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Machine Learning Framework: Competitive Intelligence and Key Drivers Identification of Market Share Trends among Healthcare Facilities

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Abstract : The necessity of data-driven decisions in healthcare strategy formulation is rapidly increasing. A reliable framework which helps identify factors impacting a healthcare provider facility or a hospital (from here on termed as facility) market share is of key importance. This pilot study aims at developing a data-driven machine learning-regression framework which aids strategists in formulating key decisions to improve the facility's market share which in turn impacts in improving the quality of healthcare services. The US (United States) healthcare business is chosen for the study, and the data spanning 60 key facilities in Washington State and about 3 years of historical data is considered. In the current analysis, market share is termed as the ratio of the facility's encounters to the total encounters among the group of potential competitor facilities. The current study proposes a two-pronged approach of competitor identification and regression approach to evaluate and predict market share, respectively. Leveraged model agnostic technique, SHAP, to quantify the relative importance of features impacting the market share. Typical techniques in literature to quantify the degree of competitiveness among facilities use an empirical method to calculate a competitive factor to interpret the severity of competition. The proposed method identifies a pool of competitors, develops Directed Acyclic Graphs (DAGs) and feature level word vectors, and evaluates the key connected components at the facility level. This technique is robust since its data-driven, which minimizes the bias from empirical techniques. The DAGs factor in partial correlations at various segregations and key demographics of facilities along with a placeholder to factor in various business rules (for ex. quantifying the patient exchanges, provider references, and sister facilities). Identified are the multiple groups of competitors among facilities. Leveraging the competitors' identified developed and fine-tuned Random Forest Regression model to predict the market share. To identify key drivers of market share at an overall level, permutation feature importance of the attributes was calculated. For relative quantification of features at a facility level, incorporated SHAP (SHapley Additive exPlanations), a model agnostic explainer. This helped to identify and rank the attributes at each facility which impacts the market share. This approach proposes an amalgamation of the two popular and efficient modeling practices, viz., machine learning with graphs and tree-based regression techniques to reduce the bias. With these, we helped to drive strategic business decisions.

Keywords : competition, DAGs, facility, healthcare, machine learning, market share, random forest, SHAP
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