

Annex D. Cross Efficiency and Dynamic Data Envelopment Analysis Calculations (R package)

Table D.1. DEA Cross Efficiency and Dynamic DEA Calculations code (compiled by author)

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#The code below produces estimates for aggregate data
# Data setup
setwd ("J:/ DEA")
library(foreign)
library (MultiplierDEA)
dea_data<-read.dta ("dea2.dta")

# DEA specifications initial
X1 = dea_data[c("i1", "i2", "i3", "i4", "i5")]
Y1 = dea_data[c("o1")]
X2 = dea_data[c("i1", "i2", "i3", "i4", "i5")]
Y2 = dea_data[c("o1", "o2", "o3")]
X3 = dea_data[c("i6", "i7", "i8")]
Y3 = dea_data[c("o1", "o3")]
X4 = dea_data[c("i1", "i2")]
Y4 = dea_data[c("o2")]
X4a = dea_data[c("i1", "i2")]
Y4a = dea_data[c("o1")]
X4b = dea_data[c("i1", "i2", "i4", "i5", "i7", "i8")]
Y4b = dea_data[c("o2")]
X5 = dea_data[c("i3", "i7")]
Y5 = dea_data[c("o3")]
X5a = dea_data[c("i3", "i7")]
Y5a = dea_data[c("o1")]
X5b = dea_data[c("i3", "i4", "i5", "i7", "i8")]
Y5b = dea_data[c("o3")]
X6 = dea_data[c("i6", "i7", "i8")]
Y6 = dea_data[c("o1")]
X7 = dea_data[c("i6")]
Y7 = dea_data[c("o1", "o2")]

# DEA models
model1 = CrossEfficiency(x=X1, y=Y1, orientation="output")
model2 = CrossEfficiency(x=X2, y=Y2, orientation="output")
model3 = CrossEfficiency(x=X3, y=Y3, orientation="output")
model4 = CrossEfficiency(x=X4, y=Y4, orientation="output")
model4a = CrossEfficiency(x=X4a, y=Y4a, orientation="output")
model4b = CrossEfficiency(x=X4b, y=Y4b, orientation="output")
model5 = CrossEfficiency(x=X5, y=Y5, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
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model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model6 = CrossEfficiency(x=X6, y=Y6, orientation="output")
model7 = CrossEfficiency(x=X7, y=Y7, orientation="output")

# Write DEA results
results_crs<-data.frame(dea_data$dmu,m1=t(model1$ce_ave),
m2=t(model2$ce_ave), m3=t(model3$ce_ave),
                        m4=t(model4$ce_ave),
m4a=t(model4a$ce_ave),m4b=t(model4b$ce_ave),

m5=t(model5$ce_ave),m5a=t(model5a$ce_ave),m5b=t(model5b$ce_ave),m6
=t(model6$ce_ave), m7=t(model7$ce_ave))
results_crs$eff<-rowMeans(results_crs[,-1])
write.csv(results_crs, "results_cross_crs.csv")

model1 = CrossEfficiency(x=X1, y=Y1, orientation="out-
put",rts="vrs")
model2 = CrossEfficiency(x=X2, y=Y2, orientation="out-
put",rts="vrs")
model3 = CrossEfficiency(x=X3, y=Y3, orientation="out-
put",rts="vrs")
model4 = CrossEfficiency(x=X4, y=Y4, orientation="out-
put",rts="vrs")
model4a = CrossEfficiency(x=X4a, y=Y4a, orientation="out-
put",rts="vrs")
model4b = CrossEfficiency(x=X4b, y=Y4b, orientation="out-
put",rts="vrs")
model5 = CrossEfficiency(x=X5, y=Y5, orientation="out-
put",rts="vrs")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="out-
put",rts="vrs")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="out-
put",rts="vrs")
model6 = CrossEfficiency(x=X6, y=Y6, orientation="out-
put",rts="vrs")
model7 = CrossEfficiency(x=X7, y=Y7, orientation="out-
put",rts="vrs")

# Write DEA results
results_vrs<-data.frame(dea_data$dmu,m1=t(model1$ce_ave),
m2=t(model2$ce_ave), m3=t(model3$ce_ave), m4=t(model4$ce_ave),
m4a=t(model4a$ce_ave),m4b=t(model4b$ce_ave),
m5=t(model5$ce_ave),m5a=t(model5a$ce_ave),m5b=t(model5b$ce_ave),m6
=t(model6$ce_ave), m7=t(model7$ce_ave))
results_vrs$eff<-rowMeans(results_vrs[,-1])
write.csv(results_vrs, "results_cross_vrs.csv")

#The code below produces estimates for panel data
# Data setup

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setwd("J:/BUSINESS/Freelance/2018/July/9 DEA/Dynamic")
library(foreign)
library(MultiplierDEA)
dea_data<-read.dta("dynamic.dta")
dea_data<-dea_data[dea_data$year<2017,]

# DEA specifications initial
X1 = dea_data[c("i1", "i2", "i3", "i4", "i5")]
Y1 = dea_data[c("o1")]
X2 = dea_data[c("i1", "i2", "i3", "i4", "i5")]
Y2 = dea_data[c("o1","o2","o3")]
X3 = dea_data[c("i6", "i7", "i8")]
Y3 = dea_data[c("o1","o3")]
X4 = dea_data[c("i1","i2")]
Y4 = dea_data[c("o2")]
X4a = dea_data[c("i1","i2")]
Y4a = dea_data[c("o1")]
X4b = dea_data[c("i1","i2","i4","i5","i7","i8")]
Y4b = dea_data[c("o2")]
X5 = dea_data[c("i3","i7")]
Y5 = dea_data[c("o3")]
X5a = dea_data[c("i3","i7")]
Y5a = dea_data[c("o1")]
X5b = dea_data[c("i3","i4", "i5","i7","i8")]
Y5b = dea_data[c("o3")]
X6 = dea_data[c("i6","i7","i8")]
Y6 = dea_data[c("o1")]
X7 = dea_data[c("i6")]
Y7 = dea_data[c("o1","o2")]

# DEA models
model1 = CrossEfficiency(x=X1, y=Y1, orientation="output")
model2 = CrossEfficiency(x=X2, y=Y2, orientation="output")
model3 = CrossEfficiency(x=X3, y=Y3, orientation="output")
model4 = CrossEfficiency(x=X4, y=Y4, orientation="output")
model4a = CrossEfficiency(x=X4a, y=Y4a, orientation="output")
model4b = CrossEfficiency(x=X4b, y=Y4b, orientation="output")
model5 = CrossEfficiency(x=X5, y=Y5, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="output")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="output")
model6 = CrossEfficiency(x=X6, y=Y6, orientation="output")
model7 = CrossEfficiency(x=X7, y=Y7, orientation="output")

# Write DEA results (CRS)
results.crs<-
data.frame(uni=dea_data$uni,year=dea_data$year,m1=t(model1$ce_ave)
, m2=t(model2$ce_ave), m3=t(model3$ce_ave),

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                                m4=t(model4$ce_ave),
m4a=t(model4a$ce_ave),m4b=t(model4b$ce_ave),

m5=t(model5$ce_ave),m5a=t(model5a$ce_ave),m5b=t(model5b$ce_ave),m6
=t(model6$ce_ave), m7=t(model7$ce_ave))
results.crs$eff<-rowMeans(results.crs[,c(-1,-2)])
write.csv(results.crs, "results_cross_crs.csv")

```

```
# DEA models (VRS)
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```

model1 = CrossEfficiency(x=X1, y=Y1, orientation="out-
put",rts="vrs")
model2 = CrossEfficiency(x=X2, y=Y2, orientation="out-
put",rts="vrs")
model3 = CrossEfficiency(x=X3, y=Y3, orientation="out-
put",rts="vrs")
model4 = CrossEfficiency(x=X4, y=Y4, orientation="out-
put",rts="vrs")
model4a = CrossEfficiency(x=X4a, y=Y4a, orientation="out-
put",rts="vrs")
model4b = CrossEfficiency(x=X4b, y=Y4b, orientation="out-
put",rts="vrs")
model5 = CrossEfficiency(x=X5, y=Y5, orientation="out-
put",rts="vrs")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="out-
put",rts="vrs")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="out-
put",rts="vrs")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="out-
put",rts="vrs")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="out-
put",rts="vrs")
model5a = CrossEfficiency(x=X5a, y=Y5a, orientation="out-
put",rts="vrs")
model5b = CrossEfficiency(x=X5b, y=Y5b, orientation="out-
put",rts="vrs")
model6 = CrossEfficiency(x=X6, y=Y6, orientation="out-
put",rts="vrs")
model7 = CrossEfficiency(x=X7, y=Y7, orientation="out-
put",rts="vrs")

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```
# Write DEA results (VRS)
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```

results.vrs<-
data.frame(dea_data$uni,dea_data$year,m1=t(model1$ce_ave),
m2=t(model2$ce_ave), m3=t(model3$ce_ave), m4=t(model4$ce_ave),
m4a=t(model4a$ce_ave),m4b=t(model4b$ce_ave),
m5=t(model5$ce_ave),m5a=t(model5a$ce_ave),m5b=t(model5b$ce_ave),m6
=t(model6$ce_ave), m7=t(model7$ce_ave))
is.na(results.vrs) <- sapply(results.vrs, is.infinite)
results.vrs$eff<-rowMeans(results.vrs[,c(-1,-2)],na.rm=TRUE)
write.csv(results.vrs, "results_cross_vrs.csv")

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