Intelligent Gasoline Demand Analytics: A Case Study of Saudi Arabia

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Overview

Gasoline plays a key role in driving our daily activities being the main fuel of the transport sector. This paper is aimed at developing a new predictive model for analyzing and forecasting Saudi Arabia's gasoline demand using artificial intelligence (AI) modeling analytics. The artificial intelligent predictive model of gasoline demand was successfully designed, trained, validated and tested using real historical data for the period 1971-2017. The developed intelligent gasoline model yields excellent predictions of gasoline demand with high performance measures. The results of the intelligent gasoline demand outlook were also benchmarked with a conventional econometric method.

This paper provides an added-value to our knowledge base of forecasting methods of domestic and global gasoline demand. The methodology proposed was found to improve and enhance the conventional process of developing the gasoline demand outlook. It also improves and enhances the predictability and accuracy of traditional forecasting models of gasoline demand. In this study, a hybrid approach of an artificial neural network and genetic algorithms was also deployed to identify and understand the endogenous and exogenous factors that influence and drive Saudi gasoline demand.

Methodology

The Saudi gasoline demand outlook was developed using artificial intelligence modeling technology. A hybrid approach of artificial neural network (ANN), genetic algorithms (GA), and data mining (DM) was devised in the development of the gasoline demand outlook model.

The intelligent model of Saudi Arabia gasoline demand was developed with a data time horizon from 1971 to 2017. The input variables of the machine learning model include gross domestic product (GDP), population, gasoline prices, diesel prices, and transport data, in addition to transformed variables and functional links. A framework for the development of the artificial intelligent model was introduced and deployed. The development methodology includes data preparation; data mining and preprocessing; features selection and identification of significant inputs; design of model architecture; model training, verification, and testing; model selection, model performance indicators; model optimization and fine-tuning; and post-processing of results.

Results

The intelligent demand model was designed, trained, validated and tested successfully and provided excellent predictions of Saudi Arabian gasoline demand. Figure 1 shows the gasoline demand of Saudi Arabia as forecasted by a hybrid approach of artificial intelligence technology including artificial neural network, genetic algorithms, and data mining techniques. The intelligent gasoline demand outlook was compared favorably to the observed data from 1971 to 2016. We used the 2017 demand data, which was made available after the completion of the model development and testing, to examine the predictability and accuracy of our model that further verified successfully the reliability and robustness of the outlook model. The data-driven analytics model confirmed the decline of Saudi gasoline demand in 2017 by 2.5% compared to the 2016 level, with an average absolute error of 0.05% and an average model accuracy of 99%. The model performance of prediction and adequacy was measured by the following key performance indicators (KPIs): the mean relative percentage error (MRPE), mean absolute percentage error (MAPE), coefficient of determination (R^2), root mean square error (RMSE), and Nash-Sutcliffe efficiency (NSE). KPIs of the model's test dataset show MRPE of -0.0112, MAPE of 0.0792, R^2 of 0.981, RMSE of 9.161, and NSE of 0.999; all KPIs indicate outstanding performance of the model for predictability, accuracy, and robustness.

Saudi gasoline demand is predicted to continue to decrease mildly for the next 5-year outlook period. This soft decline is attributed to several factors but mainly due to the launch of energy efficiency programs and new energy pricing reforms. Other factors include the improved efficiency of vehicle engines and combustion, the declining growth of population, and the change of consumer behavior. The lower population growth in 2017 has caused by a lower Saudi fertility rate, declining rate of new births, rising mortality rate, and decreasing non-Saudi population due to low-income and unskilled expats leaving the country. It is expected that the total population of Saudi Arabia will resume its growth shortly due to the new giant investment projects and the government permission for foreign investors to the Kingdom leading to an increase in the non-Saudi population. Public

behavior also helped to reduce gasoline demand in Saudi Arabia. Consumers' behaviors include increased public awareness, shifting from gasoline-95 type to a cheaper gasoline-91 type, buying more economic cars (i.e., gasoline-91 based-vehicles), and an increasing trend of using public transportation including trains, buses, metro, and carpooling. Features selection of input variables and analysis of driving factors of gasoline demand showed that the light-duty vehicles and population are found to be the most influential drivers of the Saudi gasoline demand. Prices of gasoline and diesel (the substitute) are placed after GDP, respectively.

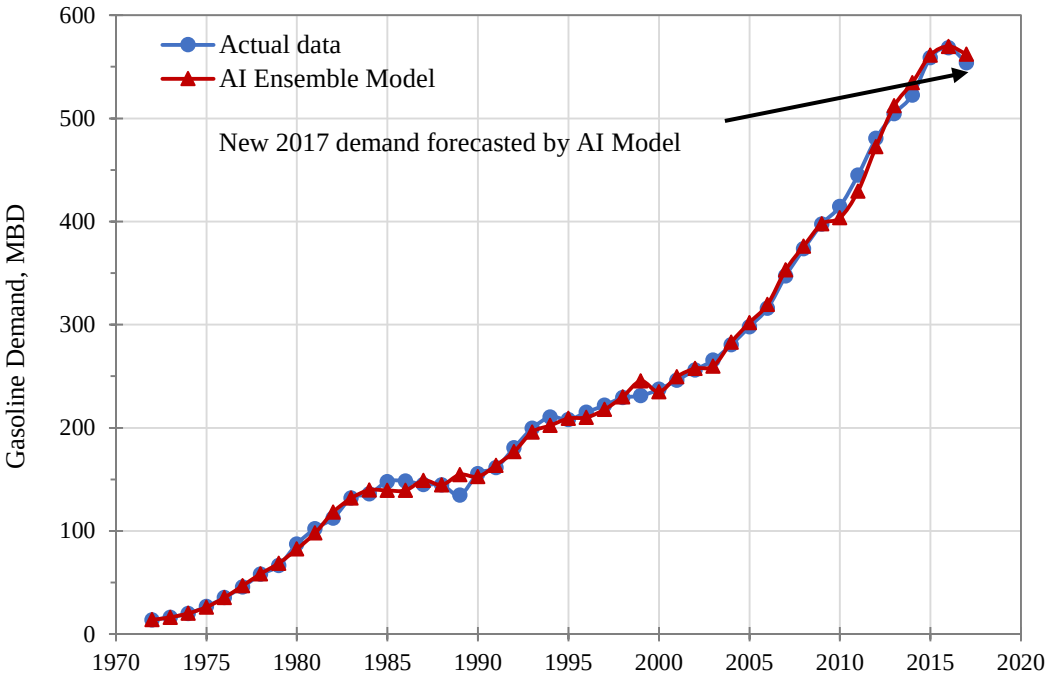

Figure 1- Saudi Arabia gasoline demand forecast.

Conclusions

- Saudi Arabia's gasoline demand has declined in 2017 by 2.5% of the 2016 level. Saudi gasoline demand is predicted to grow mildly over the next 5-year (2018-2022) outlook period.
- New energy pricing reforms, improved efficiency programs, and a change of consumer behavior have helped reduce gasoline demand.
- Declining Saudi gasoline demand is attributed mainly to improved efficiency of vehicle engines and combustion, falling population growth, and change of consumers' behavior.
- Gasoline consumption growth of Saudi Arabia is expected to resume its rise due to the new women driving policy leading to an increased number of vehicles, government's permission for foreign investments in the Kingdom, and new giant investment projects in Saudi Arabia leading to increase in population.
- Artificial intelligence by its power of forecasting capability showed promising results for analyzing and predicting gasoline demand.
- The new method of forecasting gasoline demand, in which we applied a hybrid approach of ANN, GA, and DM, showed an improved process of forecasting robustness as well as increased accuracy and predictability.
- The artificial intelligence outlook model of gasoline demand can be used to perform regional and sectoral analysis, scenario-based analysis, energy policy "What-if" analysis, and sensitivity analysis of influential factors.