Personalized Medicine: The Challenges for Public and Private Health Insurance

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Personalized Medicine Progress: Science, Institutions, Economics (Some Basic Questions)

- How fast will the required science progress?
- What are the roadblocks for institutional adoption?
- Will patients embrace genetic testing?
- Will patients take effective decisions based on genetic information?
- How will private health insurance contracts evolve?

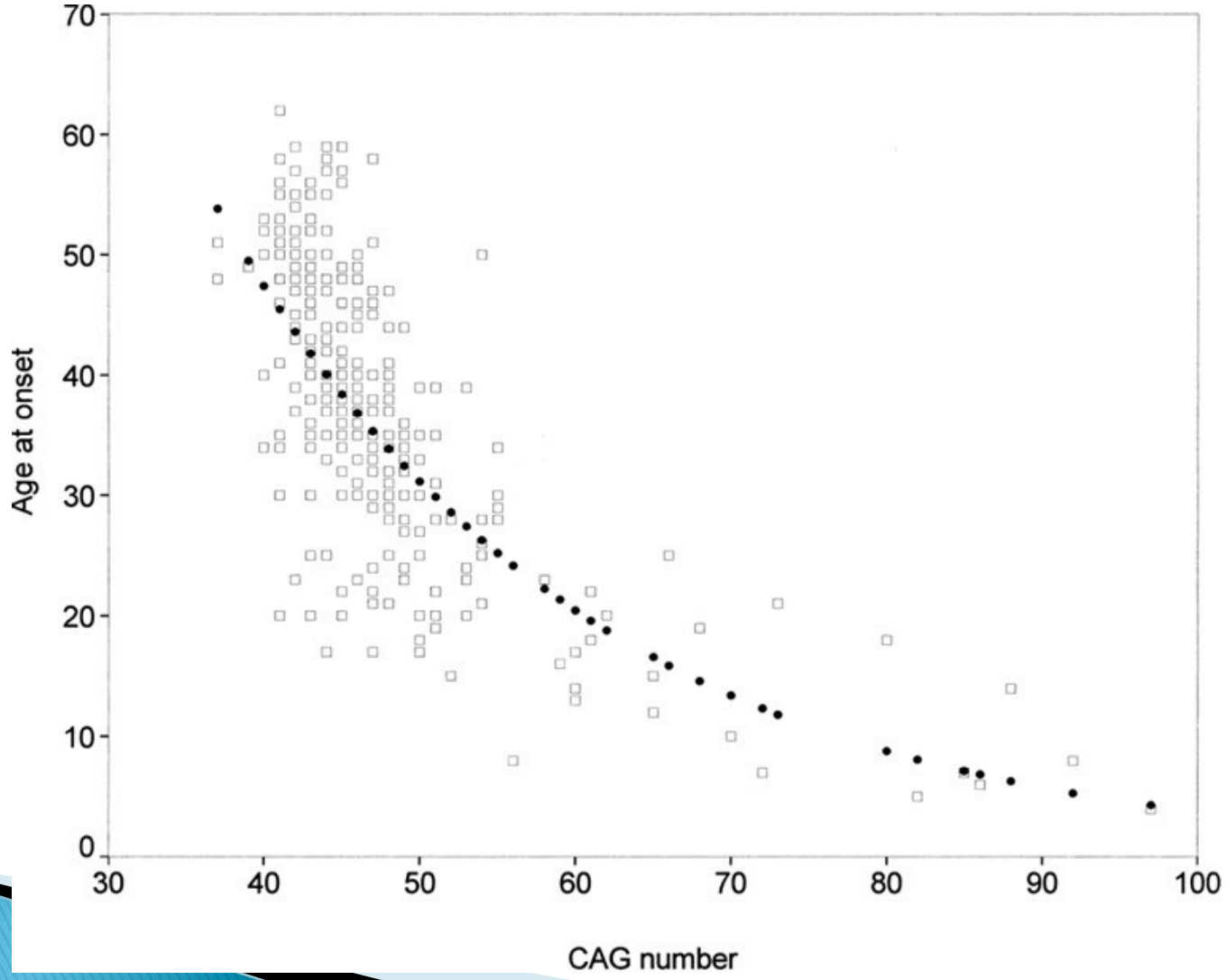
- **SO WHAT SHOULD ECONOMISTS FOCUS ON?**

How fast will the required science progress?

- Boosters and cynics
- Early view: Genetic Prophecy: Beyond the Double Helix by Dr. Zsolt Harsanyi, Richard Hutton, 1981, Bantam Books, Toronto
- Leroy Hood (a booster) – P4 Medicine Institute https://p4mi.org/leroy-hood-md-phd
- Predicted several years ago that "everyone" will have this (entire genome sequencing) done within 10 years.
- But understanding the genome is very challenging.
- Any pair of individuals differ by 6 million nucleotides plus face different environments.
- Many "simple" monogenetic diseases are even complicated (e.g., HD).

Even monogenic diseases not so straightforward!

https://insidehd.com/the-in-between-years-part-5-1786644b0eac



How fast will the required science progress? (More "cynical" view)

- Rutter, M., 2006. *Genes and Behavior: Nature-Nurture Interplay Explained.* Blackwell Publishing, Oxford, UK.

- p. 5: points out "…we are only just learning how to pursue the long path from gene discovery to determination of the causal processes."

- His estimation is that this "long path" will take many years and perhaps decades.

How fast will the required science progress? (Middle, Measured Viewpoint)

- Wilson, B.J. and Nicholls, S.G. (2015), "The Human Genome Project, and recent advances in personalized genomics," *Risk Management and Healthcare Policy*, vol. 8, pp. 9–20
- P. 11 – "Setting aside the rare monogenic forms of usually complex disorders, individual genetic variants generally confer only a small increase in individual disease risk, and even panels with multiple variants are poor at discriminating disease risk in individuals."
- P. 13 – "Panels with an inadequate number of variants will have low sensitivity, with the possibility of erroneous re-classification of some individuals to lower risk strata."
- p. 15 – "Over this 5-year period (2009 – 2013), more than 49,000 scientific articles on human genomics were published, of which only 519 were clinical trials, and 52 were reviews designed to inform clinical policy."

How fast will the required science progress? (Effect on "other" Economic Research)

- Human Capital and Economic Opportunity Global Working Group – https://hceconomics.uchicago.edu/research/papers
- Use of polygenic score to "explain" important economic phenomena (education, wealth, etc.)
- Barth, et al. (2018), HCEO Working Paper no. 2018-077, "Genetic Endowments and Wealth Inequality," $PGS_i = \sum \widehat{\beta}_i SNP_{ij}$
- They conclude; "…, our study illustrates how economists can benefit from results in behavioral genetics that link specific genetic endowments to economic outcomes."

Room for optimism for certain individual diseases

- Phenylketonuria (PKU): lack of a liver enzyme needed to convert an amino acid, phenylalanine to another amino acid, tyrosine.
- If it is not caught early, can cause mental retardation, brain damage and seizures.
- Treatment consists of a phenylalanine restricted diet and the use of a cofactor (BH4) to reduce phenylalanine in the blood.
- Alzheimer's and APOE genes.

BRCA1,2

- Petrucelli et al. (2015) “BRCA1 or BRCA2 pathogenic variant … (carries) … a lifetime risk ranging from 46% to 87%.”
  https://www.ncbi.nlm.nih.gov/sites/books/NBK1247/
- Guardian newspaper –(Nikola Davis)
  https://www.theguardian.com/science/2016/dec/14/angelina-jolie-effect-boosted-genetic-testing-rates-study-finds-breast-ovarian-cancer
- New test with greater accuracy (involving more genes) suggest dropping radical mastectomies response from 50% to 36%. Nicola Slawson:
  https://amp.theguardian.com/society/2017/oct/08/test-for-breast-cancer-risk-could-reduce-pre-emptive-mastectomies

Roadblocks for institutional adoption

- Cost and development of required expertise!!!
- Need to convince patients that their privacy is well protected.
- Powles (2017) reported that in 2015 the NHS in Britain disclosed ultimately identifiable patient records. (Royal Free London National Health Service A&E department (gifted) transferred 1.6 million patient records to Google's DeepMind.)
- Data hacking seems almost commonplace.

(Powles, J., 2017. Why are we giving away our most sensitive health data to Google? The Guardian, viewed 5 July 2017, https://www.theguardian.com/commentisfree/2017/jul/05/sensitivehealth-information-deepmind-google)

Privacy Issues – individuals and organizations

- See Miller and Tucker (2017), "Privacy Protection, Personalized Medicine, and Genetic Testing," ***Management Science***, Articles in Advance, pp. 1–21

- Ask question whether privacy regulation promotes or hinders use of genetic information (i.e., protection vs. sensitization of consumers and legal worries of health care entities).

Privacy Issues – cont'd

- Examples of "mistakes" and "data breaches".
- Sale of data not realizing privacy leaks (NHS).
- For incidental results of genetic tests: Responsibility to inform vs. Right not to know.
- Data hacking (of course).
- Examples – see Durnin and Hoy (2018)

Will patients embrace genetic testing?

- Meiser and Dunn (2000) report free testing for individuals at risk for HD accepted by only 9% to 20% (various clinics in UK and Vancouver)

- Levy, et al. (2011) report that only 30% of newly diagnosed early onset breast cancer patients choose to have a genetic test to guide treatment.

- See Hoy, Peter, Richter (2014), “Take-up for genetic tests and ambiguity,” JRU, for some summary evidence and review some relevant literature (e.g., Koszegi (2003), Caplin and Eliaz (2003))

Will patients take effective decisions based on genetic information?

- The answer appears to be **NO**, with exceptions.
- Handel and Kolstad, AER 2017- "Wearable Technologies and Health Behaviors: New Data and New Methods to Understand Population Health")
- H&K (2017) – suggest individuals need help – monitoring and support for good health decisions + use of wearables and other IT tools.
- Would financial incentives help?

Will Reactions of Private Health Insurance Providers Help or Hinder Progress?

- Insurers' goal is to screen out bad risks if they aren't willing to pay extra cost.
- Even under current regulation, plans vary by Actuarial Value: Bronze (60%), Silver (70%), Gold (80%), Platinum (90%).
- There is substantial variation in costs of plans even within a metal tier.
- Will DTC genetic tests exacerbate problems for private insurer market?

Research Phase 1: Equity and fairness

Should insurers be banned from using Genetic Tests?

Research Phase 2: How to make effective use of genetic information

More sophisticated use of policy instruments – mandates, etc.

To Ban or Not To Ban?
Why is this question so difficult?

Competing Conceptions of Fairness

Competing Predictions of Market Implications

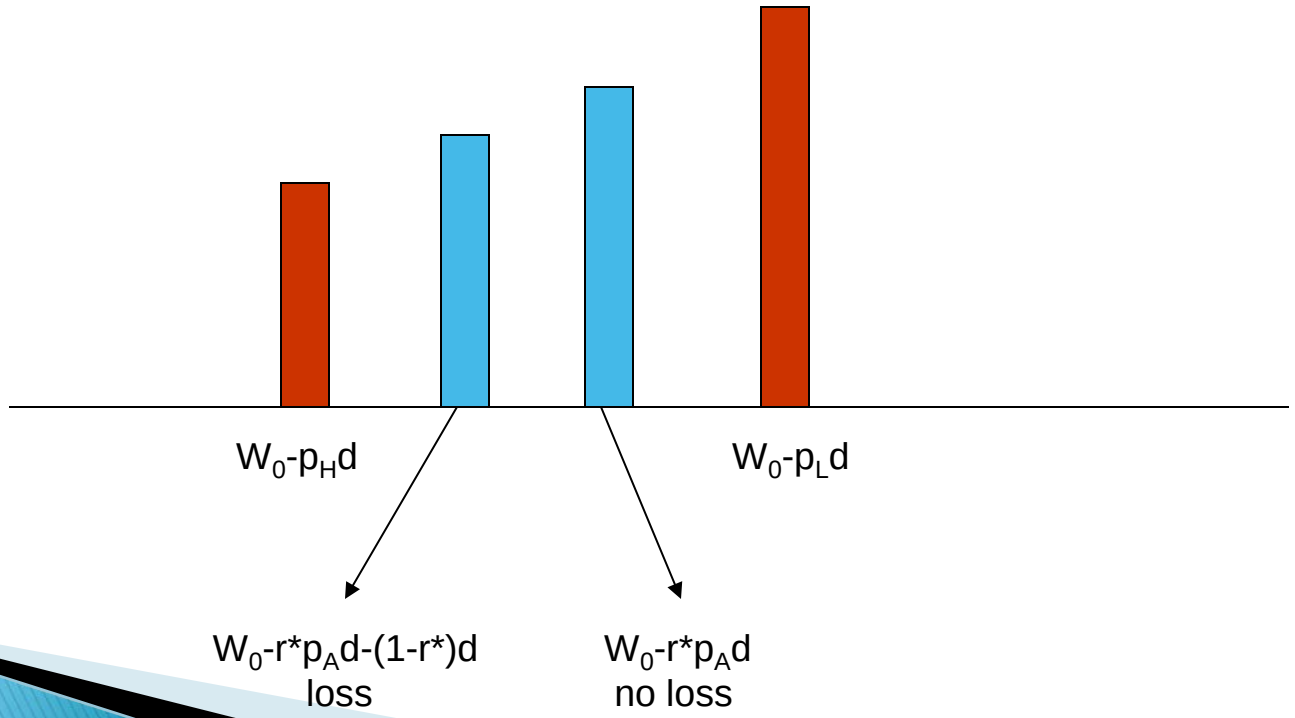
The Problem of Reclassification Risk (Effect of a ban – Classic Rothschild-Stiglitz Model)

- Consumers identical risk preferences and wealth (W)
- Single possible loss (size d $<$ W)
- Two risk types – $p_L < p_H$, average – p_A
- Ignore all costs except claim costs
- Perfectly competitive market and risk neutral firms
- Nonexclusive contracting → pooling equilibrium
- Initially everyone knows his/her risk type OR thinks he/she is an average risk.

First, suppose every one knows his/her risk type

Risk-rating Allowed – Premium Risk

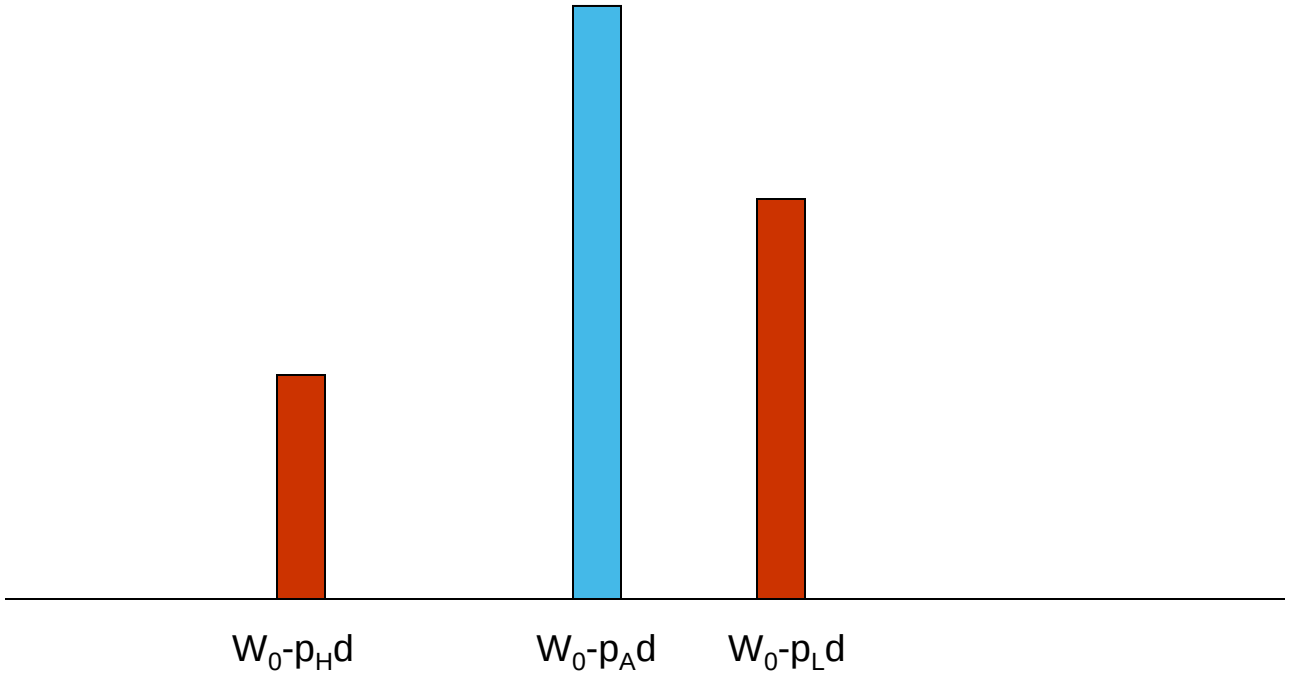
Ban on Risk-rating (pooling) – Partial Coverage Risk



Now, suppose every one is initially uninformed about his/her risk type

Spot Market Insurance – Premium Risk

Full coverage Guaranteed Renewable Insurance Purchased



Does GR Insurance effectively limit reclassification risk?

- Increasing knowledge about both risk type and demand type over time creates problems for GR insurance.

- At what age should one assess an individual's cost of reclassification risk? Before birth (veil of ignorance approach)? Age of first purchase of insurance contract?

How should economic research progress?

- System or individual disease approach? (both?)
- Model patient behaviour carefully for information acquisition and for health care decisions.
- Improve understanding of privacy concerns from patient perspective.
- Spillover effects of health/genetic information (e.g., life insurance, LTC insurance).
- Model institutions (including physicians).

Managing Genetic Tests, Surveillance and Preventive Medicine Under a Public Health Insurance System

Based on work with Lilia Filipova-Neumann (2014)
and work in progress with Wanda Mimra

Preview of Some Questions and Results

- Need to understand interaction of individual incentives (moral hazard in use of surveillance/prevention) and financial cost of health care to determine value of a genetic test.

- May need to restrict or encourage use of surveillance and prevention strategies (in unintuitive ways) to secure social welfare improvements.

- That is; it is not obvious which types (low risk or high risks) will under or over-utilize).

Preview of Some Questions and Results (cont'd)

- "Curvature" conditions on value of information and equilibrium cost schedule (as a function of probability of disease) are critical.

- Under public insurance (no risk-rating) individuals may voluntarily demand a genetic test that makes them worse off (in equilibrium) – a prisoner's dilemma type problem.

- Under private insurance and symmetric information (full risk-rating), individuals in our simple model desire a genetic test only if it is welfare improving from an interim efficiency perspective.

Disease onset and early/late detection:

Probability of disease: ρ

Detected early (E) or late (L).

Medical surveillance (monitoring) - s - improves probability of early detection

$p^{ED}(s)$: with $p^{ED'}(s) > 0, \quad p^{ED''}(s) < 0.$

Personal disutility of disease:

$$\kappa_L > \kappa_E > 0$$

Personal disutility of surveillance:

$$\Phi(s), \quad \Phi'(s) > 0 \quad \text{and} \quad \Phi''(s) > 0$$

Expected Utility:

$$EU(s) = u(y - TC) - \rho[(1 - p^{ED}(s))\kappa_L + p^{ED}(s)\kappa_E] - \Phi(s)$$

Financial/Insurance cost of medical care:

Financial cost of treating disease:

$$C^{DL} > C^{DE}$$

Financial cost of providing surveillance:

$$C(s),\ C'(s) > 0,\ C''(s) > 0.$$

Per capita (expected) cost of providing health care:

$$TC(s) = \rho[p^{ED}(s)C^{DE} + (1 - p^{ED}(s))C^{DL}] + C(s)$$

Example of Disutility and Cost of Surveillance Colon Cancer Low s: FOBT

- Cost is low - Congress report OTA-BP-H-146 (1995) - $10.
- {sensitivity, specificity} in regards to detection of cancer are {40%, 90%}, so not so effective.
- Especially poor at detecting polyps with sensitivity of 10%.

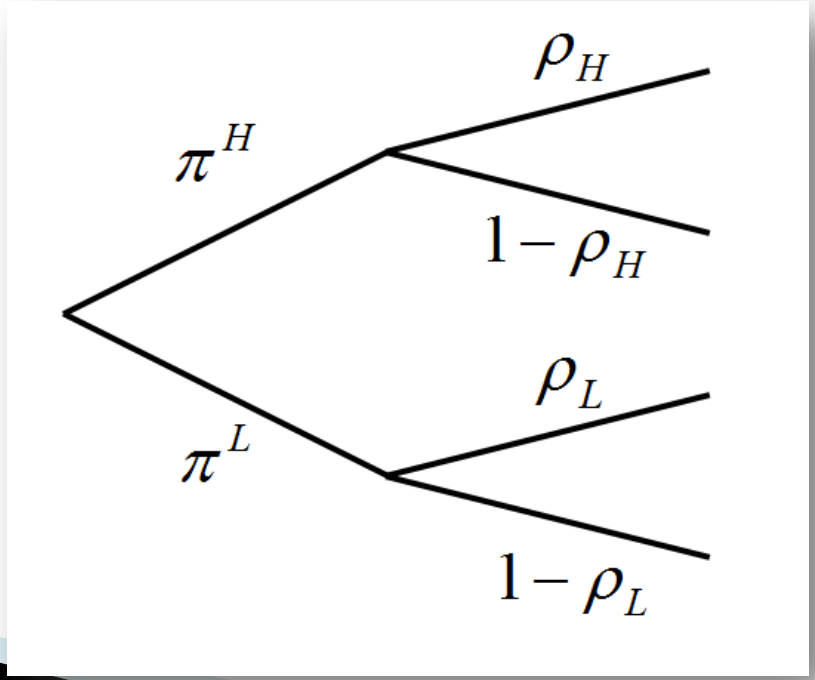
Example Cont'd
High s: CSCPY

- Monetary cost is higher - Congress report OTA-BP-H-146 (1995) - $285.
- {sensitivity, specificity} in regards to detection of cancer are {90%, 100%}, so more effective.
- Also quite good at detecting polyps with sensitivity of 90%.
- But DISUTILITY is also higher (includes possibility of "Nicking" – perforation of bowel).

Model: *Initial Information Structure*

- People hold beliefs π^H and π^L about whether they have the genetic mutation or not.

- Hence, their information structure prior to testing is given by



$$\rho^0 = \pi^L \rho_L + \pi^H \rho_H$$

represents the population (average) probability of disease

Information

Before a GT:

ρ^0 - population average probability of disease

After a GT:

ρ^H - for those who test positive

ρ^L - for those who test negative

η_H (η_L) - fraction who test pos (neg)

ε - parameter for predictive power of GT

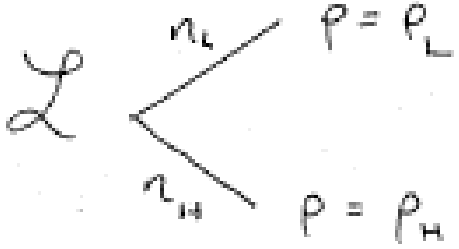
$$\rho^L = \rho^0 - \frac{\varepsilon}{\eta_L}, \quad \rho^H = \rho^0 + \frac{\varepsilon}{\eta_H}$$

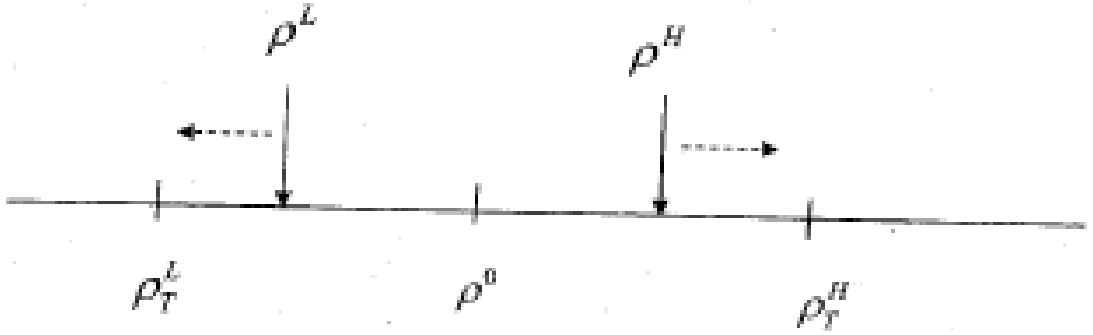
$$\rho^0 = \eta_L \rho^L + (1 - \eta_H)\rho^H$$

So, a *GT* is a mps in probabilities:

No GT

With GT





smaller rate of false negatives

smaller rate of false positives

Privately optimal demand for surveillance and acceptance of genetic tests

From a private perspective $\frac{\partial \overline{TC}}{\partial s} = 0$.

$$FOC: \rho \cdot p^{ED'}(\hat{s}) \cdot (\kappa_L - \kappa_E) - \Phi'(\hat{s}) = 0$$

Applying the implicit function theorem:

$$\frac{d\hat{s}}{d\rho} = -\frac{p^{ED'}(s)(\kappa_L - \kappa_E)}{\rho \cdot p^{ED''}(s) \cdot (\kappa_L - \kappa_E) - \Phi''(s)} > 0$$

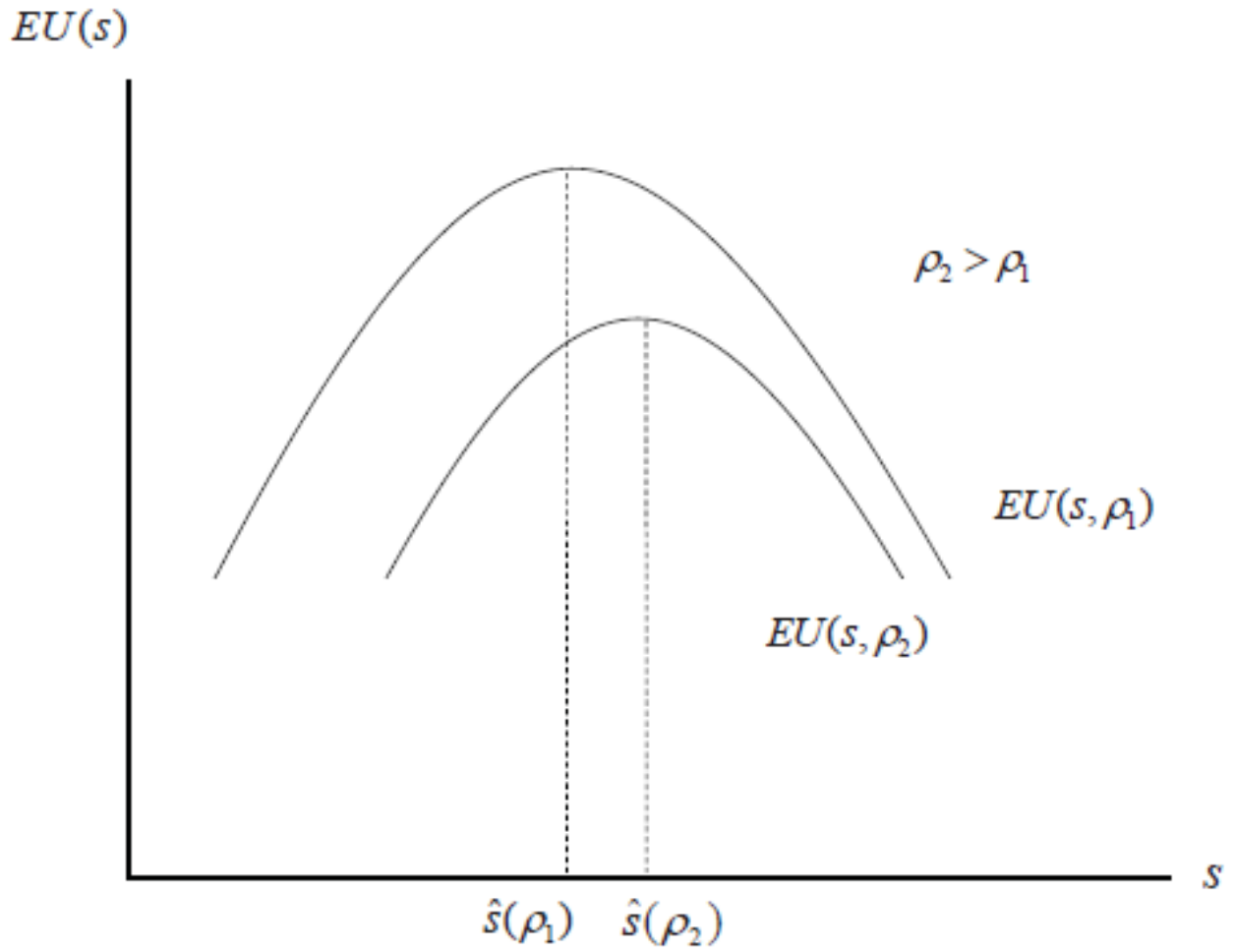
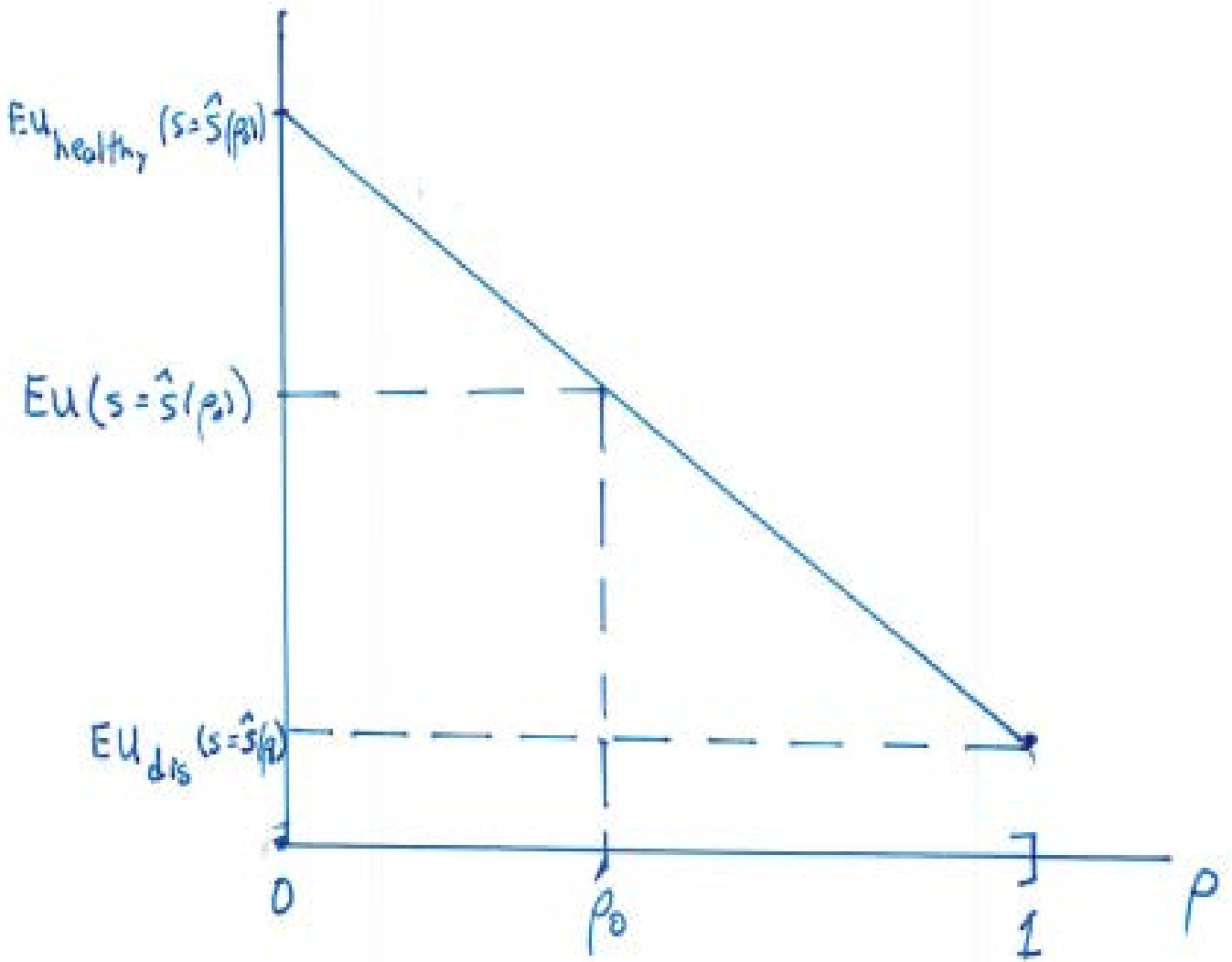
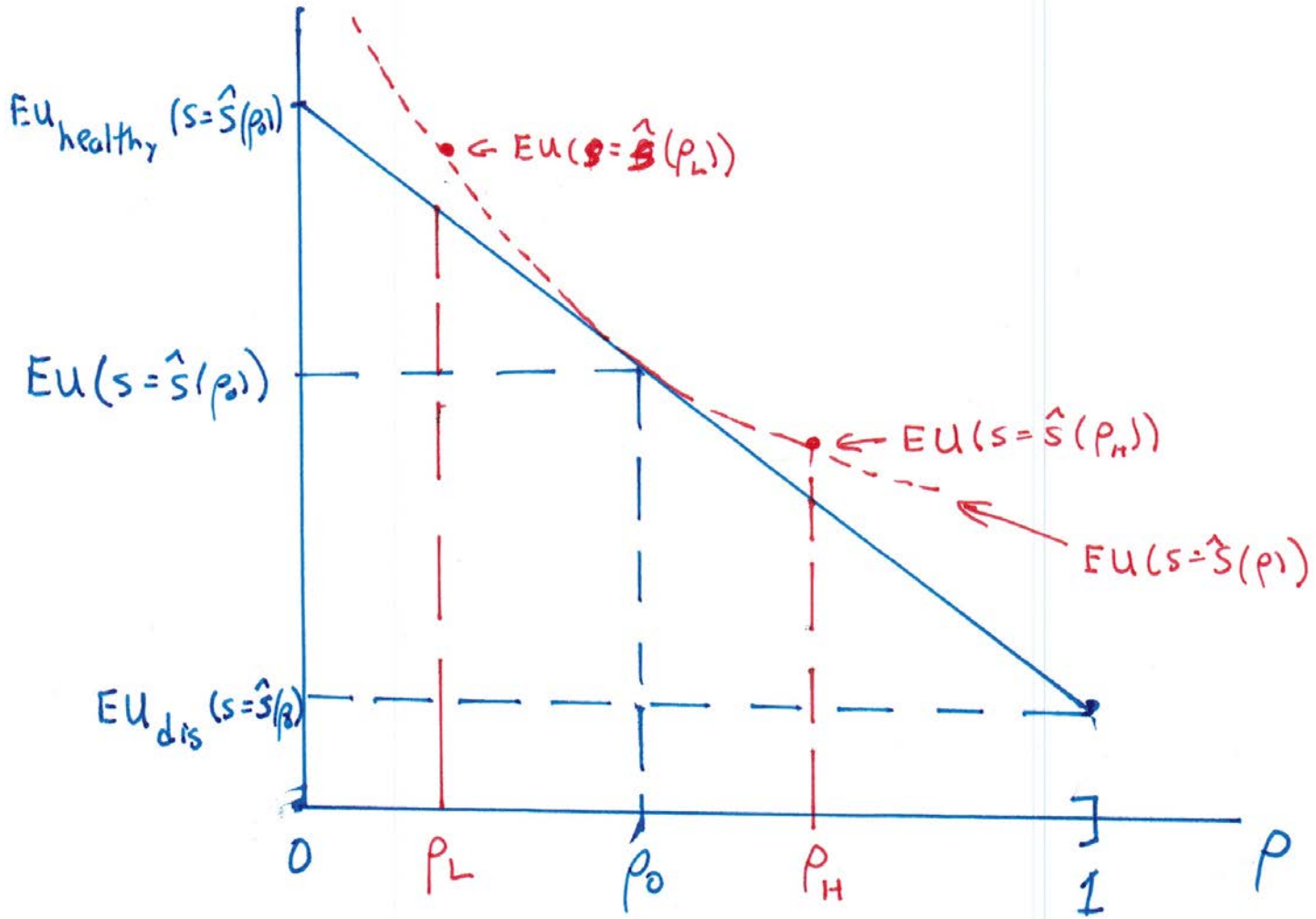


Figure 3: Shift of expected utility due to increase of probability of disease

Under what conditions will a GT create private value?

- First solve for optimal level of surveillance as a function of disease probability, s(ρ).
- Substitute s(ρ) into the utility function to find the value function.
- Determine if value function (excluding cost) is convex in ρ.
- If it is, then the GT creates value (mps in probabilities increases expected value function).


$EU_{healthy}(s=\hat{s}(p_0))$
$EU(s=\hat{s}(p_0))$
$EU_{dis}(s=\hat{s}(p_0))$
0
p_0
1
p


$EU_{healthy}(s=\hat{s}(\rho_0))$
$EU(s=\hat{s}(\rho_L))$
$EU(s=\hat{s}(\rho_0))$
$EU(s=\hat{s}(\rho_H))$
$EU(s=\hat{s}(\rho))$
$EU_{dis}(s=\hat{s}(\rho))$
0
ρ_L
ρ_0
ρ_H
1
ρ

Welfare Problem

- Each individual ignores his choice of s on health care costs.
- Thus, we need to determine how TC is affected by changes in ρ and how this affects the value function.
- TC enters negatively into the value function (of utility). Thus, if $TC^e(\rho)$ is convex in ρ, then this can create a negative value for the GT.

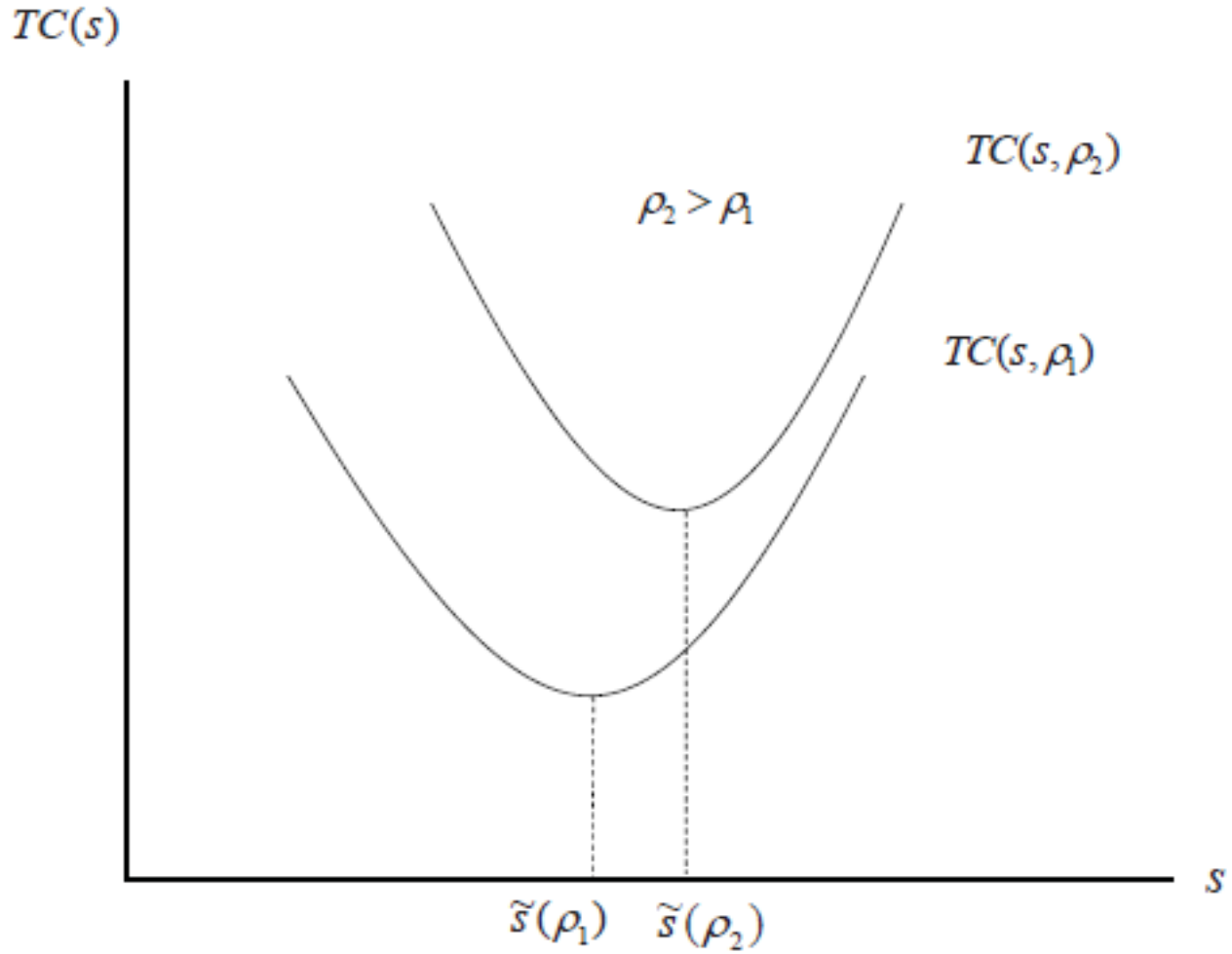
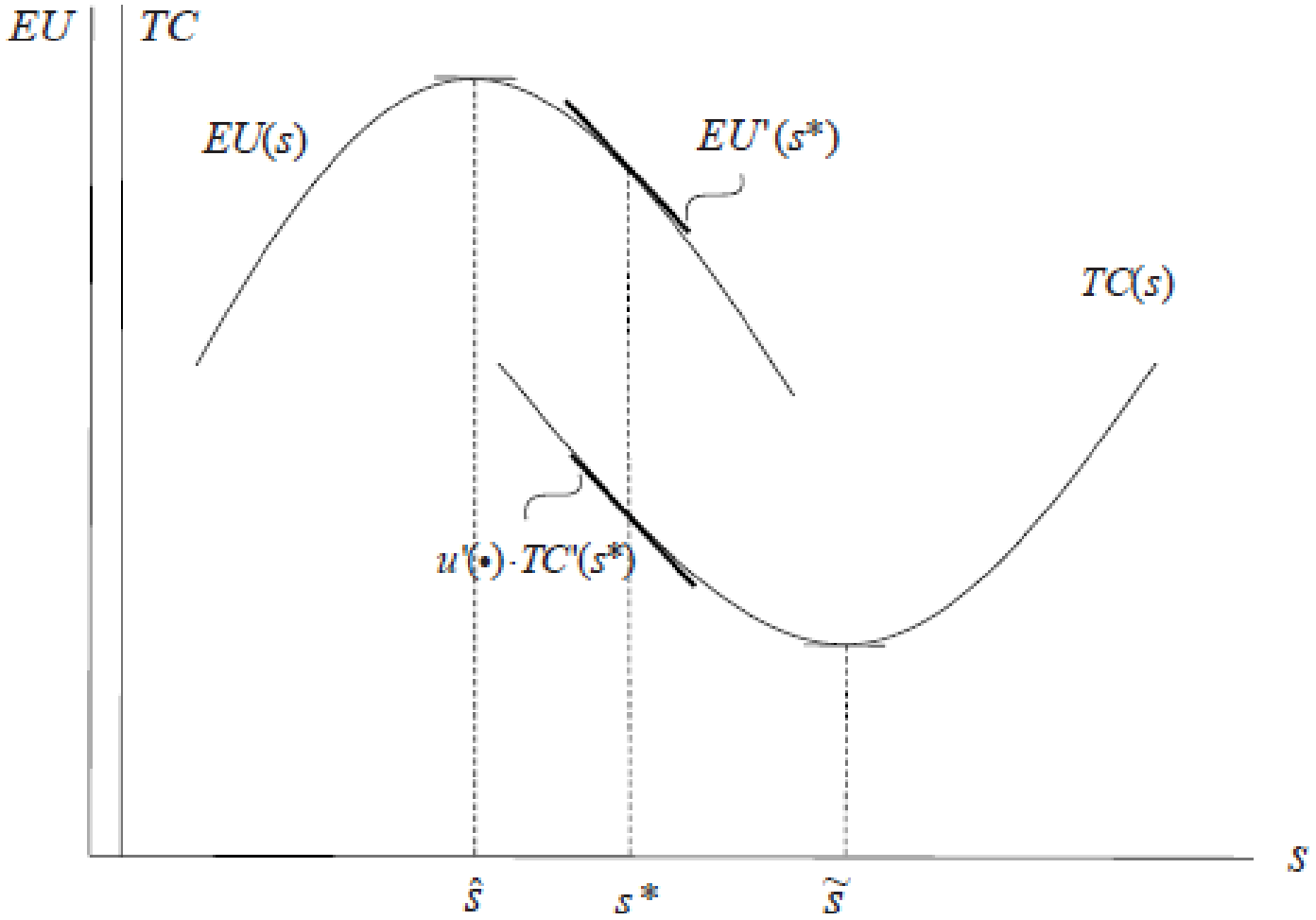
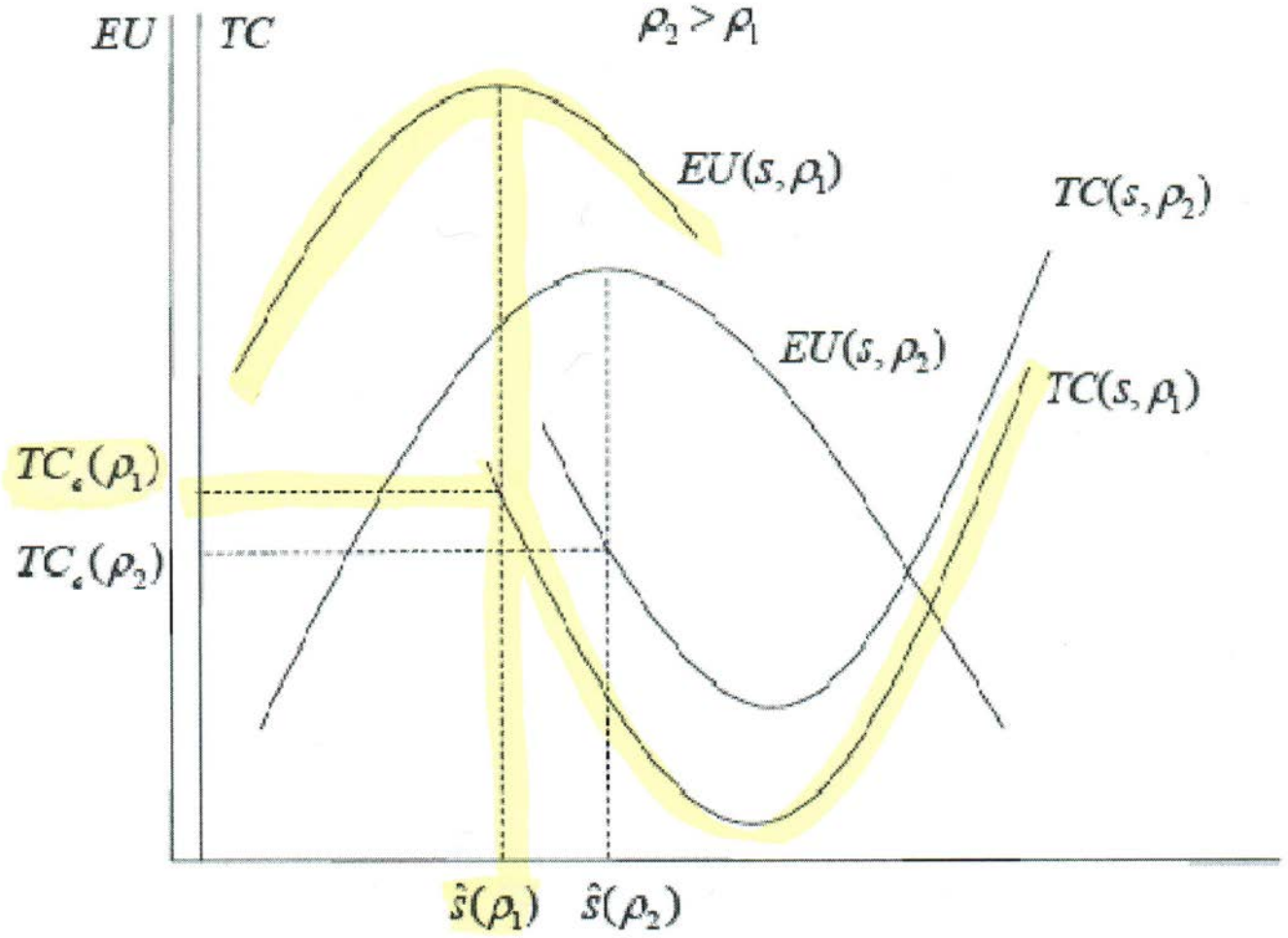


Figure 4: Shift of per capita cost of health care due to increase of probability of disease

Underutilization possibility:



Demonstration that $TC^e(\rho)$ may be decreasing in ρ:



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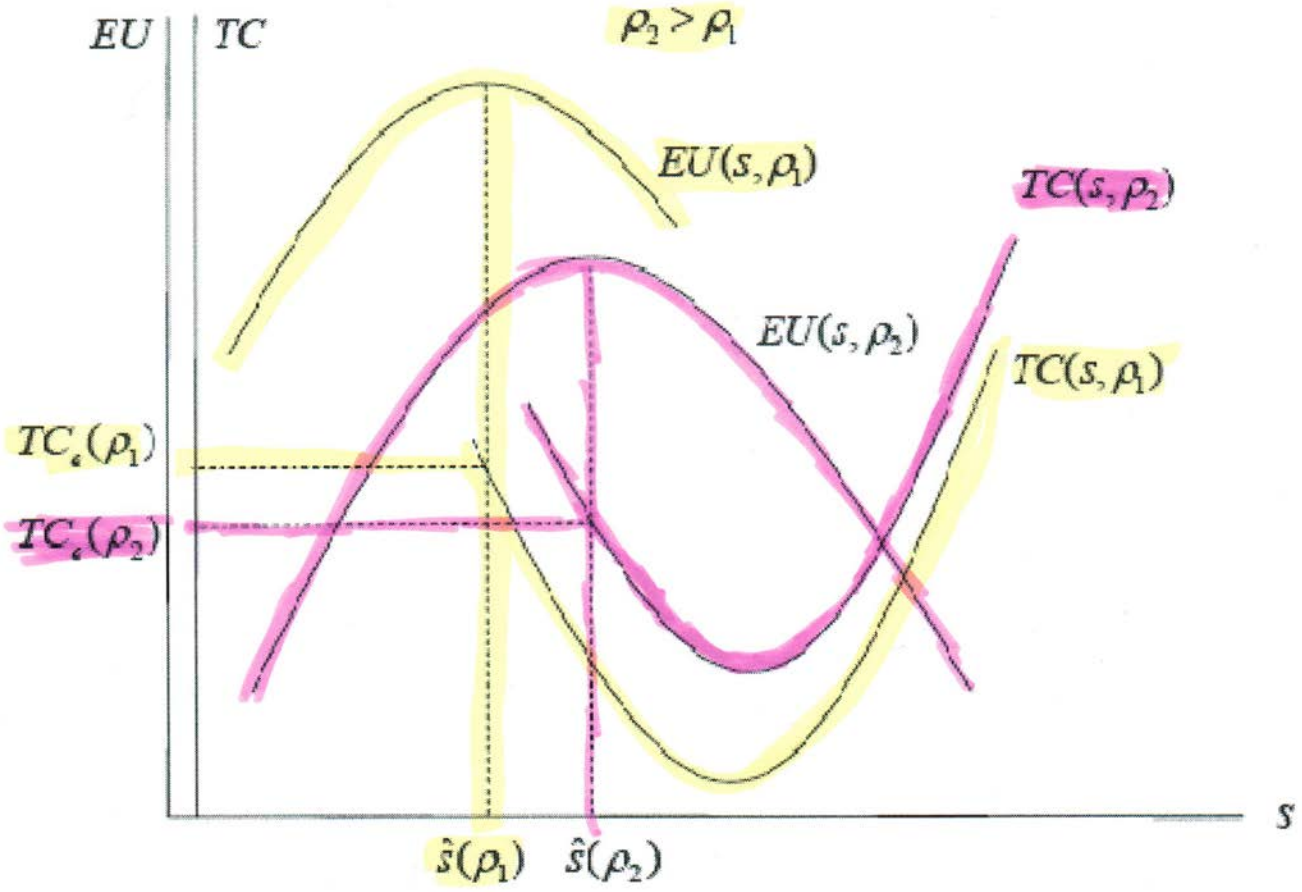


Proposition 1

- Individual always obtains a GT.
- If $TC^e(\rho)$ is concave (or linear), individuals' welfare is improved in equilibrium.
- If $TC^e(\rho)$ is strictly convex, welfare effect depends on balance of (disadvantageous) increase in (average) financial cost of medical care due to GTs and improved personal benefits from better surveillance decisions.

First-best Social Welfare Analysis:

- If individuals can choose their level of surveillance, then costless genetic tests may or may not lead to an improvement in social welfare?

- If individual choices of surveillance level can be “totally managed”, costless genetic tests will lead to an improvement in social welfare.

Social Optimum (First Best) - Results

- For social optimum, an increase in ρ increases TC_e (for s fixed) and so MU of income rises implying marginal cost of s rises (since financial cost of s is also internalized, unlike for privately optimal decision).

- Thus, s* may fall when ρ increases due to this financial cost-effect. (NOTE: For privately optimal decision this channel doesn't exist because s is treated as costless.)

- A variety of patterns of comparison between the socially optimal and individually optimal levels of self-protection for L-types and H-types is possible.

Challenges for Providing Appropriate Incentives

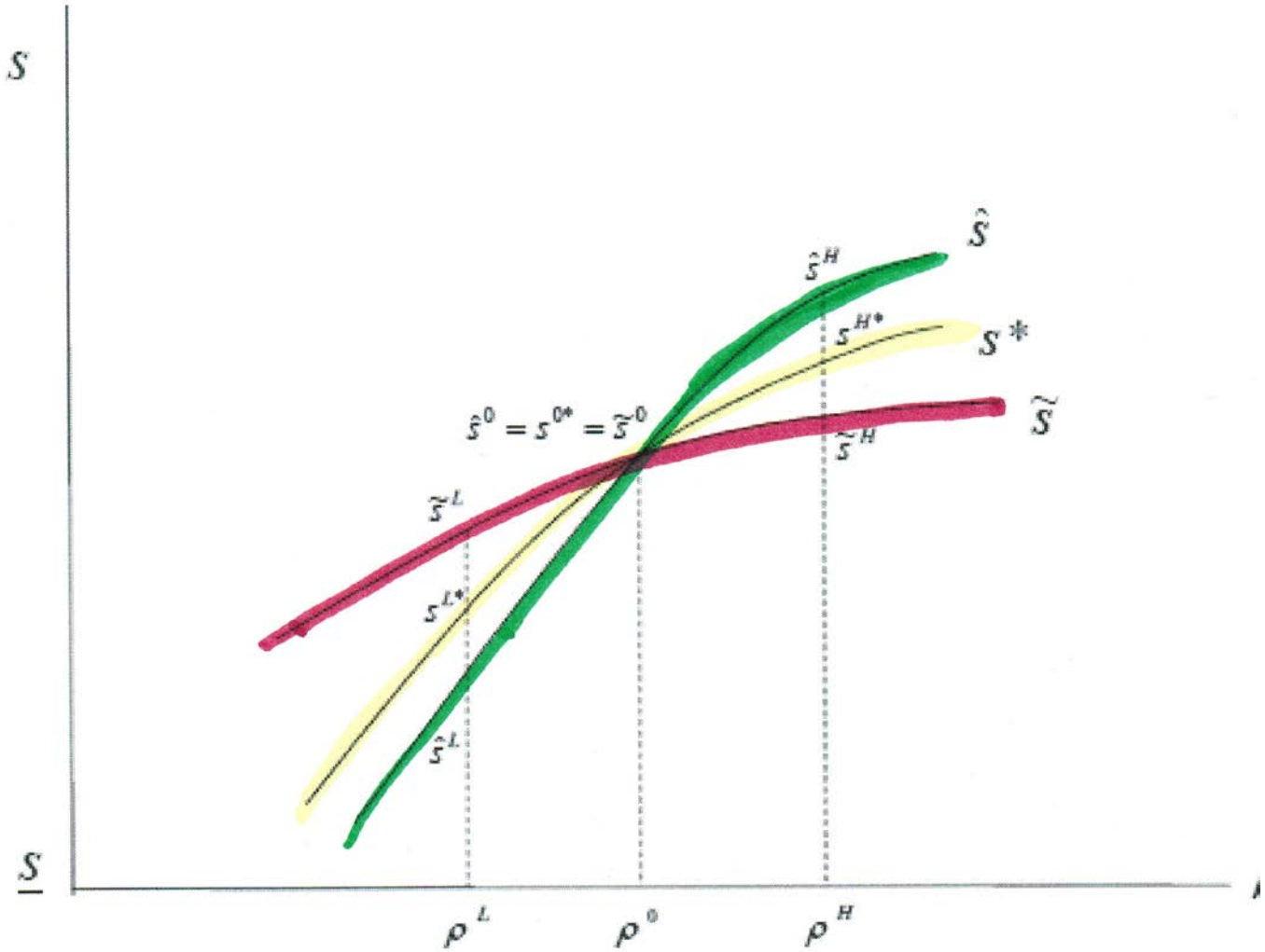
- Over-use of surveillance can be (partially) corrected by rationing or user fees for surveillance.
- Under-use of surveillance can be (partially) corrected by co-payments for treatment costs (since $C^{LD} > C^{ED}$)
- However, even with identical preferences, one risk type may over-use surveillance while the other under-uses surveillance.
- Are risk-type specific user fees or co-payments politically feasible?
- If preferences differ in other dimensions (e.g., disutility of surveillance), the above policies become more complicated.

Thanks for your participation!

And

Thanks to the organizers!

Case 1: H-types over-utilize, L-types under-utilize



Case 2: L-types over-utilize, H-types under-utilize