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Optimal pricing model based on reduction dimension: A case of study for convenience stores

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Abstract

This paper proposes a methodology to define an optimal pricing strategy for convenience stores based on dimension reduction methods and uncertainty of data. The solution approach involves a multiple linear regression (MLR) as well as a linear programming optimization model. Two strategies Principal Component Analysis (PCA) and Best Subset Regression (BSR) methods for the selection of a set of variables among a large number of predictors is presented. A linear optimization model then is solved using diverse business rules. To show the value of the proposed methodology optimal prices calculation results are compared with previous results obtained in a pilot performed for selected stores. This strategy provides an alternative solution that shows how a decision maker can include proper business rules of their particular environment in order to define a pricing strategy that meets business goals.

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1 Introduction

A convenience store is a small retail business that stocks a range of everyday items such as groceries, snack foods, candy, toiletries, soft drinks, tobacco products, magazines and newspapers. Convenience stores typically have longer opening hours, serve more locations, and have shorter cashier lines. Therefore, it is thought that such kind of store charge significantly higher prices than conventional grocery stores or supermarkets, as convenience stores order smaller quantities of inventory at higher per-unit prices from wholesalers. However, it is important to find a correct level of prices in the correct level in order to keep the customers and increase their profits. Therefore, a price strategy in this business is relevant because the price should increase the profits but also keep customers happy.

Research pricing methods fall into two main approaches: pricing the total product (pricing for a complete concept/product) or pricing other elements such as branding or features.

According to [6], the pricing strategy is by definition the effort aimed at finding a product's optimum price, typically including overall marketing objectives, consumer demand, product attributes, competitors' pricing, and market and economic trends.

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Applied research data analysis and forecasts have been treated using linear regression [14, 1] considering multiple explanatory variables combined with other methods for selecting variables in order to reduce the dimensionality of the problem, for instance stepwise and genetic algorithms [12].

Multiple linear regressions (MLR) model is one of the modelling techniques to investigate the relationship between a dependent variable and several independent variables.

MLR is a widely used technique to refine decision making in finance and economics. Ismail, et al. [7] use MLR as a tool to develop forecasting model for predicting gold prices based on economic factors. Shabri and Samsudin[2] propose a hybrid model which integrates wavelet regression and multiple linear regression for crude oil price forecasting, it is important to highlight the use of principal component analysis (PCA) to process data subs-series in MLR to reduce the dimensions of sub-time

Dimension reduction problem has been treated widely, Chun and Keleş [4] propose a sparse partial least squares formulation which aims to achieve variable selection by producing sparse linear combinations of the original predictors. Li-Ping et al [16] offer a methodology to sufficient dimension reduction and propose alternating inverse regression to estimate the central subspace which circumvents the collinearity and curse of dimensionality simultaneously [15].

The problem definition of this research considers a company that operates several convenience stores. The company desires to improve the current pricing strategy in order to maximize the business performance. The main goals are to obtain the optimum price of each product and to increase the gross margin. A first approach presented in [5] considers a three-stage proposal. First stage consists in reducing variables in order to keep the most appropriate variables. This reduction is based on Pearson's correlations and the use of a ratio based on interaction of independent vs explanatory variables. The ratio is helpful to reduce the multicollinearity issues. Then an econometric model was obtained through MLR methodology using a stepwise algorithm for reducing dimensionality, and finally the optimization model with additional business rules (internal and external) was performed in order to obtain an optimal price proposal. The strategy was tested in a real case study, where the results proved the value of the methodology.

This research is an extension of the first approach that improves each step. In this way, the first stage consists on the selection of significant variables using two methods in parallel (in order to compare later). The methods are PCA and BSR algorithms, then a MLR is performed. The multicollinearity issues are resolved using Ridge Regression. Finally, the optimization model is improved by introducing uncertainty in the expected volume sales. This variable was not introduced in the first approach.

The organization of the document is as follows, the introduction above served to set the business frame as well as to present the literature review and define problem. Then, the mathematical formulation of the optimization model is presented in section 2. Section 3 describes the design and implementation of the methodology. Section 4 compares the results with a previous methodology. The last section 5 consists of the conclusion and outlines the future work.

2 Mathematical Formulation of the optimization model

The pricing strategy proposed in this research is structured in three stages. However, it is important to define the notation to be used along the description of each stage. The main goal in the pricing strategy is to obtain the optimal price maximizing margin. Therefore, consider a set of products P of size n to be sold in a convenience store. These products are grouped according to a commercial hierarchy into m categories $C_i = \{p_k | k = 1, ..., n\}, \forall i = 1, ..., m$ and $p_k \in P$. Therefore, the union of all categories is the set of all products $\bigcup_{i=1}^{m} C_i = P$. Some