Heterogeneous Risk Perceptions in Insurance Markets

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(based on joint work with Philipp Kircher)

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People’s demand for insurance depends on the risks they face and their aversion with respect to these risks.

People face different risks and have different preferences.
  - Private information about risks leads to adverse selection (Akerlof / Rothschild & Stiglitz)
    ⇒ rationale for government intervention
  - BUT little empirical evidence for adverse selection... (Chiappori, Salanié,...)
  - ... because of heterogeneity in preferences (Cohen, Einav, Finkelstein,...)
    ⇒ reduced gains from government intervention
People differ in their perceptions of risks.
Paul Slovic: "The perception of risk is inherently subjective."

Heterogeneity in perceived relative to actual risks:
1. distorts the demand for insurance; perception bias distorts the perceived value of insurance.
2. reduces use of private info about true risk; markets may become less adversely selected.

What if heterogeneity in choices is driven by heterogeneity in perceptions rather than heterogeneity in preferences?
Overview: Three Questions

Previous work (Spinnewijn 2010):

1. Positive: How do insurance companies react to heterogeneity in perceptions?

Today:

2. Normative: How does heterogeneity in perceptions affect welfare?

3. Empirical: How can we identify preferences vs. perceptions? (joint with Philipp Kircher)
Follow sufficient statistics approach to estimate the welfare cost of insurance (Einav, Finkelstein and Cullen 2010).

- Estimate demand for insurance and cost of insuring the insured.
- Primitives underlying demand and cost are irrelevant.

With heterogeneity in perceptions, the demand does not capture the value of insurance - assuming welfare depends on true expected utility

- One additional statistic; ratio of heterogeneity in perceptions vs. heterogeneity in preferences.

Use framework for policy evaluation and calibration using estimates from Einav et al.
Welfare: Policy Conclusions

- Unadjusted formula understates the cost of adverse selection.
  - Insured are too pessimistic on average, uninsured are too optimistic on average.
  - Value of universal mandate unambiguously increases.
  - Price subsidies are less effective, being constrained by people’s perceived value of insurance.

- Informing individuals about their misperceptions has an ambiguous effect.
  - People make better choices, but market becomes more adversely selected.
  - Only provide information regarding the net-value of insurance.
Are choices driven by perceptions or preferences?

- Previous empirical work either uses surveyed risk perceptions or ignores risk perceptions.

We propose an identification approach based on choice data:

- MWP for insurance depends only on risk perceptions close to full insurance.
- Level of (individual) demand curve - evaluated at full insurance - identifies risk perception
  ~ buy full insurance at actuarially fair price, regardless of risk preferences (Mossin 1968, Arrow 1970)
- Slope of (individual) demand curve - evaluated at full insurance - identifies risk aversion.
Approach applies to MWP for standard contracts with copays and deductibles.

Approach exploits risk-neutrality implication of EUT close to full insurance.

Approach complements identification approach based on risk realizations - assuming accurate risk perceptions (Cohen, Einav, Finkelstein, ...)

Identification: Using Price Variation
1 Welfare
   - Setup
   - Sufficient Statistics Approach
   - Policy Analysis

2 Identification
   - Setup
   - Binary Risk
   - Robustness
Setup

- Model heterogeneity in preferences and risks. Allow perceived risks to differ from actual risk.

  - Value and cost of insurance:
    
    \[
    v = \pi + r \quad \text{and } c = \pi.
    \]

  - Perceived value of insurance:
    
    \[
    \hat{v} = \pi + r + \varepsilon, \text{with } E(\varepsilon) = 0.\]

- Example: Individual \(i\) has CARA preferences facing a normal loss.

  - Value and cost of insurance:
    
    \[
    v_i = \mu_{x_i} + \eta_i \sigma_{x_i}^2 / 2 \quad \text{and } c_i = \mu_{x_i}.
    \]

  - \(\varepsilon\) could capture misperceptions about \(\mu_{x_i}\) or \(\sigma_{x_i}^2\).
Individual buys insurance if $\hat{v} > p$.

Cost of providing insurance depends on the types that are buying insurance:

- **Demand**: $D(p) = 1 - F(p)$
- **Average Cost**: $AC(p) = E(\pi|\hat{v} \geq p)$
- **Marginal Cost**: $MC(p) = E(\pi|\hat{v} = p)$.

Suffices to estimate welfare cost:

- **Equilibrium**: $AC(p) = p$
- **Efficiency**: $MC(p) = p$
- **Welfare Cost**: $\hat{W} = \int_{q_c}^{q^*} [p(q) - MC(p(q))] f(p(q)) dq$. 
Perceptions determine the insurance choice, but not the insurance value. While the price reflects the marginal willingness to pay, 

\[ p = E(v + \epsilon | v + \epsilon = p), \]

the true marginal value equals 

\[ MV(p) + MC(p) = E(v | v + \epsilon = p). \]

Hence, the (marginal) bias from using the demand function to evaluate welfare equals 

\[ MB(p) = E(\epsilon | v + \epsilon = p). \]

Since \( \epsilon \) determines the willingness to pay, the average bias will vary across individuals with different willingness to pay.
Proposition

If $v$ and $\varepsilon$ are independent, the insured are (overly) pessimistic on average, while the uninsured are (overly) optimistic,

$$E (\varepsilon \mid \hat{v} \geq p) \geq 0 \geq E (\varepsilon \mid \hat{v} < p).$$

Proposition

If $v$ and $\varepsilon$ are independent and symmetric and $v$ is unimodal, the marginally uninsured are (overly) optimistic when more than half of the market is covered,

$$E (\varepsilon \mid \hat{v} = p) < 0 \text{ for any } p \leq \mu_v.$$
Rotation of the Demand Curve
Normal Heterogeneity

Assumption All components are normally distributed.

- The expected value of one component of \( \hat{\nu} = \pi + r + \varepsilon \), conditional on \( \hat{\nu} \), depends on the covariance with \( \hat{\nu} \) and the level of \( \hat{\nu} \) above its mean,

\[
MB(p) = E(\varepsilon | \hat{\nu} = p) = \frac{\text{cov}(\varepsilon, \hat{\nu})}{\text{var}(\hat{\nu})} [p - \mu_{\hat{\nu}}]
\]

\[
MV(p) = E(r | \hat{\nu} = p) = \frac{\text{cov}(r, \hat{\nu})}{\text{var}(\hat{\nu})} [p - \mu_{\hat{\nu}}] + \mu_r
\]

\[
MC(p) = E(\pi | \hat{\nu} = p) = \frac{\text{cov}(\pi, \hat{\nu})}{\text{var}(\hat{\nu})} [p - \mu_{\hat{\nu}}] + \mu_\pi
\]

- Graphically, attribute the difference between the (inverse) demand curve and the shifted marginal cost curve \( MC(p) + \mu_r \) to preferences vs. perceptions,

\[
\frac{MB(p)}{MV(p) - \mu_r} = \frac{\text{cov}(\varepsilon, \hat{\nu})}{\text{cov}(r, \hat{\nu})} \rho_{xy} = 0 \Rightarrow \frac{\text{var}(\varepsilon)}{\text{var}(r)}.
\]
The curve to evaluate welfare is thus a rotation of the demand curve, with a flatter slope if $\text{cov}(\varepsilon, \hat{\nu}) \geq 0$ and crossing at $p = \mu_v$.

- Denote by $\bar{q}$ the insurance level at which the two demand curves cross.
- $\bar{q} = .5$ with additive, normal components.

The mis-estimation of the total welfare cost of adverse selection is driven by:

- Underestimating the marginal value of the uninsured (for all uninsured if $p^{eq} < \hat{\nu}$)
- Underestimating the efficient level of insurance $q^* (> \hat{q}^*)$.

Bias in welfare estimation equals

$$
\frac{\mathcal{W}}{\hat{\mathcal{W}}} = \frac{\sigma_r^2}{\sigma_r^2 + \sigma_\varepsilon^2} \frac{p'(q) - MC'(q)}{2} \left[ q^* - q^{eq} \right]^2 \frac{p'(q) - MC'(q)}{2} \left[ \hat{q}^* - q^{eq} \right]^2.
$$
True vs. Estimated Welfare Cost

\[ P \]

\[ V \]

\[ \hat{V} \]

\[ \bar{q} \quad q^{eq} \quad \hat{q}^* \quad q^* \]

\[ AC \]

\[ MC \]
Proposition

The bias in welfare estimation equals

\[
\frac{W}{\hat{W}} = \left[ \frac{1}{\sqrt{\alpha}} \frac{\hat{q}^* - \bar{q}}{q^* - q_{eq}} - \sqrt{\alpha} \frac{q^* - q_{eq}}{q^* - q_{eq}} \right]^2
\]

where

\[
\alpha = \frac{\text{cov} (r, \hat{v})}{\text{cov} (r + \varepsilon, \hat{v})} \quad \rho_{xy}=0 \quad \frac{\sigma_r^2}{\frac{\sigma_r^2 + \sigma_{\varepsilon}^2}}.
\]
With no average bias, only one additional statistic is needed.

- \( \alpha \) captures relative importance of value-related drivers of demand.

The welfare cost is under-estimated when \( \bar{q} \leq q^{eq} < \hat{q}^* \).

- Average optimistic bias lowers \( \bar{q} \).
- When \( \bar{q} = q^{eq} \), the mistake \( \frac{W}{\hat{W}} = \frac{1}{\alpha} (\geq 1) \) is decreasing in \( \alpha \).
- When \( \bar{q} = \hat{q}^* \), the mistake \( \frac{W}{\hat{W}} = \alpha (\leq 1) \) is increasing in \( \alpha \).

Desired direction of insurance coverage may be opposite.

- e.g., \( \bar{q} \) is relatively large and adverse selection \( (q^* < q^{eq} < \hat{q}^*) \)
- e.g., \( \bar{q} \) is relatively small and advantageous selection \( (\hat{q}^* < q^{eq} < q^*) \)
Employer-provided health insurance in Alcoa, a multi-national producer of aluminium.

Employees face same set of coverage options, but at different prices in different sections of the company.

Sample of 3,779 salaried employees who chose between two options, with and without a deductible.
Figure V

Efficiency Cost of Adverse Selection—Empirical Analog
Welfare Cost and Policy Interventions

- Estimated welfare cost $\hat{W}$ equals $9.55$ of $463.5$ at stake. The required correction, for $\bar{q} = 0.5$, equals

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>1</th>
<th>.99</th>
<th>.90</th>
<th>.75</th>
<th>.50</th>
<th>.25</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W/\hat{W}$</td>
<td>1</td>
<td>1.03</td>
<td>1.30</td>
<td>1.95</td>
<td>4.03</td>
<td>7.70</td>
<td>10.2</td>
</tr>
</tbody>
</table>

- Universal mandate may imply over-insurance, but the cost of this also over-estimated.
  - Estimated welfare loss from a universal mandate equals $8.8$.
  - Universal mandate would be welfare-improving for $1 - \alpha = 0.17$

- Price policies are not as effective, as they are constrained to the perceived valuation.
  - Bias in estimated marginal gain of a price subsidy,
    $$\frac{MV}{\hat{MV}} = \frac{\hat{q}^* - \bar{q} - \alpha [\hat{q}^c - \bar{q}]}{\hat{q}^* - \hat{q}^c}.$$  
  - Large subsidy needed to encourage insurees who have low willingness to pay for insurance.
Trade-off when informing people.

- People make better decisions \( \Rightarrow \) decision utility is closer to true utility.
- Insured are more costly \( \Rightarrow \) more adverse selection.

Two applications, keeping the demand unchanged:

- \( \hat{\pi} \equiv \pi + \epsilon : \) keep \( \text{var}(\hat{\pi}) = \text{var}(\pi) \), but information reduces \( \text{var}(\epsilon) \)
- \( \hat{r} \equiv r + \epsilon : \) keep \( \text{var}(\hat{r}) = \text{var}(r) \), but information reduces \( \text{var}(\epsilon) \)

CARA-example with loss \( x \):

- provide information about the expected loss \( \mu_x \)
- provide information about the variance \( \sigma_x^2 \)
Theorem

An information policy that reduces \( \text{var}(\varepsilon) \), but keeps \( \text{var}(\hat{\pi}) = \text{var}(\pi) \), always reduces welfare.

- Demand is unaffected, but the average cost curve rotates out.
- The net marginal value of insurance \( MV(q) \) remains unchanged.

Theorem

An information policy that reduces \( \text{var}(\varepsilon) \), but keeps \( \text{var}(\hat{r}) = \text{var}(r) \), always increases welfare.

- Both demand and cost curves are unaffected.
- The net marginal value of insurance \( MV(q) \) rotates towards demand curve.
To what extent are observed choices driven by preferences or perceptions?

- **Clear identification problem:**
  - Manski (2004): "I have concluded that econometric analysis of decision making with partial information cannot prosper on choice data alone."

- **Previous work:** use choice data to identify preferences and
  - Either assume rational expectations, estimated using risk realizations (Cohen, Einav, Finkelstein,...)
  - Or use survey data to complement choice data (Manski et al., Fang & Silverman 2008)

- **Our approach:** identify region where choices depend on risk perceptions only, i.e., at full insurance.
Individual \( i \) risks to lose \( L \) with probability \( \pi_i \).

- Her perception of this risk equals \( \hat{\pi}_i \).
- Her preference is represented by Bernouilli function \( u_i (\cdot) \equiv u(\cdot|r_i) \).

Individual \( i \) chooses contract from a menu of contracts \( \{(q_j, P_j)\} \)

- \( q_j = \) insurance coverage, \( P_j = \) insurance premium.
- Resulting payoffs are \( m_g = -P \) and \( m_b = -(L - q) - P \)
- Consider a linear premium \( P(q) = p_0 + pq \). Let \( p_i(q) \) denote the price at which individual \( i \) buys \( q \) units of coverage.
Individual $i$ chooses $q$ to maximize her perceived expected utility,

$$\hat{U}_i = \max_q (1 - \hat{\pi}_i) u_i (m_g (q, P (q))) + \hat{\pi}_i u_i (m_b (q, P (q))) .$$

Her perceived expected utility depends on both on her risk perception $\hat{\pi}_i$ and preference $r_i$.

What can we learn from observing an individual’s demand curve $p_i (q)$?
Identification using Price Variation

Proposition (Identification I)

The level of an individual’s demand curve $p(q)$ evaluated at full insurance identifies her perceived risk.

Proposition (Identification II)

The slope of an individual’s demand curve $p'(q)$, divided by $p(q)[1 - p(q)]$ and evaluated at full insurance, identifies her absolute risk aversion.
Marginal Willingness to Pay

- Marginal willingness to pay equals

\[ MWP_i(q) \equiv \frac{\partial U_i}{\partial q} / \frac{\partial U_i}{\partial P} = \frac{\hat{\tau}_i u'_i(m_b)}{(1 - \hat{\tau}_i) u'_i(m_g) + \hat{\tau}_i u'_i(m_b)} \]

\[ \Rightarrow \quad 1 - \frac{u''_i(m_g)}{u'_i(m_g)} [m_g - m_b] \]

\[ \frac{1}{\hat{\tau}_i} - \frac{u''_i(m_g)}{u'_i(m_g)} [m_g - m_b] \]

\[ \Rightarrow \quad MWP_i(L) = \hat{\tau}_i. \]

- Price at which one buys full insurance is the price one perceives as actuarially fair.

Marginal willingness to pay decreases with insurance coverage

\[ MWP_i' (q) = -\hat{\pi}_i (1 - \hat{\pi}_i) \frac{u_i''(m_b)}{u_i'(m_b)} \frac{u_i'(m_b) u_i'(m_g)}{u_i'(m_b) [(1 - \hat{\pi}_i) u_i'(m_g) + \hat{\pi}_i u_i'(m_b)]^2} \]

\[ \Rightarrow \]

\[ MWP_i' (L) = -\hat{\pi}_i (1 - \hat{\pi}_i) \frac{u_i''(m(L))}{u_i'(m(L))}. \]

Reducing exposure to risk is more valuable if the perceived variance and risk aversion is higher.
\[
\text{slope} = \left[ \frac{\pi_i (1 - \pi_i) u_i''}{u_i'} \right]^{-1}
\]
Continuous Risks: Copays and Deductibles

- An individual risks to lose $x \in [0, L]$ with perceived distr. $F_{\hat{\pi}}(x)$.
- Consider a contract $c = (D, \alpha, P)$.
  - Below the deductible $D$, the individual bears the entire risk.
  - Above the deductible, the individual bears a share $\alpha$ of the risk.
- The risk preference and perceived risk distribution could be identified using price variation. Evaluated at a zero copay $\alpha = 0$,
  - the willingness to increase the deductible $D$ to reduce the copay $\alpha$ equals
    \[
    MRS_{i,D,\alpha}^D(D, 0) \equiv \frac{\partial \hat{U}_i}{\partial \alpha} / \frac{\partial \hat{U}_i}{\partial D} = E(x - D|x \geq D).
    \]
  - the change in the willingness to pay equals
    \[
    \frac{\partial MWP_{i,\alpha}^\alpha(0, 0)}{\partial \alpha} = \frac{u''_i(m(c))}{u'_i(m(c))} E_{\hat{\pi}_i} \left[ x^2 \right] - \left[ E_{\hat{\pi}_i} x \right]^2.
    \]
Our approach exploits risk-neutrality implication of EUT close to full insurance.

Some empirical evidence suggests risk aversion for small stakes.

- First-order risk aversion makes approach invalid.
- Example: loss aversion a la Koszegi and Rabin,

\[ MWP_i (L) = \hat{\pi}_i + \frac{\mu_i - 1}{u'_i (m(L))} (1 - \hat{\pi}_i) \hat{\pi}_i. \]

\[ \Rightarrow \text{wrongly attribute loss aversion } \mu_i \text{ to pessimism } \hat{\pi}_i \]

\[ \left. \frac{d\hat{\pi}_i}{d\mu_i} \right|_{MWP_i(L), \mu_i=1} = \frac{(1 - \hat{\pi}_i) \hat{\pi}_i}{u'_i (m(L))} \]

Attributing differences in MWP to heterogeneity in EUT risk aversion \( r_i \) seems worse,

\[ \left. \frac{dr_i}{d\hat{\pi}_i} \right|_{MWP_i(q), \hat{\pi}_i=\pi_i} = - \frac{1 - r_i [m_g (q) - m_b (q)]}{\pi_i (1 - \pi_i) [m_g (q) - m_b (q)]}. \]
Identification using Risk Realizations

- Approach is to use distribution of risk realizations $D(x)$ to estimate distribution of ex ante risk types $H_\pi$ and insurance choices to estimate distribution of risk preferences. (Cohen and Einav 2007, Einav et al. 2010,...)

- Two strong identifying assumptions are required
  1. Relating (ex post) risk realizations to (ex ante) risk types.
  2. Relating true risk types to perceived risk types.

- Two approaches are complementary:
  - Require different data and identifying assumptions.
  - Allows comparing perceived and actual risk types.
Identifying ex Ante Risk Types

**Proposition**

If for some $F_{\pi_i}, F_{\pi_j} \in \mathcal{F}$ and $\alpha \in (0, 1)$, there exists $F_{\pi_k} \in \mathcal{F}$ such that $\alpha F_{\pi_i}(m) + (1 - \alpha) F_{\pi_j}(m) = F_{\pi_k}(m)$ for all $m$, identification of $H_\pi$ is impossible.

- Trivially satisfied for a binary risks; $\alpha \pi_i + (1 - \alpha) \pi_j = \pi_k$.
- Identification rests on difference between empirical distribution across population and assumed distribution of an individual’s risk.

**Proposition**

When $H_\pi$ is unknown and $D(x|q)$ is increasing in FOSD-sense in $q$, homogeneity in risk-averse preferences cannot be excluded, even when perceptions are accurate.
Conclusion

- Risk perceptions seem important, but have been ignored in literature analyzing adverse selection.
- Policy recommendations are very different when heterogeneity in risk perceptions rather than preferences drives people’s insurance choices.
- Risk perceptions can be separated from risk preferences using price variation.