Retail forecasting: Research and practice

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Abstract

This paper reviews the research literature on forecasting retail demand. We begin by introducing the forecasting problems that retailers face, from the strategic to the operational, as sales are aggregated over products to stores and to the company overall. Aggregated forecasting supports strategic decisions on location. Product-level forecasts usually relate to operational decisions at the store level. The factors that influence demand, and in particular promotional information, add considerable

complexity, so that forecasters potentially <u>face</u> the dimensionality problem of too many variables and too little data. The paper goes on to evaluate evidence on comparative forecasting accuracy. Although causal models outperform simple benchmarks, adequate evidence on machine learning methods has not yet accumulated. Methods for forecasting new products are examined separately, with little evidence being found on the effectiveness of the various approaches. The paper concludes by describing company forecasting practices, offering conclusions as to both research gaps and barriers to improved practice.

Introduction

The retail industry is experiencing rapid developments in both structure, with the growth in online business, and the competitive environment which companies are facing. There is no simple story that transcends national boundaries, with consumers in different countries behaving in very different ways. For example, in 2017, online retailing accounted for 14.8% of retail sales in the US and 17.6% in the UK, but only 3.4% in Italy – in contrast to Germany, which showed a 3.5% increase to 15.1% since 2015 (Fig. 1).

Retailers' future planning depends in part on demand forecasts, delivered through methods and processes that are embedded in a forecasting support system (FSS). High-accuracy demand forecasting has an impact on organizational performance because it improves many processes along the retail supply chain. In low-margin, high-volume retailing, there is a large and direct improvement in profitability (Fisher & Raman, 2018). At the organizational level, forecasts are essential inputs to many decision activities in functional areas such as marketing, sales, and production/purchasing, as well as finance and accounting. Forecasts also provide the basis for national, regional and local distribution and replenishment plans.

A considerable amount of effort has been devoted to the development and improvement of forecasting models over the past several decades, and retailing has seen a shift from intuition to data-based decision making that can capitalize on this (Fisher & Raman, 2018). This paper reviews the research as it applies to retail forecasting, drawing boundaries around the field to focus on food and non-food including electrical goods (but excluding for example cars, petrol or telephony). This broadly matches the definitions and categories adopted in the UK and US government retail statistics, for example. We give special consideration to internet sales, as there is

less and less of a distinction between internet sales and brick-and-mortar retail. We exclude mail order and catalog sales – although online retailers may be able to learn from this field of study, the differences are fundamental (online retailers can use dynamic promotions, product recommendations tailored to a customer's search and purchase history, and availability-to-promise, including recommending substitutes) and the free-standing catalog business is quite obviously dying out. Our objective is to draw together and critically evaluate a diverse research literature in the context of the practical decisions that retailers must make that depend on quantitative forecasts. This examination looks at the variety of demand patterns in the different marketing (especially promotional) contexts and levels of aggregation at which forecasts must be made in order to support decisions, from the strategic to the operational.

We relied mainly on Scopus for literature searching. As retail forecasting is an extensive topic and concerns a wide range of research fields, many papers do not use 'retail*' as the keyword, but instead use more specific ones, such as 'promotion', 'supply chain', 'store', 'fashion', 'product', or 'demand/sales'. This makes the collection of retail forecasting papers for review a difficult task. To ensure a comprehensive review, we built a number of keyword compositions, e.g. "(retail or demand or sales) and (forecasting or prediction)", for the literature search, then browsed each of the papers thus identified to judge the extent of their relevance to retail forecasting.

The next section considers the decisions that retailers make, from the strategic to the operational, and the different levels of aggregation, from the store up to the retail chain. Section 3 considers aggregate forecasting from the market as a whole, where, as we have noted, rapid changes are taking place, down to the individual store, where again the question of where stores should be located has risen to prominence with the changes that have been observed in shopping behavior. We next turn to more detailed stock keeping unit (SKU) forecasting, and the hierarchies that these SKUs naturally fall into, discussed in Section 4. The data issues that are faced when forecasting include stock-outs, seasonality and calendar events, while the key demand drivers are the marketing mix and promotions. Online product reviews and social media are two new information sources that require considerable care if they are to prove valuable for forecasting. Section 5 provides an evaluation of the different methods that are used in product-level demand forecasting in an attempt to provide evidence as to the circumstances in which more complex methods add value, including a short discussion of the specific challenges to forecast accuracy evaluation at a low granularity. New product forecasting requires different approaches, which are considered in Section 6. Forecasting practice varies dramatically across the retail

sector, in part because of its diversity, and Section 7 provides various vignettes based on case observations, which capture some of the issues that retailers face and their operational solutions. Finally, Section 8 contains our conclusions as to both those areas in which the evidence as to best practice is strong and those in which research is mostneeded.

Section snippets

Retailers' forecasting needs

Retailers rely on forecasts to support strategic, tactical and operational decisions. Each level has a different focus; nevertheless, there is a need for compatibility across the three levels. Methods for ensuring this are considered in Section 4.1. …

Aggregate retail sales forecasting

All forecasting in retail depends on a degree of aggregation over product units, locations or time buckets, according to the objective of the forecasting activity.

This section uses the term 'aggregate retail sales forecasting' to refer to the total retail sales in a market, chain, store type (e.g. in-town) or individual store, as opposed to product (SKU/brand/category) specific forecasts; i.e., we implicitly aggregate across products and promotions and up to a specific granularity (e.g. weekly …

Product-level demand forecasting in retail

Product-level demand forecasting in retail usually aims to generate forecasts for a large number of time series over a short forecasting horizon, in contrast to long-term forecasting for only one or a few time series at a more aggregate level. The ability to forecast the demand for each item in each store or DC as accurately as can be achieved

is critical to the survival and growth of a retail chain, because many operational decisions, such as pricing, space allocation, listing/delisting, …

An evaluation of product-level demand forecasting methods

Over the past several decades, a considerable amount of effort has been devoted to the development and improvement of demand forecasting methods in retail. Beyond well-established univariate extrapolative methods such as exponential smoothing, linear regressions (and variants) that include various driver variables are better established than more complex methods. Such linear models have the important practical advantage of being easy to interpret and implement. On the other hand, more complex …

New product demand forecasting in retail

Forecasting the demand for new products is a more difficult task than forecasting for existing products, because of the lack of direct historical product data. However, such an effort is essential despite the complexity of the task and its relatively low accuracy (Brown and Hunter, 1967, Kahn, 2002), as it drives a variety of multifunctional decisions. These include purchasing, inventory levels, decisions related to logistics, the effect on the overall assortment's profitability, and financial …

Retail forecasting practice

No recent surveys of forecasting practice in retail have been carried out since Peterson (1993), who found a limited use of econometric (causal) methods: managerial judgment was used the most, followed by simple univariate methods. Apparently, test markets and surveys were also popular. McCarthy, Davis, Golicic, and Mentzer (2006) reached much the same conclusion in a general survey that included retail. A more tangential approach is to examine what software suppliers offer. The largest …

Conclusions and future research

The retail sector is experiencing seismic change. At the strategic level, existing brick-and-mortar retailers face hard choices with regard to their stores and their embrace of online activities. The forecasts, naïve though they are, shown in Fig. 1, Fig. 2 underline the continuing potential for disruption. The research literature has not been engaged

with the questions posed by such rapid structural change in the development of online competition, with most though not all companies moving from …

Declaration of Competing Interest

Acknowledgments

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References (251)

Aburto L. *et al.*

Improved supply chain management based on hybrid demand forecasts

Applied Soft Computing (2007)

Ainscough T.L. *et al.*

An empirical investigation and comparison of neural networks and regression for scanner data analysis

Journal of Retailing and Consumer Services (1999)

Alon I. *et al.*

Forecasting aggregate retail sales: A comparison of artificial neural networks and traditional methods

Journal of Retailing and Consumer Services (2001)

Andrews R.L. *et al.*

[Estimating the SCAN?PRO model of store sales: HB, FM or just OLS?](#)

International Journal of Research in Marketing (2008)

ArunrajN.S. *et al.*

[A hybrid seasonal autoregressive integrated moving average and quantile regression for daily food sales forecasting](#)

International Journal of Production Economics (2015)

AuK.F. *et al.*

[Fashion retail forecasting by evolutionary neural networks](#)

International Journal of Production Economics (2008)

AyeG.C. *et al.*

[Forecasting aggregate retail sales: The case of South Africa](#)

International Journal of Production Economics (2015)

BeutelA.-L. *et al.*

[Safety stock planning under causal demand forecasting](#)

International Journal of Production Economics (2012)

BooneT. *et al.*

[Forecasting sales in the supply chain: Consumer analytics in the big data era](#)

International Journal of Forecasting (2019)

BorinN. *et al.*

[A sensitivity analysis of retailer shelf management models](#)

Journal of Retailing (1995)

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[The M5 uncertainty competition: Results, findings and conclusions](#)

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