MSc in Data Science: A Predictive Decision Support System for E- Commerce Price Drops using Survival Analysis and Risk-Aware Optimization

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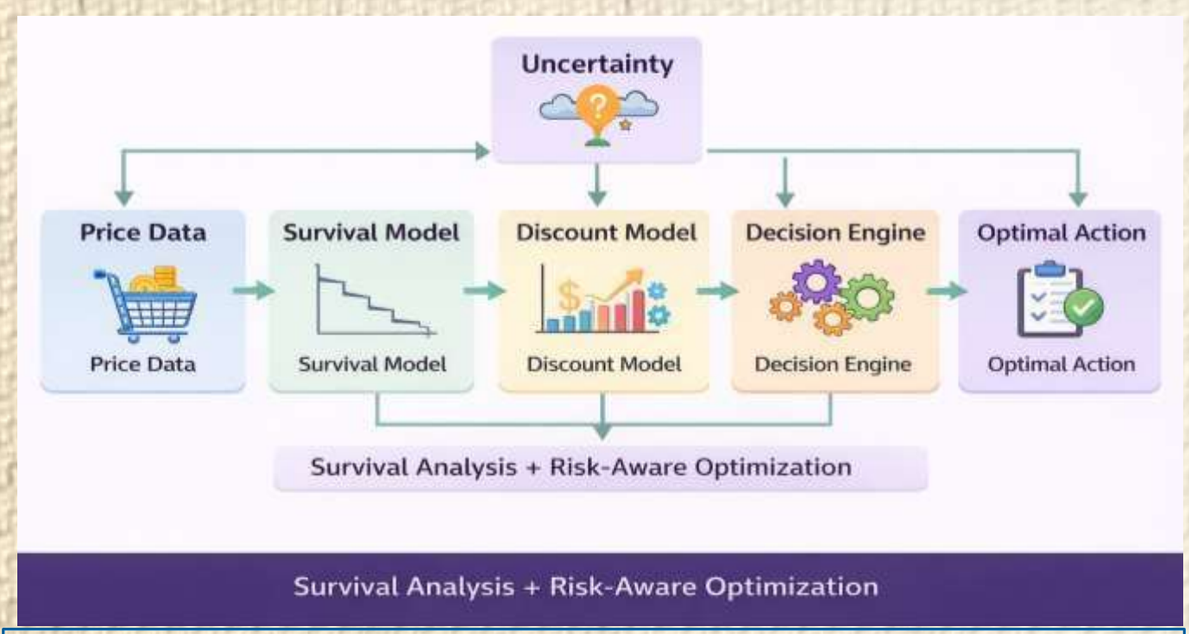
Introduction

E-commerce platforms operate in highly dynamic pricing environments where product prices frequently change due to demand fluctuations, competition, and promotional strategies. This creates uncertainty for consumers when deciding whether to purchase immediately or wait for potential discounts. Existing tools mainly provide historical price tracking or basic forecasts, but they fail to model the timing and uncertainty of price drops or support optimal decision-making. This research proposes a predictive decision support system that models price drops as time-to-event processes and integrates uncertainty-aware predictions into a risk-based optimisation framework to improve consumer purchasing decisions.



Literature Review

- Recent studies highlight that dynamic pricing is widely used in e-commerce, where prices change in real-time based on demand, competition, and user behavior, significantly influencing consumer decisions and trust.
- Modern research shows that e-commerce platforms increase price transparency and competition, enabling consumers to compare prices easily, but also creating uncertainty due to frequent fluctuations.
- Advances in machine learning and deep learning have improved predictive modelling in e-commerce, enabling better analysis of patterns and trends in large-scale data environments.
- Recent industry studies emphasize that uncertainty and volatility in pricing environments remain major challenges, requiring more advanced predictive and decision-support systems

Research Objectives

This research aims to develop a predictive decision support system for e-commerce price drops by integrating advanced modelling and optimisation techniques. It focuses on modelling price drops as time-to-event outcomes using survival analysis, while explicitly handling right-censored data. The study also seeks to estimate uncertainty in discount magnitude through quantile regression methods. In addition, a similarity-based substitution module will be developed using text embeddings to expand decision options. Finally, the research aims to incorporate predictive uncertainty into a risk-aware optimisation framework to improve consumer purchasing decisions and achieve measurable economic benefits.

Data Source

The study utilizes the Amazon Product Dataset, which contains large-scale time-stamped price histories along with rich product metadata across multiple categories. The dataset captures dynamic pricing behaviour over time, making it suitable for modelling price drops as time-to-event outcomes. It also includes products that do not experience price drops during the observation period, enabling proper handling of right-censored data.

Methodology

- Define price drop events based on significant price reductions
- Perform feature engineering (volatility, trends, product attributes)
- Apply survival models (Cox Model, Random Survival Forest)
- Estimate discount magnitude using XGBoost and LightGBM
- Develop substitution module using text embeddings
- Integrate all components into a decision optimisation framework
- Evaluate using both predictive and economic performagnce metrics

5. Early Indicators

- Data preprocessing pipeline has been defined
- Key features such as price volatility and trends identified
- Initial analysis confirms irregular and event-driven price behaviour
- Model framework for survival and regression approaches established

Next Steps

- Train and validate survival models for price drop prediction
- Implement quantile regression models for discount estimation
- Develop substitution module using similarity techniques
- Build optimisation framework for decision-making
- Evaluate system using savings, regret, and performance metrics

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