Massachusetts Institute of Technology
14.41 Public Finance & Public Policy – Problem Set 4

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QUESTION 1: Preventative Care and Heart Attacks [40 points]

According to the CDC, around half the United States adult population has hypertension (i.e. high blood pressure), a condition that often shows little or no symptoms until major complications like a stroke or heart attack arises. Although hypertension can oftentimes be treated through preventative action, not everyone with this condition changes their lifestyle to reduce their risk. Let's use a simplified model to show how this might affect the insurance market.

Suppose everyone in an economy has the same income $y > 0$. People who don't live a healthy lifestyle ("unhealthy") have a probability of being hospitalized from a heart attack that is p_u. Assume that in this economy, treating hypertension through changing individual behavior is costly (i.e. eating a healthy diet, exercising, reducing stress levels, etc. are all harder than not). Therefore, if a person chooses to live a healthy style ("healthy"), they incur a cost of h, but the probability of them being hospitalized goes to p_h, with $p_h < p_u$. Whenever a person is hospitalized from a heart attack, they are charged H in expenses for hospitalization, reducing the amount that can be spent on consumption goods. Each person's income goes to consumption, choosing to be healthy, and hospitalization expenses if they have a heart attack, such that the budget constraint is $y = c + h * \mathbf{1}\{live\ healthy\} + H * \mathbf{1}\{hospitalized\}$,

where $\mathbf{1}\{\cdot\} = 1$ if the condition is true, and 0 otherwise. Everyone's utility is given by $u = \sqrt{c}$.

1. (4 points) Set up the expected utility of people who do and don't have a healthy lifestyle. Denote these EU_h and EU_u, respectively. These should be in terms of p_u or p_h, h, H, and y.

Solution:

$$EU_u = p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y}$$

$$EU_h = p_h * \sqrt{y - H - h} + (1 - p_h) * \sqrt{y - h}$$

Assume for the rest of the questions that $EU_u > EU_h$, so conditional on not having insurance, people will always choose to live unhealthily. Suppose that the firm Ensure Inc. decides to offer an actuarially fair insurance plan only to people who live healthily. The plan fully covers the cost H of hospitalization from heart attacks. Assume Ensure Inc. can perfectly observe each person's type (e.g., has access to a person's financial transactions, can track location, etc.), and that an individual's insurance becomes invalid if they fail to adhere to living healthily.

2. (5 points) What is the actuarially fair premium, R_h, of the healthy lifestyle plan? What is the expected utility from purchasing actuarially fair "healthy" insurance? Denote this $EU_h^{h\ insurance}$.

Solution: Actuarially fair premiums would be the expected benefits paid to people who live healthily.

$$R_h = p_h * H$$

A healthy lifestyle person purchasing this actuarially fair insurance would have expected utility

$$EU_h^{h\ insurance} = p_h * \sqrt{y - R_h - h} + (1 - p_h) * \sqrt{y - R_h - h} = \sqrt{y - p_h * H - h}$$

3. (5 points) Under what conditions would someone rather live healthily with insurance over live unhealthily with no insurance? Set up the inequality. Explain the trade-offs a person faces when deciding whether to enroll in the insurance plan.

Solution:
Someone will choose living unhealthily with no insurance over healthily with insurance when:

$$EU_h^{h\ insurance} > EU_u$$

$$\sqrt{y - p_h * H - h} > p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y}$$

The trade-offs involved are that people can pay h and the average benefits of insurance to have a lower probability of being hospitalized. Living unhealthily comes with a higher risk of being hospitalized and incurring a large expense H, but doesn't have to pay h nor the cost of insurance.

4. (8 points) Suppose instead of charging the actuarially fair premium for the plan, Ensure Inc. adds a "load factor" (charges more than R_h so that it makes profit) such that premiums are now $R_h^{'} = R_h + \pi_h$. Derive the range of values $0 < \pi_h < f(y, p_h, p_u, H, h)$ that Ensure Inc. can charge to make profit. What happens if they charge more than this upper bound?

Solution:
Ensure Inc. will make positive profits as long as people still still enroll in the insurance plan even when $\pi_h > 0$:

$$\sqrt{y - p_h * H - \pi_h - h} > p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y}$$

$$y - p_h * H - \pi_h - h > (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2$$

$$0 < \pi_h < y - p_h * H - h - (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2 = f(y, p_h, p_u, H, h)$$

Therefore, there is a range of load factors that allow Ensure Inc. to make positive profit without losing sales, as long as $0 < \pi_h < f(y, p_h, p_u, H, h)$ (if $\pi_h = f(y, p_h, p_u, H, h)$, people are indifferent to buying insurance). If they charge more than this upper bound, people are better off without buying insurance, so the firm makes no sales and therefore no profits.

Now consider a slightly different scenario. As before, Ensure Inc. decides to offer the healthy lifestyle plan that fully covers the cost of a hospitalization, still at $R^{'} = R_h + \pi_h$. However, a new consumer privacy law was passed that bars insurance companies from monitoring certain aspects of consumer behavior. As a result, Ensure Inc. can no longer discriminate between people with healthy and unhealthy lifestyles.

6. (4 points) If someone buys Ensure Inc.'s insurance plan, will they choose to live healthily or unhealthily?

Solution:
Conditional on being on the insurance plan, people will choose to live unhealthily if:

$$EU_u^{h\ insurance} > EU_h^{h\ insurance}$$

$$\sqrt{y - R_h'} > \sqrt{y - R_h' - h}$$

This is always true, so anyone on an insurance plan will live unhealthily.

7. (8 points) What is Ensure Inc.'s expected profits from selling this plan? Derive the range of values for $g(p_u, p_h, H) < \pi_h < f(y, p_h, p_u, H)$ that Ensure Inc. can charge to make profit. How does Ensure Inc.'s total expected profits compare now with that of part 4? (Note: Without being able to discrimination between the lifestyles, the lower bound that ensures positive total profit changes from part 4. Additionally, people would still have to enroll, so $EU_u^{h\ insurance} > EU_u$. Also, no need to show that $g(p_u, p_h, H) < f(y, p_h, p_u, H)$ for any values– assume that's a given).

Solution:
For each plan they sell, Ensure Inc. receives in revenue $R_h^{'} = p_h * H + \pi_h$, but will pay in expectation benefits of $p_u * H$. The firm's total expected profits are given by $H * (p_h - p_u) + \pi_h$. For this to be positive, we need $g(p_u, p_h, H) = H * (p_u - p_h) < \pi_h$. Next, we need people to still enroll so $EU_u^{h\ insurance} > EU_u$. Solving this out, we get the solution:

$$H * (p_u - p_h) < \pi_h < y - p_h * H - (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2$$

Which implies total profits between

$$0 < H * (p_h - p_u) + \pi_h < y - p_u * H - (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2$$

The max total profits in part 4 was $y - p_h * H - h - (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2$. The max total profits now are $y - p_u * H - (p_u * \sqrt{y - H} + (1 - p_u) * \sqrt{y})^2$. This means that the Ensure Inc. loses more money now then before whenever $H(p_u - p_h) > h$.

8. (6 points) Ensure Inc. publicly claims it will go out of business because of the privacy law, but government says it will not roll it back. First, comment on the truthfulness of Ensure Inc.'s claim. Next, assuming the claim is true, offer two suggestions for policies the government could implement to keep the insurance market intact (i.e. increase Ensure Inc.'s total expected profits).

Solution: Ensure Inc. is telling the truth if it is selling the plan at actuarially fair rates, since $\pi_h = 0$ and their total profits would be negative. It's possible, though, it is not true if they are charging a load factor. Here are some possible answers:

- Subsidize costs so that Ensure Inc.'s total profits are given by $H(p_h - p_u) + \pi_h + s$, offsetting the effects of people lying about their healthiness.

- Mandate everyone to be healthy to force Ensure Inc.'s profit function back into part 4 territory. The government could then lower the cost of h to increase the maximum load factor too.
- Depending on the set of specific parameter values, increase or decrease p_u by, say, (dis)encouraging the use of hypertension medicines or minimum level of preventative healthcare everyone has.
- Increase the cost of hospitalization H by increasing its tax rate.
- Decrease incomes y by inducing a recession (might not be a great idea for other reasons, though!)

QUESTION 2: Health care potpourri (T/F/U) [20 points]

For each question, indicate whether the statement is true, false, or uncertain, and explain why, using evidence we discussed in class and in the textbook where relevant.

1. (5 points) **Background:** Over the past 30 years, many employers have begun offering HMO insurance plans that often contract with doctors directly, paying them a fixed salary rather than charging a fee-for-service. **Claim**: HMOs reduce moral hazard.

Solution: True. When HMOs integrate insurance and medical care, they pay flat salaries to medical providers that are independent of their diagnoses and the procedures they prescribe. This reduces moral hazard effects of health insurance on provider behavior since they can't increase their incomes by increasing health care costs.
Grading notes: 1 point for true, 2 point for flat salaries are independent of diagnoses and prescriptions, 2 point for this reduces moral hazard in health care costs.

2. (5 points) Linking health insurance to employment is inefficient.

Solution: Uncertain. There are efficiency gains from employer-provided health insurance when it reduces adverse selection in the health insurance market (by pooling risk types). There are efficiency losses from job lock (people not switching to better matched jobs because they want to keep their health insurance) and from the tax subsidy (health insurance benefits aren't taxed, unlike wages), which may raise health insurance consumption above optimal levels). Overall, the effect is uncertain.
Grading notes: 0.5 points for uncertain, 1.5 points for pooling risk types, 1.5 points for tax subsidy, 1.5 points for job lock.

3. (5 points) Making it harder to access government-provided healthcare services– such as increasing wait times, lengthy forms, or adding other hurdles– can make the people who need healthcare the most better off.

Solution: True. This is the concept behind ordeal mechanisms. Since the government has a fixed budget to offer services, it should try to target funding towards those who would benefit the most from it. But there are incentives for people who aren't really in need to "masquerade" as being in need to get the transfer, or, in the health care case, overuse fixed pools of services. By increasing the barriers to receive the transfers– say, by increasing wait times– the government can weed out the people who need the programs the least, so that funding is more targeted.

Grading notes: 0.5 points for 'True', 4.5 points for reasonable answer explaining that funding can better target people in need by increasing barriers. +0.5 points for mentioning "ordeal mechanism". Take off no points for Uncertain answer with good response.

4. (5 points) The individual mandate in the ACA had no effect on people who would have bought health insurance even without an individual mandate.

Solution: False. The individual mandate reduces adverse selection by encouraging healthy people with relatively low expected health costs to buy insurance. This reduces average costs to insurers. Since the ACA mandated community rating, insurers had to charge everyone the same price, and so bringing more healthy people into the market reduced the price that the insurers charged to people already in the market. Thus people who would buy without the individual mandate faced lower prices with the individual mandate, making them better off.

Grading notes: 0.5 for 'false', 1.5 points for discussing how the individual mandate reduces adverse selection, 1.5 points for discussing how this affects the market equilibrium under community rating, 1.5 points for noting that prices will fall for existing customers.

QUESTION 3: Altruism and Care-Giving [40 points]

Many people provide at-home care for their ill, disabled, or aging loved ones. Oftentimes, this cost is provided out-of-pocket, both in terms of accounting costs (e.g. money spent on care) and opportunity cost (e.g. from lost income or leisure). As the United States and many other countries' populations age, the best method to provide care has become an important political debate.

Suppose a society is composed of two people: a caregiver C and a person receiving care R. For now, the level of care $H \geq 0$ is entirely privately provided by C. Each unit of care costs β to provide, such that C's budget constraint is given by $y_c = c + \beta * H$, where $y_c > 0$ represents C's income and c represents C's consumption. On the other hand, R weighs the utility it receives from caregiving by γ. In total, each type of person in this society has the following utility functions, where $\delta \in [0, 1]$, $\beta > 1$ and $\gamma \geq 1$:

C's utility is given by:

$$u_C = (1 - \delta) * \ln(c) + \delta * u_R$$

R's utility is given by:

$$u_R = \gamma \ln(H)$$

1. (4 points) In words, interpret the meaning of the parameters δ. What happens to u_R as $H \to 0$, and what does this say about the demographic R?

Solution: δ represents the level of altruism of C, i.e. how much C weighs R's utility to their own. As $H \to 0$, $u_R \to -\infty$; this indicates R represents people who cannot live without at least some level of care.

Grading notes: +1 point correct interpretation of δ. +1 point for reasonable interpretation of $u_R \to -\infty$.

2. (8 points) What H will C choose to provide? Denote this H^C. Intuitively explain why the level of H increases or decreases as each of the parameters δ, β, and γ varies.

Solution: Substituting u_R, u_C's utility becomes $u_C = (1-\delta) * \ln(y_c - \beta * H) + \delta * \gamma \ln(H)$. Taking the FOC

$$\frac{du_C}{dH} = 0 = -\frac{\beta * (1-\delta)}{y_C - \beta H} + \frac{\delta * \gamma}{H}$$

Solving, we get

$$H^C = \frac{\delta \gamma y_c}{\beta(1-\delta) + \delta\gamma\beta}$$

H^C increases with δ because the more altruistic C is, the more care they are willing to provide. As long as $\delta > 0$, H^C increases with γ because the more benefit R receives from care the more C will want to provide. H^C decreases with β because the more costly it is to provide care, the less of it C will do.

Grading notes: +2 points for correct FOC. +1 point for correct H^C. +2 points for correct interpretation of how each of the parameters influences H^C

3. (5 points) What quantity of H maximizes the utilitarian social welfare function? Denote this H^*.

Solution:

$$SWF = u_C + u_R = (1-\delta)\ln(y_c - \beta H) + (\delta + 1)\gamma \ln(H)$$

FOC:

$$\frac{1-\delta}{y_c - \beta H} * (-\beta) + \frac{(\delta+1)\gamma}{H} = 0$$

Solving this yields:

$$H^* = \frac{(\delta+1)\gamma y_c}{\beta(1-\delta) + (\delta+1)\gamma\beta}$$

4. (7 points) How do H^C and H^* compare? Are there values of δ, β, γ that get $H^C = H^*$? If so, state the combination and its associated H^* and explain intuitively why this is and what this means; if not, explain intuitively why not and what this means.

Solution: $H^C < H^*$ for any values of the parameters, except for $\delta = 1$. This means the only way to achieve the socially efficient optimal outcome is if C doesn't care at all its own consumption, and only cares about the utility of R. Intuitively, in this case, there really isn't a difference between the two people, and society's optimal outcome collapses to just be R's optimal outcome (which is $H = \frac{y_c}{\beta}$ because that's the maximum H that C can give given their budget constraint, i.e. when $y_c = c_c + \beta H^C \to y_c = \beta H^C$ because all other consumption $c_c = 0$).

Individuals in this society have traditionally been very community-oriented, so the value of δ has historically been relatively close to 1. In recent years, however, the society has become more individualistic-, causing δ to trend lower. Concerned that H^C is diverging too far from H^*, the government considers a policy to subsidize care-giving. In particular, the government now gives a subsidy s to C for each unit of H they provide, so that C's budget constraint is now $y_c = c + (\beta - s) * H$:

C's utility is given by:

$$u_C = (1 - \delta) * \ln(y_c - (\beta - s) * H) + \delta * u_R$$

R's utility is still given by:

$$u_R = \gamma \ln(H)$$

For the rest of the questions, you may assume $\delta = \frac{1}{2}$ and $\gamma = 1$.

5. (5 points) Find the level of s^* that would get C to provide H^* that you found in part 3. This should be in terms of β. (Note: Your answer in part 2 still applies, just replacing β with $\beta - s$).

> **Solution:** We notice that C will provide the same amount of care as found in part 2, except we can replace β with $\beta - s$. Therefore,
>
> $$H^C = \frac{\delta\gamma y_c}{(\beta - s)(1 - \delta) + \delta\gamma(\beta - s)}$$
>
> Plugging in $\delta = \frac{1}{2}$ and $\gamma = 1$,
>
> $$= \frac{y_c}{(\beta - s) + (\beta - s)}$$
>
> $$= \frac{y_c}{2\beta - 2s}$$
>
> To get this value to be equal to H^* found earlier, we solve:
>
> $$\frac{y_c}{2\beta - 2s} = \frac{\frac{3}{2}y_c}{\frac{1}{2}\beta + \frac{3}{2}\beta}$$
>
> $$\frac{1}{\beta - s} = \frac{\frac{3}{2}}{\beta}$$
>
> $$s^* = \frac{\beta}{3}$$

6. (5 points) If the government sets the subsidy to s^* found above, what budget would the government need to make sure its subsidy is fully funded? Denote this H^G. (Hint: At s^*, how much H does C provide?).

> **Solution:** If we denote the number of units of healthcare C provides when there is a subsidy s^* as $H^C(s^*)$, the total government spending in this case would be
>
> $$H^G = s^* * H^C(s^*) = \frac{\beta}{3} * \frac{y_c}{2\beta - \frac{2}{3}\beta} = \frac{y_c}{4}$$

The government is concerned that it is the subsidy program isn't the most efficient use of its resources. It is weighing whether directly providing care-giving services would be more efficient. Suppose the government decides to offer H^G

from part 6 directly to R such that

C's utility is given by:

$$u_C = \frac{1}{2} * \ln(y_c - \beta * H^C) + \frac{1}{2} * u_R$$

R's utility is given by:

$$u_R = \ln(H^C + H^G)$$

7. (6 points) For simplicity, assume that $\beta = 2$ and $y_c = 100$. Calculate the social welfare for when the government uses H^G you found in part 6 for subsidizing C-provided care, and compare it to the social welfare for when H^G is directly provided to R. Which policy should the government implement? (Note: When H^G is given directly to R, C will provide $y_c \frac{12-\beta}{16*\beta}$ in care. PLEASE DO NOT SOLVE BY HAND– USE A CALCULATOR AFTER SETTING UP THE EXPRESSIONS!).

Solution: For the subsidies,

$$SWF^{subsidies} = \frac{1}{2}\ln(y_c - (\beta - s^*)H^C(s^*))) + \frac{3}{2} * \ln(H^C(s^*))$$

$$= \frac{1}{2}\ln(y_c - (\beta - \frac{\beta}{3})(\frac{y_c}{\frac{4}{3} * \beta})) + \frac{3}{2} * \ln(\frac{y_c}{\frac{4}{3} * \beta})$$

$$= 7.393$$

For the government-provided care,

$$SWF^{gov't\ provided} = \frac{1}{2}\ln(y_c - \beta * H^C) + \frac{3}{2} * \ln(H^C + \frac{y_c}{4})$$

$$= \frac{1}{2}\ln(y_c - \beta * (\frac{y_c * (12 - \beta)}{16 * \beta}) + \frac{3}{2} * \ln(\frac{y_c * (12 - \beta)}{16 * \beta} + \frac{y_c}{4})$$

$$= 7.857$$

The government-provided care increases social welfare more than per-unit subsidies, so the government should provide care directly.

Grading notes: The note $H^C = y_c \frac{12-\beta}{16\beta}$ is mistaken: That's actually the socially optimum amount. Instead, the private optimum is actually $H^C = y_c \frac{4-\beta}{8\beta}$. This would yield $SWF^{gov't\ provided} = 7.595$. Give full credit for either answer.

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14.41 Public Finance and Public Policy
Fall 2024

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