Helping Patients and Physicians Reach Individualized Medical Decisions: Theory and Application to Prenatal Diagnostic Testing

Edi Karni, Moshe Leshno, and Sivan Rapaport

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- **Normative** - The presumption is that the patient would like his decision to be governed by the principles (axioms) of expected utility theory, which we take as normatively compelling.
- **Non-paternalistic** - the recommended course of action maximizes the patient's expected utility, but is silent on what this utility should be. The patient is the ultimate arbiter of his own well-being.

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- λ and v - "utility cost," (e.g., the pain or discomfort) associated with actions.

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$$\pi(x,\omega) = \left[x^{r(\omega)} + 1 - r(\omega)\right] \frac{\sigma^2_{\tilde{\varepsilon}}}{2}, \omega \in \Omega.$$

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- Combining these results we ascribe to the patient the utility functions

$$U(x,\omega) := b(\omega)\left[-e^{\frac{-x^{r(\omega)}}{r(\omega)}}\right]+d(\omega), \omega \in \Omega.$$

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- Patients' preferences are represented by expected utility functional

$$\left[b(\omega_0)\left(-e^{\frac{-(x-\varphi(a))^{r(\omega_0)}}{r(\omega_0)}}\right) + d(\omega_0)\right] p(\omega_0 \mid a, c) +$$
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- Both procedures performed by average physicians in a facility of one of the HMOs is fully covered.

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- We fixed $u(x, \omega_0) = 0$ and $u(y, \omega_0) = 1$ and solved for

$$b(\omega_0) = \frac{1}{-e^{\frac{-x_1(\omega_0)^{r(\omega_0)}}{r(\omega_0)}} + e^{\frac{-x_0(\omega_0)^{r(\omega_0)}}{r(\omega_0)}}}, \; d(\omega_0) = \frac{e^{\frac{-x_0(\omega_0)^{r(\omega_0)}}{r(x_1,\omega_0)}}}{-e^{\frac{-x_1(\omega_0)^{r(\omega_0)}}{r(\omega_0)}} + e^{\frac{-x_0(\omega_0)}{r(\omega_0}}}$$

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- We obtain

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and

$$d(\omega_1) = \frac{1}{p_j(\omega_1)}\left[b(\omega_0)\left(-e^{\frac{-y(\omega_0)^{r(\omega_0)}}{r(\omega_0)}}\right) + d(\omega_0)\right] + b(\omega_1)\, e^{\frac{-x^{r(\omega_1)}}{r(\omega_1)}}.$$

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- Non of the participants in either study were unreasonable according to (a) and only 9% of the respondents in the CVS study and 3% of the participants in the amniocentesis study were qualified as unreasonable according to (b).
- Thus, broadly speaking, the participants in the study seem able to give useful answers.

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- In the amniocentesis study12% of the women participating exhibit higher degree of risk aversion in the state of continued pregnancy and 12% exhibit higher degree of risk aversion in the state of fetus loss. Thus, the outcomes do not seem to bias the risk attitudes in a systematic manner.

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- Most women (70% in the CVS study and 76% in the amniocentesis study) display the same risk attitude in the two outcome (that is, $\pi(x, \omega_0) = \pi(x, \omega_1)$). Thus, for the great majority, the risk attitudes are outcome-independent.
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- In the amniocentesis study12% of the women participating exhibit higher degree of risk aversion in the state of continued pregnancy and 12% exhibit higher degree of risk aversion in the state of fetus loss. Thus, the outcomes do not seem to bias the risk attitudes in a systematic manner.

Results: II

- Further examination of the responses indicate the following general features
- Most women (70% in the CVS study and 76% in the amniocentesis study) display the same risk attitude in the two outcome (that is, $\pi(x, \omega_0) = \pi(x, \omega_1)$). Thus, for the great majority, the risk attitudes are outcome-independent.
- Among the women that display outcome-dependent risk attitude (30% in the CVS study and 24% in the amniocentesis study) 18% of the women in the CVS study exhibit higher degree of risk aversion in the state of continued pregnancy (that is, $\pi(x, \omega_0) > \pi(x, \omega_1)$) and 12% exhibit higher degree of risk aversion in the state of fetus loss (that is, $\pi(x, \omega_0) < \pi(x, \omega_1)$).
- In the amniocentesis study12% of the women participating exhibit higher degree of risk aversion in the state of continued pregnancy and 12% exhibit higher degree of risk aversion in the state of fetus loss. Thus, the outcomes do not seem to bias the risk attitudes in a systematic manner.

Case study I

- This patient's initial wealth is: $x = 1,500,000$ *NIS*

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- $r(\omega_0) = 0.32, \quad r(\omega_1) = 0.21$

Case study I

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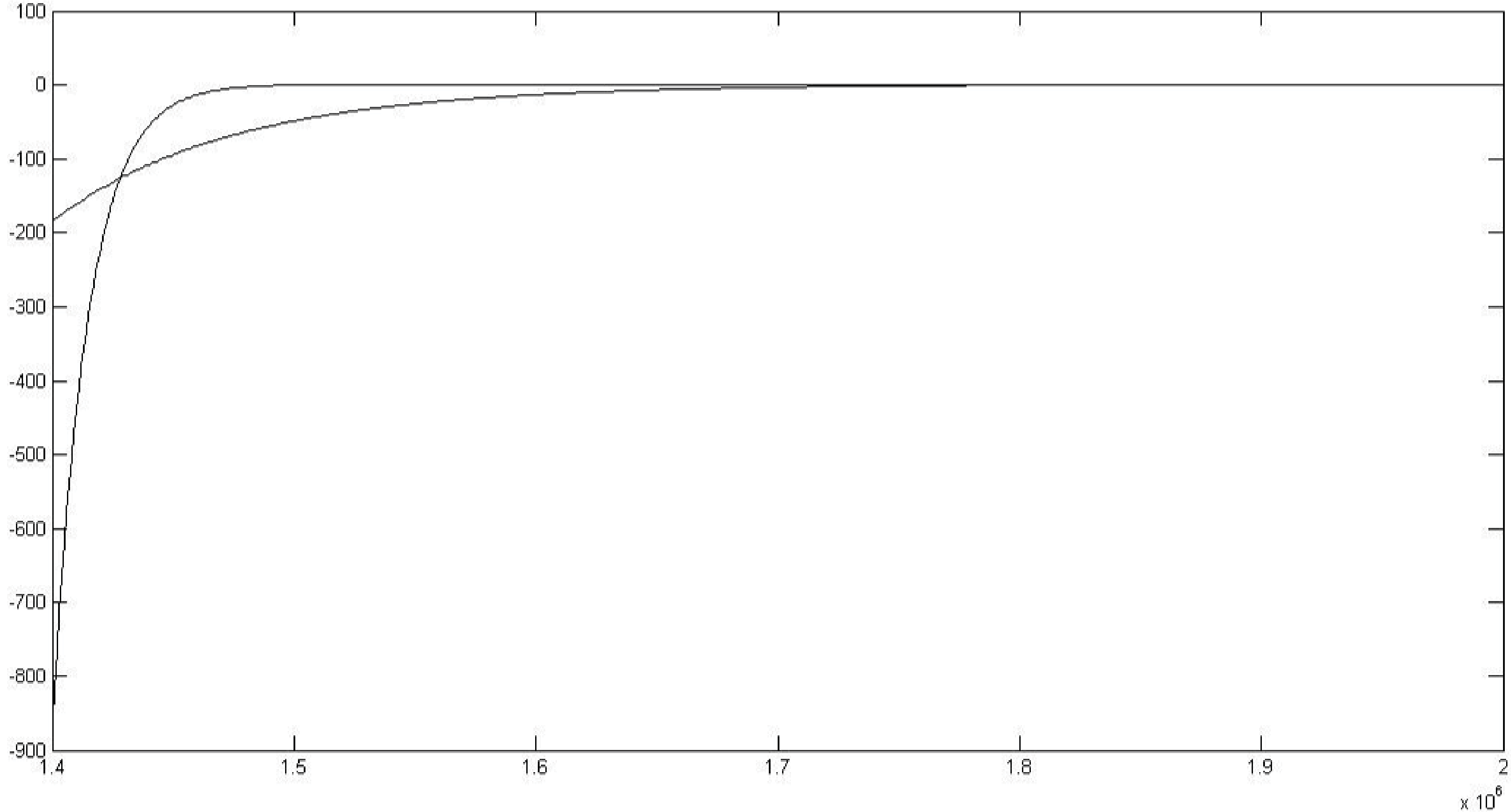
- He was asked to imagine winning *I* million *NIS*, so that $y = 2,500,000$
- $r(\omega_0) = 0.32, \quad r(\omega_1) = 0.21$
- This patient utility function is depicted in the below.



100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
1.4
1.5
1.6
1.7
1.8
1.9
2
x 10^6

	Average Free	Average 570 *NIS*	Expert (In both cases)
$p_{CVS}(\omega_1) = 0.5\%$	3,186 *NIS*	3,671 *NIS*	*Average*
$p_{CVS}(\omega_1) = 0.25\%$	4,636 *NIS*	4,500 *NIS*	*Expert*
$p_{CVS}(\omega_1) = 0.1\%$	5,646 *NIS*	4,500 *NIS*	*Expert*

Case study II

- This patient's initial wealth is: $x = 3,000,000$ *NIS*

Case study II

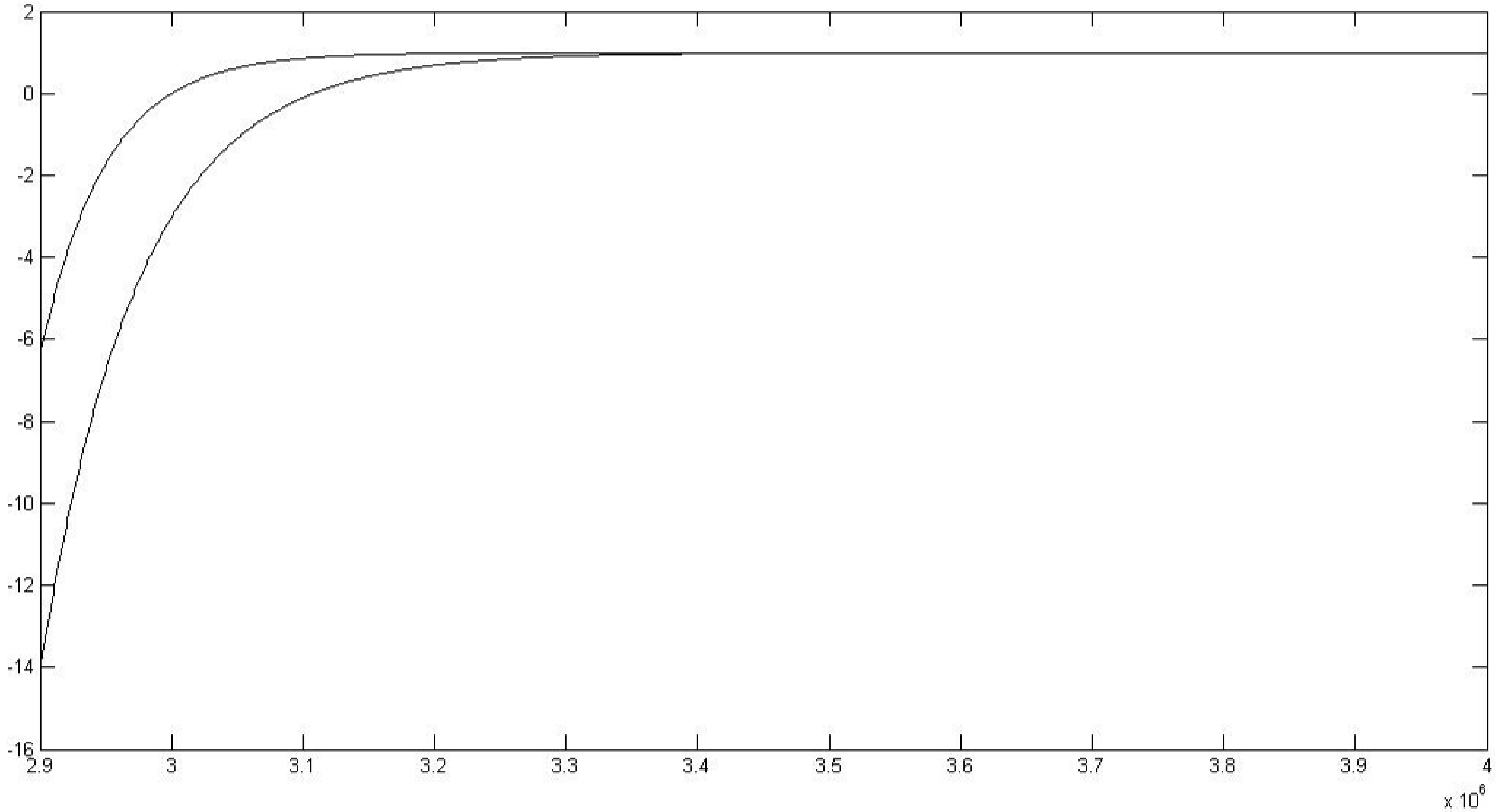
- This patient's initial wealth is: $x = 3,000,000$ *NIS*
- He was asked to imagine winning *I* million *NIS*, so that $y = 4,000,000$

Case study II

- This patient's initial wealth is: $x = 3,000,000$ *NIS*
- He was asked to imagine winning *I* million *NIS*, so that $y = 4,000,000$
- $r(\omega_0) = 0.27, \quad r(\omega_1) = 0.25$

Case study II

- This patient's initial wealth is: $x = 3,000,000$ *NIS*
- He was asked to imagine winning I million *NIS*, so that $y = 4,000,000$
- $r(\omega_0) = 0.27, \quad r(\omega_1) = 0.25$
- This patient utility function is depicted the below.



2
0
-2
-4
-6
-8
-10
-12
-14
-16
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
x 10^6

	Average Free	Average 570 *NIS*	Expert (In both cases)
$p_{CVS}(\omega_1) = 0.5\%$	750 *NIS*	1,316 *NIS*	*Average*
$p_{CVS}(\omega_1) = 0.25\%$	1,125 *NIS*	1,689 *NIS*	*Average*
$p_{CVS}(\omega_1) = 0.1\%$	1,350 *NIS*	1,913 *NIS*	*Average*