Defense Services Equations

# Setup

First we load the data. The dataset used is a U.S. Defense Contracting dataset derived from FPDS.

## Warning: replacing previous import 'Hmisc::summarize' by 'dplyr::summarize'  
## when loading 'csis360'

## Warning: replacing previous import 'Hmisc::src' by 'dplyr::src' when  
## loading 'csis360'

## Warning: replacing previous import 'dplyr::intersect' by  
## 'lubridate::intersect' when loading 'csis360'

## Warning: replacing previous import 'dplyr::union' by 'lubridate::union'  
## when loading 'csis360'

## Warning: replacing previous import 'dplyr::setdiff' by 'lubridate::setdiff'  
## when loading 'csis360'

# Options

Note that because we use the complete dataset for exercised options, there’s no 1 million entry variant.

##   
## =======================================================================  
## Some Opt All Opt   
## -----------------------------------------------------------------------  
## (Intercept) 0.05 1.15 \*\*\*  
## (0.22) (0.15)   
## cln\_US6sal 0.01 0.08   
## (0.06) (0.06)   
## cln\_PSCrate -0.06 -0.07 \*   
## (0.03) (0.03)   
## cp\_OffPerf7 -0.16 \*\*\* 0.00   
## (0.05) (0.05)   
## cp\_OffPSC7 -0.18 \*\* 0.18 \*\*   
## (0.06) (0.06)   
## cn\_PairHist7 0.26 \*\*\* 0.14 \*\*\*  
## (0.02) (0.03)   
## cln\_PairCA -0.07 -0.22 \*\*\*  
## (0.04) (0.05)   
## cln\_Base 0.23 \*\*\* -0.14 \*\*\*  
## (0.04) (0.03)   
## clr\_Ceil2Base 0.30 \*\*\* -0.80 \*\*\*  
## (0.01) (0.02)   
## cln\_Days 0.29 \*\*\* -0.45 \*\*\*  
## (0.03) (0.04)   
## Comp1 offer 0.01 0.00   
## (0.03) (0.03)   
## Comp2-4 offers -0.03 -0.04   
## (0.03) (0.03)   
## Comp5+ offers -0.07 \* -0.08 \*   
## (0.03) (0.03)   
## VehS-IDC -0.69 \*\*\* -0.20 \*\*\*  
## (0.04) (0.05)   
## VehM-IDC -0.23 \*\*\* -0.13 \*\*   
## (0.04) (0.04)   
## VehFSS/GWAC -0.17 \*\*\* -0.06   
## (0.04) (0.04)   
## VehBPA/BOA -0.29 \*\*\* 0.25 \*   
## (0.08) (0.10)   
## PricingOther FP -0.70 \*\*\* -0.50 \*   
## (0.17) (0.22)   
## PricingIncentive -0.34 0.58   
## (0.30) (0.31)   
## PricingCombination or Other 0.36 \*\*\* -0.14 \*   
## (0.09) (0.07)   
## PricingOther CB 0.25 \*\*\* 0.21 \*\*\*  
## (0.06) (0.06)   
## PricingT&M/LH/FPLOE 0.06 -0.03   
## (0.07) (0.07)   
## PricingUCA -0.09 -0.09   
## (0.12) (0.15)   
## CrisisARRA -0.42 \* -0.24   
## (0.16) (0.22)   
## CrisisDis -0.32 -1.46 \*\*\*  
## (0.31) (0.42)   
## CrisisOCO -0.34 \*\* -0.26 \*   
## (0.12) (0.12)   
## cln\_Def6HHI -0.13 \*\* -0.09   
## (0.05) (0.05)   
## clr\_Def6toUS -0.01 0.04   
## (0.04) (0.05)   
## cln\_Def3HHI -0.02 -0.05   
## (0.05) (0.06)   
## clr\_Def3toUS 0.03 -0.02   
## (0.08) (0.08)   
## cp\_PairObl7 -0.02 -0.07   
## (0.05) (0.06)   
## cln\_OffObl7 0.20 \*\*\* -0.09 \*\*   
## (0.05) (0.03)   
## cln\_OffFocus -0.32 \*\*\* -0.13 \*   
## (0.06) (0.06)   
## cp\_OffPerf7:cp\_PairObl7 0.69 \*\*\* 0.15   
## (0.08) (0.09)   
## cp\_PairObl7:cln\_OffObl7 0.13   
## (0.12)   
## cn\_PairHist7:PricingOther FP -0.09   
## (0.37)   
## cn\_PairHist7:PricingIncentive 1.55 \*\*   
## (0.51)   
## cn\_PairHist7:PricingCombination or Other -0.45 \*   
## (0.18)   
## cn\_PairHist7:PricingOther CB 0.20 \*   
## (0.10)   
## cn\_PairHist7:PricingT&M/LH/FPLOE 0.08   
## (0.12)   
## cn\_PairHist7:PricingUCA 0.16   
## (0.22)   
## cp\_OffPerf7:cln\_PairCA -0.61 \*\*\*   
## (0.06)   
## cln\_Base:clr\_Ceil2Base 0.26 \*\*\*   
## (0.02)   
## cp\_OffPSC7:cln\_OffObl7 1.03 \*\*\*   
## (0.16)   
## cp\_OffPSC7:cln\_OffFocus -0.10   
## (0.11)   
## cln\_PSCrate:PricingOther FP -0.23   
## (0.61)   
## cln\_PSCrate:PricingIncentive -0.60   
## (0.70)   
## cln\_PSCrate:PricingCombination or Other 0.40 \*   
## (0.20)   
## cln\_PSCrate:PricingOther CB 0.43 \*\*   
## (0.14)   
## cln\_PSCrate:PricingT&M/LH/FPLOE 0.17   
## (0.20)   
## cln\_PSCrate:PricingUCA 1.42 \*\*\*  
## (0.37)   
## cln\_OffObl7:cln\_OffFocus -0.00   
## (0.07)   
## -----------------------------------------------------------------------  
## AIC 75772.83 59424.62   
## BIC 76242.82 59858.10   
## Log Likelihood -37835.41 -29663.31   
## Num. obs. 74274 51357   
## Num. groups: ServArea:(NAICS6:NAICS3) 1508 1327   
## Num. groups: Office:Agency 758 676   
## Num. groups: NAICS6:NAICS3 624 573   
## Num. groups: Place 121 103   
## Num. groups: NAICS3 78 73   
## Num. groups: Agency 25 25   
## Num. groups: StartFY 9 9   
## Var: ServArea:(NAICS6:NAICS3) (Intercept) 0.14 0.03   
## Var: Office:Agency (Intercept) 0.54 0.22   
## Var: NAICS6:NAICS3 (Intercept) 0.04 0.09   
## Var: Place (Intercept) 0.27 0.07   
## Var: NAICS3 (Intercept) 0.03 0.02   
## Var: Agency (Intercept) 0.00 0.06   
## Var: StartFY (Intercept) 0.29 0.03   
## =======================================================================  
## \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05

## Some Options Likelihood

## All Options Likelihood

# Ceiling Breach

##   
## ============================================================  
## Dependent variable:   
## --------------------------------  
## b\_CBre ln\_CBre   
## generalized linear linear   
## mixed-effects mixed-effects  
## (1) (2)   
## ------------------------------------------------------------  
## cln\_US6sal -0.003 -0.02   
## (0.06) (0.06)   
##   
## cln\_PSCrate 0.06\*\*\* 0.09\*\*\*   
## (0.01) (0.02)   
##   
## cp\_OffPerf7 0.07\*\*\* -0.06   
## (0.03) (0.04)   
##   
## cp\_OffPSC7 0.19\*\*\* 0.13\*\*\*   
## (0.02) (0.03)   
##   
## cn\_PairHist7 -0.08\*\*\* 0.03   
## (0.01) (0.02)   
##   
## cln\_PairCA 0.44\*\*\* -0.01   
## (0.02) (0.03)   
##   
## cln\_Base 1.35\*\*\* 2.65\*\*\*   
## (0.01) (0.02)   
##   
## clr\_Ceil2Base 0.25\*\*\* 0.25\*\*\*   
## (0.01) (0.02)   
##   
## cln\_Days 0.28\*\*\* 0.05\*\*   
## (0.01) (0.02)   
##   
## Comp1 offer -0.03\* -0.05\*   
## (0.02) (0.03)   
##   
## Comp2-4 offers 0.11\*\*\* -0.11\*\*\*   
## (0.01) (0.02)   
##   
## Comp5+ offers 0.18\*\*\* -0.07\*\*\*   
## (0.01) (0.02)   
##   
## VehS-IDC -0.48\*\*\* -0.01   
## (0.02) (0.02)   
##   
## VehM-IDC -0.18\*\*\* -0.02   
## (0.02) (0.03)   
##   
## VehFSS/GWAC -0.01 0.12\*\*   
## (0.03) (0.05)   
##   
## VehBPA/BOA -0.29\*\*\* -0.13\*\*   
## (0.03) (0.06)   
##   
## PricingOther FP -0.40\*\*\* -0.36\*\*   
## (0.09) (0.14)   
##   
## PricingIncentive 2.39\*\*\* 0.81\*\*\*   
## (0.07) (0.12)   
##   
## PricingCombination or Other 0.26\*\*\* 0.43\*\*\*   
## (0.05) (0.07)   
##   
## PricingOther CB -0.09\*\*\* 0.81\*\*\*   
## (0.03) (0.05)   
##   
## PricingT&M/LH/FPLOE 0.11\*\* 0.66\*\*\*   
## (0.04) (0.07)   
##   
## PricingUCA 0.07\* 0.37\*\*\*   
## (0.04) (0.07)   
##   
## CrisisARRA 0.12\*\*\* -0.06   
## (0.04) (0.06)   
##   
## CrisisDis 0.07 0.39\*\*\*   
## (0.09) (0.13)   
##   
## CrisisOCO -0.10\*\* 0.08   
## (0.05) (0.08)   
##   
## cln\_Def6HHI -0.02 0.06\*\*   
## (0.02) (0.03)   
##   
## clr\_Def6toUS 0.07\*\* 0.01   
## (0.03) (0.03)   
##   
## clr\_Def3toUS -0.46\*\*\* 0.29\*\*\*   
## (0.07) (0.08)   
##   
## cp\_PairObl7 -0.24\*\*\* 0.01   
## (0.03) (0.04)   
##   
## cln\_OffObl7 0.04\*\* 0.06\*\*   
## (0.02) (0.02)   
##   
## cln\_OffFocus -0.36\*\*\*   
## (0.04)   
##   
## cp\_OffPerf7:cln\_PairCA 0.38\*\*\* -0.20\*\*\*   
## (0.03) (0.04)   
##   
## cp\_OffPerf7:cln\_Days -0.12\*\*\*   
## (0.02)   
##   
## Constant -4.55\*\*\* 8.82\*\*\*   
## (0.18) (0.13)   
##   
## ------------------------------------------------------------  
## Observations 1,000,000 61,184   
## Log Likelihood -173,798.70 -121,011.90   
## Akaike Inf. Crit. 347,679.30 242,103.90   
## Bayesian Inf. Crit. 348,163.80 242,464.80   
## ============================================================  
## Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

##   
## ============================================================================  
## Breach Likelihood BreachSize   
## ----------------------------------------------------------------------------  
## (Intercept) -4.55 \*\*\* 8.82 \*\*\*  
## (0.18) (0.13)   
## cln\_US6sal -0.00 -0.02   
## (0.06) (0.06)   
## cln\_PSCrate 0.06 \*\*\* 0.09 \*\*\*  
## (0.01) (0.02)   
## cp\_OffPerf7 0.07 \*\* -0.06   
## (0.03) (0.04)   
## cp\_OffPSC7 0.19 \*\*\* 0.13 \*\*\*  
## (0.02) (0.03)   
## cn\_PairHist7 -0.08 \*\*\* 0.03   
## (0.01) (0.02)   
## cln\_PairCA 0.44 \*\*\* -0.01   
## (0.02) (0.03)   
## cln\_Base 1.35 \*\*\* 2.65 \*\*\*  
## (0.01) (0.02)   
## clr\_Ceil2Base 0.25 \*\*\* 0.25 \*\*\*  
## (0.01) (0.02)   
## cln\_Days 0.28 \*\*\* 0.05 \*   
## (0.01) (0.02)   
## Comp1 offer -0.03 -0.05   
## (0.02) (0.03)   
## Comp2-4 offers 0.11 \*\*\* -0.11 \*\*\*  
## (0.01) (0.02)   
## Comp5+ offers 0.18 \*\*\* -0.07 \*\*   
## (0.01) (0.02)   
## VehS-IDC -0.48 \*\*\* -0.01   
## (0.02) (0.02)   
## VehM-IDC -0.18 \*\*\* -0.02   
## (0.02) (0.03)   
## VehFSS/GWAC -0.01 0.12 \*   
## (0.03) (0.05)   
## VehBPA/BOA -0.29 \*\*\* -0.13 \*   
## (0.03) (0.06)   
## PricingOther FP -0.40 \*\*\* -0.36 \*   
## (0.09) (0.14)   
## PricingIncentive 2.39 \*\*\* 0.81 \*\*\*  
## (0.07) (0.12)   
## PricingCombination or Other 0.26 \*\*\* 0.43 \*\*\*  
## (0.05) (0.07)   
## PricingOther CB -0.09 \*\* 0.81 \*\*\*  
## (0.03) (0.05)   
## PricingT&M/LH/FPLOE 0.11 \* 0.66 \*\*\*  
## (0.04) (0.07)   
## PricingUCA 0.07 0.37 \*\*\*  
## (0.04) (0.07)   
## CrisisARRA 0.12 \*\* -0.06   
## (0.04) (0.06)   
## CrisisDis 0.07 0.39 \*\*   
## (0.09) (0.13)   
## CrisisOCO -0.10 \* 0.08   
## (0.05) (0.08)   
## cln\_Def6HHI -0.02 0.06 \*   
## (0.02) (0.03)   
## clr\_Def6toUS 0.07 \* 0.01   
## (0.03) (0.03)   
## clr\_Def3toUS -0.46 \*\*\* 0.29 \*\*\*  
## (0.07) (0.08)   
## cp\_PairObl7 -0.24 \*\*\* 0.01   
## (0.03) (0.04)   
## cln\_OffObl7 0.04 \* 0.06 \*   
## (0.02) (0.02)   
## cln\_OffFocus -0.36 \*\*\*   
## (0.04)   
## cp\_OffPerf7:cln\_PairCA 0.38 \*\*\* -0.20 \*\*\*  
## (0.03) (0.04)   
## cp\_OffPerf7:cln\_Days -0.12 \*\*\*   
## (0.02)   
## ----------------------------------------------------------------------------  
## AIC 347679.35 242103.91   
## BIC 348163.79 242464.78   
## Log Likelihood -173798.68 -121011.95   
## Num. obs. 1000000 61184   
## Num. groups: ServArea:(NAICS6:NAICS3) 3242 1292   
## Num. groups: Office:Agency 1092 656   
## Num. groups: NAICS6:NAICS3 878 557   
## Num. groups: Place 186 123   
## Num. groups: NAICS3 82 75   
## Num. groups: Agency 26 24   
## Num. groups: StartFY 9 9   
## Var: ServArea:(NAICS6:NAICS3) (Intercept) 0.21 0.14   
## Var: Office:Agency (Intercept) 1.54 0.15   
## Var: NAICS6:NAICS3 (Intercept) 0.15 0.04   
## Var: Place (Intercept) 0.19 0.11   
## Var: NAICS3 (Intercept) 0.20 0.07   
## Var: Agency (Intercept) 0.16 0.06   
## Var: StartFY (Intercept) 0.02 0.01   
## Var: Residual 2.98   
## ============================================================================  
## \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05

## Breach Likelihood

## Breach Size

# Terminations

##   
## ====================================================================  
## Dependent variable:   
## ---------------------------  
## b\_Term   
## --------------------------------------------------------------------  
## cln\_US6sal -0.05   
## (0.06)   
##   
## cln\_PSCrate -0.02   
## (0.02)   
##   
## cp\_OffPerf7 0.03   
## (0.04)   
##   
## cp\_OffPSC7 0.31\*\*\*   
## (0.04)   
##   
## cn\_PairHist7 -0.28\*\*\*   
## (0.02)   
##   
## cln\_PairCA -0.04   
## (0.03)   
##   
## cln\_Base 0.29\*\*\*   
## (0.02)   
##   
## cln\_Days 0.90\*\*\*   
## (0.02)   
##   
## clr\_Ceil2Base 0.50\*\*\*   
## (0.01)   
##   
## Comp1 offer 0.30\*\*\*   
## (0.03)   
##   
## Comp2-4 offers 0.37\*\*\*   
## (0.03)   
##   
## Comp5+ offers 0.71\*\*\*   
## (0.03)   
##   
## VehS-IDC -0.67\*\*\*   
## (0.03)   
##   
## VehM-IDC -0.41\*\*\*   
## (0.03)   
##   
## VehFSS/GWAC -0.18\*\*\*   
## (0.04)   
##   
## VehBPA/BOA -0.97\*\*\*   
## (0.06)   
##   
## PricingOther FP -0.95\*\*\*   
## (0.10)   
##   
## PricingIncentive -1.02\*\*\*   
## (0.39)   
##   
## PricingCombination or Other -0.16   
## (0.10)   
##   
## PricingOther CB -0.37\*\*\*   
## (0.08)   
##   
## PricingT&M/LH/FPLOE -0.45\*\*\*   
## (0.09)   
##   
## PricingUCA -0.72\*\*\*   
## (0.14)   
##   
## CrisisARRA -0.32\*\*   
## (0.13)   
##   
## CrisisDis 0.48\*\*   
## (0.19)   
##   
## CrisisOCO -0.07   
## (0.08)   
##   
## cln\_Def6HHI 0.04   
## (0.04)   
##   
## clr\_Def6toUS 0.02   
## (0.04)   
##   
## cln\_Def3HHI 0.03   
## (0.04)   
##   
## clr\_Def3toUS 0.24\*\*\*   
## (0.09)   
##   
## cp\_PairObl7 -0.13\*\*\*   
## (0.04)   
##   
## cln\_OffObl7 0.03   
## (0.03)   
##   
## cln\_OffFocus -0.24\*\*\*   
## (0.05)   
##   
## cn\_PairHist7:PricingOther FP 0.09   
## (0.18)   
##   
## cn\_PairHist7:PricingIncentive -0.09   
## (0.65)   
##   
## cn\_PairHist7:PricingCombination or Other 0.32   
## (0.23)   
##   
## cn\_PairHist7:PricingOther CB 0.30\*\*   
## (0.13)   
##   
## cn\_PairHist7:PricingT&M/LH/FPLOE -0.60\*\*\*   
## (0.18)   
##   
## cn\_PairHist7:PricingUCA -0.51\*   
## (0.26)   
##   
## Constant -4.45\*\*\*   
## (0.15)   
##   
## --------------------------------------------------------------------  
## Observations 1,000,000   
## Log Likelihood -71,257.17   
## Akaike Inf. Crit. 142,606.40   
## Bayesian Inf. Crit. 143,149.90   
## ====================================================================  
## Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

##   
## =================================================================  
## Termination Likelihood  
## -----------------------------------------------------------------  
## (Intercept) -4.45 \*\*\*   
## (0.15)   
## cln\_US6sal -0.05   
## (0.06)   
## cln\_PSCrate -0.02   
## (0.02)   
## cp\_OffPerf7 0.03   
## (0.04)   
## cp\_OffPSC7 0.31 \*\*\*   
## (0.04)   
## cn\_PairHist7 -0.28 \*\*\*   
## (0.02)   
## cln\_PairCA -0.04   
## (0.03)   
## cln\_Base 0.29 \*\*\*   
## (0.02)   
## cln\_Days 0.90 \*\*\*   
## (0.02)   
## clr\_Ceil2Base 0.50 \*\*\*   
## (0.01)   
## Comp1 offer 0.30 \*\*\*   
## (0.03)   
## Comp2-4 offers 0.37 \*\*\*   
## (0.03)   
## Comp5+ offers 0.71 \*\*\*   
## (0.03)   
## VehS-IDC -0.67 \*\*\*   
## (0.03)   
## VehM-IDC -0.41 \*\*\*   
## (0.03)   
## VehFSS/GWAC -0.18 \*\*\*   
## (0.04)   
## VehBPA/BOA -0.97 \*\*\*   
## (0.06)   
## PricingOther FP -0.95 \*\*\*   
## (0.10)   
## PricingIncentive -1.02 \*\*   
## (0.39)   
## PricingCombination or Other -0.16   
## (0.10)   
## PricingOther CB -0.37 \*\*\*   
## (0.08)   
## PricingT&M/LH/FPLOE -0.45 \*\*\*   
## (0.09)   
## PricingUCA -0.72 \*\*\*   
## (0.14)   
## CrisisARRA -0.32 \*   
## (0.13)   
## CrisisDis 0.48 \*   
## (0.19)   
## CrisisOCO -0.07   
## (0.08)   
## cln\_Def6HHI 0.04   
## (0.04)   
## clr\_Def6toUS 0.02   
## (0.04)   
## cln\_Def3HHI 0.03   
## (0.04)   
## clr\_Def3toUS 0.24 \*\*   
## (0.09)   
## cp\_PairObl7 -0.13 \*\*\*   
## (0.04)   
## cln\_OffObl7 0.03   
## (0.03)   
## cln\_OffFocus -0.24 \*\*\*   
## (0.05)   
## cn\_PairHist7:PricingOther FP 0.09   
## (0.18)   
## cn\_PairHist7:PricingIncentive -0.09   
## (0.65)   
## cn\_PairHist7:PricingCombination or Other 0.32   
## (0.23)   
## cn\_PairHist7:PricingOther CB 0.30 \*   
## (0.13)   
## cn\_PairHist7:PricingT&M/LH/FPLOE -0.60 \*\*\*   
## (0.18)   
## cn\_PairHist7:PricingUCA -0.51   
## (0.26)   
## -----------------------------------------------------------------  
## AIC 142606.35   
## BIC 143149.86   
## Log Likelihood -71257.17   
## Num. obs. 1000000   
## Num. groups: ServArea:(NAICS6:NAICS3) 3242   
## Num. groups: Office:Agency 1092   
## Num. groups: NAICS6:NAICS3 878   
## Num. groups: Place 186   
## Num. groups: NAICS3 82   
## Num. groups: Agency 26   
## Num. groups: StartFY 9   
## Var: ServArea:(NAICS6:NAICS3) (Intercept) 0.18   
## Var: Office:Agency (Intercept) 0.66   
## Var: NAICS6:NAICS3 (Intercept) 0.11   
## Var: Place (Intercept) 0.39   
## Var: NAICS3 (Intercept) 0.04   
## Var: Agency (Intercept) 0.06   
## Var: StartFY (Intercept) 0.01   
## =================================================================  
## \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05