Challenger USA Space Shuttle O-Ring

Space shuttle Challenger tragically malfunctioned shortly after liftoff on Jan 28, 1986, killing its crewmembers. The cause was malfunction or serious thermal distress with the O-rings in one of two rocket boosters. O-rings are 37 foot circles of rubber that help pressure seal the gas and exhaust. Data from 23 shuttle flights prior to the Challenger disaster are provided. Use linear regression to predict the number of O-rings experiencing thermal distress given the four attributes.

Attributes: Number of O-rings at risk on a given flight, Launch temperature (degrees F), Leak-check pressure (psi).

Note: The number of O-rings is always 6 and the temporal order of flight is independent of each other, so the data is listed below, but not used for the linear regression.

Response Variable: Number of O-rings experiencing thermal distress

Goal: Predict the number of O-rings that experience thermal distress on a flight at 31 degrees Fahrenheit given data on the previous 23 shuttle flights. Two models are used. One with 3 parameters - Intercept, Launch temperature, and Leak check pressure and one with 2 parameters - Intercept and Launch temperature.

```
model{
        for(i in 1:n ){
                #constant term of design matrix-vector of ones
                #setting design matrix
                X[i,1] <- 1.0
                X[i,2] <- LaunchTemp[i]
                X[i,3] <- LeakPressure[i]; #Comment out for 2 parameters

                NumThermalDistress[i] ~ dnorm(mu[i], tau)     #likelihood
                mu[i] <- inprod( beta[], X[i,] )  #linear predictor
        }
        #priors
        #traditional gamma on 1/sigma^2
        tau ~ dgamma(0.001, 0.001)
        sigma2<-1/tau

        #p number of parameters
        #normal on betas
        for(i in 1:p){
                beta[i] ~ dnorm(0, 0.00001)
        }

        #Bayesian R^2
        sse <- (n-p)*sigma2
        for( i in 1:n){
                cy[i] <- NumThermalDistress[i] - mean(NumThermalDistress[])
```

```
        }
        sst <- inprod(cy[], cy[])
        BR2 <- 1 - sse/sst
        BR2adj <- 1- (n-1)*sigma2/sst

        #Mean Response and Prediction
        #3 parameters (intercept + LaunchTemp + LeakPressure)
        p.mean.LP_50 <- beta[1]+beta[2]*31+beta[3]*50; #Comment out for 2 parameters
        p.mean.LP_100 <- beta[1]+beta[2]*31+beta[3]*100; #Comment out for 2 parameters
        p.mean.LP_200 <- beta[1]+beta[2]*31+beta[3]*200; #Comment out for 2 parameters

        new.TD_50 ~ dnorm(p.mean.LP_50, tau); #Comment out for 2 parameters
        new.TD_100 ~ dnorm(p.mean.LP_100, tau); #Comment out for 2 parameters
        new.TD_200 ~ dnorm(p.mean.LP_200, tau); #Comment out for 2 parameters

        #2 parameters (intercept + LaunchTemp)
        #predict.mean <- beta[1]+beta[2]*31; #Comment out for 3 parameters
        #new.TD ~ dnorm(predict.mean, tau); #Comment out for 3 parameters
}
```

DATA 1: Select One

#3 parameters (intercept + LaunchTemp + LeakPressure)

```
list(n = 23, p = 3)
```

#2 parameters (intercept + LaunchTemp)

```
list(n = 23, p = 2)
```

#Data 2 is for both

DATA2 (unfold)

INITS: Select One

#3 parameters (intercept + LaunchTemp + LeakPressure)

```
list(beta = c(1, 0, 0), tau = 1, new.TD_50 = 0, new.TD_100 = 0, new.TD_200 = 0)
```

#2 parameters (intercept + LaunchTemp)

```
list(beta = c(1, 0), tau = 1, new.TD = 0)
```

RESULTS

3 parameter model: Intercept, Launch Temperature, and Leak-Check Pressure

	mean	sd	MC_error	val2.5pc	median	val97.5pc	start	sample
BR2	0.2829	0.2534	6.483E-4	-0.3442	0.3327	0.6223	1001	1000000
BR2adj	0.2112	0.2788	7.132E-4	-0.4786	0.266	0.5846	1001	1000000
beta[1]	3.319	1.242	0.01661	0.8619	3.316	5.771	1001	1000000
beta[2]	-0.04852	0.01748	2.339E-4	-0.08302	-0.04849	-0.01383	1001	1000000
beta[3]	0.002943	0.001826	5.694E-6	-6.623E-4	0.002942	0.00656	1001	1000000
deviance	39.19	3.087	0.01714	35.35	38.49	46.98	1001	1000000
new.TD_100	2.11	0.901	0.009185	0.326	2.11	3.891	1001	1000000
new.TD_200	2.403	0.9064	0.009035	0.6061	2.404	4.196	1001	1000000
new.TD_50	1.96	0.9125	0.00928	0.1534	1.962	3.766	1001	1000000
p.mean.LP_100	2.109	0.6876	0.009186	0.7468	2.108	3.466	1001	1000000
p.mean.LP_200	2.403	0.6938	0.009024	1.027	2.403	3.776	1001	1000000
p.mean.LP_50	1.962	0.7024	0.009279	0.5725	1.96	3.35	1001	1000000
sigma2	0.3398	0.1201	3.073E-4	0.179	0.3162	0.637	1001	1000000

sse	6.797	2.402	0.006145	3.58	6.325	12.74	1001	1000000
tau	3.27	1.034	0.002446	1.57	3.162	5.587	1001	1000000

2 parameter model: Intercept and Launch Temperature

mean	sd	MC_error	val2.5pc	median	val97.5pc		start	sample
BR2	0.184	0.2791	6.83E-4	-0.5065	0.2373	0.5628	1001	1000000
BR2adj	0.1452	0.2924	7.156E-4	-0.5782	0.201	0.542	1001	1000000
beta[1]	3.735	1.275	0.0168	1.233	3.729	6.273	1001	1000000
beta[2]	-0.04807	0.01824	2.404E-4	-0.08436	-0.04797	-0.01228	1001	1000000
deviance		41.11	2.606	0.0155	38.15	40.44	47.88	1001	1000000
new.TD	2.245	0.9369	0.009392	0.4011	2.243	4.107	1001	1000000
predict.mean		2.245	0.7143	0.009347	0.8436	2.241	3.668	1001	1000000
sigma2	0.3683	0.126	3.083E-4	0.1973	0.3442	0.6799	1001	1000000
sse	7.734	2.645	0.006474	4.144	7.229	14.28	1001	1000000
tau	3.001	0.9258	0.002121	1.471	2.905	5.068	1001	1000000