**Online Appendix**

//This file provides code to complete all models referred to in the paper regarding the use of panel data in management research

//For each model, we provide code to complete the analyses in a mixed-effect (Multi-level, or random coefficient, modeling) model, except where otherwise specified in the text (e.g. some models use OLS)

//Tells STATA not to pause or display the more message to move between pages of results

set more off

//Create data in STATA data file

input Firm str16 Industry Year Turnover ROI

1 Healthcare 2012 12 7

1 Healthcare 2013 11 8

1 Healthcare 2014 10 8.8

1 Healthcare 2015 9 9

1 Healthcare 2016 8 9.1

1 Healthcare 2017 7 9.5

2 Other 2012 33 10

2 Other 2013 32 10.5

2 Other 2014 31 11

2 Other 2015 30 11.5

2 Other 2016 29 11.9

2 Other 2017 28 12

3 Healthcare 2012 6 2

3 Healthcare 2013 5.5 2.5

3 Healthcare 2014 5 2.9

3 Healthcare 2015 4.5 3.1

3 Healthcare 2016 4 3.5

3 Healthcare 2017 3 3.6

end

//Generate variables for later use

bysort Firm: egen AverageTurnover=mean(Turnover)

bysort Firm: egen AverageROI=mean(ROI)

generate DemeanedTurnover = Turnover-AverageTurnover

generate DemeanedROI = ROI-AverageROI

//Set data as panel data

xtset Firm

//Raw correlation (r=0.797)

corr Turnover ROI

//Raw between correlation (r=0.848)

bysort Firm: gen first = sum(1)

corr AverageTurnover AverageROI if first==1

//Standard OLS model - (B=0.247, p<0.001)

regress ROI Turnover

//TESTS OF WITHIN-ENTITY RELATIONSHIPS

//Table 3 - OLS fixed effects regression with firm and time fixed effects - B=-0.278, p=0.03

regress ROI Turnover i.Firm i.Year

//Random effects fully crossed model with two non-nested intercepts (B=-0.412, p<0.001)

//This example is not core to the paper because many programs have trouble estimating fully crossed designs

mixed ROI Turnover || \_all: R.Firm || \_all: R.Year, reml

//Random effects model with random intercept for firm, fixed effects for time (B=-0.235)

mixed ROI Turnover i.Year || Firm:, reml

//Hausman test - non-significant

quietly mixed ROI Turnover i.Year || Firm:

estimates store random

quietly mixed ROI Turnover i.Year i.Firm

estimates store fixed

hausman random fixed

//Note that a significant Hausman test is identified if a different random effects estimator is used, see footnote 6 in the paper

xtreg ROI Turnover i.Year, re

estimates store random

xtreg ROI Turnover i.Year, fe

estimates store fixed

hausman random fixed

//Alternatives to recover the fixed effects estimate using a mixed effect model

//Alternative 1 - Random effects with demeaned (group mean centered) IV, including group mean as additional predictor with demeaned IV (Certo et al's hybrid approach)

mixed ROI DemeanedTurnover AverageTurnover i.Year || Firm:, reml

//Alternative 2 - Random effects with group mean of the IV as predictor with the raw IV

mixed ROI Turnover AverageTurnover i.Year || Firm:, reml

//Alternative 3 - Demean the IV and omit the group mean

mixed ROI DemeanedTurnover i.Year || Firm:, reml

//TESTS OF BETWEEN ENTITY-RELATIONSHIPS

//OLS of basic relationship using 1 year of data; Using one year of data returns an unbiased estimate of the relationship between the AverageROI and Average Turnover across the 3 entities; Alternatively, xtreg can specify the same relationship with between effects, as in the second line below

regress AverageROI AverageTurnover if Year==2012

xtreg AverageROI AverageTurnover, be

//Hybrid approach, Alternative 1 above (B=0.260, SE=0.16), could also include year fixed effects

mixed ROI DemeanedTurnover AverageTurnover || Firm:, reml

//Biased hybrid model in OLS (B=0.260, SE=0.042)

regress ROI DemeanedTurnover AverageTurnover

//TESTS OF INCREMENTAL OR EMERGENT RELATIONSHIPS

//Table 4 - Emergent or incremental test of within-firm and between-firm turnover, same as Alternative 2 above

mixed ROI Turnover AverageTurnover i.Year || Firm:, reml

//ANALYZING CROSS-LEVEL INTERACTIONS

//Create industry dummy variables, Industry1 = Healthcare, Industry2 = Other

tabulate Industry, generate(Industry)

//Fixed effects with cross-level industry interaction

regress ROI i.Year i.Firm c.Turnover##Industry1

//Random effects model with cross-level industry interaction returning the same parameter estimate and standard error

mixed ROI i.Year AverageTurnover c.Turnover##Industry1 || Firm:

//Test for significant slope variance using the random effects model with cross-level interaction

//Note that STATA cannot estimate standard errors for the variance estimates due to the small sample size and lack of degrees of freedom

mixed ROI i.Year AverageTurnover Turnover Industry1 || Firm:

mixed ROI i.Year AverageTurnover Turnover Industry1 || Firm:Turnover, cov(unstruc) //if the variance associated with Turnover is meaningful, include a random slope of Turnover in the interaction model

mixed ROI i.Year AverageTurnover c.Turnover##Industry1 || Firm: //per preceding line, if the variance associated with Turnover was meaningful, the model would be specified as || Firm:Turnover, cov(unstruc) instead

//ANALYZING GROWTH MODELS

//Recode time as a vector

generate Time = Year-2012

//Fixed effects growth model using time as a vector (Turnover B=-0.233, Time B=0.20)

regress ROI Turnover Time i.Firm

//Random effects growth model using time as a vector; Returns same parameter estimates and standard errors as fixed effects model

mixed ROI Turnover AverageTurnover Time || Firm:, reml

//VARIANCE DECOMPOSITION

//Null model (ICC = 0.97)

icc ROI Firm

//ICC conditional on Firm and Time

icc ROI Firm Year, mixed

//Approximating the ICC with null fixed effects model (rho=0.97 in xtreg, adjusted r2=0.95 in OLS)

xtreg ROI, fe

regress ROI i.Firm

//Approximating the conditional ICC with time fixed effects (rho=0.998 in xtreg, adjusted r2=0.997 in OLS)

xtreg ROI i.Year, fe

regress ROI i.Firm i.Year

//-------------------------------------------------------------------------------------------------------------------

//To this point, all analyses are conducted with mixed effects models or OLS, where specified. These models can also be specified econometrically

//Starting here, we provide code to run each model in the paper with econometric techniques such as GLS or GEE, although we specify differences where identified from those reported in the paper

//TESTS OF WITHIN-ENTITY RELATIONSHIPS

//Table 3 - Alternative specification using fixed effects within regression (xtreg) (returns same B=-0.278, p=0.03)

xtreg ROI Turnover i.Year, fe

//Random effects model (B=-0.415, p<0.001) - Estimates across R and STATA are different due to the fully crossed nature of the analytical design, note that using population average can replicate mixed effects model coefficients as well

xtreg ROI Turnover, re

xtreg ROI Turnover, pa

//Random effects model with random intercept for firm, fixed effects for time - Note that the GLS random effects model produces a different coefficient estimate, while GEE and population-averaged models are roughly equivalent to the mixed-effect model

xtreg ROI Turnover i.Year, re

xtgee ROI Turnover i.Year

xtreg ROI Turnover i.Year, pa

//Hausman test - non-significant

quietly xtgee ROI Turnover i.Year

estimates store random

quietly xtreg ROI Turnover i.Year, fe

estimates store fixed

hausman fixed random

//Note that a significant Hausman test is identified if the Random effects (Swamy-Arora) estimator is used rather than population-averaged, see footnote 6 in the paper

xtreg ROI Turnover i.Year, re

estimates store random

xtreg ROI Turnover i.Year, fe

estimates store fixed

hausman random fixed

//Alternatives to recover the fixed effects estimate using random effects models in xtreg

//Alternative 1 - Random effects with demeaned (group mean centered) IV, including group mean as additional predictor with demeaned IV (Certo et al's hybrid approach)

//Note that using GLS random effects can bias the standard error, while GEE reduces the associated bias

xtreg ROI DemeanedTurnover AverageTurnover i.Year, re vce(cluster Firm)

xtgee ROI DemeanedTurnover AverageTurnover i.Year

//Alternative 2 - Random effects with group mean of the IV as predictor with the raw IV

xtreg ROI Turnover AverageTurnover i.Year, re

xtgee ROI Turnover AverageTurnover i.Year

//Alternative 3 - Demean the IV and omit the group mean

xtreg ROI DemeanedTurnover i.Year, re

xtreg ROI DemeanedTurnover i.Year

//TESTS OF BETWEEN ENTITY-RELATIONSHIPS

//OLS of basic relationship using 1 year of data

regress AverageROI AverageTurnover if Year==2012

//Hybrid approach, Alternative 1 above (B=0.260)

xtreg ROI DemeanedTurnover AverageTurnover, re vce(cluster Firm)

xtgee ROI DemeanedTurnover AverageTurnover

//TESTS OF INCREMENTAL OR EMERGENT RELATIONSHIPS

//Table 4 - Emergent or incremental test of within-firm and between-firm turnover, same as Alternative 2 above

xtreg ROI Turnover AverageTurnover i.Year, re

xtgee ROI Turnover AverageTurnover i.Year

//ANALYZING CROSS-LEVEL INTERACTIONS

//Fixed effects with cross-level industry interaction

xtreg ROI i.Year c.Turnover##Industry1, fe

regress ROI i.Year i.Firm c.Turnover##Industry1

//Random effects model with cross-level industry interaction returning the same parameter estimate and standard error

xtreg ROI i.Year AverageTurnover c.Turnover##Industry1, re

//ANALYZING GROWTH MODELS

//Fixed effects growth model using time as a vector (Turnover B=-0.233, Time B=0.20)

regress ROI Turnover Time i.Firm

xtreg ROI Turnover Time, fe

//Random effects growth model using time as a vector; Returns same parameter estimates and standard errors as fixed effects model

xtreg ROI Turnover AverageTurnover Time, re

R Code for all models

Firm<-rep(1:3,each=6)

Industry<-rep(c("Healthcare","Other","Healthcare"),each=6)

Year<-rep(2012:2017,3)

Turnover<-c(12.0,11.0,10.0,9.0,8.0,7.0,33.0,32.0,31.0,30.0,

29.0,28.0,6.0,5.5,5.0,4.5,4.0,3.0)

ROI<-c(7.0,8.0,8.8,9.0,9.1,9.5,10.0,10.5,11.0,11.5,11.9,12.0,

2.0,2.5,2.9,3.1,3.5,3.6)

ROI.DAT<-data.frame(Firm=Firm,Industry=Industry,Year=Year,

Turnover=Turnover, ROI=ROI)

rm(Firm,Industry,Year,Turnover,ROI)

#Generate Variables for Later Use

#Group means in data.frame G.DAT

#Firm means assigned back to Firms

#Group mean centered (demeaned)

G.DAT<-aggregate(ROI.DAT[,c("Turnover","ROI")],list(ROI.DAT$Firm),mean)

names(G.DAT)<-c("Firm","AverageTurnover","AverageROI")

nrow(G.DAT)

ROI.DAT<-merge(ROI.DAT,G.DAT,by=1)

names(ROI.DAT)

nrow(ROI.DAT)

ROI.DAT$DemeanedTurnover<-ROI.DAT$Turnover-ROI.DAT$AverageTurnover

ROI.DAT$DemeanedROI<-ROI.DAT$ROI-ROI.DAT$AverageROI

ROI.DAT[1:10,]

#Create pseudo-groups, calculate group means from the pseudo groups

#and calculate the between-group correlation based on pseudo group means

set.seed(353178)

rmix.cor<-function(DATA,nreps){DATA$RGRP<-sample(rep(1:3,6))

GDAT<-aggregate(DATA[,c("Turnover","ROI")],list(DATA$RGRP),mean)

return(cor(GDAT$Turnover,GDAT$ROI))}

RDAT<-replicate(10000,rmix.cor(ROI.DAT))

mean(RDAT,na.rm=TRUE)

#Raw correlation (r=0.797)

cor.test(ROI.DAT$Turnover, ROI.DAT$ROI)

#Raw between correlation (r=0.848)

cor(ROI.DAT$AverageTurnover, ROI.DAT$AverageROI)

nrow(G.DAT)

cor.test(G.DAT$AverageTurnover,G.DAT$AverageROI)

#Standard OLS model - (B=0.247, p<0.001)

summary(lm(ROI~Turnover,data=ROI.DAT))$coef

#TESTS OF WITHIN-ENTITY RELATIONSHIPS ####

#Table 3 - OLS fixed effects regression with firm and time fixed

#effects - B=-0.278, p=0.03

summary(lm(ROI~Turnover+factor(Firm)+factor(Year),data=ROI.DAT))$coef

#Fully crossed model with two non-nested intercepts. This example is

#not core to the paper because many programs have trouble estimating

#fully crossed designs.

#Also provides example of calculating Year Means and including in model

library(lme4)

summary(lmer(ROI~Turnover+(1|Firm)+(1|Year),data=ROI.DAT))$coef

#Calculate Year Means and assign back to data

Y.DAT<-aggregate(ROI.DAT[,c("Turnover","ROI")],list(ROI.DAT$Year),mean)

names(Y.DAT)

nrow(Y.DAT)

ROI.DAT<-merge(ROI.DAT,Y.DAT,by.x="Year",by.y=1,suffixes=c("",".Y"))

ROI.DAT[1:10,]

ROI.DAT<-ROI.DAT[order(ROI.DAT$Firm,ROI.DAT$Year),]

ROI.DAT[1:10,]

#Fully crossed model that returns gold standard within estimate

summary(lmer(ROI~Turnover+AverageTurnover+Turnover.Y+(1|Firm)+(1|Year),

data=ROI.DAT))$coef

#Random effects model with random intercept for firm, fixed effects

#for time (B=-0.235)

library(nlme)

summary(lme(ROI~Turnover+factor(Year),random=~1|Firm,data=ROI.DAT))$tTable

#Hausman tests

#Note that choice of "random.method" option makes a difference in this

#Extreme example. Default of "swar" produces an estimate of -.109 which

#significantly differs from fixed estimat of -.278. See footnote 6 in paper.

library(plm)

wi<-plm(ROI~Turnover+factor(Year),index=c("Firm"),data=ROI.DAT,

model="within")

summary(wi)$coef

re<-plm(ROI~Turnover+factor(Year),index=c("Firm"),data=ROI.DAT,

model="random",random.method="amemiya")

summary(re)$coef

re2<-plm(ROI~Turnover+factor(Year),index=c("Firm"),data=ROI.DAT,

model="random")

summary(re2)$coef

phtest(wi,re)

phtest(wi,re2)

#Alternatives to recover the fixed effects estimate in mixed effect model

#Alternative 1 - Random effects with demeaned (group mean centered) IV,

#including group mean as additional predictor with demeaned IV (Certo

#et al's hybrid approach)

library(nlme)

summary(lme(ROI~DemeanedTurnover+AverageTurnover+factor(Year),

random=~1|Firm,data=ROI.DAT))$tTable

#Alternative 2 - Random effects with group mean of the IV as predictor

#with the raw IV

summary(lme(ROI~Turnover+AverageTurnover+factor(Year),

random=~1|Firm,data=ROI.DAT))$tTable

#Alternative 3 - Demean the IV and omit the group mean

summary(lme(ROI~DemeanedTurnover+factor(Year),

random=~1|Firm,data=ROI.DAT))$tTable

#TESTS OF BETWEEN ENTITY-RELATIONSHIPS ####

#OLS of firm-means (B=0.260, SE=0.162)

nrow(G.DAT)

summary(lm(AverageROI~AverageTurnover,data=G.DAT))$coef

#Mixed-Effect hybrid approach. Could also include fixed-effects

#for year to recover gold standard within effect (B=0.260, SE=0.162),

summary(lme(ROI~DemeanedTurnover+AverageTurnover,random=~1|Firm,

data=ROI.DAT))$tTable

#Biased hybrid model in OLS (B=0.260, SE=0.042)

summary(lm(ROI~DemeanedTurnover+AverageTurnover,data=ROI.DAT))$coef

#TESTS OF INCREMENTAL OR EMERGENT RELATIONSHIPS ####

#Table 4 - Emergent or incremental test of within-firm

#and between-firm turnover, same as Alternative 2 above

summary(lme(ROI~Turnover+AverageTurnover+factor(Year),

random=~1|Firm,data=ROI.DAT))$tTable

#ANALYZING CROSS-LEVEL INTERACTIONS ####

#Fixed effects with cross-level industry interaction

summary(lm(ROI~Turnover+factor(Firm)+factor(Year)+Turnover:Industry,

data=ROI.DAT))$coef

#Random effects model with cross-level industry interaction returning

#the same parameter estimate and standard error. Warning because sample

#size is too small

summary(lme(ROI~Turnover\*Industry+AverageTurnover+factor(Year),

random=~1|Firm,data=ROI.DAT))$tTable

#Test for significant slope variance using the random effects model

#with cross-level interaction.

#Note that -2log likelihood value essentially 0 due to the small sample

#size and lack of degrees of freedom

mod.int<-lme(ROI~Turnover+AverageTurnover+Industry+factor(Year),

random=~1|Firm,data=ROI.DAT)

mod.slope<-update(mod.int,random=~Turnover|Firm)

anova(mod.int,mod.slope) #log likelihood test

#ANALYZING GROWTH MODELS ####

#Create time vector

ROI.DAT$Time<-ROI.DAT$Year-2012

#Fixed effects growth model using time as a vector (Turnover B=-0.233,

#Time B=0.20); Could also omit Turnover from models or include average

#turnover as cross-level predictor.

summary(lm(ROI~Time+Turnover+factor(Firm),data=ROI.DAT))$coef

#Random effects growth model using time as a vector;

#Returns same parameter estimates and standard errors as fixed effects model

summary(lme(ROI~Time+Turnover+AverageTurnover,random=~1|Firm,

data=ROI.DAT))$tTable

#VARIANCE DECOMPOSITION ####

#Null model (ICC = 0.97)

null.mod<-lme(ROI~1,random=~1|Firm,data=ROI.DAT)

VarCorr(null.mod)

17.5513703/(17.5513703+0.6134444)

#ICC for Firm conditional on Year

null.mod.c<-lme(ROI~factor(Year),random=~1|Firm,data=ROI.DAT)

VarCorr(null.mod.c)

#Approximating the ICC with null fixed effects model

#(rho=0.97 in xtreg, adjusted r2=0.95 in OLS)

mod.fe<-lm(ROI~factor(Firm)+factor(Year),data=ROI.DAT)

summary(mod.fe)$adj.r.squared