

Example 4-5

September 12, 2020

```
[ ]: # install the following package and libraries
```

```
install.packages("plm")
```

```
library("plm")
```

```
# the nlme package allows to estimate the maximum likelihood estimator
```

```
# with or without random individual effects or serial correlation
```

```
library("nlme")
```

```
[3]: ##-----Block 1-----
```

```
#### Example 4-5 ####
```

```
## -----
```

```
data(Grunfeld, package = "plm")
```

```
# random effect GLS and maximum likelihood models.
```

```
reGLS <- plm(inv ~ value + capital, data = Grunfeld, model = "random")
```

```
# the random option sets the number of random effects to 1, the intercept
```

```
reML <- lme(inv ~ value + capital, data = Grunfeld, random = ~1 | firm)
```

```
rbind(coef(reGLS), fixef(reML))
```

(Intercept)	value	capital
-57.83441	0.1097812	0.3081130
-57.86442	0.1097897	0.3081881

```
[5]: ##-----Block 2-----
```

```
# linear model with groupwise structures of time dependence fitted with GLS
```

```
# must specify the correlation structure (AR(1), etc.)
```

```
lmAR1ML <- gls(inv ~ value + capital, data = Grunfeld,  
  correlation = corAR1(0, form = ~ year | firm))
```

```
## -----
```

```
# random effects with AR(1) errors
```

```
reAR1ML <- lme(inv ~ value + capital, data = Grunfeld,
```

```

    random = ~ 1 | firm, correlation = corAR1(0, form = ~ year | firm))
summary(reAR1ML)

```

Linear mixed-effects model fit by REML

Data: Grunfeld

	AIC	BIC	logLik
	2094.802	2114.501	-1041.401

Random effects:

Formula: ~1 | firm

(Intercept) Residual

StdDev: 78.04129 72.80316

Correlation Structure: AR(1)

Formula: ~year | firm

Parameter estimate(s):

Phi

0.823845

Fixed effects: inv ~ value + capital

	Value	Std.Error	DF	t-value	p-value
(Intercept)	-40.27651	30.694247	188	-1.312184	0.1911
value	0.09337	0.007933	188	11.769948	0.0000
capital	0.31323	0.032170	188	9.736772	0.0000

Correlation:

(Intr) value

value -0.239

capital -0.280 -0.125

Standardized Within-Group Residuals:

	Min	Q1	Med	Q3	Max
	-2.40759098	-0.31847478	0.04847325	0.19862564	3.30039568

Number of Observations: 200

Number of Groups: 10

```

[6]: ##-----Block 3-----

# GLS with no correlation
lmML <- gls(inv ~ value + capital, data = Grunfeld)
anova(lmML, lmAR1ML)

```

	call
lmML	<code>gls(model = inv ~ value + capital, data = Grunfeld)</code>
lmAR1ML	<code>gls(model = inv ~ value + capital, data = Grunfeld, correlation = corAR1(0, form = ~year firm))</code>

```

[7]: ##-----Block 4-----

```

```
# AR(1) test on random effects model
anova(reML, reAR1ML)
```

	call
reML	lme.formula(fixed = inv ~ value + capital, data = Grunfeld, random = ~1 firm)
reAR1ML	lme.formula(fixed = inv ~ value + capital, data = Grunfeld, random = ~1 firm, correlation = cor.

[8]: ##-----Block 5-----

```
# likelihood ratio test for random effects
anova(lmML, reML)
```

	call	Model	df	AIC
lmML	gls(model = inv ~ value + capital, data = Grunfeld)	1	4	2400.2
reML	lme.formula(fixed = inv ~ value + capital, data = Grunfeld, random = ~1 firm)	2	5	2205.8

[9]: ##-----Block 6-----

```
# likelihood ration test for random effects sub AR(1) errors
anova(lmAR1ML, reAR1ML)
```

	call
lmAR1ML	gls(model = inv ~ value + capital, data = Grunfeld, correlation = corAR1(0, form = ~year firm)
reAR1ML	lme.formula(fixed = inv ~ value + capital, data = Grunfeld, random = ~1 firm, correlation = cor