Likelihood-Based Statistical Decisions

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observation A

$\leadsto$ **likelihood function** $lik : \theta \mapsto P_\theta(A)$

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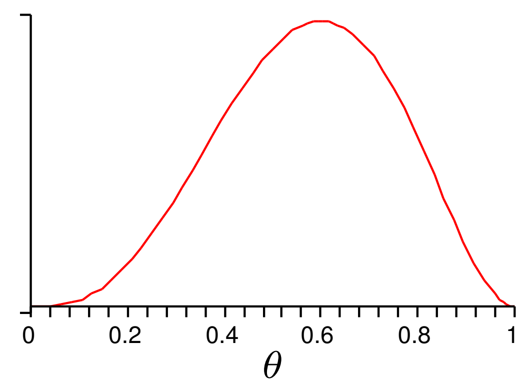
Example.
$X \sim Binomial\,(n, \theta)$
$n = 5, \quad \theta \in \Theta = [0, 1]$

$x = 3 \quad \Rightarrow \quad lik(\theta) \propto \theta^3\,(1-\theta)^2$



Statistical Decision Problem

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set of possible **decisions** $\mathcal{D}$
loss function $L : \Theta \times \mathcal{D} \to [0, \infty)$

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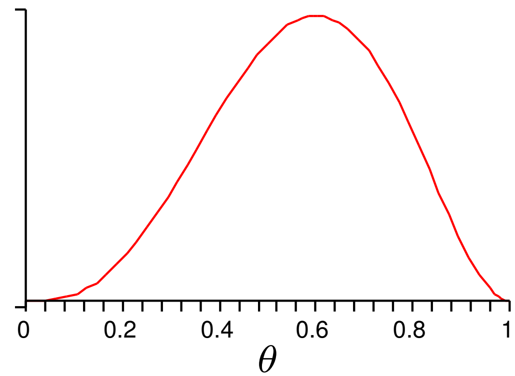
minimax criterion: minimize $\sup_\theta L(\theta, d)$

MPL = minimax if lik is constant (i.e., *complete ignorance* about Θ)
MPL: Minimax Plausibility-weighted Loss

Example

$$lik(\theta) \propto \theta^3 (1-\theta)^2$$
$$L(\theta, d) = |d - \theta^2|$$

$$d_{ML} = 0.36, \quad d_{MPL} \approx 0.385, \quad d_{BU} \approx 0.335$$



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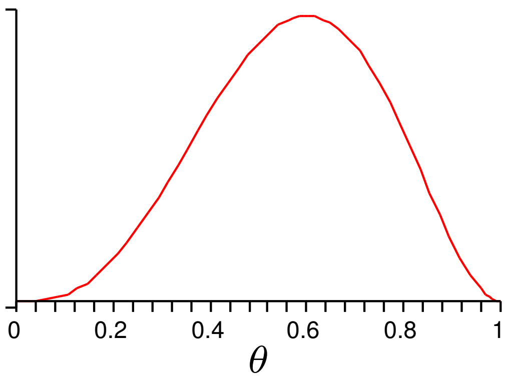

$$\tau = \theta^2, \quad lik(\tau) \propto \tau^{\frac{3}{2}} (1 - \sqrt{\tau})^2$$
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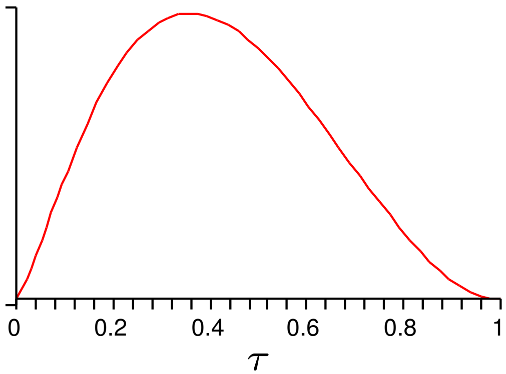
$$d_{ML} = 0.36, \quad d_{MPL} \approx 0.385, \quad d_{BU} \approx 0.404$$



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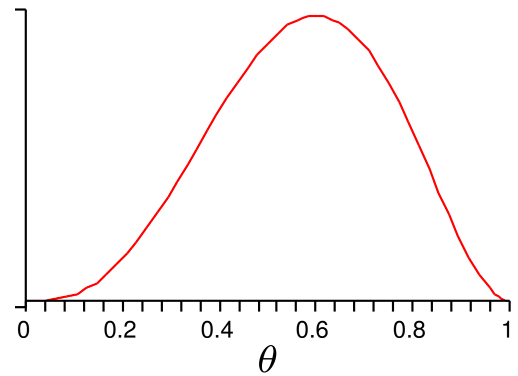

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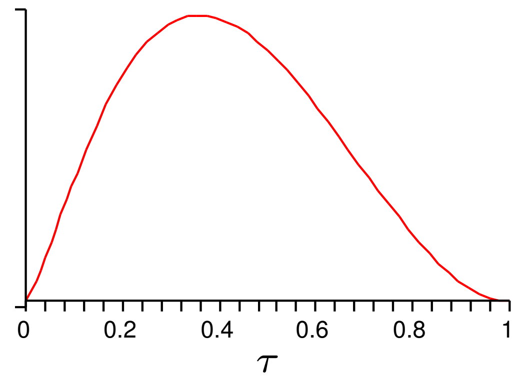

$$L(\tau, d) = \begin{cases} 2\,|d-\tau| & \text{if } d \le \tau \\ |d-\tau| & \text{if } d \ge \tau \end{cases}$$

$$d_{ML} = 0.36, \quad d_{MPL} \approx 0.468, \quad d_{BU} \approx 0.502 \ (d_{BU} \approx 0.435 \text{ using } \theta)$$

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The relative plausibility is thus a *quantitative description of the uncertain knowledge about the models* P_θ, that can start with complete ignorance or with prior information, that can be easily updated when new data are observed, and that can be used for inference and decision making.

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If Γ is a set of probability measures on Θ, the consideration of the (second-order) relative plausibility on Γ leads to a *non-calibrated possibilistic hierarchical model*, which allows non-vacuous conclusions even if Γ is the set of all probability measures on Θ.

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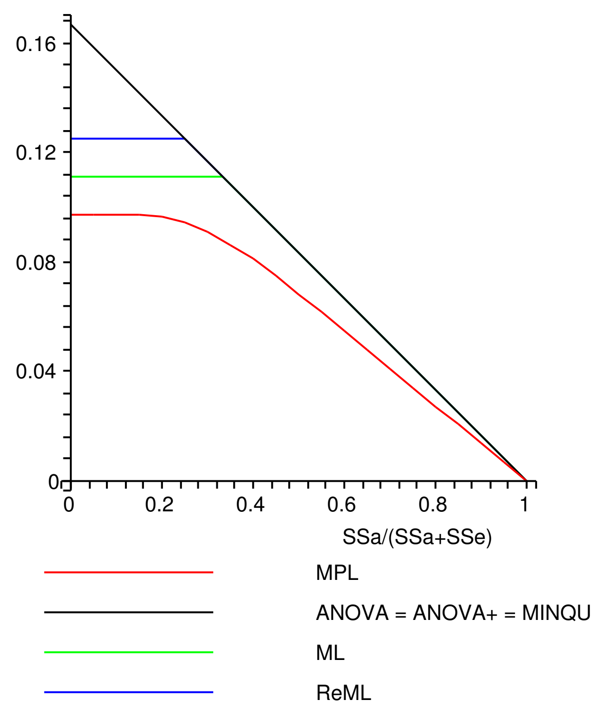
- satisfy the strong likelihood principle.
- can use pseudo likelihood functions.
- can represent complete (or partial) ignorance.
- can handle prior information in a natural way.

Example

Estimation of the variance components in the 3×3 random effect one-way layout, under normality assumptions and weighted squared error loss.

$$\frac{\widehat{v_e}}{(SS_a+SS_e)}$$



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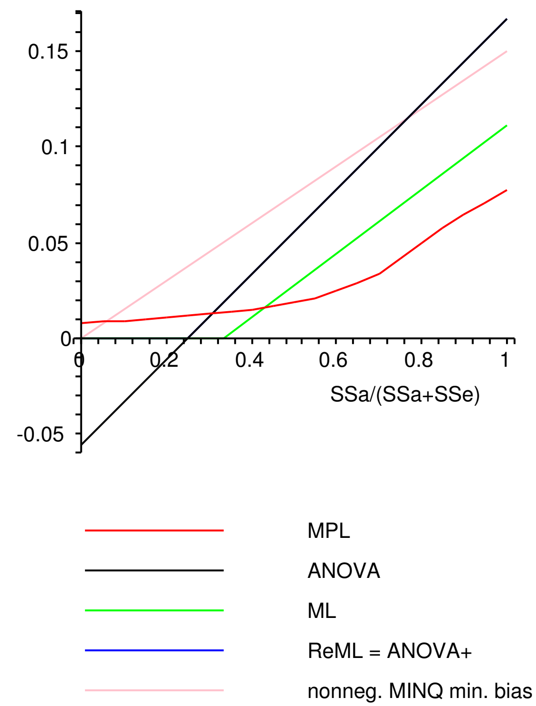
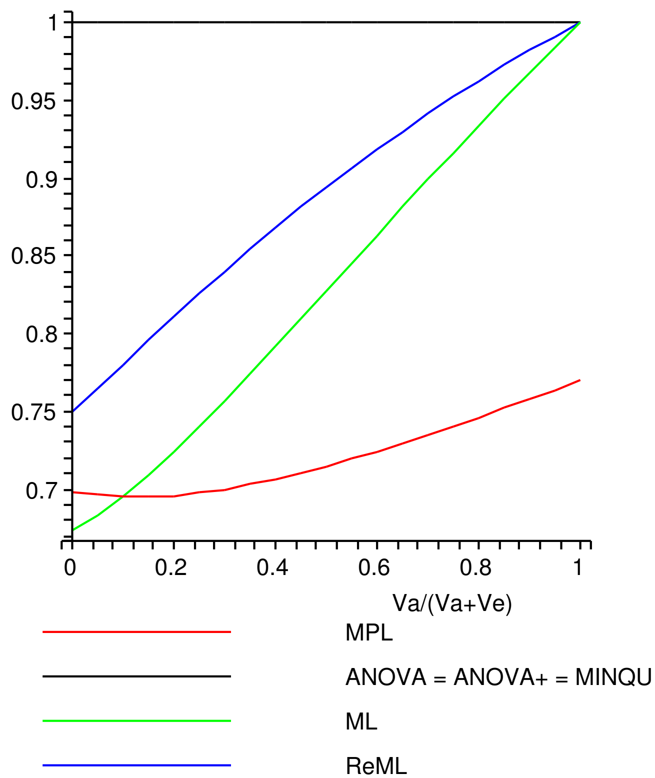


Example

$$3\,\frac{E[(\widehat{ve}-ve)^2]}{ve^2}$$



$$\frac{E[(\widehat{va}-va)^2]}{(va+\frac{1}{3}\,ve)^2}$$