A Model of Scientific Communication

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Classical Model of Statistics (Wald 1950)

- Analyst observes data $X \in \mathcal{X}$
- Uses $X$ to form estimate of unknown parameter $\theta \in \Theta$
- Estimate is “good” if close to true value of parameter
- Formalized by imagining a decision problem in which
  - estimate is a decision $d \in \mathcal{D}$
  - want to minimize loss $L(d, \theta)$
- Dominant paradigm for point estimation
  - e.g., $L(d, \theta) = (d - \theta)^2$ gives MSE criterion
  - Foundation of most optimality claims
Example: Analyst works for a firm that must make a pricing decision.
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Alternative Model of Statistics in Science

- Data-generating Process
- Analyst
- Audience
- Loss

Example: Analyst reports to scientists with diverse opinions, policymakers with diverse objectives.
• Example: Analyst reports to scientists with diverse opinions, policymakers with diverse objectives
Today

- Argue that these two models represent fundamentally different, and at times conflicting, views of the analyst’s goal
- Can lead to very different recommended procedures
- (Time permitting) Discuss possible implications for empirical research
Setting
Timing

- Analyst publicly commits to a rule $c : \mathcal{X} \rightarrow \mathcal{D}$
- Analyst observes data $X \in \mathcal{X}$, where $X \sim F_\theta$
- Analyst makes report $c(X)$ to an audience $\mathcal{A}$
- Each agent $a \in \mathcal{A}$ selects decision $d$ and realizes loss $L(d, \theta)$
Agents $a \in \mathcal{A}$ have different priors on $\theta$
- Write $E_a [\cdot]$ for expectation under $a$’s prior
- Identify each agent with their prior, so $\mathcal{A} \subseteq \Delta (\Theta)$

All disagreement expressed via priors

Paper shows that nests cases with disagreement over
- Loss function $L$
- Likelihood $F_\theta$
Analyst’s Goal

- Analyst tries to minimize expected loss (i.e. risk) for the agents
  - Benevolent analyst: no conflict of interest between analyst and agents
- Consider two possible definitions for the risk of rule $c$ for agent $a$
  - Decision risk (classical model)
    \[
    E_a [L(c(X), \theta)],
    \]
    as if analyst makes decision on agent’s behalf
  - Communication risk (alternative model)
    \[
    E_a \left[ \min_{d \in D} E_a [L(d, \theta) | c(X)] \right],
    \]
    as if agent makes optimal decision given report
Analyst’s Goal

- In special case of squared-error loss \( L(d, \theta) = (d - \theta)^2 \)

  - **Decision risk (classical model)**
    \[
    E_a [L(c(X), \theta)] = E_a [(c(X) - \theta)^2],
    \]
    is mean squared error

  - **Communication risk (alternative model)**
    \[
    E_a \left[ \min_{d \in D} E_a [L(d, \theta) | c(X)] \right] = E_a [\text{Var}_a (\theta|c(X))],
    \]
    is expected posterior variance

- Decision/communication distinction irrelevant when \(|\mathcal{A}| = 1\)
  - Benevolent analyst will pick \(c(X) = E_a [\theta|X]\), so coincide

- Distinction can matter when \(|\mathcal{A}| > 1\)
Example
• Analyst conducts a randomized trial with a binary outcome
• Goal is to learn the success probability \( \theta = (\theta_1, \ldots, \theta_J) \) at each of a finite set of ordered treatments \( \{1, \ldots, J\} \)
  • e.g., Probability of purchase at a set of prices
  • e.g., Probability of callback at a set of unemployment spell lengths
• Success probabilities known to be decreasing, \( \theta_1 \geq \theta_2 \geq \ldots \geq \theta_J \)
  • e.g., Demand slopes down
  • e.g., Longer unemployment spells deter employers
• Quadratic loss \( L(d, \theta) = \sum_j (d_j - \theta_j)^2 \)
Example

- $n$ independent observations for each treatment
- Data $X = (X_1, ..., X_J)$ are fraction of successes for each
- Decision space $\mathcal{D} = \mathcal{X}$ rich enough to communicate full data
- Audience $\mathcal{A} = \Delta (\Theta)$ includes all possible priors
  - Everyone agrees that $\theta_j \geq \theta_{j+1}$ for all $j$
  - ...but may disagree about everything else
Two Rules

- Consider two possible rules
  - Full data: \( c_j(X) = X_j \)
    - Reports success fraction for each treatment \( j \)
  - Rearranged data: \( c^*_j(X) = j\text{th highest element of } \{X_1, ..., X_J\} \)
    - Sorts success fractions in descending order
Illustration

Callback rate $X_j$ vs. Unemployment spell duration $z_j$

Reported callback rate $d_j^*(X)$ vs. Unemployment spell duration $z_j$
Rearranged data $c^*$ dominates full data $c$ in decision risk
- Achieves weakly lower risk for all agents, strictly lower for some
- Intuitively, gets closer to true parameter
- cf. Chernozhukov et al. (2009)

Classical model would recommend $c^*$ over $c$
Illustration

- **Callback rate $X_j$:**
  - Unemployment spell duration $z_j$
  - The plot shows a pattern where the callback rate increases with the duration $z_j$.

- **Reported callback rate $d_j(X)$:**
  - Unemployment spell duration $z_j$
  - The plot shows a decreasing trend of the callback rate as the duration $z_j$ increases.

The graphs illustrate the relationship between the callback rate $X_j$ and the reported callback rate $d_j(X)$ as a function of the unemployment spell duration $z_j$. The x-axis represents the duration $z_j$, while the y-axis shows the callback rates.
Illustration

![Graph 1: Callback rate \( X_j \) vs. Unemployment spell duration \( z_j \)]

![Graph 2: Reported callback rate \( d_j^*(X) \) vs. Unemployment spell duration \( z_j \)]
- Full data $c$ dominates rearranged data $c^*$ in communication risk
- Intuitively, preserves decision-relevant information
• So far, we’ve shown that different models made different selections from the pair of rules \{c, c^*\}

• A stronger statement is true

• **Definition**: A rule is admissible (in a given notion of risk) if it is not dominated by another rule

• In this example, any rule that is admissible in decision risk is inadmissible in communication risk, and vice versa
  • No choice of rule resolves conflict between two notions of risk
Takeaways

- Shows conflict between goals of decision and communication
- *Recommendations of classical model may not achieve goals of scientific analyst who cares about communication*
- In this example, communication-optimal rules seem more in line with empirical practice
  - e.g. we’re not aware of any unemployment audit studies that report only the sorted data, though many report unsorted results
  - Kroft, Lange, and Notowidigdo (2013) report both unsorted and sorted versions
Generalizations, and Implications
Generalizations

- Paper considers more general settings
  - Focus on discrete $\mathcal{X}, \Theta, \mathcal{D}$
  - Results for some continuous cases in supplement
- Provide sufficient conditions for admissibility conflict
- Intuition is the same: good decision rules discard useful information
Generalizations

- We also provide results for other optimality criteria
  - Weighted average of risk over the audience
  - Worst-case risk over the audience
Generalizations

- We also provide results for other optimality criteria
  - Weighted average of risk over the audience
  - Worst-case risk over the audience
- Negative results extend to weighted average case
- For worst case risk, get a positive result
Implications for Practice

- In example, analyst concerned with communication can solve problem by reporting $X$
- Doesn’t seem fully satisfactory in general
  - Otherwise, why does anyone write papers?
- Suggests communication or information processing constraints
- Raises question of optimal constrained communication
  - Optimal rules will depend on details of how model constraints
- Less ambitious: short of optimal rules, can we find simple, practical ways for analyst to reduce communication risk?
  - e.g. showing sensitivity to misspecification in the spirit of Conley, Hansen, and Rossi (2012), Andrews, Gentzkow, and Shapiro (2017)
Summary

- Focusing on communication rather than decision-making changes understanding of the goals of empirical scientist
- Leads to very different recommendations than classical decision-theoretic model in some cases
- Hope that change in perspective may help suggest good procedures for communicating scientific results
Thank you!