Escaping Cannibalization? Correlation-Robust Pricing for a Unit-Demand Buyer

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• Setting with Unknown Correlation:
  • 1 seller, 1 buyer, \( n \) items

• Terminology:
  • \( F_1, \ldots, F_n \) = marginals for the \( n \) item values
  • Correlated distribution \( F \) is “compatible” if the marginals of \( F \) are \( F_1, \ldots, F_n \)

• Correlation-Robust Mechanism Design studies mechanisms whose worst-case (across all compatible distributions) revenue guarantee is highest [Carroll].
  • Selling separately is optimal for an additive buyer [Carroll’17].
Our Research Question

• Correlation-robust pricing for a unit-demand buyer
  • (For unit-demand, item pricing is wlog)

In particular:
• Consider the best robust pricing
  • Is it correlation-agnostic?
  • Is it otherwise simple?
• If not, what about approximately-best robust pricing?

• Questions posed/inspired by [Gravin-Lu’18,Bei-Gravin-Lu-Tang’19]
Our Results: General Marginals

• **Starting point:** Best robust pricing is **not** correlation-agnostic.

• **Theorem:** **Worst** compatible distribution $F$ can be computed in **polytime**.

• **Q:** Given $F_1, \ldots, F_n$, what is the (approximately-)**best robust pricing** $\hat{p}$?
  \[
  \max_{\hat{p}} \min_{\text{compatible } F} \mathbb{E}_{\tilde{\nu} \sim F} \left[ \text{revenue from buyer given } \tilde{\nu}, \hat{p} \right]
  \]

• **Theorem [main]:** Computing the **best** robust pricing $\hat{p}$ is **NP-hard**.
  • NP-hard even for an approximately-best $\hat{p}$ up to approx. factor $O(n^{1/2-\epsilon})$.
  • To our knowledge, first hardness result in the correlation-robust framework.
“Nice” Marginals

• **Theorem:** For MHR marginals there is a simple, correlation-agnostic, approximately-best robust pricing with approximation factor 3.5.
  - Offer the item with highest median for price equal to median.

• **Open Question:** For regular marginals, can the (approximately)-best robust pricing be computed in polytime?
  - **Challenge:** If so, would require using many distinct prices.

• What Makes Unit-Demand Complex? **Cannibalization!**
  - A term from marketing strategy referring to a reduction in sales [...] of one product as a result of the introduction of [another] product by the same producer.”