Do not blame the weather:
a study of the relationship between weather and online retail sales
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Project Background

Retailers are positioned at the end of the supply chain, which means that they need to have the ability to promptly react to situations – such as weather changes – which affect customers' behaviour. Forecasting products' demand is a fundamental activity for retailers: low accuracy forecasts can cause a surplus of unsold items or a shortage of products, which represents a source of lost revenue. As such, many pieces of research have been conducted to understand the relationship between weather conditions (such as temperature, wind speed, pressure, humidity) and sales with the aim of improving sales forecasts' accuracy. Prior research has generally been conducted on 'offline' retailers; therefore the aim of this project is to analyse how weather affects the sales of an online-only retailer, to understand which ranges of products are affected by changes of weather conditions, and to understand whether this relationship is similar to the one discovered in the literature regarding offline retailers.

Data and Methods

This study used five data sets provided by Shop Direct. Weather data was purchased on the OpenWeatherMap website: it comprised of 660,000 observations of historical weather data between 29th April 2013 to 29th April 2018. Our sales data covered the same span of time, and it included 10.5 million observations. The other datasets included information on city codes, UK postcodes, and product line numbers. Hourly weather data was aggregated at a daily level, and then merged with the sales dataset. An exploratory data analysis was completed and time series decomposition techniques were applied to remove seasonality and trend from the data. A correlation analysis identified which ranges of products had a relationship with weather, and the Kruskal-Wallis test was used to analyse how statistically different the groups previously identified were. Lastly, a cluster analysis was conducted to find common features in four groups of weather-sensitive products (Fig. 1).

Key Findings

With the correlation analysis first and the cluster analysis second, it was proved that the weather does influence online sales trends. However, it was observed that the majority of ranges of products sold in London in the past five years have low correlations with the weather components taken into consideration for this analysis (temperature, humidity, wind speed, pressure and rain hours). 54 of the product ranges were weather-sensitive: this means that they were affected in some way by variations of certain weather conditions. It was also discovered which day influenced most of the sales of these weather-sensitive products.
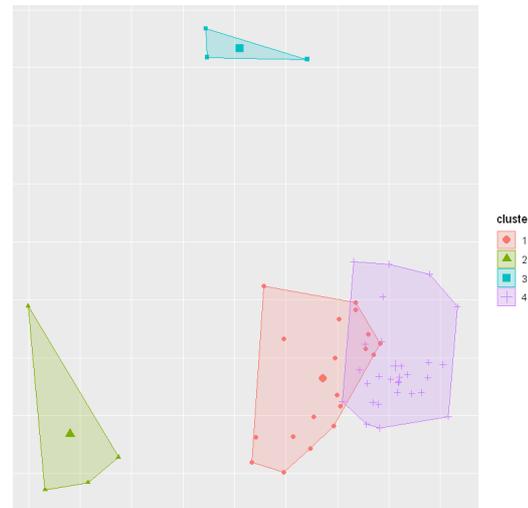

Fig. 1 – K-means cluster analysis output.

These 54 ranges of products were grouped into four clusters according to common features, such as a tendency to see their sales levels increase or decrease according to an increase of certain weather conditions. The fact that some ranges were statistically detected to be sensitive to weather means that short- to middle-term weather forecasts can be leveraged to predict an increase or decrease in sales. This can be used for adapting the marketing strategy for these products as well as short-term inventory management.

Value of the Research

This research identified the products whose sales are affected in some way by weather variations. Shop Direct can use this information in many ways: for example, personalised marketing email campaigns can contribute in exploiting weather forecasts to gain competitive advantage; short-term inventory management can also be adjusted and optimised based on the results provided by this research. In any case, weather will not be seen as an excuse anymore, but as an advantage to surprise and involve customers even more than usual.