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C.1 GENERAL PRINCIPLES

- **Risk-pooling** is the reason insurance works.
- **Risk-aversion** is the reason people demand insurance.
- **Adverse-selection** can lead to failure of insurance markets
- **Moral hazard** can lead to welfare loss due to excess consumption of health.
- We consider these in order.

C.2 RISK POOLING

Methods to pay for covering risks such as high health care expenses

- savings
- family and friends
- charity (particularly early hospitals)
- private market insurance contracts (U.S. emphasizes)
- social insurance (many other countries and Medicare).

Insurance pools individuals together to reduce the risk faced by the insurer. (Some of the other methods can also be viewed as pooling).

<u>RISK POOLING EXAMPLE</u>

- A heart attack may occur with probability 0.01 and would cost $50,000 to treat.
- Let X denote health costs due to a heart attack.
- Then X = $50,000 with probability 0.01
  = $0 with probability 0.99.
- Pool 10,000 similar people. Then we show that
  - standard deviation of average claim is 100^{th} of that for individual
  - the average claim has a normal distribution.
- People will buy insurance to reduce their individual risk.
- Insurance companies will sell insurance as they face lower risk for a pool.

C.2.1 Losses for an Individual

Expected loss

- $E[X] = \Sigma_x \Pr[X=x] \times x$

  $= \Pr[X=50{,}000] \times 50{,}000 + \Pr[X=0] \times 0$

  $= 0.01 \times \$50{,}000 + 0.99 \times \$0$

  $= \$500$

Variance of Loss

- $V[X] = E[(X - E[X])^2]$

  $= \Sigma_x \Pr[X=x] \times (x - E[X])^2$

  $= \Pr[X=50{,}000] \times (50{,}000 - 500)^2 + \Pr[X=0] \times (0 - 500)^2$

  $= 0.01 \times (\$49{,}500)^2 + 0.99 \times (\$500)^2$

  $= 24{,}750{,}000$

Standard Deviation of Loss is square root of the variance

- St Dev[X] = Sq.root(V[X])

  = \$4,975

C.2.2 Losses for Health Insurance Company

- Suppose insure 10,000 people.
- Each may have a heart attack with probability 0.01 that would cost \$50,000 to treat.
  - as shown earlier $\mu = E[X] = \$500$ and $\sigma = Sqrt(V[X]) = \$4{,}975$.
- Let $\bar{x} = (x_1 + x_2 + \ldots + x_{10000}) / 10{,}000$

  Denote the **average loss** due to heart attack for sample size 10,000.
- **Mean of the Average**

  The expected value of $\bar{x}$ is $E[\bar{x}] = \mu = \$500$
- **Standard deviation of the Average**

  The standard deviation of $\bar{x}$ is

  $S.D.[\bar{x}] = \sigma / n^{1/2} = \$4{,}975 / 10{,}000^{1/2} = \$49.75$.

  This is much less than \$4,975. **Pooling reduces variability** !!

Distribution of the Average

- The sample average $\bar{x}$ can be shown to be normally distributed, with mean \$500 and standard deviation \$49.75.

- From normal distribution tables it follows that for 10,000 insured we can be

  67% sure that average claims will be within \$49.75 of \$500

  95% sure that ave. claims are within 2×\$49.75 = \$99.50 of \$500.

  [Note that this is a narrow range: roughly \$400 to \$600].

- If instead only 100 are insured we can only be

  67% sure that average claims will be within \$497.50 of \$500.

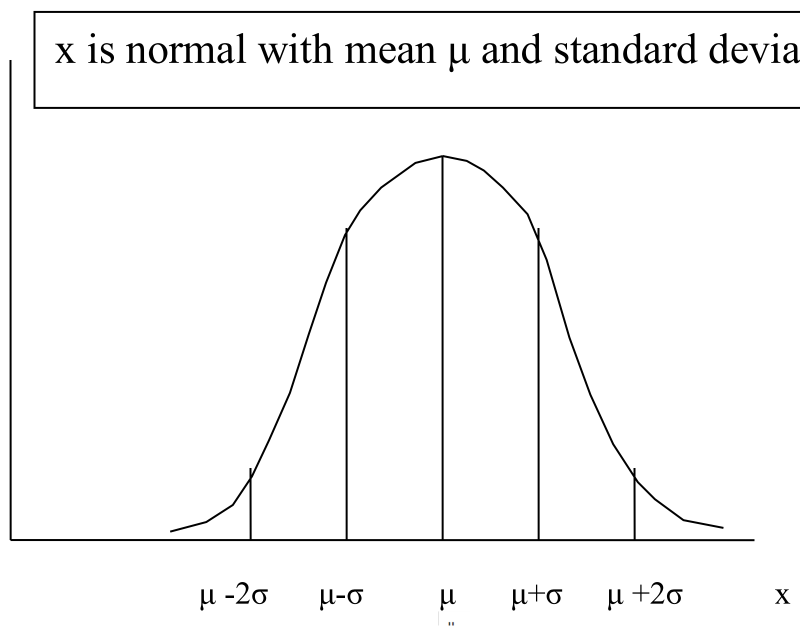
Normal Distribution

The normal distribution is a bell-shaped curve with formula

$$f(x) = (1/2\pi\sigma^2)^{1/2} \exp(-(x-\mu)^2/2\sigma^2)$$

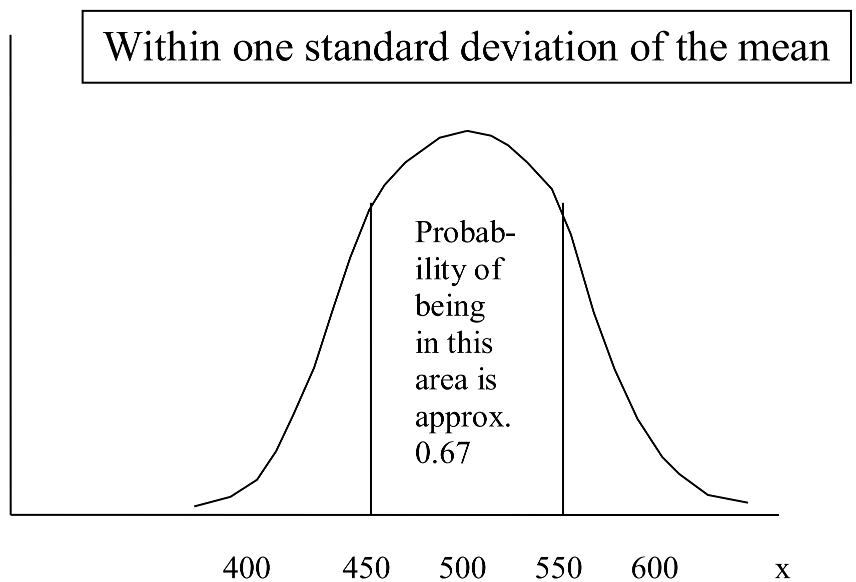
where $\mu = E[x]$ is the mean of the random variable x

and $\sigma = Sqrt(V[x])$ is the standard deviation of the random variable x

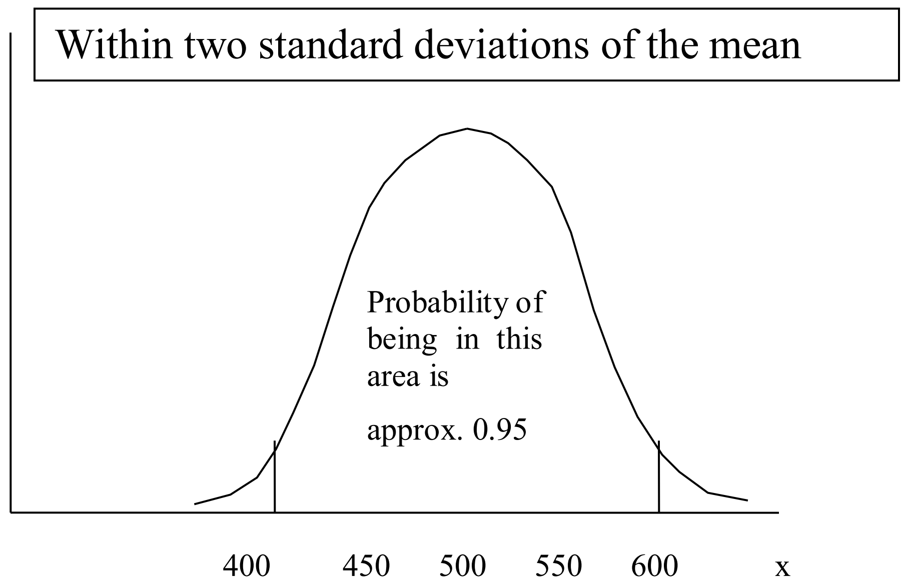


Total area under the curve equals one. Area under the curve between any two points gives the probability of being between those points.

Example: Show the probability of being within **one standard deviation** of the mean when average losses have mean \$500 and standard deviation \$50.



Example: Show the probability of being within **two standard deviations** of the mean when average losses have mean \$500 and standard deviation \$50



C.3. HEALTH INSURANCE: RISK AVERSION

- Premium = price of insurance contract
  = losses + administrative fees + profits
- Actuarially fair premium = expected value of loss
  (so losses just paid for on average)
- Load = Actual premium - actuarially fair premium
- Loading factor = Load as a % of actuarially fair premium
  (≥ 10% for group plans and much higher for individual plans.)

Why buy insurance if the premium exceeds the actuarially fair premium? Because of **risk-aversion** by the consumer.
- a person will prefer a certain outcome to a gamble that has expected outcome of the same value.
- e.g. Prefer $100 for sure to a 50/50 coin toss with outcome of either $0 or $200.

C.3.1 Model for Insurance

- Let x denote the **random outcome** of interest, such as health expenses or income net of health expenses.
- For example x = annual income (in thousands of dollars)
  and suppose x = 50 with probability 0.5
  or x = 150 with probability 0.5
- Then **expected income** is
  $$E[x] = 0.5 \times 50 + 0.5 \times 150 = 100.$$
- Interested in comparing
  - happiness of a certain 100
  - to the happiness of either 50 with probability 0.5 or 150 with probability 0.5.

- Let U(x) denote the **utility** or happiness that comes from particular values of x.
- For concreteness assume

Income x	Utility U(x)	Marginal Utility (per 50 change in x)
0	0	0
50	100	100
100	170	70
150	200	30

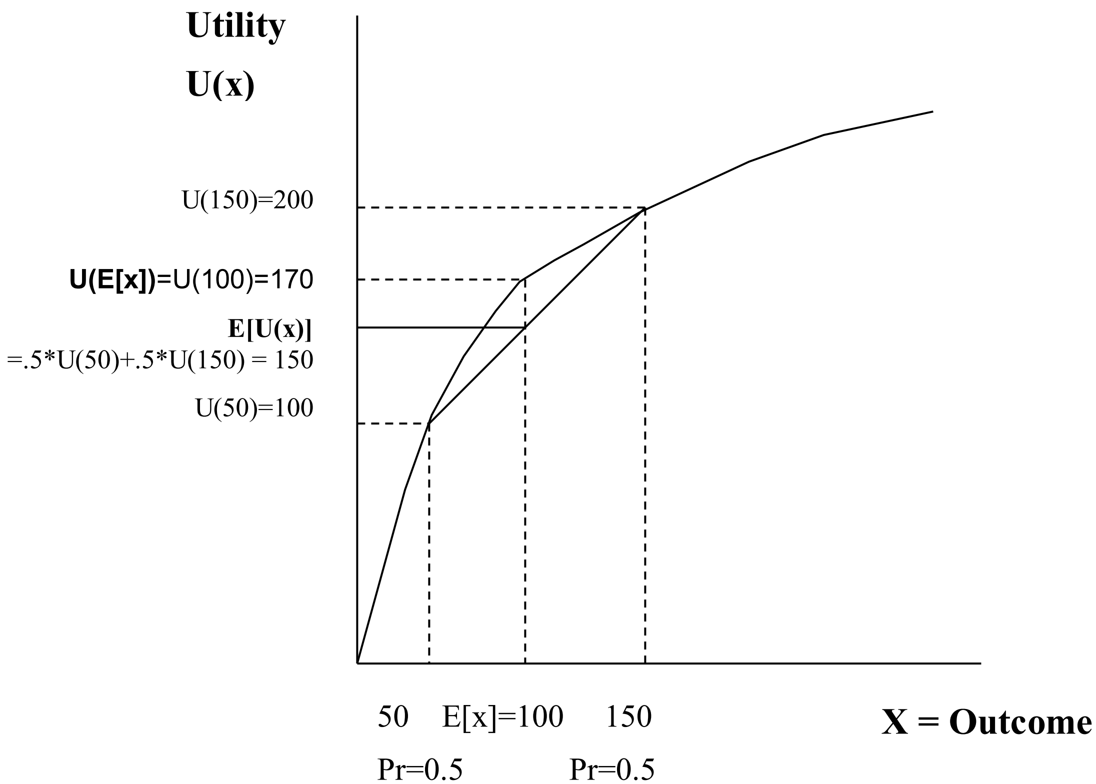
- Utility increases in income, as expected, with derivative $U'(x)>0$.
- In this example the increase in utility declines as income increases, however.
  - e.g. first 50 has utility ↑ by 100; next 50 has utility ↑ by 70.

For a **risk-averse consumer** $U'(x)$ ↓ as x ↑ (so $U''(x) < 0$)

For a **risk-neutral consumer** $U'(x)$ constant as x ↑ (so $U''(x) = 0$)

For a **risk-prefer consumer** $U'(x)$ ↑ as x ↑ (so $U''(x) > 0$)

The following is a risk-averse consumer.



- The **expected utility** is

$$E[U(x)] = 0.5 \times U(50) + 0.5 \times U(150)$$
$$= 0.5 \times 100 + 0.5 \times 200$$
$$= 150.$$

- This is less than the utility of 100 with certainty, since

$$U(E[x]) = U(100)$$
$$= 170$$
$$> 150.$$

- The consumer will purchase insurance that guarantees 100 with certainty, provided the premium is not too high.
- [Formally the certainty equivalent c is the amount such that U(c) = E[U(x)]. Here U(c) = E[U(x)] = 150 ==> c ≈ 80 from the diagram. So indifferent between $80 for certain and $50 / $150 equal probability. Since fair bet is $100 will pay up to ($100 - $80) = $20 above fair premium].

More generally, the **benefit of insurance** against the uncertain outcome is larger for

- **more risk-averse** individuals, i.e. greater curvature $U''(x)$ of the utility function.
- **more exposure to risk**, i.e. greater Var[x], the variance of x.

More formally, the **benefit of risk reduction** equals

$R \times Var[x]/2$,

where $R = \frac{-U''(x)}{U'(x)}$ is called the coefficient of relative risk aversion.

This is larger for greater risk-aversion (R) and greater risk exposure (Var[x]).

C.4. HEALTH INSURANCE: MORAL HAZARD

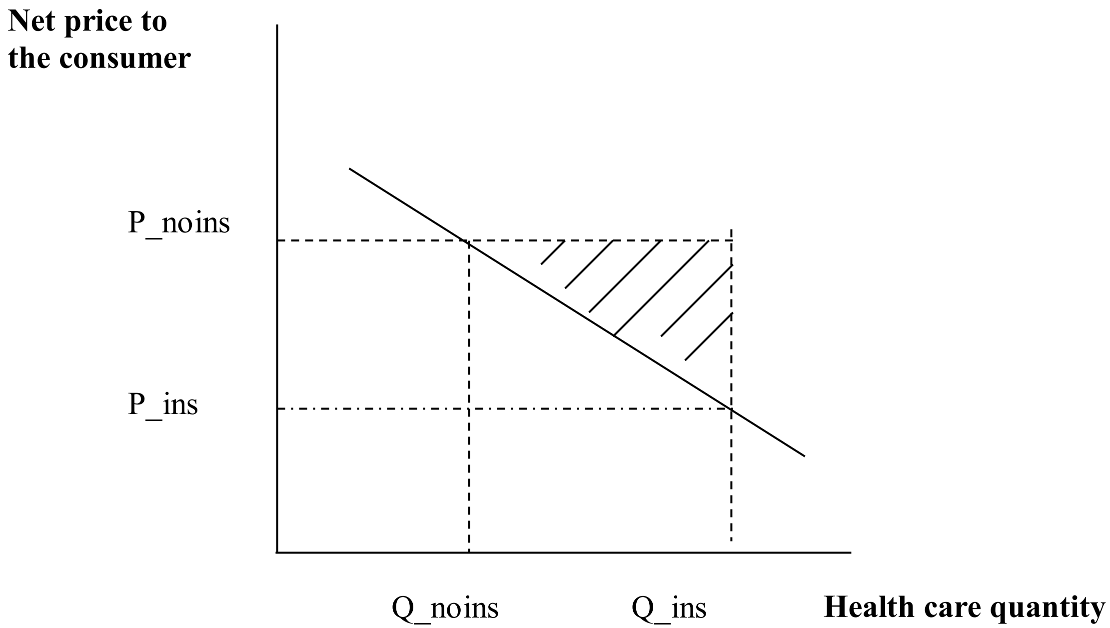


Diagram shows going from **no insurance** to **partial insurance**.

Moral hazard: Decrease in price to consumer leads to increased consumption.

Shaded area gives welfare loss due to moral hazard

= cumulative diff. between expense (P_noins) & value to consumer (D curve)

= health expenses covered by insurance: [P_noins - P_ins] × Q_ins
less gain in consumer surplus (area under D curve between P_noins and P_ins).

Economic methods to minimize moral hazard:

- **coinsurance:** percentage of bill paid by insured patient (e.g. 20%)
- **copayment:** flat amount paid by insured patient (e.g. $10 per doctor visit).
- **deductible:** initial amount per year or illness that patient pays fully.

These mitigate moral hazard but can also effect insurance choice.

- e.g. Healthy person may choose insurance with a high annual deductible.

Arrow (1963) in seminal article that essentially created health economics argued for government intervention to provide health insurance if it was not commercially provided.

- Kenneth Arrow (1963), "Uncertainty and the Welfare Economics of Medical Care", American Economic Review, 941-973.

Paully (1968) replied that Arrow hadn't allowed for the complication of moral hazard, weakening the case for government intervention to ensure private insurance for all people.

- Mark Paully (1968), "The Economics of Moral Hazard: Comment", American Economic Review, 531-537.

Paully's model given in diagram on next slide

- compared full insurance to no insurance
- assumed health care is priced at marginal cost, so p = MC
- added uncertainty by considering three health events – no event (probability 0.5), moderate event (probability 0.25), and serious event (probability 0.25).

He assumed greater health demand if fully insured (vs. not insured).

No insurance: Expected loss = 0.5×0×MC + 0.25×**50**×MC + 0.25×**200**×MC = 62.5MC

If risk-averse will buy insurance sold for premium 62.5MC

- or even higher depending on degree of risk aversion

Full insurance: Expected loss = 0.5×0×MC + 0.25×**150**×MC + 0.25×**300**×MC = 112.5MC

Now even if risk-averse may not buy insurance because now sold at premium 112.5MC.

- This is much higher than expected loss of 62.5MC if not insured.

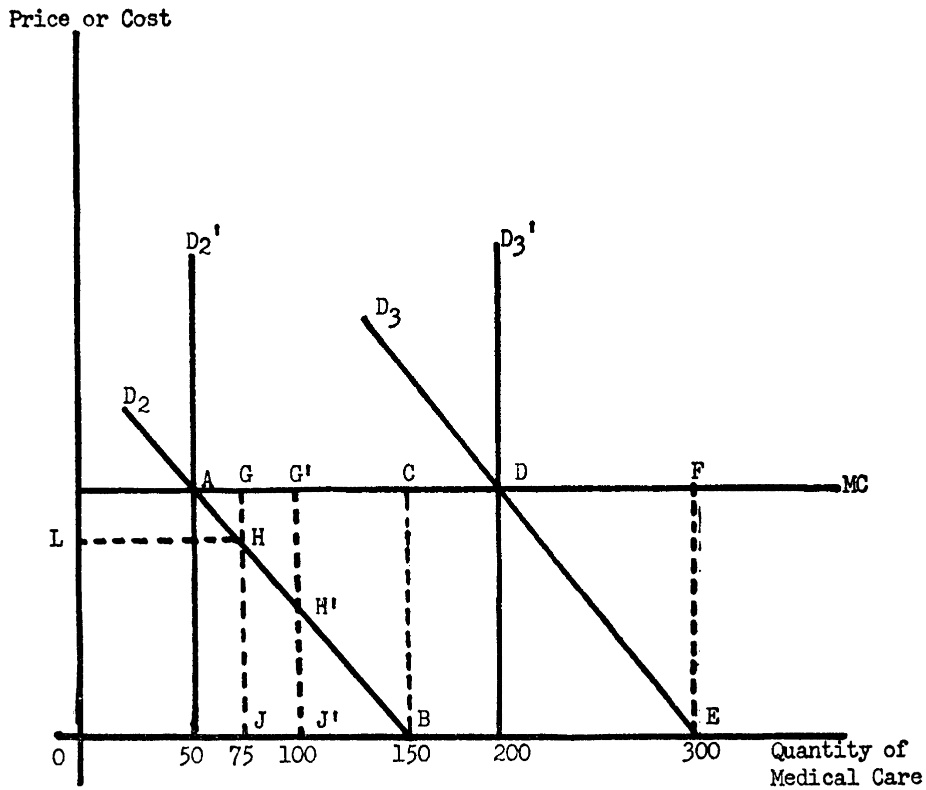


Figure 1

Note: Price per unit = MC as assume that price at marginal cost.

Welfare loss of full insurance:

Welfare loss = 0.25×triangle ABC + 0.25×triangle DEF

C.5. MORAL HAZARD: RAND STUDY REVISITED

Recall

TABLE 3—VARIOUS MEASURES OF PREDICTED MEAN ANNUAL USE OF MEDICAL SERVICES, BY PLAN

Plan	Likelihood of Any Use (%)	One or More Admissions (%)	Medical Expenses (1984 $)
Free	86.7	10.37	777
	(0.67)	(0.420)	(32.8)
Family Pay			
25 Percent	78.8	8.83	630
	(0.99)	(0.379)	(29.0)
50 Percent	74.3	8.31	583
	(1.86)	(0.400)	(32.6)
95 Percent	68.0	7.75	534
	(1.48)	(0.354)	(27.4)
Individual Deductible	72.6	9.52	623
	(1.14)	(0.529)	(34.6)

Price Elasticity of Demand

- Table 9 converts table 2 and 3 results into a **price elasticity estimate.**
- The price elasticity is defined as $\varepsilon = -[dQ/Q]/[dp/p]$ so that $\varepsilon > 0$. The **arc elasticity** measure is used, evaluating at average Q & p.
- e.g. move from the 25 percent plan with **effective** average coinsurance rate of 16% to the free plan with coinsurance rate of 0% then all care expenses from Table 3 rose from $630 to $777.
- The price elasticity is then

$$\frac{-(777-630)/[(777+630)/2]}{(0-16)/[(0+16)/2]} = \frac{147/703.5}{16/8} = \frac{0.209}{2} = 0.10.$$

- Thus going from a generous insurance to free care the price elasticity of demand is 0.10.

Welfare Loss

Page 270 calculates the **welfare loss** due to insurance
- Ideally from no insurance to full insurance

In fact from **partial insurance** (95% plan) to **full insurance** (free plan) as Rand experiment did not have no insurance.
- Note: This differs from earlier diagram of no insurance to partial.

Furthermore the 95% coinsurance became 0% (free) once expenses became high
- the effective coinsurance rate was 31% on the 95% plan.

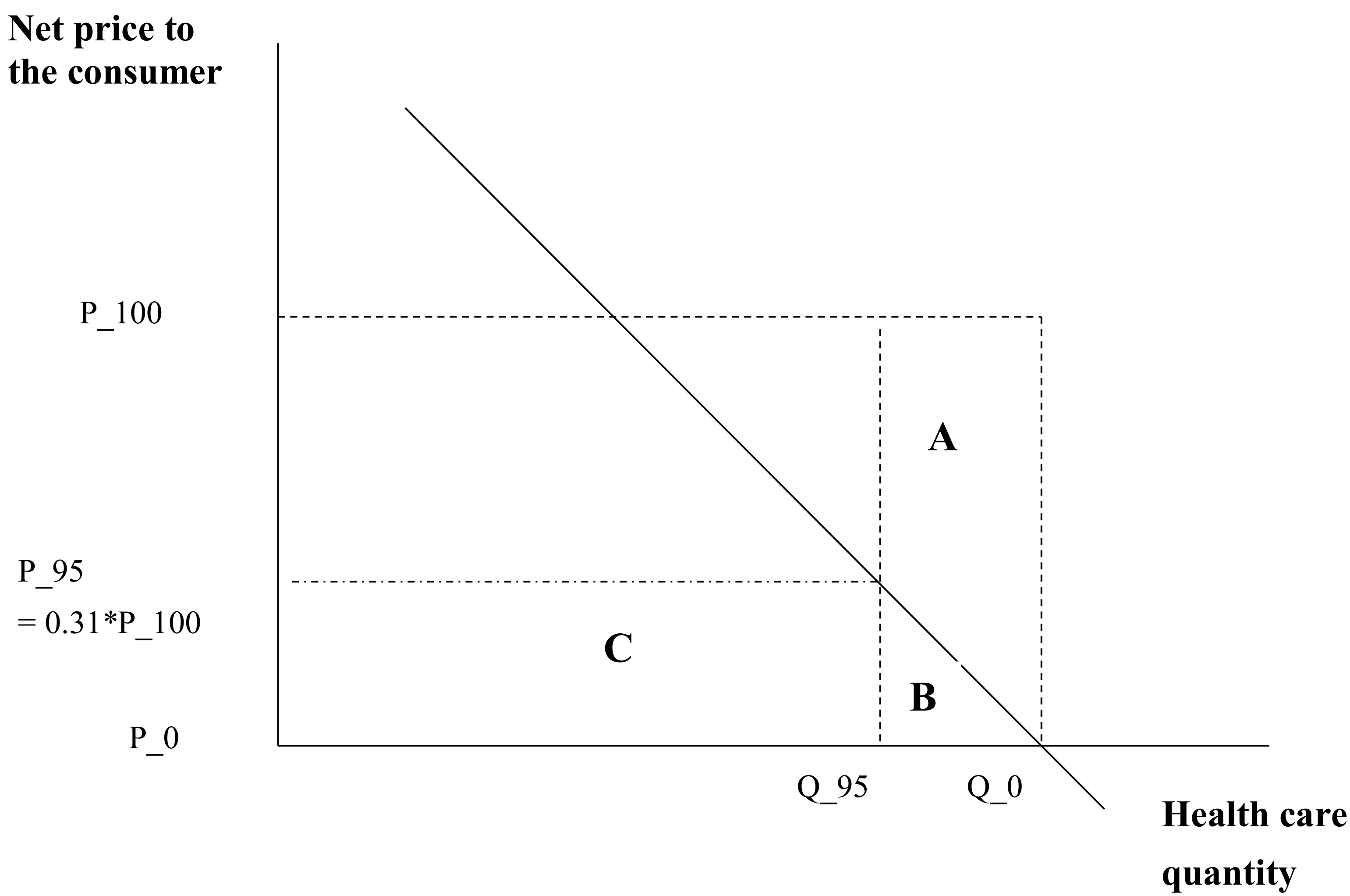
- Rand estimates the increase in health expenses to be
207 million people × [Medical increase + Dental increase + Mental increase]
= 207 million × [(777 – 534) + (261 – 179) + 19]
= 207 million × $344
= $71 billion.

- If we were going from no insurance to full insurance the welfare loss estimate is half this, or $35.5 billion.

- But actually we need to compare full insurance to partial insurance
- see diagram on next page.

- Welfare loss
= increased health expenses–increased consumer surplus
= (A + B) – B (see figure)
= 71 – 0.5 × 0.31 × 71 (ave coinsurance in 95% plan was 31%).
= $60 billion.

Diagram shows going from **partial insurance** to **full insurance**.



Insured (effective coinsurance 31% vs. theoretical rate 95%)

Price to consumer is $P\_95 = 0.31 * P\_100$

Health expenses (combined consumer and insurer share) are Q_95.

Free care

Price to the consumer is P_0

Health expenses rise to Q_0.

Health expenses rise by area A + B [= $P\_100*(Q\_0 – Q\_95)$].

Consumer surplus rises by B on net [= $(1/2) \times P\_95 \times *(Q\_0 – Q\_95)$]

(Gross increase is C + B, but C is old consumption now paid through insurance. Consumer pays premium for this. So only B is a net gain.)

Welfare loss = (A + B) – B = A.

Risk Reduction

Welfare gains and losses due to health insurance are

1. welfare gain due to risk reduction
2. welfare loss due to moral hazard (= health expense increase – consumer surplus increase)
3. further welfare loss if increased demand leads to increased gross price of health care
4. welfare gain due to better health but studies have found this difficult to measure as the benefits can arise many years later.

What is the combined effect?

- Manning et al (*AE R*, 1987) considered only 2 for the Rand study.
- Feldstein (*JPE* 1973) estimated 1. to 3. and argued that Americans are over insured against medical expenses. He favored catastrophic cover: high coinsurance rates up to a deductible that is also quite high.
- Feldman and Dowd (*American Economic Review*, 1989) used Rand data to additionally estimate item 1, and also estimate item 3. They support Feldstein.

Compare the 95% coinsurance plan (almost no insurance) to the free plan (complete insurance).

Item 2 has already been discussed. (Feldman and Dowd have slightly different estimates and find the welfare loss to be at least $45.4 billion in 1984 dollars).

Item 3 is somewhat speculative. Feldman and Dowd assumed increases in gross price of 0%, 10% and 20%.

Item 1 Feldman and Dowd estimate to be $11.9 billion. Small compared to 1.

[Method: Use the **benefit of risk reduction** equals

$R \times Var[x]/2$, where $R=-U''(x)/U'(x)$ is coefficient of relative risk aversion and in this application

$R = 0.0036$; $Var[x] = 25{,}828$;
inflation adjustment 106.8/28.2; 67 million families]

Tradeoff between moral hazard and risk reduction

We want to show individual tradeoff between moral hazard and risk reduction on the one diagram. To do this we plot level of insurance coverage (x axis) against premium per unit of coverage (y axis) where a unit of coverage is e.g. one percent of annual medical expenses.

No moral hazard: The premium per unit of coverage is constant. For example, we would use $10,000 of medical services in a year regardless of whether insurance covers 0% of the total or 50% or … Then we are paying $100 for each percentage covered.

Moral hazard: The Premium per unit of coverage rises as coverage rises. We would use, say, $10,000 of medical services in a year if insurance covers 0% of the total, but this increases to, say, $11,000 at 50% coverage (so 50% coverage costs $110 per percentage covered), and to, say, $13,000 at 90% coverage.
Then at 90% cover we are paying $130 per each percentage covered.

Indifference curves: **prefer bottom right** so I3 best then I2 then I1.

1. **No moral hazard**: same premium per unit of cover at all levels of insurance, so line p_0–F gives the premium per unit of coverage. The highest possible indifference curve gives F: **full insurance.**

2. With moral hazard: increasing premium per unit of coverage with level of insurance, so now on or above solid line p_0–F', so at A: partial insurance. (Full ins. at F' requires really steep indiff curves.)

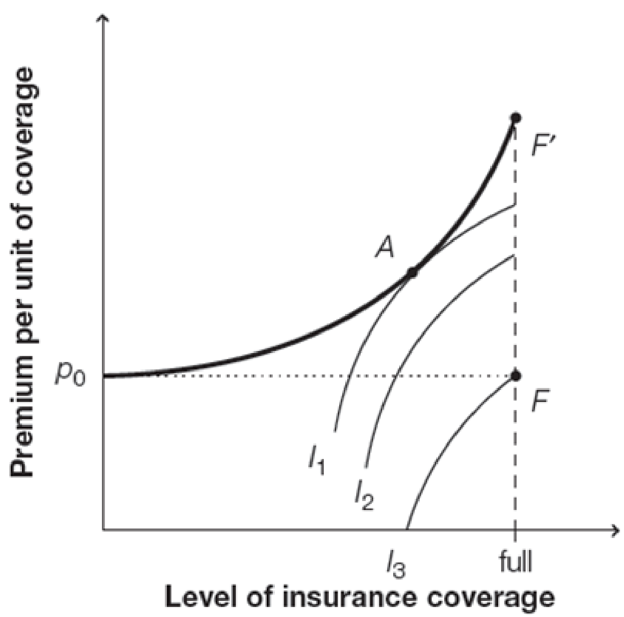


Figure 11.8. *The locus of feasible contracts in a world with moral hazard.*

C.6. HEALTH INSURANCE: ADVERSE SELECTION

- **Adverse selection** arises if there is a difference between those who buy insurance (high-risk where high-risk here means large expected loss) and those who do not (low-risk).
- Adverse selection can lead to an insurance death spiral … only the unhealthy buy insurance, so premium up, so the healthiest unhealthy drop out, etc.
- Minimize adverse selection by
  - vary premium by measurable characteristics related to health risk (family structure is used. Age is used for nongroup policies)
  - move the highest risk into a separate pool (e.g. Medicare for over 65's).
  - not offer insurance to highest risk (exclude on pre-existing conditions)
  - restrict ability to opt out (e.g. all employees at firm get health insurance)

C.6.1 Akerlof's Market for Lemons

- Suppose there is **asymmetric information** about value of car
  - value of car X is uniformly distributed on (0, 100)
    i.e. a car can take any equally-likely value between 0 and 100
  - sellers know X and their utility of car = X
  - buyers do not know X, only that value is uniform on (0, 100)
    and buyers are **risk neutral** so $E[U(X)] = U(E[X])$.

- Case 1: Buyers U = X (and sellers U = X) and posted price = 60.
  - buyers know sellers will only sell if their car is worth $<= 60$
  - so given price of 60 buyers now believe X is uniform on (0, 60)
  - so buyers believe on average $E[X] = (60 – 0) / 2 = 30$.
  - so will not buy as $E[U] = U(E[X]) = U(30) = 30 < 60$.

- Case 2: Change to Buyers U = 3X, otherwise same as case 1
  - now problem solved as $E[U] = U(30) = 3×30 = 90 > 60$.

- Case 3: Information can help: e.g. X is uniform on (40,70).

- Case 4: Minimum guarantee (warranty) can help similarly.

C.6.2 Application to Health

- Now adapt to health insurance.
- Suppose expenses X are uniform on (0, $20,000).
- Consumers know their exact X but insurance company does not, it only knows expenses are equally likely on $0 to $20,000.
- Suppose insurer posts price of $10,000 (the expected loss)
  - only those who know their costs are > $10,000 will insure
  - the average loss is $15,000 (= midpoint of 10,000 and 20,000)
  - insurers need to set price at $15,000
  - but then only those who know their costs are > $15,000 insure
  - by similar argument average loss is $17,500 …… a death spiral
  - this has happened e.g. Harvard 1994-1996 PPO to HMO.
- This is reduced
  - if insurer has some info on individual losses & can vary premia
  - if consumers are uncertain about losses & risk-averse (next).

C.6.3 Application to Health Insurance

- Now suppose add **uncertainty by consumers** about losses
  - Then consumers don't know health expenses
  - and suppose they are **risk-averse**.
- The theory is difficult (Rothschild – Stiglitz).
- It is not possible to have a **pooling equilibrium**
  - where one policy works for everyone same premium and same payout if sick.
- It may be possible to have a **separating equilibrium**
  - where one policy attracts frail (fully insured, high premium) and one policy attracts robust (partial insurance, low premium).
- Adverse selection does sometimes lead to market failure
  - e.g. this is a reason for Medicare for > 65
  - e.g. employer-provided insurance with low-coinsurance and high premium (Buchmueller/Feldstein & Cutler/Reber).

C.6.4 Policy Implications

- A **single freely chosen plan won't work**.
  - need mandates or automatic provision.
- For those with robust health it is best to have partial insurance
  - i.e. relatively high coinsurance and high deductibles
  - many economists think current health insurance is too generous (though policies increasingly have higher deductibles).
- For some forms of insurance (e.g. auto) experience-rating is used
  - premia vary with past use of insurance
  - but for health insurance this is viewed as unfair to the frail.
- A theoretical possibility is a lifetime health insurance contract
  - pay up front before knowing health status
  - but this is too expensive.
- Bottom line is it is very difficult to have a private market in health insurance.

C.7 HEALTH CARE SYSTEMS ACROSS COUNTRIES

- Various **types of health insurance** market
  - completely private insurance can fail due to adverse selection and is not equitable.
  - universal public insurance run by government is equitable but with low coinsurance can have high costs due to moral hazard
  - compulsory insurance requires subsidies or payroll tax to be equitable and regulation to minimize adverse selection.
- Various methods are used to **control moral hazard**
  - cover only procedures that are cost-effective (next topic)
  - use coinsurance, copays, deductibles
  - ration by gatekeeping and queuing
  - use prospective payment systems (covered later).
- Various **methods to provide health care**
  - public provision is usually cheaper but lower quality
  - private provision but regulate to prevent monopoly power or have government set prices.

Three Leading Different Models

- 1. Beveridge Model e.g. Britain, Canada, Sweden, Australia
  - government single-payer insurance
    (for some countries with private supplemental insurance)
  - government provision (or at least control) of health care.
- 2. Bismarck Model e.g. Germany, Japan, France
  - universal insurance often through (regulated) private insurance
  - private provision of health care but regulated with price controls.
- 3. American Model e.g. U.S. and nowhere else
  - private and public insurance but no universal insurance
  - private provision with little price control.

Book gives detailed analysis. We discuss briefly.

https://www.commonwealthfund.org/international-health-policy-center/system-profiles