Code for Figure 2

August 28, 2016

Load the necessary libraries, source the file with the R functions:

```
library(ggplot2)

source("functions.R")
```

Will use the same theme throughout, so just declare this variable:

```
themeUsed <- theme_bw(base_size = 20) +
  theme(axis.line = element_line(colour = "black"),
        plot.title = element_text(size = 15, hjust=0.5),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        panel.border = element_blank(),
        panel.background = element_blank(),
        legend.background = element_rect(fill="transparent"),
        legend.key = element_blank(),
        legend.text.align = 0,
        legend.position = c(0.15,0.28),
        axis.line.x = element_line(color="black", size = 0.5), ##this is to show axes - bug in this vers
        axis.line.y = element_line(color="black", size = 0.5))
```

1 Panel a)

Get what is needed for panel a): Load the files representing the summary for each scenario with 0 heterogeneity and save the results in a single dataframe, Vars0:

```
allFiles <- list.files("simResultsComb")
##remove files that have "AR1_het" in the title
allFiles <- allFiles[-grep("AR1_het", allFiles)]

##save the three Vars for the different combinations
VarsAll <- expand.grid(I = c(5, 10, 15, 20),
                       p = 2:10,
                       corrBtw = c(0,0.5),
                       varBtw = c(0, 1))

##only keep combinations of corrBtw=0 & varBtw=0, corrBtw=0.5 & varBtw=1
VarsAll <- VarsAll[(VarsAll$corrBtw == 0 & VarsAll$varBtw == 0) |
                   (VarsAll$corrBtw == 0.5 & VarsAll$varBtw == 1) ,]
```

```
VarsAll$known <- VarsAll$unknown <- VarsAll$univKnown <- VarsAll$univ <-
  VarsAll$Bayes <- VarsAll$univBayes <- NA

for(file in 1:length(allFiles))
{
    load(paste("simResultsComb",
               allFiles[file], sep="/"))

    rowNr <- gsub("combine_cost_of_estimation_", "", allFiles[file])
    rowNr <- gsub(".RData", "", rowNr)
    rowNr <- as.numeric(rowNr)

    VarsAll[rowNr, colnames(VarsAll)] <- Vars[rowNr, colnames(VarsAll)]
}
VarsAll$Ratio <- VarsAll$known/VarsAll$unknown
VarsAll$RelEff <- VarsAll$unknown/VarsAll$univ
VarsAll$RelEffT <- VarsAll$known/VarsAll$univKnown
VarsAll$RelEffB <- VarsAll$Bayes/VarsAll$univBayes
VarsAll$MVMAcomp <- VarsAll$unknown/VarsAll$Bayes
range(VarsAll$Ratio)

## [1] 0.9089231 0.9947634

##only keep the ones with varBtw = 0 and I=20
Vars0 <- VarsAll[VarsAll$varBtw == 0 & VarsAll$I == 20 ,]
```

Load the files representing the summary for each scenario with non-0 heterogeneity and save the results in a single dataframe, VarsAll:

```
allFiles <- list.files("simResultsComb")
##keep only files that have "AR1_het" in the title
allFiles <- allFiles[grep("AR1_het", allFiles)]

##save the three Vars for the different combinations
VarsAll <- expand.grid(I = 20,
                       p = 2:10,
                       corrBtw = c(0.5),
                       varBtw = c(1/5, 1, 5))

VarsAll$known <- VarsAll$unknown <- VarsAll$univKnown <- VarsAll$univ <-
  VarsAll$Bayes <- VarsAll$univBayes <- NA

for(file in 1:length(allFiles))
{
    load(paste("simResultsComb", allFiles[file], sep="/"))

    rowNr <- gsub("combine_cost_of_estimation_AR1_het_", "", allFiles[file])
    rowNr <- gsub(".RData", "", rowNr)
    rowNr <- as.numeric(rowNr)

    VarsAll[rowNr, colnames(VarsAll)] <- Vars[rowNr, colnames(VarsAll)]
}
VarsAll$Ratio <- VarsAll$known/VarsAll$unknown
VarsAll$RelEff <- VarsAll$unknown/VarsAll$univ
```

```
VarsAll$RelEffT <- VarsAll$known/VarsAll$univKnown
VarsAll$RelEffB <- VarsAll$Bayes/VarsAll$univBayes
VarsAll$MVMAcomp <- VarsAll$unknown/VarsAll$Bayes
range(VarsAll$Ratio)

## [1] 0.9649353 0.9996242
```

Separate out what is needed for Panel a):

```
Vars <- VarsAll[VarsAll$corrBtw == 0.5,]

##add in the 0 heterogeneity case
Vars <- rbind(Vars, Vars0)

RelEff.b <-
  rbind(cbind(as.matrix(Vars[,c("I", "p", "corrBtw", "varBtw", "RelEff","MVMAcomp"),]),"RelEff"),
        cbind(as.matrix(Vars[,c("I", "p", "corrBtw", "varBtw", "RelEffT","MVMAcomp"),]),"RelEffT"),
        cbind(as.matrix(Vars[,c("I", "p", "corrBtw", "varBtw", "RelEffB", "MVMAcomp"),]),"RelEffB"))
colnames(RelEff.b)[ncol(RelEff.b)] <- "Estimate"
RelEff.b <- as.data.frame(RelEff.b)
sapply(RelEff.b, class)

##         I         p   corrBtw    varBtw    RelEff MVMAcomp
## "factor" "factor" "factor" "factor" "factor" "factor"
## Estimate
## "factor"

RelEff.b$p <- as.numeric(as.character(RelEff.b$p))
RelEff.b$corrBtw <- as.numeric(as.character(RelEff.b$corrBtw))
RelEff.b$varBtw <- as.numeric(as.character(RelEff.b$varBtw))
RelEff.b$RelEff <- as.numeric(as.character(RelEff.b$RelEff))
RelEff.b$MVMAcomp <- as.numeric(as.character(RelEff.b$MVMAcomp))
```

```
panelA <- ggplot(RelEff.b, aes(x=p, y=RelEff))+
  geom_point(size=3.0, aes(color=as.factor(varBtw), shape=as.factor(varBtw)))+
  geom_line(aes(linetype=Estimate,color=as.factor(varBtw), shape=as.factor(varBtw)))+
  themeUsed +
  ylab(expression(RelEff)) +
  ylim(limits=c(0.45, 1)) +
  scale_color_discrete(name = "",
                       labels =
                         c(expression(paste(sigma^2, "/", S^2, "=",
                                            0)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1/5)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            5)))) +
  scale_shape_discrete(name = "",
                       labels =
                         c(expression(paste(sigma^2, "/", S^2, "=",
                                            0)),
```

```
                          expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                           1/5)),
                          expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                           1)),
                          expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                           5)))) +
  labs(color="", shape="",
       title=expression(atop("(a)",paste("Random effects: ",
                                         S[i]^2,  phantom() %~~% phantom() , 1, ", ",
                                         rho[i], phantom() %~~% phantom(), (i-1)/I, ", ",
                                         rho^BS, " = ", 0.5, ", ",
                                         ##"\n",
                                         I, " = ", 20)))) +
  scale_linetype_manual(name = "",
                        labels =
                          c(expression(paste(RelEff)),
                            expression(paste(RelEff^B)),
                            expression(paste(RelEff^T))),
                        values=c(2,3,1))
```

Panel b):

```
panelB <- ggplot(RelEff.b, aes(x=p, y=MVMAcomp))+
  geom_point(size=3.0, aes(color=as.factor(varBtw), shape=as.factor(varBtw)))+
  geom_line(aes(color=as.factor(varBtw), shape=as.factor(varBtw)))+
  themeUsed+
  ylab(expression(paste(Var, "(", mu[1]^M, ")", "/",
                        Var, "(", mu[1]^MB, ")"))) +
  ylim(min(RelEff.b$MVMAcomp)*0.8, 1.2) +
  labs(color="", shape="",
       title=expression(atop("(b)",paste("Random effects: ",
                                         S[i]^2,  phantom() %~~% phantom() , 1, ", ",
                                         rho[i], phantom() %~~% phantom(), (i-1)/I, ", ",
                                         rho^BS, " = ", 0.5, ", ",
                                         ##"\n",
                                         I, " = ", 20)))) +
  scale_color_discrete(name = "",
                       labels =
                         c(expression(paste(sigma^2, "/", S^2, "=",
                                            0)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1/5)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            5)))) +
  scale_shape_discrete(name = "",
                       labels =
                         c(expression(paste(sigma^2, "/", S^2, "=",
                                            0)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1/5)),
                           expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                            1)),
```

```
                          expression(paste(sigma^2, "/", S^2, phantom() %~~% phantom(),
                                           5))))
```

2 Panels c) and d)

Load the files representing the summary for each scenario and save the results in a single dataframe, VarsAll:

```
allFiles <- list.files("simResultsComb")
##remove files that have "AR1_het" in the title
allFiles <- allFiles[-grep("AR1_het", allFiles)]

##save the three Vars for the different combinations
VarsAll <- expand.grid(I = c(5, 10, 15, 20),
                       p = 2:10,
                       corrBtw = c(0, 0.5),
                       varBtw = c(0, 1))

##only keep combinations of corrBtw=0 & varBtw=0, corrBtw=0.5 & varBtw=0.5
VarsAll <- VarsAll[(VarsAll$corrBtw == 0 & VarsAll$varBtw == 0) |
                   (VarsAll$corrBtw == 0.5 & VarsAll$varBtw == 1) ,]

VarsAll$known <- VarsAll$unknown <- VarsAll$univKnown <- VarsAll$univ <-
  VarsAll$Bayes <- VarsAll$univBayes <- NA

for(file in 1:length(allFiles))
{
    load(paste("simResultsComb",
               allFiles[file], sep="/"))

    rowNr <- gsub("combine_cost_of_estimation_", "", allFiles[file])
    rowNr <- gsub(".RData", "", rowNr)
    rowNr <- as.numeric(rowNr)

    ##only consider files which have the Bayesian results included
    if(length(grep("Bayes", colnames(Vars)))>0)
    {
      VarsAll[rowNr, colnames(VarsAll)] <- Vars[rowNr, colnames(VarsAll)]
    }
}
VarsAll$Ratio <- VarsAll$known/VarsAll$unknown
VarsAll$RelEff <- VarsAll$unknown/VarsAll$univ
VarsAll$RelEffT <- VarsAll$known/VarsAll$univKnown
VarsAll$RelEffB <- VarsAll$Bayes/VarsAll$univBayes
VarsAll$MVMAcomp <- VarsAll$unknown/VarsAll$Bayes
range(VarsAll$Ratio)

## [1] 0.9089231 0.9947634

VarsAll$I <- as.factor(paste("I=", VarsAll$I, sep=""))
VarsAll$I <- relevel(VarsAll$I, ref="I=5")
```

Get what is needed for panels c) and d):

```
Vars.b <- VarsAll[VarsAll$corrBtw == 0 &
  VarsAll$varBtw == 0,]

##for panel c, have RelEff, RelEffT, RelEffB
##probably easier to just create another object
RelEff.c <-
  rbind(cbind(as.matrix(Vars.b[,c("I", "p", "corrBtw", "varBtw", "RelEff", "MVMAcomp"),]),"RelEff"),
        cbind(as.matrix(Vars.b[,c("I", "p", "corrBtw", "varBtw", "RelEffT", "MVMAcomp"),]),"RelEffT"),
        cbind(as.matrix(Vars.b[,c("I", "p", "corrBtw", "varBtw", "RelEffB", "MVMAcomp"),]),"RelEffB"))
colnames(RelEff.c)[ncol(RelEff.c)] <- "Estimate"
RelEff.c <- as.data.frame(RelEff.c)
sapply(RelEff.c, class)

##         I         p   corrBtw    varBtw    RelEff MVMAcomp
## "factor" "factor" "factor" "factor" "factor" "factor"
## Estimate
## "factor"

RelEff.c$p <- as.numeric(as.character(RelEff.c$p))
RelEff.c$corrBtw <- as.numeric(as.character(RelEff.c$corrBtw))
RelEff.c$varBtw <- as.numeric(as.character(RelEff.c$varBtw))
RelEff.c$RelEff <- as.numeric(as.character(RelEff.c$RelEff))
RelEff.c$MVMAcomp <- as.numeric(as.character(RelEff.c$MVMAcomp))
RelEff.c$I <- relevel(RelEff.c$I, ref="I=5")
```

3 Create plots

Panel c):

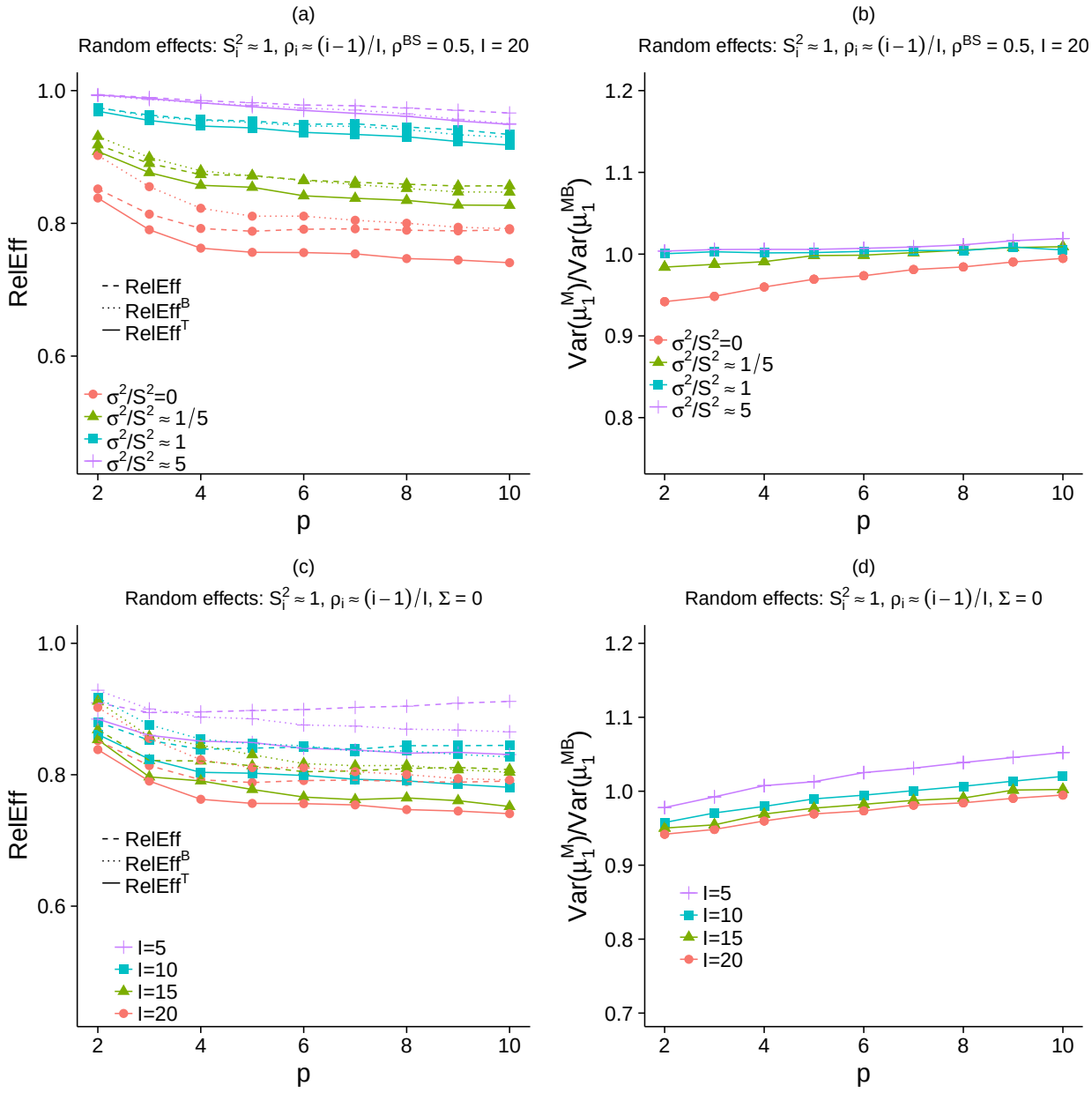
```
panelC <- ggplot(RelEff.c, aes(x=p, y=RelEff))+
  geom_point(size=3.0, aes(color=I, shape=I))+
  geom_line(aes(color=I, shape=I, linetype=Estimate))+
  themeUsed+
  ylab(expression(RelEff)) +
  ylim(min(RelEff.c$RelEff)*0.6, 1) +
  labs(color="", shape="",
       title=expression(atop("(c)", paste("Random effects: ",
                                          S[i]^2,  phantom() %~~% phantom() , 1, ", ",
                                          rho[i], phantom() %~~% phantom(), (i-1)/I, ", ",
                                          ##"\n",
                                          Sigma, " = ", 0)))) +
  scale_linetype_manual(name = "",
                        labels =
                          c(expression(paste(RelEff)),
                            expression(paste(RelEff^B)),
                            expression(paste(RelEff^T))),
                        values=c(2,3,1))+
  scale_color_manual(values=rev(gg_color_hue(4)), name="")+
  scale_shape_manual(values=c(3,15,17,16),name="")
```

Panel d):

```
panelD <- ggplot(RelEff.c, aes(x=p, y=MVMAcomp))+
  geom_point(size=3.0, aes(color=I, shape=I))+
  geom_line(aes(color=I, shape=I))+
  themeUsed+
  ylab(expression(paste(Var, "(", mu[1]^M, ")", "/",
                        Var, "(", mu[1]^MB, ")"))) +
  ylim(min(RelEff.c$MVMAcomp)*0.75, 1.2) +
  labs(color="", shape="",
       title=expression(atop("(d)", paste("Random effects: ",
                                          S[i]^2,  phantom() %~~% phantom() , 1, ", ",
                                          rho[i], phantom() %~~% phantom(), (i-1)/I, ", ",
                                          ##"\n",
                                          Sigma, " = ", 0)))) +
    scale_color_manual(values=rev(gg_color_hue(4)), name="")+
    scale_shape_manual(values=c(3,15,17,16),name="")
```

```
multiplot(panelA, panelC, panelB, panelD, cols=2)

## Loading required package:  grid
```


(a)
Random effects: $S_i^2 \approx 1$, $\rho_i \approx (i-1)/I$, $\rho^{BS} = 0.5$, I = 20
RelEff
p
RelEff
RelEff^B
RelEff^T
σ^2/S^2=0
$\sigma^2/S^2 \approx 1/5$
$\sigma^2/S^2 \approx 1$
$\sigma^2/S^2 \approx 5$
(b)
Random effects: $S_i^2 \approx 1$, $\rho_i \approx (i-1)/I$, $\rho^{BS} = 0.5$, I = 20
$Var(\mu_1^M)/Var(\mu_1^{MB})$
p
σ^2/S^2=0
$\sigma^2/S^2 \approx 1/5$
$\sigma^2/S^2 \approx 1$
$\sigma^2/S^2 \approx 5$
(c)
Random effects: $S_i^2 \approx 1$, $\rho_i \approx (i-1)/I$, $\Sigma = 0$
RelEff
p
RelEff
RelEff^B
RelEff^T
I=5
I=10
I=15
I=20
(d)
Random effects: $S_i^2 \approx 1$, $\rho_i \approx (i-1)/I$, $\Sigma = 0$
$Var(\mu_1^M)/Var(\mu_1^{MB})$
p
I=5
I=10
I=15
I=20