Forecasting demand with internet searches and (social media shares)

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Nikolaos Kourentzes
Robert Fildes

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Santander, 20th June 2016
Improving forecast with search traffic data...

<table>
<thead>
<tr>
<th>Field</th>
<th>Target Variable</th>
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<tbody>
<tr>
<td>Econometric Ind.</td>
<td>Unemployment claims be:</td>
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<td>Consumer confidence Index</td>
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<td></td>
<td>Private consumption$^{4}$</td>
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<td></td>
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<tr>
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<td>Services</td>
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<td>Visitor arrivals$^{6}$</td>
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<td>Car brand sales$^{9}$</td>
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<td>Motor Vehicles and Parts</td>
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<td>Car sales$^{9}$</td>
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<td>Car sales$^{10}$</td>
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<td>Speciality-food SKUs$^{11}$</td>
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<td>Video game sales$^{12}$</td>
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<table>
<thead>
<tr>
<th>% Improvement</th>
<th>y</th>
<th>ST Lag</th>
<th>Horizon</th>
<th>hold-out</th>
<th>% Improvement</th>
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<tbody>
<tr>
<td>13.6% MAE</td>
<td>76% RMSFE</td>
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<td>9.3% MAE</td>
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<td>12% MAE</td>
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<td></td>
<td>27% MAPE</td>
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<tr>
<td></td>
<td>5.6% MAPE</td>
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<tr>
<td>10.5% MAE</td>
<td>2.3% MAPE</td>
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<tr>
<td>10.3% MAE</td>
<td>5.3% RMSE</td>
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<td>45% Corr.</td>
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Forecast evaluation

Several studies use a weak benchmark i.e.

- Lack of out-of-sample evaluation (e.g. Boone et al. 2015; Goel et al. 2010)
- Lack of adequate benchmark model, i.e. Naïve (e.g. Choi and Varian 2012; Vosen and Schmidt 2011; Geva et al. 2015)

Most of identified studies only forecast 1-step ahead

- Du et al. (2015) first forecast search traffic 24 step ahead before including in their market response model.
- It is not clear what Fantazzini and Toktamysova (2015) do. I assume that they include true future values of search traffic for 24 step ahead forecast (!)
Is search traffic information leading?

No lead time required for nowcasting applications (i.e. Choi & Varian 2012; Vosen 2011)

Lag 1 to Lag 2 most commonly used. Few studies tested explicitly for lag structure

- less than 8 weeks for cars (Geva et al. 2015)
- less than three days for tourism destination (Peng et al. 2016)

Number of lags fixed in the model but is this structure consistent over a product life-cycle?
Meanwhile at Lancaster Island™...
Yes, but it matters in practice as...

life-cycles are often short
  • Minimum window size often after peak sales
lead time is required
  • Multi-step ahead forecasts require larger lead
we might be estimating many SKUs
  • Should companies re-estimate their model because of time-varying effects?
Application to Supply Chain Forecasting

Studies with focus on the supply chain are sparse

- Boone (2015) found significant better insample fit for speciality-food SKUs, but did not test for out-of-sample.
- Geva et al. (2015) found marginal 1-step ahead improvements for car sales and general higher forecasting error due to more noise.
- Goel et al. (2011) only predicted the first 4 weeks after launch. They found search traffic to be predictive but not more than other traditional explanatory variables.

No article in IJF on incorporating search traffic data (?)
Let's look at some data...
Google Trends data vs. actual sales

Call of Duty 3

Wii Sports
Experiment setting

Video game sales from VGchartz

- Global physical sales information of 98 popular game titles launched between 2005 and 2014 at a weekly frequency
- Aggregate across various gaming platforms such as PC, XBox, PS3 or Wii

Search Traffic Popularity from Google Trends

- Weekly global search traffic popularity information
- Game title used as search traffic keyword
**Method**

Rolling window based AR(m)X model

\[ \Delta^d y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i \Delta^d y_{t-i} + \sum_{i=1+h}^{k} \beta_i \Delta^d x_{t-i} + \epsilon \]

\( \Delta^d y_t \) = sales \quad m = \) number of AR terms \quad d = \) number of differences

\( \Delta^d x_t \) = Google Trends \quad k = \) number of lags \quad h = \) step ahead
Experiment setting

Model setting: \( d = 1, k = \{1, \ldots, 18\} \, h = \{1, 12\} \)

Two-stage model selection process

- AR part on AIC selection
- LASSO for explanatory variable selection (Tibshirani 1996)

Re-estimation at each origin for window sizes: 20,..,N-h

Accuracy measure with AvgRelMAE (Davydenko & Fildes 2013)

- Benchmark 1: \( \text{RelMAE}_j = \frac{\text{AR}(m)}{\text{ARX}(m,k)} \)
- Benchmark 2: \( \text{RelMAE}_j = \frac{\text{Naïve}}{\text{ARX}(m,k)} \)
Performance across series

1 step ahead

<table>
<thead>
<tr>
<th>AR(m)</th>
<th>Naïve</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.934</td>
<td>0.825</td>
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</table>

<1 = better  
Window Size = 24, N=98

12 steps ahead

<table>
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<tr>
<th>AR(m)</th>
<th>Naïve</th>
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<tbody>
<tr>
<td>0.975</td>
<td>0.726</td>
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<1 = better  
Window Size = 24, N=98

Results are relatively consistent throughout different window sizes
Current results suggest **no benefit** at all in using search traffic information. What are the problems?

Can we think of other fields of applications?

- Products with longer decision process, i.e. cars
- Pre-launch forecasting (Xiong & Bhradwaj 2014, Kulkarni et al. 2012)

Task will remain challenging in practice

- Key word selection (Peng 2016; Brynjolfsson et al. 2015)
- Overfitting problem
- How is this now with time varying causality? Ignore it?
Thank you!

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www.forecasting-centre.com
## Online Videos performance across series

### 1 step ahead

<table>
<thead>
<tr>
<th></th>
<th>AR</th>
<th>Naïve</th>
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<tbody>
<tr>
<td></td>
<td>0.996</td>
<td>0.871</td>
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<1 = better  
Window Size = 24, N=3

### 12 steps ahead

<table>
<thead>
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<th>AR</th>
<th>Naïve</th>
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<tbody>
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<td></td>
<td>0.987</td>
<td>1.050</td>
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<1 = better  
Window Size = 24, N=3


References


