Disaggregate Model to Forecast Transformer Usage

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INTRODUCTION

The purpose of this work is to create a tool that can be used to forecast monthly transformer usage for a large investor-owned electric and gas utility based in St. Louis, Missouri, USA. The company works to ensure reliable, low-cost service to all of its customers by continuously improving its systems. In order to ensure efficient operation of the company into the future, it is important that the correct items be provided in the correct locations whenever they are required. Transformers are one of the key items that the company must have to provide continuous supply of power to its customers, thereby maintaining overall customer satisfaction. Hence, the ability to properly forecast the usage of transformer is very important.

The use of forecasting models during inventory planning is a widely accepted, yet critical, practice in a variety of industries (Sanders and Manrodt, 1994). Among various forecasting models, appropriate forms of exponential smoothing are often recommended due to their relatively good performance (Chatfield and Yar, 1988; Gardner 2006). However, these traditional models do not perform well when historical data are not sufficient to predict future usage levels. The transformer usage data from the company reveal that trends in usage levels could quickly change before any backward-looking forecasting model could adapt.

We also observe that the traditional forecasts at the aggregate level are unsatisfactory because several unrelated causes of transformer usage are not considered. This leads to the identification of the various causes of transformer usage and the development of a specialized disaggregate model. Although it is recognized that disaggregation generally increases variance, this is alleviated due to the benefits of more accurate disaggregate forecasts, which exploit the characteristics that are specific to each disaggregate segment. Weatherford et al. (2001) has shown that it is essential to forecast disaggregate segments within the data when they are known to have significantly unique usage patterns. This disaggregation concept is applied to forecast the company's monthly transformer usage for the coming year.

Our disaggregate forecasting model recognizes three distinct segments with notably unique causes of transformer usage such as new construction (NC), storm and emergency (SE), and general maintenance (GM). Of these three, new construction is of particular interest due to its dependence on outside factors. We develop a new forecasting model for the NC portion of the data, incorporating a forward-looking trend variable that is exogenously determined. The benefits of creating disaggregate, demand-pattern-specific forecasting models are further realized for both the SE and GM portions of the data. SE usage is volatile by nature, so a model that can smooth this tendency better is selected. The final disaggregate segment, GM, shows a stable demand pattern with a gradual change in trend that occurred over a long period of time. For this reason, an exponential smoothing model is a good forecasting technique for this

DOI: 10.4018/978-1-4666-5202-6.ch070

segment. By combining the forecasting results for these three segments, we obtain the overall forecast for future transformer usage.

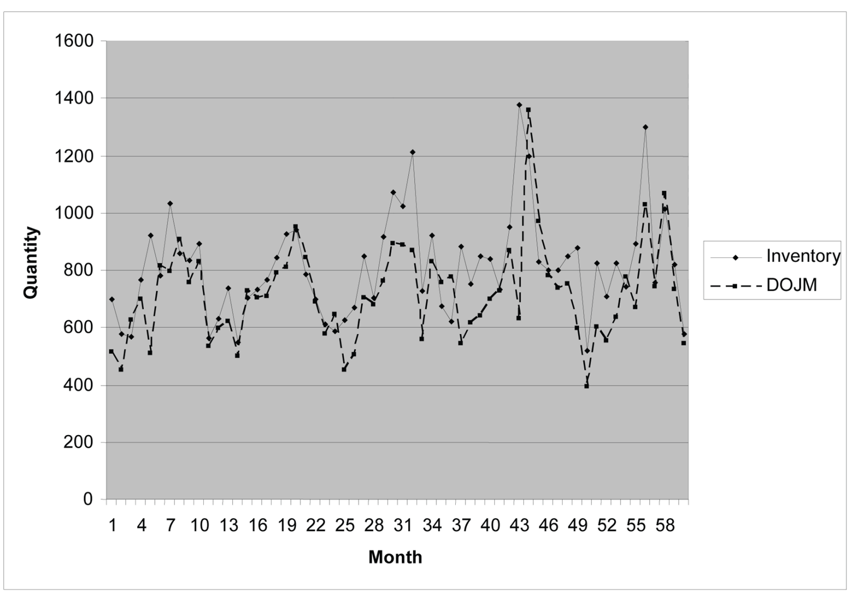
In our evaluation of the company's data, the disaggregate forecasting model strongly outperforms the more traditional forecasting models. The complete forecasting model is programmed as Microsoft Excel based software to enable automatic updates and to facilitate the use of the data by company personnel. This is one of the first works to apply a disaggregate forecasting model for the transformer usage in the utility industry.

DATA PREPARATION

Two databases of usage information were provided by the company, such as an inventory database and a Distribution Operations Job Management (DOJM) database. All transformers issued from inventory over the past five years were in the inventory database. However, there was no way to separate the data based on the reasons the transformers were used. The DOJM database was much more informative because it provided project activity codes and showed installation records of transformers, which allowed the separation of transformer usage into the three subcategories, i.e., NC, SE, and GM. Unfortunately, the DOJM database showed lower usage levels than the inventory database in almost every month because of reporting errors and delays during the installation operation. Figure 1 compares the monthly usage levels reported in the inventory and DOJM databases over the provided five years (60 months) of data.

Each database provided unique and significant advantages, so, in order to gain maximum benefit from the available data, we used the more complete inventory data but separated them in accordance with the historical records shown in the DOJM database. That is, we first computed the ratio of each disaggregate segment for each month in the DOJM database. The ratio was then applied to the data contained in the inventory database to create the historical monthly demand for the NC, SE, and GM segments. During periods in which the DOJM database did not have a sufficient amount of data, we used an average ratio for that particular month of the year. Figure 2 shows the historical usage of transformers both for aggregate and disaggregate levels, as determined from the above process.

Figure 1. Usage of transformers in the inventory and DOJM database



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