equations

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## R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

summary(cars)

## speed dist   
## Min. : 4.0 Min. : 2.00   
## 1st Qu.:12.0 1st Qu.: 26.00   
## Median :15.0 Median : 36.00   
## Mean :15.4 Mean : 42.98   
## 3rd Qu.:19.0 3rd Qu.: 56.00   
## Max. :25.0 Max. :120.00

## Including Plots

You can also embed plots, for example:

dat <- readRDS("data/finalpanel.rds")  
  
dat %>%  
 group\_by(year) %>%  
 summarise(mean = mean(yield, na.rm=T))

# A tibble: 36 × 2

year mean

1 1981 4.26 2 1982 4.38 3 1984 3.69 4 1985 5.23 5 1986 4.65 6 1987 4.39 7 1988 5.68 8 1989 6.08 9 1990 6.38 10 1991 6.70 # … with 26 more rows

## require 5 obs per year per province  
summaryobs <- dat %>% group\_by(year, provence, color, bt) %>%  
 summarise(count = n()) # check bt if in more than one observation per province/year

## `summarise()` has grouped output by 'year', 'provence', 'color'. You can  
## override using the `.groups` argument.

summaryobs <- summaryobs[summaryobs$count < 5,]  
summaryobs$count <- "1"  
dat <- merge(dat,summaryobs, by = c("year","provence", "bt","color"),all = TRUE, no.dups= TRUE)  
dat$count <- if\_else(dat$count %in% c(NA), "0", "1")  
dat <- dat[!dat$count== "1", ]  
  
summaryobs <- dat %>% group\_by(technology, year, provence, color) %>%  
 summarise(count = n())

## `summarise()` has grouped output by 'technology', 'year', 'provence'. You can  
## override using the `.groups` argument.

dat$GM <- 0  
dat$GM <- ifelse(dat$technology != "conv", 1, 0)  
  
bandconv <- dat[dat$technology %in% c("B", "conv"),]  
bandconv <- bandconv[!bandconv$provence == "LP",]  
  
dat <- bandconv  
  
  
summarynew <- dat %>% group\_by(provence,color, technology, year, .add = FALSE) %>%   
 summarise(mean = mean(yield, na.rm = T),   
 SD = sd(yield, na.rm = T))

## `summarise()` has grouped output by 'provence', 'color', 'technology'. You can  
## override using the `.groups` argument.

summaryyellow <- dat[!dat$color == "yellow",] %>% group\_by(provence, technology, year, .add = FALSE) %>%   
 summarise(mean = mean(yield, na.rm = T),   
 SD = sd(yield, na.rm = T))

## `summarise()` has grouped output by 'provence', 'technology'. You can override  
## using the `.groups` argument.

reg1 <- glm(yield ~ GM + color + provence + factor(year) + irrigated,data = dat)  
  
  
dat$yearsq <- dat$year\*dat$year  
  
reg2 <- glm(yield ~ GM + color + year\*GM + yearsq\*GM + provence + factor(year)+ irrigated,data = dat)  
  
  
  
dat$y\_effect <- reg2$coefficients["GM"] + reg2$coefficients["GM:year"] \* dat$year  
dat$ysq\_effect <- reg2$coefficients["GM"] + reg2$coefficients["GM:year"] \* dat$year + reg2$coefficients["GM:yearsq"] \* dat$yearsq  
  
  
# Provence by year by GM effects in one model  
  
reg3 <- glm(yield ~ GM + color+ year\*provence\*GM + provence\*yearsq\*GM + provence + factor(year)+ + irrigated,data = dat)  
  
  
models <- list(reg1,reg2,reg3)

extract\_eq(reg1)

$$
E( \operatorname{yield} ) = \alpha + \beta\_{1}(\operatorname{GM}) + \beta\_{2}(\operatorname{color}\_{\operatorname{yellow}}) + \beta\_{3}(\operatorname{provence}\_{\operatorname{FS}}) + \beta\_{4}(\operatorname{provence}\_{\operatorname{GP}}) + \beta\_{5}(\operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{6}(\operatorname{provence}\_{\operatorname{MP}}) + \beta\_{7}(\operatorname{provence}\_{\operatorname{NC}}) + \beta\_{8}(\operatorname{provence}\_{\operatorname{NW}}) + \beta\_{9}(\operatorname{provence}\_{\operatorname{WC}}) + \beta\_{10}(\operatorname{factor(year)}\_{\operatorname{1982}}) + \beta\_{11}(\operatorname{factor(year)}\_{\operatorname{1984}}) + \beta\_{12}(\operatorname{factor(year)}\_{\operatorname{1985}}) + \beta\_{13}(\operatorname{factor(year)}\_{\operatorname{1986}}) + \beta\_{14}(\operatorname{factor(year)}\_{\operatorname{1987}}) + \beta\_{15}(\operatorname{factor(year)}\_{\operatorname{1988}}) + \beta\_{16}(\operatorname{factor(year)}\_{\operatorname{1989}}) + \beta\_{17}(\operatorname{factor(year)}\_{\operatorname{1990}}) + \beta\_{18}(\operatorname{factor(year)}\_{\operatorname{1991}}) + \beta\_{19}(\operatorname{factor(year)}\_{\operatorname{1993}}) + \beta\_{20}(\operatorname{factor(year)}\_{\operatorname{1994}}) + \beta\_{21}(\operatorname{factor(year)}\_{\operatorname{1995}}) + \beta\_{22}(\operatorname{factor(year)}\_{\operatorname{1996}}) + \beta\_{23}(\operatorname{factor(year)}\_{\operatorname{1997}}) + \beta\_{24}(\operatorname{factor(year)}\_{\operatorname{1998}}) + \beta\_{25}(\operatorname{factor(year)}\_{\operatorname{1999}}) + \beta\_{26}(\operatorname{factor(year)}\_{\operatorname{2000}}) + \beta\_{27}(\operatorname{factor(year)}\_{\operatorname{2001}}) + \beta\_{28}(\operatorname{factor(year)}\_{\operatorname{2002}}) + \beta\_{29}(\operatorname{factor(year)}\_{\operatorname{2003}}) + \beta\_{30}(\operatorname{factor(year)}\_{\operatorname{2004}}) + \beta\_{31}(\operatorname{factor(year)}\_{\operatorname{2005}}) + \beta\_{32}(\operatorname{factor(year)}\_{\operatorname{2006}}) + \beta\_{33}(\operatorname{factor(year)}\_{\operatorname{2007}}) + \beta\_{34}(\operatorname{factor(year)}\_{\operatorname{2008}}) + \beta\_{35}(\operatorname{factor(year)}\_{\operatorname{2009}}) + \beta\_{36}(\operatorname{factor(year)}\_{\operatorname{2010}}) + \beta\_{37}(\operatorname{factor(year)}\_{\operatorname{2011}}) + \beta\_{38}(\operatorname{factor(year)}\_{\operatorname{2012}}) + \beta\_{39}(\operatorname{factor(year)}\_{\operatorname{2013}}) + \beta\_{40}(\operatorname{factor(year)}\_{\operatorname{2014}}) + \beta\_{41}(\operatorname{factor(year)}\_{\operatorname{2016}}) + \beta\_{42}(\operatorname{factor(year)}\_{\operatorname{2017}}) + \beta\_{43}(\operatorname{factor(year)}\_{\operatorname{2018}}) + \beta\_{44}(\operatorname{factor(year)}\_{\operatorname{2019}}) + \beta\_{45}(\operatorname{irrigated})
$$

extract\_eq(reg2)

## Warning in mapply(...): longer argument not a multiple of length of shorter

$$
E( \operatorname{yield} ) = \alpha + \beta\_{1}(\operatorname{GM}) + \beta\_{2}(\operatorname{color}\_{\operatorname{yellow}}) + \beta\_{3}(\operatorname{year}) + \beta\_{4}(\operatorname{yearsq}) + \beta\_{5}(\operatorname{provence}\_{\operatorname{FS}}) + \beta\_{6}(\operatorname{provence}\_{\operatorname{GP}}) + \beta\_{7}(\operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{8}(\operatorname{provence}\_{\operatorname{MP}}) + \beta\_{9}(\operatorname{provence}\_{\operatorname{NC}}) + \beta\_{10}(\operatorname{provence}\_{\operatorname{NW}}) + \beta\_{11}(\operatorname{provence}\_{\operatorname{WC}}) + \beta\_{12}(\operatorname{factor(year)}\_{\operatorname{1982}}) + \beta\_{13}(\operatorname{factor(year)}\_{\operatorname{1984}}) + \beta\_{14}(\operatorname{factor(year)}\_{\operatorname{1985}}) + \beta\_{15}(\operatorname{factor(year)}\_{\operatorname{1986}}) + \beta\_{16}(\operatorname{factor(year)}\_{\operatorname{1987}}) + \beta\_{17}(\operatorname{factor(year)}\_{\operatorname{1988}}) + \beta\_{18}(\operatorname{factor(year)}\_{\operatorname{1989}}) + \beta\_{19}(\operatorname{factor(year)}\_{\operatorname{1990}}) + \beta\_{20}(\operatorname{factor(year)}\_{\operatorname{1991}}) + \beta\_{21}(\operatorname{factor(year)}\_{\operatorname{1993}}) + \beta\_{22}(\operatorname{factor(year)}\_{\operatorname{1994}}) + \beta\_{23}(\operatorname{factor(year)}\_{\operatorname{1995}}) + \beta\_{24}(\operatorname{factor(year)}\_{\operatorname{1996}}) + \beta\_{25}(\operatorname{factor(year)}\_{\operatorname{1997}}) + \beta\_{26}(\operatorname{factor(year)}\_{\operatorname{1998}}) + \beta\_{27}(\operatorname{factor(year)}\_{\operatorname{1999}}) + \beta\_{28}(\operatorname{factor(year)}\_{\operatorname{2000}}) + \beta\_{29}(\operatorname{factor(year)}\_{\operatorname{2001}}) + \beta\_{30}(\operatorname{factor(year)}\_{\operatorname{2002}}) + \beta\_{31}(\operatorname{factor(year)}\_{\operatorname{2003}}) + \beta\_{32}(\operatorname{factor(year)}\_{\operatorname{2004}}) + \beta\_{33}(\operatorname{factor(year)}\_{\operatorname{2005}}) + \beta\_{34}(\operatorname{factor(year)}\_{\operatorname{2006}}) + \beta\_{35}(\operatorname{factor(year)}\_{\operatorname{2007}}) + \beta\_{36}(\operatorname{factor(year)}\_{\operatorname{2008}}) + \beta\_{37}(\operatorname{factor(year)}\_{\operatorname{2009}}) + \beta\_{38}(\operatorname{factor(year)}\_{\operatorname{2010}}) + \beta\_{39}(\operatorname{factor(year)}\_{\operatorname{2011}}) + \beta\_{40}(\operatorname{factor(year)}\_{\operatorname{2012}}) + \beta\_{41}(\operatorname{factor(year)}\_{\operatorname{2013}}) + \beta\_{42}(\operatorname{factor(year)}\_{\operatorname{2014}}) + \beta\_{43}(\operatorname{factor(year)}\_{\operatorname{2016}}) + \beta\_{44}(\operatorname{factor(year)}\_{\operatorname{2017}}) + \beta\_{45}(\operatorname{factor(year)}\_{\operatorname{2018}}) + \beta\_{46}(\operatorname{factor(year)}\_{\operatorname{2019}}) + \beta\_{47}(\operatorname{irrigated}) + \beta\_{48}(\operatorname{GM} \times \operatorname{year}) + \beta\_{49}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{sq}} \times \operatorname{yearsq}\_{\operatorname{GM}})
$$

extract\_eq(reg3)

## Warning in mapply(...): longer argument not a multiple of length of shorter  
  
## Warning in mapply(...): longer argument not a multiple of length of shorter  
  
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$$
E( \operatorname{yield} ) = \alpha + \beta\_{1}(\operatorname{GM}) + \beta\_{2}(\operatorname{color}\_{\operatorname{yellow}}) + \beta\_{3}(\operatorname{year}) + \beta\_{4}(\operatorname{provence}\_{\operatorname{FS}}) + \beta\_{5}(\operatorname{provence}\_{\operatorname{GP}}) + \beta\_{6}(\operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{7}(\operatorname{provence}\_{\operatorname{MP}}) + \beta\_{8}(\operatorname{provence}\_{\operatorname{NC}}) + \beta\_{9}(\operatorname{provence}\_{\operatorname{NW}}) + \beta\_{10}(\operatorname{provence}\_{\operatorname{WC}}) + \beta\_{11}(\operatorname{yearsq}) + \beta\_{12}(\operatorname{factor(year)}\_{\operatorname{1982}}) + \beta\_{13}(\operatorname{factor(year)}\_{\operatorname{1984}}) + \beta\_{14}(\operatorname{factor(year)}\_{\operatorname{1985}}) + \beta\_{15}(\operatorname{factor(year)}\_{\operatorname{1986}}) + \beta\_{16}(\operatorname{factor(year)}\_{\operatorname{1987}}) + \beta\_{17}(\operatorname{factor(year)}\_{\operatorname{1988}}) + \beta\_{18}(\operatorname{factor(year)}\_{\operatorname{1989}}) + \beta\_{19}(\operatorname{factor(year)}\_{\operatorname{1990}}) + \beta\_{20}(\operatorname{factor(year)}\_{\operatorname{1991}}) + \beta\_{21}(\operatorname{factor(year)}\_{\operatorname{1993}}) + \beta\_{22}(\operatorname{factor(year)}\_{\operatorname{1994}}) + \beta\_{23}(\operatorname{factor(year)}\_{\operatorname{1995}}) + \beta\_{24}(\operatorname{factor(year)}\_{\operatorname{1996}}) + \beta\_{25}(\operatorname{factor(year)}\_{\operatorname{1997}}) + \beta\_{26}(\operatorname{factor(year)}\_{\operatorname{1998}}) + \beta\_{27}(\operatorname{factor(year)}\_{\operatorname{1999}}) + \beta\_{28}(\operatorname{factor(year)}\_{\operatorname{2000}}) + \beta\_{29}(\operatorname{factor(year)}\_{\operatorname{2001}}) + \beta\_{30}(\operatorname{factor(year)}\_{\operatorname{2002}}) + \beta\_{31}(\operatorname{factor(year)}\_{\operatorname{2003}}) + \beta\_{32}(\operatorname{factor(year)}\_{\operatorname{2004}}) + \beta\_{33}(\operatorname{factor(year)}\_{\operatorname{2005}}) + \beta\_{34}(\operatorname{factor(year)}\_{\operatorname{2006}}) + \beta\_{35}(\operatorname{factor(year)}\_{\operatorname{2007}}) + \beta\_{36}(\operatorname{factor(year)}\_{\operatorname{2008}}) + \beta\_{37}(\operatorname{factor(year)}\_{\operatorname{2009}}) + \beta\_{38}(\operatorname{factor(year)}\_{\operatorname{2010}}) + \beta\_{39}(\operatorname{factor(year)}\_{\operatorname{2011}}) + \beta\_{40}(\operatorname{factor(year)}\_{\operatorname{2012}}) + \beta\_{41}(\operatorname{factor(year)}\_{\operatorname{2013}}) + \beta\_{42}(\operatorname{factor(year)}\_{\operatorname{2014}}) + \beta\_{43}(\operatorname{factor(year)}\_{\operatorname{2016}}) + \beta\_{44}(\operatorname{factor(year)}\_{\operatorname{2017}}) + \beta\_{45}(\operatorname{factor(year)}\_{\operatorname{2018}}) + \beta\_{46}(\operatorname{factor(year)}\_{\operatorname{2019}}) + \beta\_{47}(\operatorname{irrigated}) + \beta\_{48}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{FS}}) + \beta\_{49}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{GP}}) + \beta\_{50}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{51}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{MP}}) + \beta\_{52}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{NC}}) + \beta\_{53}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{NW}}) + \beta\_{54}(\operatorname{year} \times \operatorname{provence}\_{\operatorname{WC}}) + \beta\_{55}(\operatorname{GM} \times \operatorname{year}) + \beta\_{56}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{FS}}) + \beta\_{57}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{GP}}) + \beta\_{58}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{59}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{MP}}) + \beta\_{60}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{NC}}) + \beta\_{61}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{NW}}) + \beta\_{62}(\operatorname{GM} \times \operatorname{provence}\_{\operatorname{WC}}) + \beta\_{63}(\operatorname{year}\_{\operatorname{provenceFS}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceFS}}) + \beta\_{64}(\operatorname{year}\_{\operatorname{provenceGP}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceGP}}) + \beta\_{65}(\operatorname{year}\_{\operatorname{provenceKZN}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceKZN}}) + \beta\_{66}(\operatorname{year}\_{\operatorname{provenceMP}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceMP}}) + \beta\_{67}(\operatorname{year}\_{\operatorname{provenceNC}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceNC}}) + \beta\_{68}(\operatorname{year}\_{\operatorname{provenceNW}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceNW}}) + \beta\_{69}(\operatorname{year}\_{\operatorname{provenceWC}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{provenceWC}}) + \beta\_{70}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{sq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{71}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{FS}}) + \beta\_{72}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{GP}}) + \beta\_{73}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{KZN}}) + \beta\_{74}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{MP}}) + \beta\_{75}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{NC}}) + \beta\_{76}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{NW}}) + \beta\_{77}(\operatorname{GM} \times \operatorname{year} \times \operatorname{provence}\_{\operatorname{WC}}) + \beta\_{78}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceFS}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{79}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceGP}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{80}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceKZN}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{81}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceMP}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{82}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceNC}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{83}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceNW}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}}) + \beta\_{84}(\operatorname{GM} \times \operatorname{year}\_{\operatorname{provenceWC}} \times \operatorname{provence}\_{\operatorname{yearsq}} \times \operatorname{yearsq}\_{\operatorname{GM}})
$$

Note that the echo = FALSE parameter was added to the code chunk to prevent printing of the R code that generated the plot.