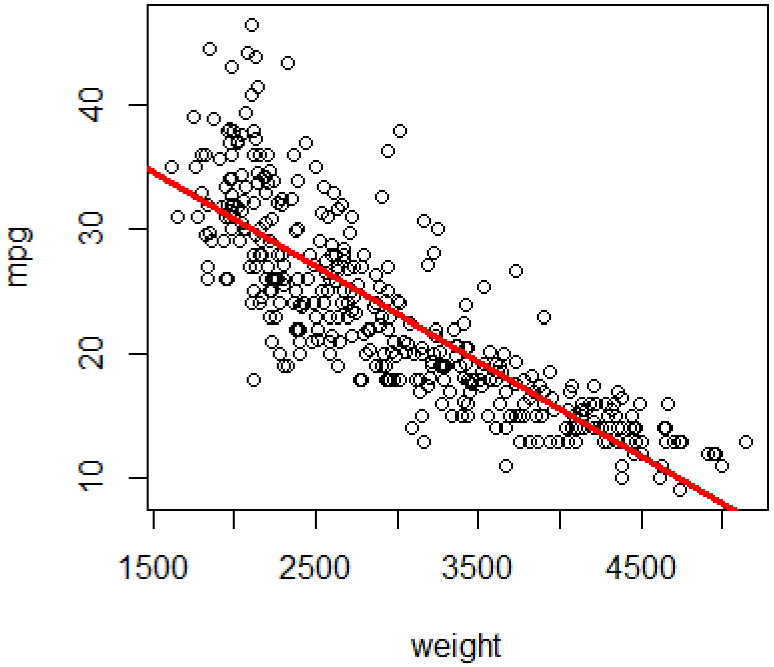
# Dr. M. Baron, Statistical Machine Learning class, STAT-427/627

### DEGREE OF FLEXIBILITY… REGRESSION VS SMOOTH SPLINES

```
> setwd("C:/Users/baron/627 Statistical Machine Learning/data")
> load("Auto.rda")
> attach(Auto)
```

# Fit REGRESSION model predicting miles per gallon based on weight.
# Plot the regression line in red color with thickness=3

```
> reg = lm(mpg~weight)
> plot(weight,mpg)
> abline(reg,col="red",lwd=3)
```



# In general, abline(a,b) plots the line y = a + bx

# Fit a SPLINE with 2 degrees of freedom (straight line) to our data and plot it.

```
> spline2 = smooth.spline(weight,mpg,df=2)
> lines(spline2,col="blue")
```

# Add one more degree of freedom -> quadratic spline

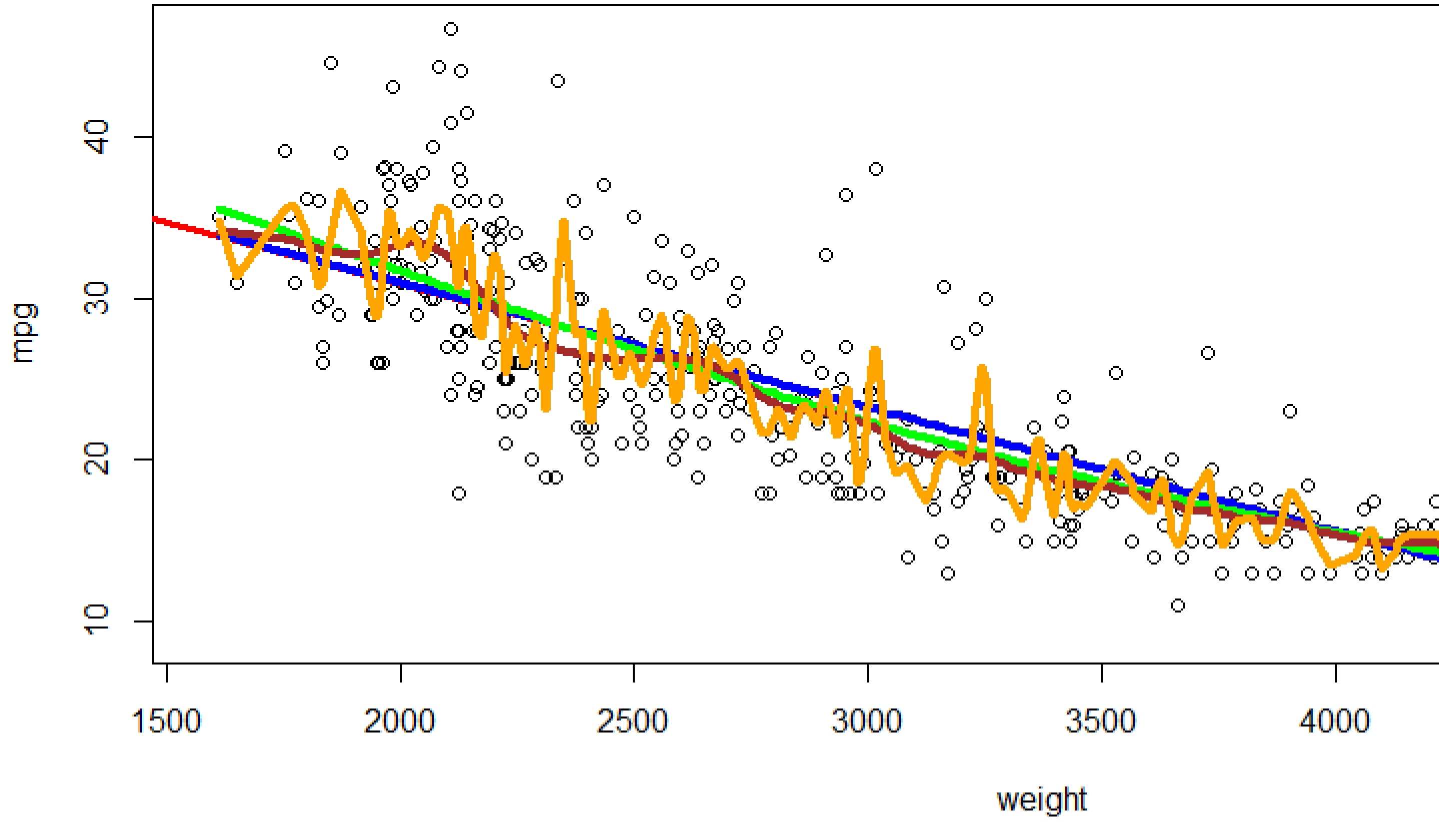
```
> spline3 = smooth.spline(weight,mpg,df=3)
> lines(spline3,col="green",lwd=4)
```

# Increase flexibility by adding more d.f.

```
> spline20 = smooth.spline(weight,mpg,df=20)
> lines(spline20,col="brown",lwd=4)
```

# Blow flexibility to 100 degrees of freedom.
# The resulting spline is heavily dependent on each data point.
# Its prediction power is very low.

```
> spline100 = smooth.spline(weight,mpg,df=100)
> lines(spline100,col="orange",lwd=4)
```



# While spline100 is very flexible, and it matches the data most closely, it would not be powerful for prediction. We'll learn how to measure prediction accuracy with various cross-validation tools.

How to choose the optimal method? Cross-validation technique.

> n = length(mpg);   Z = sample(n,n/2);   attach(Auto[Z,]);   **# This will be our training data**

> ss5 = smooth.spline(weight, mpg, df=5)   **# Fit the spline using training data only**

> attach(Auto);

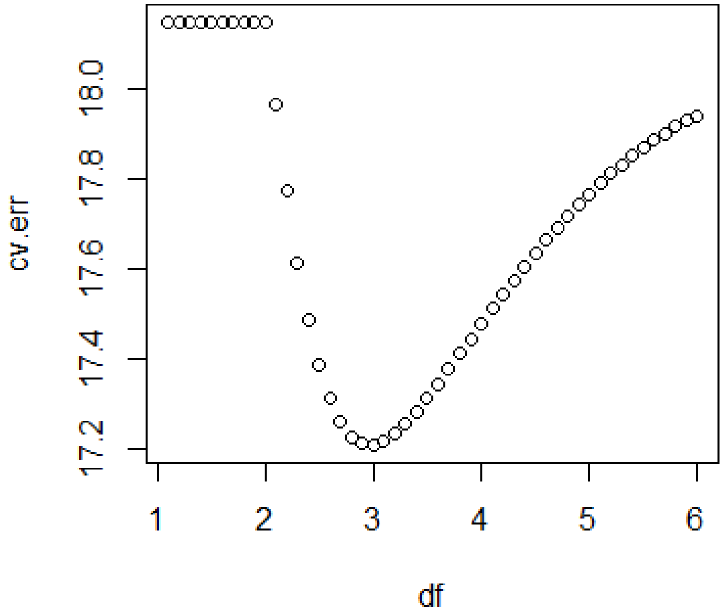
```
> Yhat = predict(ss5, x=weight)
> names(Yhat)                                        # Notice: prediction consists
of two parts – predictor x and
[1] "x" "y"                                          # predicted response y. We
can call them Yhat$x and Yhat$y.

> mean(( Yhat$y[-Z] - mpg[-Z] )^2)                   # Then, compute prediction
mean-squared error on test data
[1] 17.76551                                         # This is the cross-validation
error for a spline with df=5


# Try many different splines and choose the one with the smallest prediction error.

> cv.err = rep(0,50);
> for (p in 1:50){
+ attach(Auto[Z,]);  ss = smooth.spline(weight, mpg, df=1+p/10)    # Try DF = 1.1, 1.2, …, 6.0
+ attach(Auto);      Yhat = predict(ss, weight)                     # DF must be > 1
+ cv.err[p] = mean( (Yhat$y[-Z] - mpg[-Z])^2 )
}

> df = 1+(1:50)/10
> plot(df,cv.err)
```



```
> which.min(cv.err)
[1] 20
> df[20]
[1] 3
```

```
# This cross-validation method chooses the spline with 3 d.f.
```