left(\varepsilon+r,\hat{v}\right)$ and the difference with the estimated welfare cost Γ^{RP} is already substantial for seemingly low friction shares; if 1 percent (10 percent) of the residual variation is explained by frictions, the actual cost of adverse selection is 3 percent (31 percent) higher than estimated when using the demand function. If half of the residual variation is explained by frictions, the actual cost of adverse selection is more than 4 times higher than estimated based on the demand function. This corresponds to 25 percent of the surplus generated in this market at the efficient price.

These results are sensitive to the assumption that frictions drive no average wedge between the true and revealed value. A negative friction mean further increases the true value relative to the demand and thus the actual under-insurance in this market. A positive mean has the opposite effect. In fact, a constant friction $\bar{\varepsilon} = \$137$ ($\sim$ 50 percent of the true value for the marginal consumers) would be needed to offset the under-insurance due to average-cost pricing and make the competitive equilibrium constrained efficient ($p^c = p^*$). Even with a mean friction value of $E\left(\varepsilon\right) = \$137$, the welfare cost Γ would again increase above 0 when frictions are heterogeneous and exceed the estimated cost Γ^{RP} for $cov\left(\varepsilon,\hat{v}\right)/cov\left(r+\varepsilon,\hat{v}\right) \geq 1/3$.

Empirical Implementation The question remains how to obtain plausible values for the covariance ratio in this context. Recent empirical evidence documents strong correlates between demand frictions and insurance choices. The role of frictions, however, varies across contexts and providing a precise estimate of their importance is challenging. In an ideal setting we would observe the insurance choices (in this environment) for the same individuals with and without frictions. This would allow us to

[28] EFC consider the choice between two insurance contracts and the medical insurance claims of 3,779 salaried employees of Alcoa, a multi-national producer of aluminium. They estimate the (relative) demand for the contract providing more insurance and the associated cost of providing the additional insurance to implement their sufficient statistics approach.

[29] I assume a linear system in this numerical example to make the welfare results comparable to the EFC estimates for linear demand and cost curves. This assumes that the relative slopes of the linear curves take the values of the covariance ratio's as in the case of normal heterogeneity. Note also that for such linear system the welfare cost approximation in (5) would be exact. For robustness purposes, I also relax this linearity assumption and calculate the welfare costs when assuming that the different demand components are normally distributed, now assuming that the estimated relative slopes determine the covariance ratio's. Table App1 in the web appendix shows that the welfare implications are very similar.

estimate the joint distribution of the willingness-to-pay $\hat{v}$ (distorted by frictions) and the true value v across the population. For example, one could compare individuals' choices before and after an information workshop or the introduction of choice aids. If such interventions were to fully eliminate demand frictions, this type of data would be sufficient to construct the value curve and estimate the share of demand variation explained by frictions.[30]

A promising approach, coming close to this ideal setting, is to identify friction measures affecting the insurance choice, but unrelated to the insurance value. This approach has been followed most recently by Handel and Kolstad (2015) who complement standard insurance data with survey questions to estimate the impact of frictions on the willingness-to-pay for insurance in a random utility model. These friction estimates allow to construct a friction value ε_i for each individual and to recover the individual's true insurance value v_i from the estimated willingness-to-pay $\hat{v}_i$.[31]

Even without additional choice data, we can rely on existing empirical estimates to get an indication of what friction shares are plausible and predict the corresponding impact of demand frictions. Consider again the empirical analysis in EFC. They find that the slope of the marginal cost curve is one third of the demand curve, implying an estimate for $cov\left(\pi, \hat{v}\right)/var\left(\hat{v}\right)$ of 1/3. This leaves about two third of the variation in demand to be explained by frictions or preferences, since

$$\frac{cov\left(\pi, \hat{v}\right)}{var\left(\hat{v}\right)} + \frac{cov\left(r, \hat{v}\right)}{var\left(\hat{v}\right)} + \frac{cov\left(\varepsilon, \hat{v}\right)}{var\left(\hat{v}\right)} = 1.$$

Example 3 in Section 2 provides a direct lower bound on $cov\left(\varepsilon, \hat{v}\right)/var\left(\hat{v}\right)$ as this ratio would correspond to the share of boundedly rational individuals. While the stylized representation of individuals simply mimicking their peers in this example is quite extreme, Loewenstein et al. (2013) find that between 22 and 66 percent of surveyed individuals do not even understand basic plan features like deductibles and coinsurance. Now if 1/6 of individuals were mimicking the insurance choice of a random peer in the EFC setting (with $cov\left(\pi, \hat{v}\right)/var\left(\hat{v}\right) = 1/3$), the covariance ratio $cov\left(\varepsilon, \hat{v}\right)/cov\left(r+\varepsilon, \hat{v}\right)$ would be at least .25.

Example 1 in Section 2 suggests that when individuals' perceptions do not accurately reflect their true risks, this would drive down $cov\left(\pi, \pi+\varepsilon\right)/var\left(\pi+\varepsilon\right)$. The relation between true and perceived risks has been analyzed in many settings. For example, Finkelstein and McGarry (2006) find estimates of around 0.1 when estimating a linear probability model of nursing home use using the self-reported beliefs of this probability.[32] If the expected insurance cost π were linear in this probability, this low

[30] Note that it is not sufficient to have choice data respectively with and without frictions for otherwise comparable groups if the correlation between true value and frictions is unknown. Chetty et al. (2009) uses such data in the context of tax salience, but their welfare analysis relies on the assumption that the inattention is the same for all consumers.

[31] See Harris and Keane (1999) and Fang et al. (2008) for alternative examples.

[32] Notice that Finkelstein and McGarry (2006) find a positive relationship between the self-reported

value would be the estimate of $cov(\pi, \pi+\varepsilon)/var(\pi+\varepsilon)$.[33] However, even allowing for values up to .5 in the EFC context (with $cov(\pi, \hat{v})/var(\hat{v}) = 1/3$), a back-of-the-envelope calculation indicates that the covariance ratio $cov(\varepsilon, \hat{v})/cov(\varepsilon + r, \hat{v})$ would still exceed .5.[34]

4 Insurance Markets: Policy Interventions

In this section I use the framework with demand frictions to analyze different policy interventions that are currently in place in insurance markets. I provide some policy results that clearly demonstrate how the impact of these interventions is affected by demand frictions and identify potentially opposing forces. I illustrate these qualitative differences using some numerical examples that build on the empirical analysis in EFC.

I first compare price subsidies and insurance mandates, two commonly used policies that do not change the sorting of individuals along the demand curve. Hence, the covariance ratio $cov(\varepsilon, \hat{v})/cov(r, \hat{v})$ remains sufficient to evaluate welfare gains (conditional on the observed demand and cost functions). I also analyze risk-rating and friction-reducing policies. These policies affect individuals' willingness to insure differentially and thus change the sorting of individuals along the demand curve. Here, correlations between the different demand components would be needed to predict the consequences of these policies.

4.1 Subsidy vs. Mandate

The question whether insurance should be subsidized or mandated plays a central role in the policy debate in various countries.[35] The main difference between the two policies is that price subsidies leave the choice to buy insurance to individuals. Demand frictions determine how big the price incentives need to be to change individuals' choices, but only the true value of insurance determines the welfare impact of these changes. Encouraging the purchase of insurance through a price policy is less effective the lower the revealed value relative to the true value. In contrast, a mandate forces an individual

probability and insurance coverage, but no significant relationship between the true risk and insurance coverage, consistent with the role played by demand frictions.

[33] Surveyed risk perceptions are found to predict risk realizations, often better than any other set of covariates, but the estimated relation is generally very small (see Hurd (2009) for a recent overview). Clearly, the self-reported probability does not measure the demand-driving perceived probability without error and measurement error attenuates the estimate of $cov(\pi, \pi+\varepsilon)/var(\pi+\varepsilon)$ towards 0.

[34] Here, I use the following decomposition,

$$\frac{cov(\varepsilon, \hat{v})}{var(\hat{v})} = \frac{cov(\pi+\varepsilon, \hat{v})}{var(\hat{v})} - \frac{cov(\pi, \hat{v})}{var(\hat{v})} \cong \left[\frac{1}{\frac{cov(\pi,\pi+\varepsilon)}{var(\pi+\varepsilon)}} - 1\right] \times \frac{cov(\pi, \hat{v})}{var(\hat{v})}, \tag{6}$$

where the approximation relies on the correlation of the surplus with either risk or frictions to be small.

[35] A recent example is the much debated health insurance mandate as part of the Affordable Care Act in the United States.

to buy insurance, regardless of the demand frictions. I illustrate this contrast in our stylized insurance model with demand frictions.

I consider an *efficient-price* subsidy and a *universal* mandate, following EFC, and continue to assume that only the true value is relevant to evaluate the policy. An efficient-price subsidy reduces the equilibrium price to the efficient price p^*. This subsidy induces the original pool of inefficiently uninsured to buy insurance and thus realizes the welfare gain Γ. The welfare cost of this subsidy equals $\Phi^S = \lambda q^* \left[p^c - p^*\right]$, which depends on the implied expenditures and the net cost of public funds λ.[36] By forcing everyone to buy insurance, a universal mandate realizes the same welfare gain Γ, but entails a different welfare cost $\Phi^M = \int_0^{p^*} \left[MC(p) - MV(p)\right] dD(p)$. For individuals with revealed value $\hat{v}$ below the efficient price p^*, the expected surplus of insurance is negative.

The following policy result illustrates the differential welfare impact of the two policy interventions when frictions underly the observed demand and cost curves, .

Policy Result 1 *For given demand and cost functions, demand frictions satisfying MLRP and $E(\varepsilon) = 0$ increase the net welfare gain from a universal mandate, $\Gamma - \Phi^M$, but may decrease this for an efficient-price subsidy, $\Gamma - \Phi^S$. A mandate becomes more desirable relative to an efficient price-subsidy when frictions lower the efficient price p^*.*

As already argued in Proposition 1, frictions tend to increase the expected insurance surplus for the uninsured and thus the welfare gain $\Gamma - \Phi^M$ from a universal mandate. Although the gain Γ from an efficient-price subsidy is the same, the impact on the net gain $\Gamma - \Phi^S$ is ambiguous. The differential impact of frictions on the two policies is particularly clear when frictions increase the efficient level of market coverage q^* (and thus decreases the efficient price p^*), as is the case in the numerical example. While the group of the *efficiently* uninsured becomes smaller, the group of the *inefficiently* uninsured becomes larger. The former causes the cost of the mandate Φ^M to decrease, while the latter causes the cost of an efficient price subsidy Φ^S to increase. The opposite effects naturally imply that a universal mandate becomes more desirable relative to an efficient-price subsidy. Moreover, if the increase in the cost Φ^S exceeds the increase in the gain Γ, frictions would in fact reduce the net gain from an efficient-price subsidy.

Note that it is the discrepancy between the true and revealed values that is driving these opposite effects. Frictions affect the gain from extending coverage by changing the surplus for the marginal buyers, but the cost of extending the market coverage through a subsidy continues to depend on the price these marginal buyers are willing to pay.[37]

[36] Note that the cost of a price subsidy makes that the subsidy that induces the efficient price is not welfare optimal. In particular, the welfare gain for the marginal buyers at the efficient price is zero and thus exceeded by the marginal cost of the subsidy required to induce them to buy insurance.

[37] Note also that the implementation of an efficient-price subsidy would require knowledge of the

Numerical Example I briefly build on the previous example to illustrate the differential impact of frictions on mandates and subsidies quantitatively. Setting the cost of public funds λ equal to 0.3, EFC find that the welfare cost of the efficient price subsidy Φ^S is almost five times as large as the welfare gain Γ and thus implies a welfare loss from using this policy. The gain Γ from inducing efficient insurance coverage increases when frictions are underlying the estimated demand curve, but the subsidy's cost Φ^S increases even more, as shown in column (1) of Table 2.[38] The net loss of a price subsidy is thus larger in the presence of frictions. The opposite is true for the mandate. The estimates of EFC imply that a universal mandate would be welfare decreasing in the absence of frictions. This loss, however, decreases when frictions are underlying the demand, as reported in column (2). In fact, when more than 17 percent of the variation in residual demand, left unexplained by risks, is driven by frictions, a universal mandate becomes welfare increasing. Frictions can thus reverse the net impact of a government intervention on welfare and the decision to implement it or not.

4.2 Risk-Rating

An alternative intervention in insurance markets related to adverse selection is the regulation of risk-rating or pricing based on pre-existing conditions. While risk-rating is often being rejected on equity grounds (e.g., the ban on gender discrimination in insurance pricing by the European Court of Justice), earlier work has emphasized the efficiency aspect of adjusting premia to reflect an individual's specifc risk (e.g., Bundorf, Levin and Mahoney 2012). Underlying the problem of adverse selection is the fact that buyers of insurance plans do not internalize the individual-specific cost they impose on their insurer. Adjusting prices for their individual-specific risk corrects this type of externality and induces a more efficient decision. However, the efficiency gain crucially depends on these risks being perceived accurately or not being neutralized by other demand frictions. I use our stylized model to illustrate how risk-rating can entail efficiency losses due to the presence of demand frictions.

I consider a risk-adjusted insurance premium $p+\beta(\pi_i)$, where the adjustment $\beta(\pi_i)$ is weakly increasing in the individual's risk type π_i and equal to 0 if $\pi_i = \mu_\pi$. Perfect risk-rating would be obtained when $\beta(\pi_i) = \pi_i - \mu_\pi$. We can re-express the value and cost of providing insurance net of the risk-adjustment and apply the equilibrium and welfare analysis as before. That is, an individual buys insurance if and only if $\hat{v}_i^\beta \geq p$,

heterogeneity driving the demand for insurance. For example, an RP-policy maker would implement a subsidy equal to $p^c - p^{\mathrm{RP}}$ that is too small. An additional advantage of the universal mandate is therefore that the implementation requires no prior knowledge.

[38] I again use a linear system in this numerical example, following EFC, but find that the policy implications are similar when the different demand components are normally distributed (see Table App2).

where $\hat{v}_i^{\beta} = \hat{v}_i - \beta(\pi_i)$. The cost for the insurer, net of the risk-adjustment, now equals

$$
\begin{aligned}
AC^{\beta}(p) &= E\left(\pi - \beta(\pi) \,|\hat{v}^{\beta} \geq p\right), \\
MC^{\beta}(p) &= E\left(\pi - \beta(\pi) \,|\hat{v}^{\beta} = p\right).
\end{aligned}
$$

As argued in previous work, risk-rating will lower the equilibrium price and thus increase equilibrium coverage, $\Pr\left(\hat{v}^{\beta} \geq p^c\right)$. Pricing risks mechanically reduces difference between the unpriced risk among the insured and the uninsured. Moreover, it makes high risk types less likely to buy insurance and low risk types more likely to buy insurance. Both effects lower the average cost curve and thus the competitive price.

Equilibrium welfare $S^c = E\left(r|\hat{v}^{\beta} \geq p^c\right)\Pr\left(\hat{v}^{\beta} \geq p^c\right)$, however, also depends on the type of individuals buying insurance at the competitive price.[39] The surplus $E\left(r|\hat{v}^{\beta} \geq p\right)$ for a given price p is higher the more preferences rather than any other variable drive the demand for insurance. Without frictions, reducing the selection based on risks necessarily increases the selection based on preferences. The issue is that when demand frictions distort the relation between risk and insurance demand, adjusting the prices for an individual's risk may have a very different impact on the selection into insurance depending on the correlation between risk and frictions. In fact, the selection on preferences can even decrease when this correlation is strongly negative. This is the case when people differ in their risks, but underestimate these differences.[40]

I consider two extreme cases to illustrate these opposing effects on the equilibrium surplus:

Policy Result 2 *Without frictions $\varepsilon_i = 0$, perfect risk-rating unambiguously increases equilibrium welfare S^c. With frictions $\varepsilon_i = \mu_{\pi} - \pi_i$ and $corr(\pi, r) = 0$, perfect risk-rating unambiguously decreases equilibrium welfare.*

Perfect risk-rating corrects the externality an individual imposes on the insurer. In the absence of frictions, this induces an individual to buy insurance if and only the net-value r_i is positive, which is exactly efficient. Frictions make that an individual does not accurately internalize the value of buying insurance for herself either. For $\varepsilon_i = \mu_{\pi} - \pi_i$, the friction already offsets the externality such that the introduction of risk-rating creates the inefficiency that it is supposed to eliminate. This extreme case arises when all individuals perceive their risk to be exactly equal to the average risk.

The policy result again indicates that by ignoring frictions a policy maker would misperceive the efficiency gains from policy. The bias, however, does not simply de-

[39] Notice that I continue to ignore equity considerations by using the equilibrium surplus as the welfare criterion. Clearly, risk-rating makes insurance more expensive for high risk-types, which may be undesirable for redistributive reasons, but this is not captured when considering the aggregate equilibrium surplus.

[40] When the preference term is independently distributed, risk-rating increases the surplus at a given equilibrium price only if $var(\pi + \varepsilon) \geq var(\pi + \varepsilon - \beta(\pi))$. For perfect risk-rating, this simplifies to $\rho_{\varepsilon,\pi} \geq -\frac{1}{2}\frac{\sigma_{\pi}}{\sigma_{\varepsilon}}$.

pend on the difference between the demand and value curve. More generally, since risk-rating changes the ordering of individuals along the demand curve, the original demand, cost and value curves are no longer sufficient to evaluate the impact of such policy intervention. Instead we would need information on the correlations between the different demand components.

Numerical Example I extend the numerical example based on the analysis in EFC to now illustrate the potential role of frictions for the welfare impact of risk-rating. I consider three different assumptions on the correlation between frictions and the other demand components, which I use to calibrate the covariance matrix of (π, r, ε).[41] I consider a linear risk-adjustment of the insurance premium $\beta(\pi) = \beta[\pi - \mu_\pi]$ and simulate the new demand, cost and value curves and the corresponding equilibrium for different values of β. Table 3 shows how risk-rating affects equilibrium welfare S^c and the cost of inefficient selection Γ for the different cases.

The first two columns (0a) and (0b) in Table 3 show the positive welfare impact of risk-rating in the absence of frictions. Equilibrium welfare increases by up to 11 percent when the risk-adjustment is perfect, $\beta = 1$. The reduction in Γ due to the elimination of the inefficient wedge between p^c and p^* accounts for about one third of the welfare increase. Note that these welfare estimates are very similar to the estimates in Bundorf et al. (2012), analyzing employees choices between HMO plans and PPO plans.[42]

The remaining columns of Table 3 show how different the welfare conclusions are in the presence of frictions. I assume an initial value of 0.25 for $cov(\varepsilon, \hat{v}) / cov(\varepsilon + r, \hat{v})$ (in the absence of risk-rating), but allow for different correlations $\rho_{\pi,\varepsilon}$ between risk and frictions. In the first scenario, all components are independent and the welfare impact of risk-rating is hardly affected (see columns (1a) and (1b)). In the second scenario, the noise term is negatively correlated with the risk such that $var(\pi) = var(\pi + \varepsilon)$. One interpretation is that the dispersion in true and perceived risks is the same, but the correlation between the two is imperfect. Risk-rating still increases welfare, but the increase is reduced to 7 percent for $\beta = 1$, as shown in column (2a). The third scenario increases the magnitude of the negative correlation $\rho_{\varepsilon,\pi}$ further such that $var(\pi + \varepsilon) = 0.5 var(\pi)$. Following the above interpretation, this assumes that the perceived risks are not only imperfectly correlated with the true risks, but also less dispersed. This last scenario, shown in column (3a), illustrates that frictions may not only reduce but even reverse the positive welfare effect of risk-rating. The introduction

[41] I still assume that all curves are linear with their slopes depending on the covariance matrix of (π, r, ε), but establish robustness for normal heterogeneity in Table App3. I assume an initial value of .33 for $cov(\pi, \hat{v}) / var(\hat{v})$ corresponding to the relative slope of the average cost curve in EFC and of .25 for the covariance ratio $cov(\varepsilon, \hat{v}) / cov(\varepsilon + r, \hat{v})$ capturing the relative importance of frictions.

[42] Bundorf et al. (2012) allow for private information about risks over the observed risk scores, but assume accurate risk perceptions. They find a potential welfare increase of 2-11 percent from pricing the observable risk, where about one fourth is due to eliminating the wedge between the equilibrium and efficient price.

of risk-rating initially offsets adverse selection and increases welfare by decreasing the equilibrium price. However, the selection of insured individuals becomes more and more dependent on their risk types when increasing the risk-adjustment factor β. This effect decreases the generated surplus at a given price and eventually dominates the welfare gain from the reduced equilibrium price. Perfect risk-rating now reduces welfare by 3 percent.

4.3 Reducing Frictions

When choices are distorted by the presence of frictions or constraints, a natural government intervention is to alleviate these constraints. For example, the provision of information can reduce information frictions and help individuals to improve the quality of their choices, as illustrated in the context of Medicare Part D by Kling et al. (2012). The setup of Health Insurance Exchanges in the US is another recent policy meant to improve insurance choices by regulating the types of insurance plans that can be offered, how information about them is presented to consumers, the defaults individuals face, etc. The issue with these interventions is that the pool of insured individuals and thus the equilibrium price is affected as well. While reducing frictions induces people to make better decisions, it may decrease welfare by increasing adverse selection. I use the stylized framework to disentangle the two opposing effects on welfare.

Consider two friction-reducing policies decreasing the variance of zero-mean frictions. The first policy, by reducing σ_ε, increases the correlation between π and $\pi + \varepsilon$. The second policy, by reducing σ_ε, increases the correlation between r and $r + \varepsilon$. A natural interpretation in case of inaccurate risk perceptions is that the first policy provides information about the average expenses one expects to make, while the second policy provides information about the variance in these expenses. Graphically, the first policy entails a clockwise rotation of both the marginal cost curve and the value curve, while the second policy only rotates the value curve. For both policies, the demand curve remains unchanged.

The first policy makes an individual's demand more aligned with her risk type; individuals with high π become more likely to buy insurance, individuals with low π become less likely to buy insurance. The average expected cost of the individuals buying insurance at a given price level increases, which increases the equilibrium price as the demand function is unaffected. However, the expected net-value of the individuals buying insurance at a given price is still the same. Hence, the same surplus is generated for those buying insurance, but less individuals buy insurance so that the competitive surplus is unambiguously lower if the market equilibrium already exhibits under-insurance. The second policy makes an individual's demand more aligned with her preference and has the opposite effect. The policy induces people with a high net-value r to buy insurance, but the competitive price remains unchanged as the expected cost of the individuals buying insurance is not affected. Hence, as many people buy insurance in equilibrium, but a higher welfare surplus is generated for those buying insurance. The competitive surplus thus unambiguously increases.

Policy Result 3 *Assuming normal heterogeneity, a friction-reducing policy that increases the correlation between r and $r+\varepsilon$ unambiguously increases equilibrium welfare S^c. A friction-reducing policy that increases the correlation between π and $\pi+\varepsilon$ reduces welfare when the equilibrium exhibits under-insurance (i.e., $p^c > p^*$).*

For information policies, the potential trade-off between improving the selection on preferences vs. risks could be avoided by providing the right type of information. Information regarding the cost-related value of insurance will be detrimental, as it only affects the market price, while information regarding the net-value of insurance will be beneficial, as it only affects the selection of the individuals buying insurance. The trade-off is similar when other constraints drive a wedge between the revealed and true value, but identifying policies that leave the equilibrium price unaffected may be more difficult. For example, when switching costs prevent individuals from buying a new insurance contract, as considered by Handel (2013), a policy that reduces the switching costs will be welfare decreasing when the individuals facing higher switching costs face higher risks.

Numerical Example I use the same numerical example to now illustrate the potential opposing welfare effects from reducing frictions. Since friction-reducing policies affect the sorting into insurance, I again consider different scenarios for the correlation between frictions and the other demand components, starting from an initial value of 0.25 for $cov(\varepsilon, \hat{v})/cov(\varepsilon + r, \hat{v})$. Table 4 shows for each scenario how a reduction in the variance of the noise term σ_{ε}^2 affects welfare S^c and the cost of inefficient selection Γ in the new equilibrium.

The first scenario assumes that the three demand components π, r and ε are independent. A reduction in σ_{ε} increases the selection on both risks and preferences. While in theory the net impact is ambiguous, column (1a) in Table 4 shows that reducing frictions increases welfare in this example, up to 4 percent when all frictions are eliminated. The cost of inefficient selection Γ - which is now only due to average-cost pricing - is lower as well. The second and third scenario disentangle the importance of the two opposing effects. The second scenario assumes that the reduction in σ_{ε} only increases the correlation between π and $\pi+\varepsilon$, as for the first policy in Result 3. This scenario also corresponds to the second scenario considered in Table 3. The policy induces the more costly types to buy insurance and thus worsens the adverse selection. Welfare is lower in the new equilibrium and the cost of adverse selection has increased. With all frictions eliminated, welfare decreases by 3 percent, while the cost of inefficient selection Γ has now increased. Finally, the third scenario assumes that a reduction in σ_{ε} only increases the correlation between r and $r+\varepsilon$, as for the second policy in Result 3. The information policy improves the selection of individuals, without affecting the equilibrium price, so that welfare unambiguously increases. With all frictions eliminated, welfare increases by 12 percent. This is three times as high as in the first scenario with independent noise. The welfare consequence of eliminating frictions in this example crucially depends on their relation with risks and preferences.

5 Conclusion

What explains the variation in demand for insurance? This difficult question has been central in a recent, but already prominent empirical literature. A number of recent studies suggest that what drives insurance choices is often unrelated to the actual value of insurance. Nevertheless, the literature analyzing the importance of adverse selection in insurance markets has evaluated potential government interventions under the assumption that individuals' choices reveal the actual value of insurance. This paper provides a tractable framework to analyze welfare and policies when the true and revealed value of insurance no longer coincide. The analysis uses a simple selection argument to show that the welfare conclusions based on the insurance demand are systematically biased, even without an average bias in the valuation of insurance. This approach complements the choice-based behavioral welfare analysis proposed by Bernheim and Rangel (2009). An individual's insurance choice may be suboptimal when induced by a friction or constraint that is not considered relevant for welfare. When these constraints affect individuals differently, but cannot be individually identified, no allocation could be found to be welfare-dominated for a particular individual based on her observed choice. However, choices may still be indicative of the constraints that have affected individuals making this choice. This selection effect could be accounted for when evaluating the expected value of a policy for individuals who made a particular choice. A numerical example illustrates that for plausible differences between the true and revealed value of insurance, the welfare conclusions regarding the efficiency cost of adverse selection are substantially different. The analysis also reveals that the welfare gains of the common policy interventions in insurance markets crucially depend on the source of the heterogeneity underlying the demand for insurance. Further research should shed more light on these sources of heterogeneity in different insurance markets to guide the optimal design of policy interventions.

References

Abaluck, J., and J. Gruber, 2011. Choice Inconsistencies among the Elderly: Evidence from Plan Choice in the Medicare Part D Program. American Economic Review, 101(4), 1180–1210.

Akerlof, G., 1970. The Market for "Lemons": Quality Uncertainty and the Market

Mechanism. Quarterly Journal of Economics, 84(3), 488-500.

Azevedo, E., and D. Gottlieb. Perfect Competition in Markets with Adverse Selection. Mimeo, University of Pennsylvania.

Barghava, S., Loewenstein, G., and J. Sydnor, 2015. Do Individuals Make Sensible Health Insurance Decisions? Evidence from a Menu with Dominated Options. Mimeo.

Barseghyan, L., Molinari, F., O'Donoghue, T., and J. Teitelbaum, 2012. The Nature of Risk Preferences: Evidence from Insurance Choices. American Economic Review. forthcoming

Barseghyan, L., Prince, J., and J. Teitelbaum, 2011. Are Risk Preferences Stable Across Contexts? Evidence from Insurance Data. American Economic Review, 101(2), 591-631.

Bernheim, D., and A. Rangel, 2009. Beyond Revealed Preference: Choice-Theoretic Foundations for Behavioral Welfare Economics. Quarterly Journal of Economics, 124(1), 51-104.

Brown, J., and A. Finkelstein, 2008. The Interaction of Public and Private Insurance: Medicaid and the Long-Term Insurance Market. American Economic Review, 98(3), 1083-1102.

Bruhin, A., Fehr-Duda, H. and T. Epper, 2010. Risk and Rationality: Uncovering Heterogeneity in Probability Distortion. Econometrica, 78(4), 1375-1412.

Bundorf, K., Levin, J. and N. Mahoney, 2012. Pricing and Welfare in Health Plan Choice. American Economic Review, 102(7), 3214-3248.

Chetty, R., 2009. Sufficient Statistics for Welfare Analysis: A Bridge Between Structural and Reduced-Form Methods. Annual Review of Economics, 1, 451-488.

Chetty, R., and A. Finkelstein 2013. Social Insurance: Connecting Theory to Data. forthcoming in the Handbook of Public Economics, Volume 5.

Chetty, R., Kroft, L., and A. Looney 2009. Salience and Taxation: Theory and Evidence. American Economic Review, 99(4), 1145-1177.

Chiappori, P., and B. Salanié, 1997. Empirical Contract Theory: The Case of Insurance Data. European Economic Review, 41(3), 943-950.

Chiappori, P., and B. Salanié, 2000. Testing for asymmetric information in insurance markets. Journal of Political Economy, 108(1), 56-78.

Chiappori, P., and B. Salanié, 2012. Asymmetric Information in Insurance Markets: Predictions and Tests. forthcoming in Handbook of Insurance, 2nd edition (G. Dionne, ed.).

Cohen, A., Einav, L., 2007. Estimating Risk Preferences from Deductible Choice. American Economic Review 97(3), 745-788.

Cohen, A., Siegelman, P., 2010. Testing for Adverse Selection in Insurance Markets. Journal of Risk and Insurance 77(1), 39-84.

Cole, S., Giné, X., Tobacman, J., Townsend, R., Topalova, P., and J., Vickery, 2012. Barriers to Household Risk Management: Evidence from India. American Economic

Journal: Applied Economics, 5(1), 104-135

Congdon, W., Kling, J. and S. Mullanaithan, 2011. Policy and Choice: Public Finance Through the Lens of Behavioral Economics. Brookings Institute.

Cutler, D., Finkelstein, A., and K. McGarry, 2008. Preference Heterogeneity and Insurance Markets: Explaining a Puzzle of Insurance. American Economic Review, 98(2), 157-162.

Cutler, D., and R., Zeckhauser, 2004. Extending the Theory to Meet the Practice of Insurance. In R. Litan and R. Herring, eds., Brookings-Wharton Papers on Financial Service. Washington, D.C.: Brookings Institution.

Einav, L., Finkelstein, A., Cullen, M., 2010a. Estimating Welfare in Insurance Markets using Variation in Prices. Quarterly Journal of Economics 125(3), 877-921.

Einav, L., Finkelstein, A., Schrimpf, P., 2010b. Optimal Mandates and The Welfare Cost of Asymmetric Information: Evidence from the U.K. Annuity Market. Econometrica, 78(3), 1031-1092.

Einav, L., Finkelstein, A., Levin, J., 2010c. Beyond Testing: Empirical Models of Insurance Markets. Annual Review of Economics 2, 311-336.

Einav, L., Finkelstein, A., Cullen, M., and I. Pascu 2011. How general are risk preferences? Choices under uncertainty in different domains. American Economic Review. forthcoming

Fang, H., Keane, M. and D. Silverman, 2008. Sources of Advantageous Selection: Evidence from the Medigap Insurance Market. Journal of Political Economy, 116(2), 303-350.

Finkelstein, A. and K. McGarry, 2006. Multiple dimensions of private information: Evidence from the long-term care insurance market. American Economic Review, 96(4), 938–958.

Gruber, J., 2005. Tax Policy for Health Insurance. In J. Poterba, ed., Tax Policy and the Economy. Cambridge: MIT Press.

Hackmann, M., Kolstad, J. and A. Kowalski, 2015. Adverse Selection and an Individual Mandate: When Theory meets Practice. American Economic Review, 105(3), 1030-66.

Handel, B., 2013. Adverse Selection and Inertia in Health Insurance Markets: When Nudging Hurts. American Economic Review, 103 (7), 2643-2682.

Handel, B., and J. Kolstad, 2015. Health Insurance for Humans: Information Frictions, Plan Choice, and Consumer Welfare. American Economic Review, 105(8), 2449-2500.

Handel, B., Kolstad, J., and J. Spinnewijn, 2015. Information Frictions and Adverse Selection: Policy Interventions in Health Insurance Markets, NBER working paper w21759.

Harris, K., and M. Keane, 1999. A Model of Health Plan Choice: Inferring Preferences and Perceptions from a Combination of Revealed Preference and Attitudinal

Data. Journal of Econometrics, 89, 131-157.

Hurd, M., 2009. Subjective Probabilities in Household Surveys. Annual Review of Economics, 1, 543-562.

Jullien, B., Salanié, B. and F. Salanié, 2007. Screening Risk-Averse Agents under Moral Hazard: Single-Crossing and the CARA Case. Economic Theory, 30(1), 151-169.

Kling, J., Mullainathan, S., Shafir, E., Vermeulen, L. and M. Wrobel, 2012. Comparison Friction: Experimental Evidence from Medicare Drug Plans. Quarterly Journal of Economics, 127(1), 199-235.

Loewenstein, G., et al., 2013. Consumers' Misunderstanding of Health Insurance. Journal of Health Economics 32(5), 850-862.

Mahoney, N., and G. Weyl, 2014. Imperfect Competition in Selection Markets. Mimeo, University of Chicago

Mullainathan, S., Schwartzstein, J., and W. Congdon, 2012. A Reduced Form Approach to Behavioral Public Finance. forthcoming Annual Review of Economics.

Rothschild, M., Stiglitz, J., 1976. Equilibrium in Competitive Insurance markets: An Essay on the Economics of Imperfect Information. Quarterly Journal of Economics 90, 630-649.

Sandroni, A., Squintani, F., 2007. Overconfidence, insurance and Paternalism. American Economic Review 97(5), 1994-2004.

Sandroni, A., Squintani, F., 2013. Overconfidence and Adverse Selection: The Case of Insurance. Journal of Economic Behavior & Organization, 93, 149-165.

Savage, L., 1954. The Foundations of Statistics. New York, Wiley.

Slovic, P., 2000. The Perception of Risk. London: Earthscan.

Snowberg, E., and J. Wolfers, 2010. Explaining the Favorite–Long Shot Bias: Is it Risk-Love or Misperceptions? Journal of Political Economy, 118(4), 723-746.

Spinnewijn, J., 2015. Unemployed but Optimistic: Optimal Insurance Design with Biased Beliefs. Journal of European Economic Association, 13(1), 130-167.

Spinnewijn, J., 2013. Insurance and Perceptions: How to Screen Optimists and Pessimists. Economic Journal, 123, 606-633.

Sydnor, J., 2010. (Over)insuring Modest Risks. American Economic Journal: Applied Economics, 2(4), 177–99.

Tversky, A. and D. Kahneman, 1974. Judgment under Uncertainty: Heuristics and Biases. Science, 185, 1124-1131.

Tversky, A., and R. Thaler, 2006. Utility Maximization and Experience Utility. Journal of Economic Perspectives, 20(1), 221-234.

Veiga, A. and G. Weyl, 2015. Product Design in Selection Markets. Mimeo, University of Chicago.

Tables

Table 1: Cost of adverse selection Depending on Frictions.

Cov. Ratio	**Cost of Adverse Selection**		
$\dfrac{cov\left(\varepsilon,\hat{v}\right)}{cov\left(\varepsilon+r,\hat{v}\right)}$	Γ (1)	Γ/S^{*} (2)	$\Gamma/\Gamma^{\mathrm{RP}}$ (3)
0	9.5	.04	1
.01	9.8	.04	1.03
.10	12.4	.06	1.31
.25	18.6	.10	1.95
.50	38.4	.25	4.03
1	96.6	.62	10.1

Column (1) shows the cost of adverse selection Γ expressed in \$ / indiv in the market analyzed in Einav, Finkelstein and Cullen (2010a). Note that the actual efficient allocation is bounded by complete market coverage (i.e., $q^{*} \leq 1$). Column (2) expresses this cost relative to the surplus $S^{*} = E(r|\hat{v} \geq p^{*})\Pr(\hat{v} \geq p^{*})$ when the price is (constrained) efficient $p = p^{*}$. Column (3) expresses this cost relative to the estimated cost when ignoring frictions, Γ^{RP}. The first row corresponds to the original welfare estimates in EFC, assuming absence of frictions. The covariance ratio $cov(\varepsilon,\hat{v})/cov(\varepsilon+r,\hat{v})$ captures the importance of frictions relative to preferences in explaining the residual demand variation.

Table 2: The welfare gain of subsidies and mandates.

Cov. Ratio	**Government Interventions**	
$\frac{cov\,(\varepsilon, \hat{v})}{cov\,(\varepsilon + r, \hat{v})}$	Price Subsidy $\Gamma - \Phi^S$ (1)	Universal Mandate $\Gamma - \Phi^M$ (2)
0	-35.4	-19.8
.01	-35.7	-18.6
.10	-37.2	-8.1
.25	-41.1	9.3
.50	-125.7	38.4
1	-67.2	96.6

Column (1) shows the net welfare gain from the efficient-price subsidy closing the gap between the equilibrium price p^c and the efficient price p^*, with $\Phi^S = \lambda q^*[p^c - p^*]$, again in the market analyzed by Einav, Finkelstein and Cullen (2010a). The efficient allocation and thus the efficient price are bounded by complete market coverage (i.e., $q^* \leq 1$). Column (2) shows the net welfare gain from a universal mandate obliging all individuals to buy insurance, where Φ^M denotes the welfare loss from mandating individuals with expected valuation below the expected marginal cost to buy insurance. The first row corresponds to the original welfare estimates in EFC, assuming absence of frictions. The covariance ratio $cov(\varepsilon, \hat{v})/cov(\varepsilon + r, \hat{v})$ captures the importance of frictions relative to preferences in explaining the residual demand variation.

Table 3: The Welfare Impact of Risk-Rating.

Risk Adj.	**No Noise**		**Scenario 1** *Independ.*		**Scenario 2** $var(\pi+\varepsilon) = var(\pi)$		**Scenario 3** $var(\pi+\varepsilon) = \frac{1}{2}var(\pi)$	
β	$\Delta S^c/S^c$ $(0a)$	Γ $(0b)$	$\Delta S^c/S^c$ $(1a)$	Γ $(1b)$	$\Delta S^c/S^c$ $(2a)$	Γ $(2b)$	$\Delta S^c/S^c$ $(3a)$	Γ $(3b)$
0	0	9.5	0	18.6	0	18.6	0	18.6
.10	.02	6.8	.02	15.0	.02	14.5	.03	13.2
.25	.05	3.6	.05	10.5	.05	9.9	.05	8.5
.50	.08	.8	.09	5.4	.08	5.7	.06	6.8
.75	.10	.1	.11	2.9	.08	4.7	.02	10.6
1	.11	0	.11	2.2	.07	6.4	$-.03$	19.8

Columns (0a),(1a),(2a) and (3a) show the change in equilibrium welfare $S^c = E(r|\hat{v}^\beta \geq p^c)\Pr(\hat{v}^\beta \geq p^c)$ for positive linear shares of the risk-premium adjustment $\beta(\pi) = \beta[\pi - \mu_\pi]$ (relative to the case with no risk-adjustment, $\beta = 0$). Columns (0b), (1b), (2b) and (3b) show the welfare cost in the new equilibrium due to the adverse selection Γ. Scenario 1 assumes independence between r, π and ε. Scenario 2 assumes $var(\pi+\varepsilon) = var(\pi)$. Scenario 3 assumes $var(\pi+\varepsilon) = \frac{1}{2}var(\pi)$. The three scenario's start from an initial value for $cov(\varepsilon,\hat{v})/cov(\varepsilon+r,\hat{v})$ equal to .25. Notice that equilibrium welfare equals $S^c = \$243$ given this initial value, while it equals $S^c = \$272$ without frictions.

The demand curve is taken from EFC with linear slope $p'(q) = -1/0.0007$ and remains unchanged in the calibrations. The value and marginal cost curve are assumed to be linear with slope $\frac{cov(\pi,\hat{v})}{var(\hat{v})}p'(q)$ and $\frac{cov(\pi+r,\hat{v})}{var(\hat{v})}p'(q)$ respectively and intersect with the estimated demand and marginal cost curve at $q = .5$. I set the standard deviation $\sigma_{\hat{v}}$ equal to $571.43 = \frac{1}{2.5\times 0.0007}$ based on the estimated slope of the demand curve. That is, for a normal demand curve with cdf Φ, the slope equals $p'(q) = \sigma_{\hat{v}} \times \left[\Phi^{-1}\right]'(1-q)$ and I find $\frac{\Delta\Phi^{-1}(1-q)}{\Delta(1-q)} \cong -2.5$ when taking the estimated revealed values for $q = 0.5$ and $q = 0.7$, in between which all observations in EFC are. The estimated slope of the marginal cost curve determines the initial value of $cov(\pi,\hat{v})$, while the initial values of $cov(r,\hat{v})$ and $cov(\varepsilon,\hat{v})$ are determined by the initial value for the covariance ratio. To calibrate the remaining parts of the covariance matrix, I assume $\rho_{\pi,\varepsilon} = \rho_{r,\varepsilon} = \rho_{r,\pi} = 0$ under scenario 1. Under scenario 2, I continue to assume $\rho_{r,\varepsilon} = \rho_{r,\pi} = 0$, but $\rho_{\pi,\varepsilon} = -\frac{1}{2}\frac{\sigma_\varepsilon}{\sigma_\pi}$ such that $var(\pi+\varepsilon) = var(\pi)$. In scenario 3, this negative correlation is further increased such that $var(\pi+\varepsilon) = \frac{1}{2}var(\pi)$. Table App3 in the web appendix shows the equilibrium welfare and cost of adverse selection when the demand components are normally distributed. The results are similar.

Table 4: The Welfare Impact of Information Policies.

Noise Reduction	**Scenario 1** *Independence*		**Scenario 2** $corr\,(\pi, \pi+\varepsilon)\nearrow$		**Scenario 3** $corr\,(r, r+\varepsilon)\nearrow$	
$\Delta\sigma_\varepsilon^2/\sigma_\varepsilon^2$	$\Delta S^c/S^c$ (1a)	Γ (1b)	$\Delta S^c/S^c$ (2a)	Γ (2b)	$\Delta S^c/S^c$ (3a)	Γ (3b)
0	0	18.6	0	18.6	0	18.6
.10	.00	18.1	$-.00$	19.2	.01	17.4
.25	.01	17.5	$-.01$	20.3	.03	15.7
.50	.02	16.4	$-.01$	22.2	.06	13.3
1	.04	14.2	$-.03$	26.5	.12	9.5

Columns (1a),(2a) and (3a) show the change in equilibrium welfare $S^c = E(r|\hat{v} \geq p^c)\Pr(\hat{v} \geq p^c)$ when reducing the variance in noise under the three respective scenario's (relative to the case with no noise reduction). Columns (1b),(2b) and (3b) show the welfare cost due to the adverse selection Γ in the new equilibrium. Scenario 1 assumes independence between r, π and ε. Scenario 2 assumes that $var(\pi+\varepsilon) = var(\pi)$, which implies that the correlation between π and $\pi+\varepsilon$ increases as σ_ε decreases. Scenario 3 assumes $var(r+\varepsilon) = var(r)$, which implies that the correlation between r and $r+\varepsilon$ increases as σ_ε decreases. The three scenario's start from an initial value for $cov(\varepsilon,\hat{v})/cov(\varepsilon+r,\hat{v})$ equal to .25. Notice that equilibrium welfare equals $S^c = \$243$ given this initial value.

The calibration of the demand and cost curves is similar as for the information polices (see Table 3). To recalibrate the three covariances when σ_ε decreases, I assume $\rho_{\pi,\varepsilon} = \rho_{r,\varepsilon} = \rho_{r,\pi} = 0$ under scenario 1. Under scenario 2, I continue to assume $\rho_{r,\varepsilon} = \rho_{r,\pi} = 0$, but $\rho_{\pi,\varepsilon} = -\frac{1}{2}\frac{\sigma_\varepsilon}{\sigma_\pi}$. This ensures that $var\,(\pi+\varepsilon)$ remains unchanged and only the correlation between π and $\pi+\varepsilon$ increases when reducing σ_ε. Under scenario 3, I assume $\rho_{\pi,\varepsilon} = \rho_{r,\pi} = 0$, but $\rho_{r,\varepsilon} = -\frac{1}{2}\frac{\sigma_\varepsilon}{\sigma_r}$. Table App4 in the web appendix shows the equilibrium welfare and cost of adverse selection when the demand components are normally distributed. The results are again similar.

Appendix A: Proofs

A.1 Propositions

Proof of Proposition 1

Denote the density functions of $\hat{v}, v$ and ε by f, h and g respectively. Since by Bayes' law $g(\varepsilon|\hat{v}) = \frac{f(\hat{v}|\varepsilon)g(\varepsilon)}{f(\hat{v})}$, we can rewrite

$$\begin{aligned} g(\varepsilon|\hat{v} \geq p) &= \frac{\int_p^\infty g(\varepsilon|\hat{v})\, d\hat{v}}{\int_p^\infty f(\hat{v})\, d\hat{v}} \\ &= \frac{\int_p^\infty f(\hat{v}|\varepsilon)\, g(\varepsilon)\, d\hat{v}}{\int_p^\infty f(\hat{v})\, d\hat{v}} = \frac{\Pr(\hat{v} \geq p|\varepsilon)}{\Pr(\hat{v} \geq p)} g(\varepsilon), \end{aligned}$$

with $\int \frac{\Pr(\hat{v}\geq p|\varepsilon)}{\Pr(\hat{v}\geq p)} g(\varepsilon) = 1$. Since v and ε are independent, $\Pr(\hat{v} \geq p|\varepsilon) = \int_{p-\varepsilon}^\infty h(v)\, dv$ is increasing in ε. Hence, the conditional distribution of $\varepsilon|\hat{v} \geq p$ first-order stochastically dominates the unconditional distribution of ε and thus

$$E(\varepsilon|\hat{v} \geq p) = \int \varepsilon g(\varepsilon) \frac{\Pr(\hat{v} \geq p|\varepsilon)}{\Pr(\hat{v} \geq p)} d\varepsilon \geq \int \varepsilon g(\varepsilon)\, d\varepsilon = E(\varepsilon) = 0.$$

Similarly, we find

$$E(\varepsilon|\hat{v} \leq p) = \int \varepsilon g(\varepsilon) \frac{\Pr(\hat{v} \leq p|\varepsilon)}{\Pr(\hat{v} \leq p)} d\varepsilon \leq \int \varepsilon g(\varepsilon)\, d\varepsilon = E(\varepsilon) = 0.\square$$

Proof of Proposition 2

This is an immediate application of Proposition 1 in Milgrom (1981). That is,

$$\int \varepsilon g(\varepsilon|\hat{v}_1)\, d\varepsilon \geq \int \varepsilon g(\varepsilon|\hat{v}_2)\, d\varepsilon \text{ for any } \hat{v}_1 \geq \hat{v}_2$$

iff

$$\frac{f(\hat{v}_1|\varepsilon_1)}{f(\hat{v}_1|\varepsilon_2)} \geq \frac{f(\hat{v}_2|\varepsilon_1)}{f(\hat{v}_2|\varepsilon_2)} \text{ for any } \varepsilon_1 \geq \varepsilon_2.$$

Hence, the expected value of ε, conditional on $\hat{v}$, is increasing in $\hat{v}$.$\square$

Proof of Proposition 3

In an adversely selected market, the average cost $AC(p)$ exceeds the marginal cost $MC(p)$ and $MC'(p) > AC'(p) > 0$. With the demand curve steeper than the cost curves ($AC'(p) < MC'(p) < 1$), the price p^c at which demand curve and average cost curve intersect (i.e., $p^c = AC(p^c)$) exceeds the price p^{RP} at which demand curve and marginal cost curves intersect (i.e., $p^{\mathrm{RP}} = MC(p^{\mathrm{RP}})$). MLRP implies that the value curve is a counter-clockwise rotation of the demand curve (i.e., $MV'(p) < 1$). Since the price p^x at which the value curve and the demand curve intersect (i.e., $p^x = MV(p^x)$)

exceeds p^c, the constrained-efficient price p^* at which the value curve intersects with the marginal cost curve (i.e., $MV(p^*) = MC(p^*)$) will be lower than p^{RP} for $MV'(p) \geq 0$. (In the special case with $MV'(p) \geq 0$ and $MV(p) > MC(p)$ for all $p < p^c$ or with $MV'(p) < 0$ and $E(v - c) \geq 0$, it will be efficient for all individuals to buy insurance and again $p^* \leq p^{\mathrm{RP}}$.) Hence, we have established that $p^x \geq p^c \geq p^{\mathrm{RP}} \geq p^*$.

Combining this with $MV(p) > p$ for all $p < p^x$ and $MV(p) > MC(p)$ for all $p \geq p^*$, we find

$$\begin{aligned} \int_{p^{\mathrm{RP}}}^{p^c} [MV(p) - p]\, dD(p) &\geq 0, \\ \int_{p^*}^{p^{\mathrm{RP}}} [MV(p) - MC(p)]\, dD(p) &\geq 0, \end{aligned}$$

and thus $\Gamma \geq \Gamma^{\mathrm{RP}}$.□

A.2 Corollaries

Proof of Corollary 1

By normality,

$$\begin{aligned} E(\varepsilon|\hat{v} \geq p) &= E(\hat{v}|\hat{v} \geq p) - E(v|\hat{v} \geq p) \\ &= \mu_{\hat{v}} + \sigma_{\hat{v}} \frac{\phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)}{1 - \Phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)} - \mu_v - \sigma_v \rho \frac{\phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)}{1 - \Phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)} \\ &= [\sigma_{\hat{v}} - \sigma_v \rho] \frac{\phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)}{1 - \Phi\left(\frac{p-\mu_{\hat{v}}}{\sigma_{\hat{v}}}\right)}. \end{aligned}$$

Hence, $E(\varepsilon|\hat{v} \geq p) \geq 0$ iff $\sigma_{\hat{v}} \geq \sigma_v \rho$. Similarly, we find $E(\varepsilon|\hat{v} \leq p) \leq 0$ iff $\sigma_{\hat{v}} \geq \sigma_v \rho$.

By normality,

$$E(\varepsilon|\hat{v} = p) = \mu_\varepsilon + \frac{cov(\varepsilon, \hat{v})}{var(\hat{v})} [p - \mu_{\hat{v}}].$$

Since

$$\frac{cov(\varepsilon, \hat{v})}{var(\hat{v})} = \frac{cov(\hat{v}, \hat{v})}{var(\hat{v})} - \frac{cov(v, \hat{v})}{var(\hat{v})} = 1 - \rho \frac{\sigma_v}{\sigma_{\hat{v}}}$$

Hence, $E(\varepsilon|\hat{v} = p)$ is increasing in p if and only if $\rho \frac{\sigma_v}{\sigma_{\hat{v}}} < 1$.□

Proof of Corollary 2

An RP-policy maker estimates the cost of adverse selection as

$$
\begin{aligned}
\Gamma^{\mathrm{RP}} &= \int_{p^{\mathrm{RP}}}^{p^c} \left[p - MC(p)\right] dD(p) \\
&= \int_{p^{\mathrm{RP}}}^{p^c} \left[p - \frac{cov(\pi,\hat{v})}{var(\hat{v})}\left[p-\mu_{\hat{v}}\right] - \mu_\pi\right] dD(p) \\
&= \int_{p^{\mathrm{RP}}}^{p^c} \left(1 - \frac{cov(\pi,\hat{v})}{var(\hat{v})}\right)\left[p - p^{\mathrm{RP}}\right] dD(p),
\end{aligned}
$$

where $p = MC(p)$ evaluated at $p = p^{\mathrm{RP}}$. Notice that Γ^{RP} is always positive, since $p \geq MC(p)$ for $p \in \left[p^{\mathrm{RP}}, p^c\right]$ if $p^{\mathrm{RP}} \leq p^c$ and $p \leq MC(p)$ for $p \in \left[p^c, p^{\mathrm{RP}}\right]$ if $p^{\mathrm{RP}} \geq p^c$. Linearizing the demand function, (i.e., assuming that the density at each price level is the same and equal to $\bar{f}$), this is approximately equal to

$$
\begin{aligned}
\Gamma^{\mathrm{RP}} &\cong \left(1 - \frac{cov(\pi,\hat{v})}{var(\hat{v})}\right)\left[p^c - p^{\mathrm{RP}}\right]^2 \frac{\bar{f}}{2} \\
&= \frac{cov(r+\varepsilon,\hat{v})}{var(\hat{v})}\left[p^c - p^{\mathrm{RP}}\right]^2 \frac{\bar{f}}{2}.
\end{aligned}
$$

A similar argument allows to approximate the true cost of adverse selection,

$$
\begin{aligned}
\Gamma &= \left|\int_{p^*}^{p^c} \left[MV(p) - MC(p)\right] dD(p)\right| \\
&= \left|\int_{p^*}^{p^c} \left[\frac{cov(\pi+r,\hat{v})}{var(\hat{v})}\left[p-\mu_{\hat{v}}\right] + \mu_{\hat{v}} - \frac{cov(\pi,\hat{v})}{var(\hat{v})}\left[p-\mu_{\hat{v}}\right] - \mu_\pi\right] dD(p)\right| \\
&= \left|\int_{p^*}^{p^c} \frac{cov(r,\hat{v})}{var(\hat{v})}\left[p-p^*\right] dD(p)\right| \\
&\cong \left|\frac{cov(r,\hat{v})}{var(\hat{v})}\left[p^c - p^*\right]^2 \frac{\bar{f}}{2}\right|.
\end{aligned}
$$

I take absolute values such that the formula also applies if $p^* > p^c$. Hence, the ratio equals

$$
\begin{aligned}
\frac{\Gamma}{\Gamma^{\mathrm{RP}}} &\cong \left|\frac{cov(r,\hat{v})}{cov(r+\varepsilon,\hat{v})}\frac{\left[p^c-p^*\right]^2}{\left[p^c-p^{\mathrm{RP}}\right]^2}\right| \\
&= \left|\frac{cov(r,\hat{v})}{cov(r+\varepsilon,\hat{v})}\left[1 + \frac{p^{\mathrm{RP}}-p^*}{p^c-p^{\mathrm{RP}}}\right]^2\right|.
\end{aligned}
$$

Now we still want to substitute for the unobservable p^*. By normality, we find that

$$
\begin{aligned}
p - MC(p) &= \frac{cov(r+\varepsilon,\hat{v})}{var(\hat{v})}\left[p - p^{\mathrm{RP}}\right], \\
MV(p) - MC(p) &= \frac{cov(r,\hat{v})}{var(\hat{v})}\left[p - p^*\right],
\end{aligned}
$$

since respectively $p^{\mathrm{RP}} = MC\left(p^{\mathrm{RP}}\right)$ and $MV(p^*) = MC(p^*)$. Moreover, at $p = \mu_{\hat{v}}$, $p = MV(p)$ and thus $\mu_{\hat{v}} - MC(\mu_{\hat{v}}) = MV(\mu_{\hat{v}}) - MC(\mu_{\hat{v}})$ .Hence,

$$\frac{cov\,(r+\varepsilon,\hat{v})}{var\,(\hat{v})}\left[\mu_{\hat{v}} - p^{\mathrm{RP}}\right] = \frac{cov\,(r,\hat{v})}{var\,(\hat{v})}\left[\mu_{\hat{v}} - p^*\right].$$

Rearranging, we find

$$\left[p^{\mathrm{RP}} - p^*\right] = \frac{cov\,(\varepsilon,\hat{v})}{cov\,(r,\hat{v})}\left[\mu_{\hat{v}} - p^{\mathrm{RP}}\right].$$

Substituting this in the expression for $\Gamma/\Gamma^{\mathrm{RP}}$, we find

$$\begin{aligned} \frac{\Gamma}{\Gamma^{\mathrm{RP}}} &\cong \left|\frac{cov\,(r,\hat{v})}{cov\,(r+\varepsilon,\hat{v})}\left[1 + \frac{cov\,(\varepsilon,\hat{v})}{cov\,(r,\hat{v})}\frac{\mu_{\hat{v}} - p^{\mathrm{RP}}}{p^c - p^{\mathrm{RP}}}\right]^2\right| \\ &= \left|\frac{\left[1 + \frac{cov(\varepsilon,\hat{v})}{cov(r,\hat{v})}\frac{\mu_{\hat{v}} - p^{\mathrm{RP}}}{p^c - p^{\mathrm{RP}}}\right]^2}{1 + \frac{cov(\varepsilon,\hat{v})}{cov(r,\hat{v})}}\right|. \end{aligned}$$

The expression in the Proposition immediately follows.□

A.3 Policy Results

Proof of Policy Result 1

When MLRP is satisfied and $E(\varepsilon) = 0$, frictions induce a counter-clockwise rotation of the value curve. If the demand and cost functions remain unchanged, the equilibrium price remains the same and the rotation unambiguously increases the insurance value for the uninsured $E(v|\hat{v} \leq p^c)$. This immediately follows from condition (2) in combination with $E(\varepsilon) = 0$. If the cost functions remain unchanged, the cost of providing insurance to the uninsured $E(\pi|\hat{v} \leq p^c)$ remains unchanged as well. Hence, the net gain from mandating the uninsured to buy insurance unambiguously increases.

If the counter-clockwise rotation decreases the efficient price p^*, the cost of the efficient-price subsidy $\Phi^S = \lambda q^*[p^c - p^*]$ increases. However, the cost of the universal mandate,

$$\Phi^M = \int_0^{p^*}\left[MC(p) - MV(p)\right]dD(p),$$

decreases when p^* decreases, since $MC(p) \geq MV(p)$ for $p \leq p^*$. Hence, the cost differential increases. If the cost increase Φ^S dominates the increase in Γ, the net gain $\Gamma - \Phi^S$ decreases as well.□

Proof of Policy Result 2

Consider first the case without frictions. With perfect risk-rating, $\beta(\pi) = \pi - \mu_\pi$, the average cost equals $E(\pi - \beta(\pi)\,|\pi + r \geq p + \beta(\pi)) = \mu_\pi$ and is independent of the price. Hence, $p^c = \mu_\pi$. An individual thus buys insurance if and only if

$$\pi + r \geq p^c + \beta(\pi) \Leftrightarrow r \geq 0.$$

This is the first-best. Hence, perfect risk-rating improves welfare in an adversely selected market.

Consider now the case with $\varepsilon = \mu_\pi - \pi$ and independent risk and preferences. Without risk-rating, the average cost equals $E(\pi|\mu_\pi + r \geq p) = \mu_\pi$ due to the independent preferences. Hence, $p^c = \mu_\pi$. An individual thus buys insurance if and only if

$$\mu_\pi + r \geq p^c \Leftrightarrow r \geq 0.$$

This is the first-best. With perfect risk-rating, the competitive price still equals $p^c = \mu_\pi$. However, an individual buys insurance only if $r \geq \pi$, which is inefficient. The generated surplus $E(r|r \geq \pi)\Pr(r \geq \pi)$ is lower than $E(r|r \geq 0)\Pr(r \geq 0)$.□

Proof of Policy Result 3

The first policy reduces the noise dispersion such that the correlation between r and $r + \varepsilon$ increases, but the covariance matrix of $(r + \varepsilon, \pi)$ remains unchanged. Since

$$var(\hat{v}) = var(r + \varepsilon) + var(\pi) + 2cov(r + \varepsilon, \pi),$$

this implies that the demand function $D(p) = 1 - F_{\hat{v}}(p)$ is unaffected. Moreover,

$$\frac{cov(\pi, \hat{v})}{\sqrt{var(\hat{v})}} = \frac{var(\pi) + cov(\pi, r + \varepsilon)}{\sqrt{var(\hat{v})}}$$

and thus the average cost $AC(p)$ is unaffected. Hence, the competitive price p^c remains the same. Since

$$\frac{cov(r, \hat{v})}{\sqrt{var(\hat{v})}} = \frac{cov(r, r + \varepsilon) + cov(r, \pi)}{\sqrt{var(\hat{v})}}$$

increases, the expected net-value at a price p,

$$E(r|\hat{v} \geq p) = \mu_r + \frac{cov(r, \hat{v})}{\sqrt{var(\hat{v})}} \frac{\phi\left(\frac{p - \mu_{\hat{v}}}{\sqrt{var(\hat{v})}}\right)}{1 - \Phi\left(\frac{p - \mu_{\hat{v}}}{\sqrt{var(\hat{v})}}\right)},$$

increases. Hence, the welfare surplus,

$$\int_{p^c}^{\infty} E(r|\hat{v} = p)\, dF(p) = \Pr(\hat{v} \geq p^c)\, E(r|\hat{v} \geq p),$$

increases unambiguously. This proves the first part of the Policy Result.

The second policy reduces the noise dispersion such that the correlation between π and $\pi + \varepsilon$ increases but the covariance matrix of $(\pi + \varepsilon, r)$ remains unchanged. This again leaves the demand function $D(p) = 1 - F_{\hat{v}}(p)$ is unaffected. Moreover,

$$\frac{cov(r, \hat{v})}{var(\hat{v})} = \frac{var(r) + cov(r, \pi + \varepsilon)}{var(\hat{v})}$$

and thus the conditional expected net-value $E(r|\hat{v} = p)$ remains unaffected as well. Since

$$\frac{cov(\pi, \hat{v})}{\sqrt{var(\hat{v})}} = \frac{cov(\pi, \pi + \varepsilon) + cov(\pi, r)}{\sqrt{var(\hat{v})}}$$

increases, the average cost

$$AC(p) = \mu_\pi + \frac{cov(\pi, \hat{v})}{\sqrt{var(\hat{v})}} \frac{\phi\left(\frac{p-\mu_{\hat{v}}}{\sqrt{var(\hat{v})}}\right)}{1-\Phi\left(\frac{p-\mu_{\hat{v}}}{\sqrt{var(\hat{v})}}\right)},$$

increases for any p. Hence, the competitive price $p^c = AC(p^c)$ increases. If the market already exhibits under-insurance (i.e., $p^c > p^*$), the increase in the competitive price unambiguously decreases welfare. This proves the second part of the Policy Result.

Finally, notice that the proposed changes in the noise distribution are feasible. For the second policy, a reduction $d\sigma_\varepsilon$ and a corresponding change $d\rho_{\pi,\varepsilon} = -\frac{\sigma_\varepsilon + \rho_{\pi,\varepsilon}\sigma_\pi}{\sigma_\pi\sigma_\varepsilon} d\sigma_\varepsilon$ leaves $var(\pi + \varepsilon) = \sigma_\pi^2 + \sigma_\varepsilon^2 + 2\rho_{\pi,\varepsilon}\sigma_\pi\sigma_\varepsilon$ unchanged and increases $cov(\pi, \varepsilon) = \rho_{\pi,\varepsilon}\sigma_\pi\sigma_\varepsilon$ and thus $cov(\pi, \pi + \varepsilon)$. Moreover, if $\rho_{r,\varepsilon} \neq 0$, the change $d\rho_{r,\varepsilon} = -\frac{\rho_{r,\varepsilon}}{\sigma_\varepsilon} d\sigma_\varepsilon$ keeps $cov(\pi + \varepsilon, r)$ unchanged. The argument is analogue for the first policy.$\square$