EVALUATION OF MEDICAL TECHNOLOGIES WITH UNCERTAIN BENEFITS

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OBJECTIVE: To incorporate risk measures (variance, skew) into CEA measures to assess "value of insurance" and "value of hope."

METHODS: Taylor Series expansion of expected utility, using relative risk aversion, relative prudence and relative temperance ($r^* = -M\left(\frac{U''}{U'}\right), \pi^* = -M\left(\frac{U'''}{U''}\right)$, means, variances and Pearson skewness estimates of health outcomes. We use r* = 1 π^*= 1.75. Full methods also incorporate kurtosis.

RESULT 1: THE RELATIVE EFFECT OF UNCERTAINTY, ϵ_Δ, DEPENDS ON KNOWN PREFERENCE PARAMETERS AND THE OUTCOME DISTRIBUTION

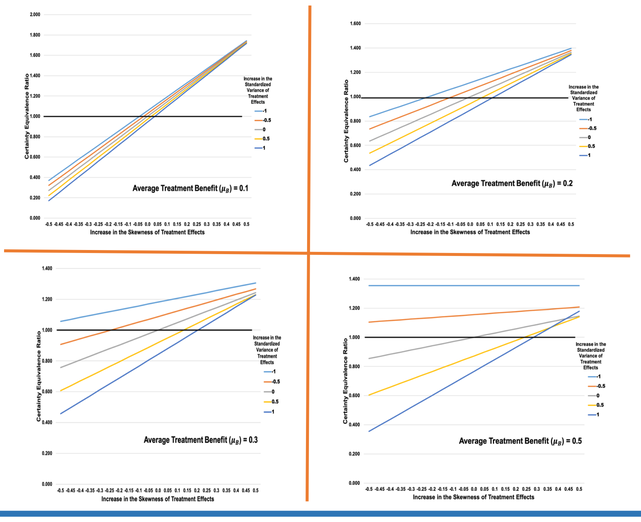
$$\epsilon_\Delta \approx \left[1 - \{\frac{1}{2} r_H^* \left(\frac{1}{\overline{H}_S}\right) \Delta\sigma^2 + \frac{1}{6} \pi_H^* r_H^* \left(\frac{1}{\overline{H}_S^2}\right) \gamma_1 \Delta\sigma^3 + \ldots\ldots\right]$$

$$\equiv 1 + (Risk\ components)/\mu_B$$

μ_B = average health gain, $\overline{H}_S$ = average health level for untreated patients. If $\epsilon_\Delta > 1$, stochastic elements show greater value (and vise-versa).

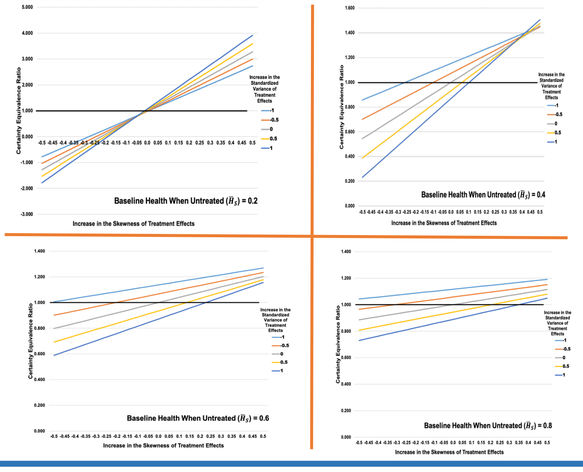
RESULT 2: UNCERTAINTY MATTERS LESS AS TREATMENT BENEFIT GROWS

Vertical axes show ϵ_Δ. Horizontal axes show changes in Pearson Skewness. Lines depict different change in standardized skewness, largest negative changes (reductions in variance, an economic "good") on top. Successive panels show increasing levels of μ_B, hence decreasing relative importance of stochastic terms. (Scales change panel by panel.)



RESULT 3: UNCERTAINTY MATTERS MORE FOR SICKEST PATIENTS

Vertical axes show ϵ_Δ. Horizontal axes show changes in Pearson Skewness. Each line depicts different change in standardized skewness, largest negative changes (reductions in variance, an economic "good") on top. Successive panels show different untreated illness levels (lower $\overline{H}_S$) most severe illness first, hence decreasing relative importance of stochastic terms. (Scales change by panel.)



RESULT 4: QUALITY-AND RISK-ADJUSTED LIFE-YEARS (QRALYS) GENERALIZE THE STANDARD QALY TO INCORPORATE UNCERTAINTY.

Our framework creates a nearly-identical decision rule for technology adoption. Costs per QRALY gained must exceed the same threshold that decision makers currently employ for standard cost per QALY calculations. If $\epsilon_\Delta = 1$, QRALYs = QALYs.

CONCLUSIONS

1) Risk-averse, prudent consumers dislike variance but like positive skew.
2) Ignoring variance and skew can bias CEA estimates, with bias traveling in both directions, depending on how a new technology alters risk.
3) Risk matters most for severe disease and modest treatment benefit.
4) Need new data on variance and skewness to measure full importance.
5) No new CEA cutoff needed – these measure expected utility