Linear Programming-Based Scheme Recommendation

# 1. Methodology

## A. Linear Programming Optimization

Goal: Recommend the best promotional schemes for each partner-product combination by optimizing business objectives under constraints.  
Method:  
- Linear programming (LP) is used to maximize overall impact (e.g., expected sales uplift or partner engagement).  
- Objective function: Maximize total utility based on partner-product affinity, past performance, and scheme effectiveness.  
- Constraints: Scheme budget, maximum allocation per product, and fairness across regions.  
- Each product receives top 3 ranked schemes based on the optimization solution (Scheme\_1, Scheme\_2, Scheme\_3).

## B. Input Features & Variables

- Product-wise partner lists (based on product recommendations).  
- Scheme performance indicators (discount response, volume lift, loyalty effect).  
- Partner-level flags (bulk tendency, new stockist, region).  
- Constraints matrix modeled using `scipy.optimize.linprog` or `pulp` libraries for LP solving.

# 2. Key Findings & Business Insights

Strategic Scheme Bundling:  
- LP identified that combining 'Discount' with 'Loyalty' followed by 'Bulk Purchase' schemes maximized reach and effectiveness.  
  
Fair Distribution:  
- Optimization ensured equitable distribution of schemes across product lines and partner regions, avoiding bias toward high performers only.  
  
Product-Specific Sensitivity:  
- High-value products like ACB, RMU, and E-House benefited most from Bulk Purchase offers, while entry-level SKUs were more responsive to Loyalty programs.  
  
Business Efficiency:  
- LP enabled controlled application of business logic—ensuring ROI-friendly recommendations within budgetary constraints.

# 3. Assumptions, Limitations & Edge Cases

Assumptions:  
- Scheme effectiveness scores are reliable and based on historical data trends.  
- All partners are eligible for the recommended schemes.  
- Partner engagement and sales uplift are proportional to scheme utility.  
  
Limitations:  
- Real-time constraints like logistics and partner onboarding are not modeled.  
- External market changes (competitor pricing, supply shocks) are excluded.  
- Assumes linear behavior in partner response which may not hold in all cases.  
  
Edge Cases:  
- Products with limited partner adoption history may have biased scheme assignments.  
- LP may prioritize high-volume segments and under-serve niche markets if not balanced by weights.  
- Budget-heavy schemes may be underutilized despite their higher effectiveness.

# 4. Reference Links

- https://realpython.com/linear-programming-python/  
- https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.linprog.html  
- https://towardsdatascience.com/linear-programming-and-optimization-with-python-using-pulp-449f3c5f6fcb