An Overview of Retail Forecasting
- and an introduction

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With Shaohui Ma and Stephan Kolassa

Three additional talks:
1. Stephan Kolassa: Random Forest Density forecasts in retail
2. Shaohui Ma: Customer flow forecasts
3. Patricia Ramos: Characterizing retail demand with promotions
Outline

1. Decisions facing a retail chain
2. Forecast requirements
   - Retail forecasting practice
3. Aggregate forecasting
4. Product SKU level demand forecasting
   - Data Issues and Business Rules at product level
5. Many explanatory variables
   - Price optimization
   - Product SKU level forecasting
5. Conclusions
6. New Products
7. Channels, Social Media and Big data
8. Research Issues and Challenges in Retail forecasting
Challenges in Retail Forecasting

• Strategic decisions
  – Rapidly changing competitive environment
    • channels
  – Store locations
  – On-line / in-town presence
  – CRM issues, e.g financing, loyalty cards

• Tactical
  – Categories and assortment
    • Brand forecasts
  – Promotional plan and business rules
  – On-shelf availability and service level
  – Distribution center planning (space, fleet, staffing, service): volume forecasts by size and store

• Operational
  – ‘Big data’
    • SKU x store models for promotional planning and price optimization
  – Short life cycles/ new products
Aggregate forecasting

Retail sales at country or regional level

- No models linking Retail sales to more aggregate economic variables (e.g. GDP)
  - Comparison with time series alternatives ✗

- By channel, by product category
  - Sophisticated weighting schemes for combination ✓
  - Effects of distribution ✓

- By chain
  - Including info on the store mix ✓
Product level demand forecasting

Decisions:

- **Category (tactical)**
  - Brand, sku mix
  - Space allocation
- **Brand**
  - Promotional strategy (frequency)
  - Feature & display
- **SKU (operational)**
  - Revenue Optimisation
- **SKU x Store**
  - Segmented stores (e.g. in-town vs out-of-town)
- **Distribution Centre: Store x volume**
  - Logistics plan

**No research on DC dependence on demand?**

**Aggregation approach?**
**SAP F&R forecasts**: causal model
- By SKU and Store: 40K in 400 stores, 25K ‘regular’
- All skus held at two distribution centres
- Focal Horizon: 26 weeks, 1-6 days for DC
- 10 promotional types: promotions across chain
- Focal horizon for orders: 13 weeks

**Orders** to vendors monthly
- Stock control
- Order to stores

**Sales & Marketing**
- Rolling two year promotional plan store level, FMCG, DIY, ...
- 4 analysts; Interventions based on: Weather, advertising
- New products

**Distribution Centre**:
- Translates into picks
- Updated daily: depends on current stock levels
- Forecast horizon? 1-10 days

**Staff Scheduling**

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**Tactical & Operational**

**Retail Forecasting in practice**

**Promotional info**
Explanatory variables in SKU level models

\[
\ln Q_{bp,t} = \beta_{bp0} + \beta_{bp, bp} \ln X_{bp,t} + \beta_{bp, b1} \ln X_{b1,t} + \beta_{bp, 1p} \ln X_{1p,t} + \beta_{bp, 11} \ln X_{11,t} + \epsilon_{bp,t}.
\]

- **Focal price-promotion variables**
  - Promotion types (Temporary price, BOGOF), feature, display
- **Focal brand competitors**
- **Competitors same pack**
- **Competitors other**
- **Weather, events, holidays, seasonal factors**
- **Other category variables**

Many variables
Data issues and Business Rules

- Censored observations (out-of-stock)

Product types
- Regular (2 years min. data history)
- Intermittence
- New products
  - Dramatic variation between product categories (5% to ?)

Business Rules
- Length, depth of promotion, no. displays
- All stores, all SKUs in brand
- Discrete pricing, smoothed price changes, corridor pricing
Research issues and solutions in SKU level forecasting in the hierarchy

• Aggregation and consistency
  – Top down vs bottom-up vs middle out
  – Consistent optimal forecasting (Hyndman et al., 2011)
    • But no consistent best performer
    • Consistency vs accuracy

• Aggregation and explanatory variable effects
  – Disaggregate models needed for heterogeneous effects
    • Store level
    • Category SKUs
  – Many variable model selection

• Aggregation over time and intermittence
## Demand models & Price optimization studies

### Table 1
The studies on retailing promotion optimization

<table>
<thead>
<tr>
<th>Paper</th>
<th>Data</th>
<th>Planning level</th>
<th>Cross-product influences</th>
<th>Cross-period influences</th>
<th>Forecast validation</th>
<th>Business Rules</th>
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</thead>
<tbody>
<tr>
<td>Mulhern &amp; Leone (1991)</td>
<td>Panel</td>
<td>Brand</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td>Tellis &amp; Zufryden (1995)</td>
<td>Panel</td>
<td>Brand</td>
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<tr>
<td>Vilcassim &amp; Chintagunta (1995)</td>
<td>Panel</td>
<td>Brand</td>
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<tr>
<td>Ailawadi et al. (2007a)</td>
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<td>Category</td>
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<td>Natter et al. (2007)</td>
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<tr>
<td>Ferreira et al. (2015)</td>
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<td>Cohen et al. (2014)</td>
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<td>SKU</td>
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</tbody>
</table>

### Academic work limited
- Commercial implementations, e.g. SAP, SAS
Conclusions from SKU modelling of regular products

• Base models using last promotional uplift wholly inadequate

• Increasing complex models deliver value
  – Using focal SKU
  – using core SKUs
  – Using all SKUs in category

• Category effects

Research issues:
• Impact of business rules
• Use of software
  • Judgment?
New Products I

*Defined as products with less than 2 seasons data history*

- How prevalent?
  - In IRI
  - In UK non-food hardware, homeware and garden

- Retailers as manufacturers
  - Same techniques: market testing, choice models, diffusion

- Fashion forecasting as new product forecasting

- Decision context
  - Short Life cycle (fashion goods: electronics)
    - Buying ahead: re-order?
  - The assortment decision: adding a new SKU to a category
  - Distributional consequences of new SKU
New Products II

New product forecasting methods for retail

- Continuity of data with past SKUs
- Judgment
- Structured judgment
  - Analogous products
  - Interactions with manufacturers ( & their forecasts)
- Attribute models of similar products (Vaidyanathan, 2011)
- Bayesian methods based on analogous products
  - Clustering (see Goodwin et al.)

Major application possibilities in fashion forecasting but...
Channels
On-line, catalogue vs Bricks & Mortar

• Rapid growth (in some categories) in on-line
• Competition, cannibalization and complementarity between channels (strategic/ tactical)
  – Generic
  – Niche
  – Search
• On-line shopping (Operational)
  – Web-site design and effects on sales
  – Individual Customer Models
    • Recommender systems (If you like that you’ll like this)
    • Returns (and profitability)
Retailing, internet sources (social media) and big-data

The Claim

• A switch to ‘Analysis and forecasting of customer behaviour’
  – Rather than aggregate SKU x location
  – Better accuracy, better insight ‘on a whole new level’

The Counter-claim (Snapp, Foresight, Spring, 2017)

• OK for important/segmented customers
  – But done already

• At a micro-level, adding noise
  – Aggregation still required (in $s?)

• Causal models not limited by lack of ‘big data’
Retailing, internet sources (social media) and big-data II

- Customer behavioural data
  - Useful for short-term sales generation
  - Potential
    - At SKU level
    - Promotional ‘customer centric’ targeting

- Social media data
  - Some value for short-term forecasting of ‘instant’ impulse products, e.g. games, music
  - Weak signals (Kolassa, 2017)
    - Do they help?
Research issues in Retail forecasting

• Robust methods for SKU level forecasting
  – Many market drivers + Uncertainty (Kolassa)
• Internet Sources: Big data applications (Ma)
• Integration of customer data in aggregate demand forecasting
  – Greater granularity
• Characterizing retail data (Ramos/Fildes)
  – Best models with promotions

And other issues?

• Aggregation
• New products
• Practice and the software interface
• Collaboration with suppliers