Forecasting

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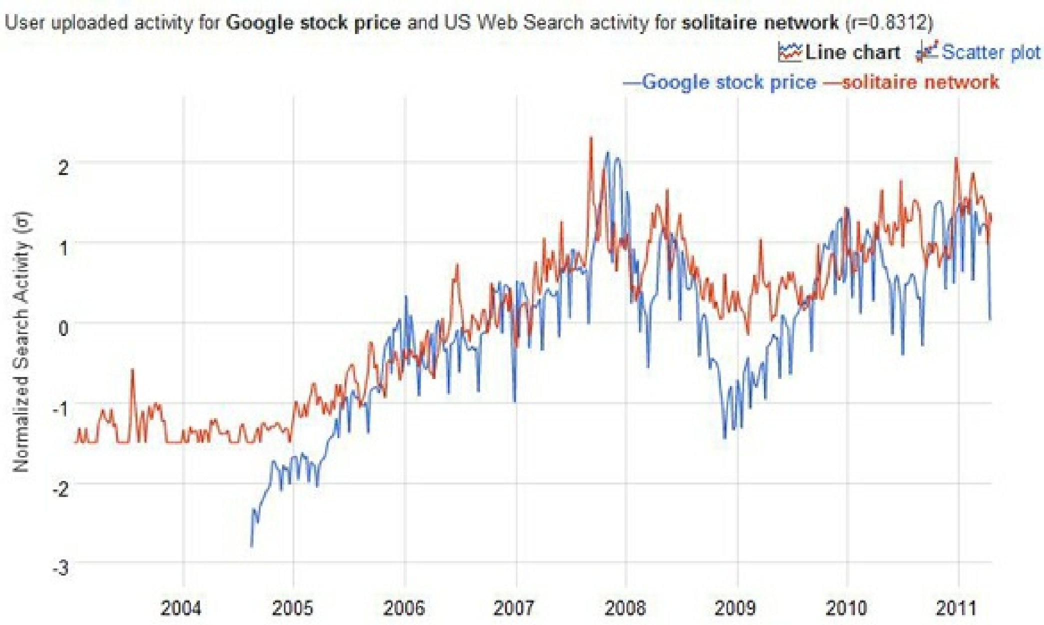
Time series data

https://www.google.com/finance

What is different?

- Data are dependent over time
- Specific pattern types
  - Trends - long term increase or decrease
  - Seasonal patterns - patterns related to time of week, month, year, etc.
  - Cycles - patterns that rise and fall periodically
- Subsampling into training/test is more complicated
- Similar issues arise in spatial data
  - Dependency between nearby observations
  - Location specific effects
- Typically goal is to predict one or more observations into the future.
- All standard predictions can be used (with caution!)

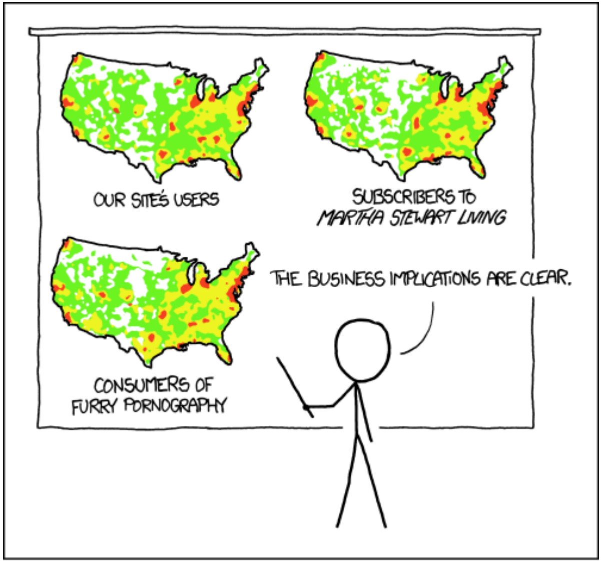
Beware spurious correlations!



http://www.google.com/trends/correlate

http://www.newscientist.com/blogs/onepercent/2011/05/google-correlate-passes-our-we.html

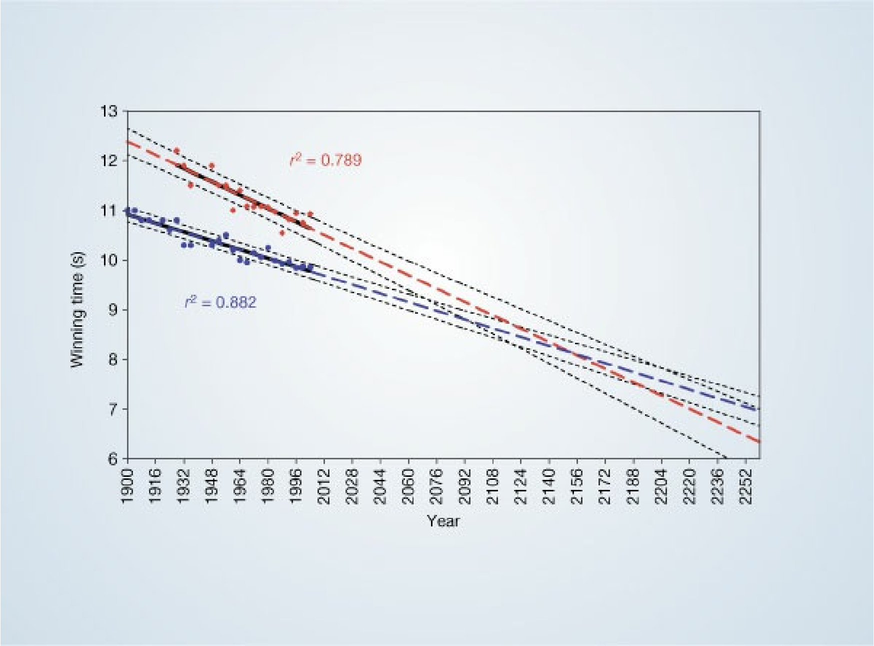
Also common in geographic analyses



PET PEEVE #208:
GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS

http://xkcd.com/1138/

Beware extrapolation!



http://www.nature.com/nature/journal/v431/n7008/full/431525a.html

Google data

```r
library(quantmod)
from.dat <- as.Date("01/01/08", format="%m/%d/%y")
to.dat <- as.Date("12/31/13", format="%m/%d/%y")
getSymbols("GOOG", src="google", from = from.dat, to = to.dat)
```

```
[1] "GOOG"
```

```r
head(GOOG)
```

```
           GOOG.Open GOOG.High GOOG.Low GOOG.Close GOOG.Volume
2008-01-02     692.9     697.4    677.7      685.2     4306848
2008-01-03     685.3     686.9    676.5      685.3     3252846
2008-01-04     679.7     681.0    655.0      657.0     5359834
2008-01-07     653.9     662.3    637.4      649.2     6404945
2008-01-08     653.0     660.0    631.0      631.7     5341949
2008-01-09     630.0     653.3    622.5      653.2     6744242
```

Summarize monthly and store as time series

```
mGoog <- to.monthly(GOOG)
googOpen <- Op(mGoog)
ts1 <- ts(googOpen,frequency=12)
plot(ts1,xlab="Years+1", ylab="GOOG")
```

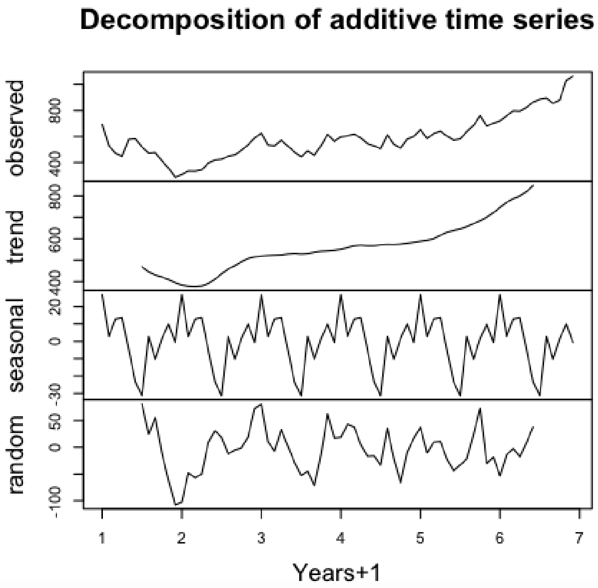
Example time series decomposition

- **Trend** - Consistently increasing pattern over time
- **Seasonal** - When there is a pattern over a fixed period of time that recurs.
- **Cyclic** - When data rises and falls over non fixed periods

https://www.otexts.org/fpp/6/1

Decompose a time series into parts

```
plot(decompose(ts1),xlab="Years+1")
```



Training and test sets

```
ts1Train <- window(ts1,start=1,end=5)
ts1Test <- window(ts1,start=5,end=(7-0.01))
ts1Train
```

```
    Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
1 692.9 528.7 471.5 447.7 578.3 582.5 519.6 472.5 476.8 412.1 357.6 286.7
2 308.6 334.3 333.3 343.8 395.0 418.7 424.2 448.7 459.7 493.0 537.1 588.1
3 627.0 534.6 529.2 571.4 526.5 480.4 445.3 489.0 455.0 530.0 615.7 563.0
4 596.5 604.5 617.8 588.8 545.7 528.0 506.7 611.2 540.8 509.9 580.1 600.0
5 652.9
```

Simple moving average

$$Y_t = \frac{1}{2 * k + 1} \sum_{j=-k}^{k} y_{t+j}$$

```
plot(ts1Train)
lines(ma(ts1Train,order=3),col="red")
```

Exponential smoothing

Example - simple exponential smoothing

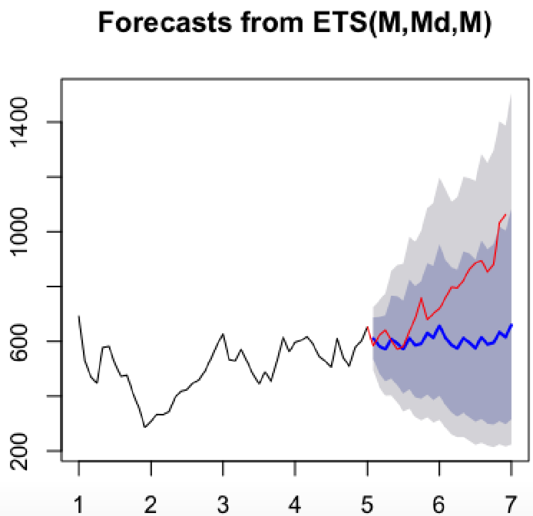
$$\hat{y}_{t+1} = \alpha y_t + (1 - \alpha)\hat{y}_{t-1}$$

		Seasonal Component	
Trend Component	N (None)	A (Additive)	M (Multiplicative)
N (None)	(N,N)	(N,A)	(N,M)
A (Additive)	(A,N)	(A,A)	(A,M)
A_d (Additive damped)	(A_d,N)	(A_d,A)	(A_d,M)
M (Multiplicative)	(M,N)	(M,A)	(M,M)
M_d (Multiplicative damped)	(M_d,N)	(M_d,A)	(M_d,M)

https://www.otexts.org/fpp/7/6

Exponential smoothing

```
ets1 <- ets(ts1Train,model="MMM")
fcast <- forecast(ets1)
plot(fcast); lines(ts1Test,col="red")
```



Get the accuracy

```
accuracy(fcast,ts1Test)
```

```
                    ME   RMSE    MAE     MPE   MAPE   MASE    ACF1 Theil's U
Training set    0.9464  48.78  39.35 -0.3297  7.932 0.3733 0.07298        NA
Test set      156.1890 205.76 160.78 18.1819 18.971 1.5254 0.77025     3.745
```

Notes and further resources

- Forecasting and timeseries prediction is an entire field
- Rob Hyndman's Forecasting: principles and practice is a good place to start
- Cautions
  - Be wary of spurious correlations
  - Be careful how far you predict (extrapolation)
  - Be wary of dependencies over time
- See quantmod or quandl packages for finance-related problems.