

```
In [29]: import numpy as np
import pandas as pd
from scipy import stats
# set up panel data
pdata = pd.read_csv("Bank-5.csv", index_col = ["ID", "Year"],
                    parse_dates = True)

pdata
# alternatively
# data = pd.read_csv("http://web.pdx.edu/~crkl/ceR/data/airline.txt", sep='\s+',
# Set data as panel data
# pdata = data.set_index(['I', 'T'], inplace=True)
```

Out[29]:

		SL	Market Capitalization	Market Cap Growth	de	df	roe	roa	roic	ta	
ID	Year										
BOKF	2004-01-01	1	2,889,069,788	0.30743	1.94645	8.43194	0.135	0.013	0.017	0.062697	0.050
	2005-01-01	1	3,023,672,153	0.04659	1.74653	9.09780	0.135	0.013	0.018	0.037701	0.038
	2006-01-01	1	3,676,927,974	0.21605	1.88263	14.24817	0.130	0.012	0.017	0.026666	0.032
	2007-01-01	1	3,470,470,088	-0.05615	2.40312	16.25542	0.118	0.011	0.015	0.026347	0.013
	2008-01-01	1	2,724,327,015	-0.21500	2.67886	40.67754	0.079	0.007	0.008	0.920015	0.067
...
COLB	2017-01-01	20	2,535,730,288	-0.02221	0.06899	1.00060	0.077	0.011	0.018	-0.003037	0.067
	2018-01-01	20	2,658,524,655	0.04843	0.24394	2.05074	0.087	0.014	0.018	-0.085148	0.061
	2019-01-01	20	2,934,863,006	0.10394	0.48759	5.13913	0.091	0.014	0.018	0.007901	0.049
	2020-01-01	20	2,570,642,368	-0.12410	0.04957	0.62387	0.068	0.010	0.013	0.575604	0.143
	2021-01-01	20	2,569,284,274	-0.00053	0.04391	0.46435	0.085	0.011	0.015	0.175592	0.071

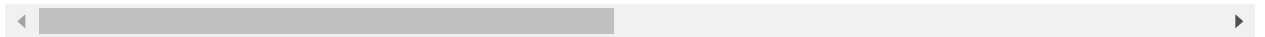
360 rows × 18 columns



```
In [30]: pdata.describe()
df = pdata
# Descriptive statistics
df.describe()
```

Out[30]:

	SL	Market Cap Growth	de	df	roe	roa	roic	
count	360.000000	360.000000	360.000000	360.000000	360.000000	360.000000	360.000000	360.000000
mean	10.500000	0.144246	0.897066	10.915104	0.079881	0.008744	0.012639	0.144246
std	5.774307	0.410973	0.680102	52.405240	0.084881	0.008488	0.009891	0.240973
min	1.000000	-0.656710	0.026000	-109.443000	-0.692000	-0.069000	-0.060000	-0.060000
25%	5.750000	-0.081395	0.376320	2.167350	0.069750	0.008000	0.011000	-0.081395
50%	10.500000	0.093700	0.732990	5.801075	0.091000	0.010000	0.015000	0.093700
75%	15.250000	0.299200	1.242723	10.150288	0.114250	0.012000	0.017000	0.114250
max	20.000000	3.729530	3.601420	678.411760	0.340000	0.036000	0.029000	0.915104



```
In [31]: #with ROA
# Pooled OLS estimator
from linearmodels import PooledOLS
pooled = PooledOLS.from_formula('roa ~ 1 + ta + ffr + cc + lf', df).fit()
print(pooled)
```

PooledOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.106
7
Estimator:              PooledOLS    R-squared (Between):    0.000
0
No. Observations:       360    R-squared (Within):      0.120
3
Date:                   Thu, Jul 14 2022    R-squared (Overall):    0.106
7
Time:                   08:42:52    Log-likelihood          1226.
9
Cov. Estimator:         Unadjusted
                                F-statistic:            10.60
4
Entities:               20    P-value                0.000
0
Avg Obs:                18.000    Distribution:           F(4,35
5)
Min Obs:                18.000
Max Obs:                18.000    F-statistic (robust):   10.60
4
                                P-value                0.000
0
Time periods:           18    Distribution:           F(4,35
5)
Avg Obs:                20.000
Min Obs:                20.000
Max Obs:                20.000
```

Parameter Estimates

```
=====
-----
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept   0.0095      0.0012    8.1153    0.0000     0.0072     0.0118
cc          -0.0192     0.0191   -1.0029    0.3166    -0.0567     0.0184
ffr         0.0012     0.0006    1.9785    0.0486     7.29e-06     0.0024
lf          0.0003    5.584e-05  4.7240    0.0000     0.0002     0.0004
ta          0.0028     0.0034    0.8383    0.4024    -0.0038     0.0094
=====
```



```
In [15]: #with ROA
# Pooled OLS estimator
from linearmodels import PooledOLS
pooled = PooledOLS.from_formula('roa ~ 1 + de + df + ta + ffr +cc + lf', df).fit()
print(pooled)
```

PooledOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.108
8
Estimator:             PooledOLS    R-squared (Between):    -0.001
9
No. Observations:      360    R-squared (Within):      0.122
9
Date:                  Tue, Jul 12 2022    R-squared (Overall):      0.108
8
Time:                  15:44:48    Log-likelihood            1227.
3
Cov. Estimator:        Unadjusted
                          F-statistic:          7.182
7
Entities:              20    P-value            0.000
0
Avg Obs:               18.000    Distribution:          F(6,35
3)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):      7.182
7
                          P-value            0.000
0
Time periods:          18    Distribution:          F(6,35
3)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
-----
Parameter    Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept    0.0085      0.0016    5.2283    0.0000      0.0053      0.0117
cc           -0.0110     0.0213   -0.5157    0.6064     -0.0529      0.0309
de            0.0006     0.0007    0.9014    0.3680     -0.0008      0.0021
df           -1.521e-06  8.306e-06 -0.1832    0.8548    -1.786e-05   1.481e-05
ffr           0.0011     0.0006    1.7985    0.0730     -0.0001      0.0024
lf            0.0003     5.754e-05 4.7471    0.0000      0.0002      0.0004
ta            0.0020     0.0035    0.5816    0.5612     -0.0048      0.0089
=====
```




```
In [33]: # Fixed effects or within estimator
# with constant included or not, will have the same results
# with constant term suppressed
from linearmodels import PanelOLS
fixed = PanelOLS.from_formula('roa ~ ta + ffr + cc + lf + EntityEffects', df).fit()
print(fixed)
```

PanelOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.120
3
Estimator:              PanelOLS    R-squared (Between):    -0.154
6
No. Observations:      360    R-squared (Within):      0.120
3
Date:                  Thu, Jul 14 2022    R-squared (Overall):    -0.036
4
Time:                  08:43:22    Log-likelihood          1251.
2
Cov. Estimator:        Unadjusted
                          F-statistic:          11.48
7
Entities:              20    P-value          0.000
0
Avg Obs:               18.000    Distribution:          F(4,33
6)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):    11.48
7
                          P-value          0.000
0
Time periods:          18    Distribution:          F(4,33
6)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
-----
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
cc          -0.0192     0.0184    -1.0438    0.2973     -0.0553     0.0169
ffr         0.0012     0.0006     2.0593    0.0402     5.445e-05     0.0024
lf          0.0003    5.365e-05    4.9167    0.0000     0.0002     0.0004
ta          0.0028     0.0032     0.8725    0.3835     -0.0035     0.0092
=====
```

F-test for Poolability: 2.5557

P-value: 0.0004

Distribution: F(19,336)

Included effects: Entity


```
In [23]: # Fixed effects or within estimator
# with constant included or not, will have the same results
# with constant term suppressed
from linearmodels import PanelOLS
fixed = PanelOLS.from_formula('roa ~ de + df + ta + ffr +cc + lf + EntityEffects')
print(fixed)
```

PanelOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.123
2
Estimator:              PanelOLS    R-squared (Between):    0.156
1
No. Observations:      360    R-squared (Within):    0.123
2
Date:                  Tue, Jul 12 2022    R-squared (Overall):    0.142
0
Time:                  15:47:11    Log-likelihood          1251.
8
Cov. Estimator:        Unadjusted
                               F-statistic:          7.823
9
Entities:              20    P-value          0.000
0
Avg Obs:               18.000    Distribution:          F(6,33
4)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):    7.823
9
                               P-value          0.000
0
Time periods:          18    Distribution:          F(6,33
4)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
-----
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
cc          -0.0066     0.0221    -0.2977    0.7661     -0.0500     0.0369
de           0.0010     0.0009     1.0523    0.2934     -0.0009     0.0028
df          -1.711e-06  8.249e-06  -0.2074    0.8358    -1.794e-05  1.452e-05
ffr          0.0011     0.0006     1.7667    0.0782     -0.0001     0.0023
lf           0.0003    5.621e-05  4.9560    0.0000     0.0002     0.0004
ta           0.0016     0.0034     0.4659    0.6416     -0.0052     0.0084
=====
```

F-test for Poolability: 2.5609

P-value: 0.0004

Distribution: F(19,334)

Included effects: Entity

```
In [34]: ###WITHOUT DE/DF
# extract fixed effects
fixed.estimated_effects
fixed_effects = fixed.estimated_effects.unstack(level=0).values[0]
print(fixed_effects)
# F test for fixed effects versus OLS
print(fixed.f_pooled)
```

```
[0.00760683 0.00871794 0.00966238 0.01260683 0.00516238 0.01155127
 0.01166238 0.01249571 0.01282905 0.01016238 0.01055127 0.01016238
 0.01082905 0.00571794 0.00966238 0.00860683 0.01127349 0.01221794
 0.0018846 0.0058846 ]
Pooled F-statistic
H0: Effects are zero
Statistic: 2.5557
P-value: 0.0004
Distributed: F(19,336)
```

```
In [17]: # extract fixed effects
fixed.estimated_effects
fixed_effects = fixed.estimated_effects.unstack(level=0).values[0]
print(fixed_effects)
# F test for fixed effects versus OLS
print(fixed.f_pooled)
```

```
[-0.00158864 -0.00131012 0.00025158 0.00390885 -0.00415552 0.00139392
 0.00204194 0.00304556 0.00365657 0.00069459 0.00165493 0.00028019
 0.00159464 -0.00362247 0.00030459 -0.00177821 0.00182457 0.00255154
 -0.00740112 -0.00334739]
Pooled F-statistic
H0: Effects are zero
Statistic: 2.5609
P-value: 0.0004
Distributed: F(19,334)
```

```
In [18]: # with constant term included
fixed1 = PanelOLS.from_formula('roa ~ 1 + de + df + ta + ffr +cc + lf + EntityEff
print(fixed1)
# extract fixed effects
fixed1.estimated_effects
fixed1_effects = fixed1.params.Intercept + fixed1.estimated_effects.unstack(level1
print(fixed1_effects)
```

PanelOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.123
2
Estimator:             PanelOLS    R-squared (Between):    -0.009
7
No. Observations:      360    R-squared (Within):      0.123
2
Date:                  Tue, Jul 12 2022    R-squared (Overall):      0.108
2
Time:                  15:46:26    Log-likelihood            1251.
8
Cov. Estimator:        Unadjusted
F-statistic:           7.823
9
Entities:              20    P-value            0.000
0
Avg Obs:               18.000    Distribution:          F(6,33
4)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):      7.823
9
P-value            0.000
0
Time periods:          18    Distribution:          F(6,33
4)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept    0.0079    0.0018    4.3051    0.0000    0.0043    0.0116
cc           -0.0066    0.0221   -0.2977    0.7661   -0.0500    0.0369
de            0.0010    0.0009    1.0523    0.2934   -0.0009    0.0028
df          -1.711e-06  8.249e-06  -0.2074    0.8358  -1.794e-05  1.452e-05
ffr           0.0011    0.0006    1.7667    0.0782   -0.0001    0.0023
lf            0.0003    5.621e-05  4.9560    0.0000    0.0002    0.0004
ta            0.0016    0.0034    0.4659    0.6416   -0.0052    0.0084
=====
```

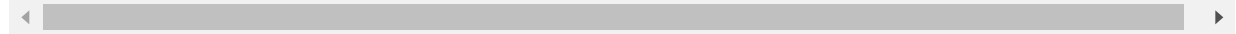
F-test for Poolability: 2.5609

P-value: 0.0004

Distribution: F(19,334)

Included effects: Entity

```
[0.00636028 0.0066388 0.0082005 0.01185778 0.00379341 0.00934285  
0.00999087 0.01099448 0.01160549 0.00864351 0.00960386 0.00822912  
0.00954356 0.00432646 0.00825352 0.00617071 0.0097735 0.01050047  
0.00054781 0.00460153]
```

A horizontal scrollbar with a light gray track and a darker gray slider, positioned below the text.

```
In [35]: # with constant term included
fixed1 = PanelOLS.from_formula('roa ~ 1 + ta + ffr + cc + lf + EntityEffects', df)
print(fixed1)
# extract fixed effects
fixed1.estimated_effects
fixed1_effects = fixed1.params.Intercept + fixed1.estimated_effects.unstack(level1)
print(fixed1_effects)
```

PanelOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.120
3
Estimator:              PanelOLS    R-squared (Between):    0.000
0
No. Observations:      360    R-squared (Within):    0.120
3
Date:                  Thu, Jul 14 2022    R-squared (Overall):    0.106
7
Time:                  08:44:12    Log-likelihood          1251.
2
Cov. Estimator:        Unadjusted
                          F-statistic:          11.48
7
Entities:              20    P-value          0.000
0
Avg Obs:               18.000    Distribution:          F(4,33
6)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):    11.48
7
                          P-value          0.000
0
Time periods:          18    Distribution:          F(4,33
6)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept  0.0095    0.0011    8.4464    0.0000    0.0073    0.0117
cc         -0.0192    0.0184   -1.0438    0.2973   -0.0553    0.0169
ffr        0.0012    0.0006    2.0593    0.0402    5.445e-05    0.0024
lf         0.0003    5.365e-05    4.9167    0.0000    0.0002    0.0004
ta         0.0028    0.0032    0.8725    0.3835   -0.0035    0.0092
=====
```

F-test for Poolability: 2.5557

P-value: 0.0004

Distribution: F(19,336)

Included effects: Entity

```
[0.00760683 0.00871794 0.00966238 0.01260683 0.00516238 0.01155127
 0.01166238 0.01249571 0.01282905 0.01016238 0.01055127 0.01016238
```

```
0.01082905 0.00571794 0.00966238 0.00860683 0.01127349 0.01221794  
0.0018846 0.0058846 ]
```

```
In [19]: # F test for fixed effects versus OLS  
print(fixed1.f_pooled)
```

```
Pooled F-statistic  
H0: Effects are zero  
Statistic: 2.5609  
P-value: 0.0004  
Distributed: F(19,334)
```

```
In [20]: # Random effects estimator, constant term must be included
# should not have EntityEffects or TimeEffects in the formula
from linearmodels import RandomEffects
random = RandomEffects.from_formula('roa ~ 1 + de + df + ta + ffr +cc + lf', df)
print(random)
# extract fixed effects
random.estimated_effects
random_effects = random.params.Intercept + random.estimated_effects.unstack(level=1)
print(random_effects)
print(random.variance_decomposition)
```

```

RandomEffects Estimation Summary
=====
=
Dep. Variable:          roa    R-squared:          0.118
9
Estimator:              RandomEffects    R-squared (Between):    -0.006
0
No. Observations:      360    R-squared (Within):      0.123
2
Date:                  Tue, Jul 12 2022    R-squared (Overall):      0.108
6
Time:                  15:46:40    Log-likelihood            1244.
8
Cov. Estimator:        Unadjusted
                                F-statistic:          7.939
6
Entities:              20    P-value              0.000
0
Avg Obs:               18.000    Distribution:          F(6,35
3)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):    7.939
6
                                P-value              0.000
0
Time periods:          18    Distribution:          F(6,35
3)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000

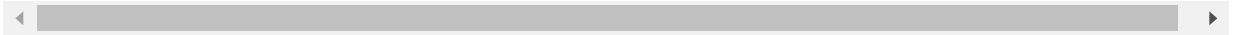
```

```

Parameter Estimates
=====
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept    0.0082    0.0018    4.4218    0.0000    0.0045    0.0118
cc           -0.0084    0.0213   -0.3933    0.6944   -0.0502    0.0335
de            0.0009    0.0008    1.0122    0.3121   -0.0008    0.0025
df          -1.629e-06  8.104e-06 -0.2010    0.8408  -1.757e-05  1.431e-05
ffr           0.0011    0.0006    1.8245    0.0689  -8.537e-05  0.0023
lf            0.0003    5.537e-05  4.9920    0.0000    0.0002    0.0004
ta            0.0018    0.0034    0.5259    0.5993   -0.0049    0.0084
=====
[0.00737989 0.00757118 0.00828433 0.0099941 0.00615366 0.0088812
0.00915769 0.00962953 0.00990476 0.00850129 0.00892215 0.00832713
0.00891632 0.0064102 0.00830321 0.00736906 0.0090414 0.00940631

```

```
0.00458754 0.00653589]
Effects          0.000009
Residual         0.000060
Percent due to Effects 0.131308
Name: Variance Decomposition, dtype: float64
```

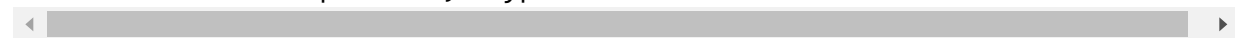



```
In [36]: # Random effects estimator, constant term must be included
# should not have EntityEffects or TimeEffects in the formula
from linearmodels import RandomEffects
random = RandomEffects.from_formula('roa ~ 1 + ta + ffr + cc + lf', df).fit()
print(random)
# extract fixed effects
random.estimated_effects
random_effects = random.params.Intercept + random.estimated_effects.unstack(level=1)
print(random_effects)
print(random.variance_decomposition)
```

```
RandomEffects Estimation Summary
=====
=
Dep. Variable:          roa    R-squared:          0.115
8
Estimator:              RandomEffects    R-squared (Between):          0.000
0
No. Observations:          360    R-squared (Within):          0.120
3
Date:                    Thu, Jul 14 2022    R-squared (Overall):          0.106
7
Time:                    08:44:39    Log-likelihood          1243.
3
Cov. Estimator:          Unadjusted
                                F-statistic:          11.61
8
Entities:                20    P-value          0.000
0
Avg Obs:                 18.000    Distribution:          F(4,35
5)
Min Obs:                 18.000
Max Obs:                 18.000    F-statistic (robust):          11.61
8
                                P-value          0.000
0
Time periods:            18    Distribution:          F(4,35
5)
Avg Obs:                 20.000
Min Obs:                 20.000
Max Obs:                 20.000
```

```
Parameter Estimates
=====
-----
Parameter    Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept    0.0095    0.0013    7.4573    0.0000    0.0070    0.0120
cc           -0.0192    0.0183   -1.0498    0.2945   -0.0551    0.0167
ffr          0.0012    0.0006    2.0710    0.0391    6.124e-05    0.0024
lf           0.0003    5.335e-05    4.9447    0.0000    0.0002    0.0004
ta           0.0028    0.0032    0.8775    0.3808   -0.0035    0.0091
=====
[0.00863813 0.00913169 0.00955122 0.01085917 0.00755228 0.01039029
 0.01043964 0.01080982 0.01095789 0.00977333 0.00994608 0.00977333
 0.01006947 0.00779906 0.00955122 0.00908233 0.01026689 0.01068643
 0.00609626 0.0078731 ]
Effects          0.000007
```

```
Residual          0.000060
Percent due to Effects  0.110552
Name: Variance Decomposition, dtype: float64
```



```
In [37]: from linearmodels.panel.results import compare
```

```
In [24]: # compare fixed effects and random effects models
res2 = {'Pooled':pooled,'Fixed+1':fixed1,'Fixed':fixed,'Random':random}
print(compare(res2))

effects = pd.DataFrame({'Fixed Effects':fixed_effects,'Random Effects':random_eff
                        index=pdata.index.levels[0])
print(effects)
```

Model Comparison				
	Pooled	Fixed+1	Fixed	
Random				
Dep. Variable	roa	roa	roa	
Estimator	PooledOLS	PanelOLS	PanelOLS	Random
No. Observations	360	360	360	
Cov. Est.	Unadjusted	Unadjusted	Unadjusted	Una
R-squared	0.1088	0.1232	0.1232	
R-Squared (Within)	0.1229	0.1232	0.1232	
R-Squared (Between)	-0.0019	-0.0097	0.1561	
R-Squared (Overall)	0.1088	0.1082	0.1420	
F-statistic	7.1827	7.8239	7.8239	
P-value (F-stat)	0.0000	0.0000	0.0000	
Intercept	0.0085	0.0079		
cc	-0.0110	-0.0066	-0.0066	
de	0.0006	0.0010	0.0010	
df	-1.521e-06	-1.711e-06	-1.711e-06	-1.
ffr	0.0011	0.0011	0.0011	

lf	0.0003	0.0003	0.0003
0.0003			
	(4.7471)	(4.9560)	(4.9560)
(4.9920)			
ta	0.0020	0.0016	0.0016
0.0018			
	(0.5816)	(0.4659)	(0.4659)
(0.5259)			

```

=====
=====
Effects                                Entity      Entity
-----
-----

```

T-stats reported in parentheses

	Fixed Effects	Random Effects
--	---------------	----------------

ID		
ABCB	-0.001589	0.007380
ASB	-0.001310	0.007571
AUB	0.000252	0.008284
BANF	0.003909	0.009994
BANR	-0.004156	0.006154
BOKF	0.001394	0.008881
CATY	0.002042	0.009158
CBU	0.003046	0.009630
CFR	0.003657	0.009905
CMA	0.000695	0.008501
COLB	0.001655	0.008922
SASR	0.000280	0.008327
SFNC	0.001595	0.008916
SNV	-0.003622	0.006410
SSB	0.000305	0.008303
TCBI	-0.001778	0.007369
TRMK	0.001825	0.009041
UBSI	0.002552	0.009406
UCBI	-0.007401	0.004588
ZION	-0.003347	0.006536



```
In [38]: # compare fixed effects and random effects models
res2 = {'Pooled':pooled,'Fixed+1':fixed1,'Fixed':fixed,'Random':random}
print(compare(res2))

effects = pd.DataFrame({'Fixed Effects':fixed_effects,'Random Effects':random_eff
                        index=pdata.index.levels[0])
print(effects)
```

Model Comparison				
=====				
	Pooled	Fixed+1	Fixed	
Random				

Dep. Variable	roa	roa	roa	
roa				
Estimator	PooledOLS	PanelOLS	PanelOLS	Random
Effects				
No. Observations	360	360	360	
360				
Cov. Est.	Unadjusted	Unadjusted	Unadjusted	Una
djusted				
R-squared	0.1067	0.1203	0.1203	
0.1158				
R-Squared (Within)	0.1203	0.1203	0.1203	
0.1203				
R-Squared (Between)	0.0000	0.0000	-0.1546	
0.0000				
R-Squared (Overall)	0.1067	0.1067	-0.0364	
0.1067				
F-statistic	10.604	11.487	11.487	
11.618				
P-value (F-stat)	0.0000	0.0000	0.0000	
0.0000				
=====	=====	=====	=====	=====
=====				
Intercept	0.0095	0.0095		
0.0095				
	(8.1153)	(8.4464)		
(7.4573)				
cc	-0.0192	-0.0192	-0.0192	
-0.0192				
	(-1.0029)	(-1.0438)	(-1.0438)	(-
1.0498)				
ffr	0.0012	0.0012	0.0012	
0.0012				
	(1.9785)	(2.0593)	(2.0593)	
(2.0710)				
lf	0.0003	0.0003	0.0003	
0.0003				
	(4.7240)	(4.9167)	(4.9167)	
(4.9447)				
ta	0.0028	0.0028	0.0028	
0.0028				
	(0.8383)	(0.8725)	(0.8725)	
(0.8775)				

Effects	Entity	Entity

T-stats reported in parentheses		
	Fixed Effects	Random Effects
ID		
ABCB	0.007607	0.008638
ASB	0.008718	0.009132
AUB	0.009662	0.009551
BANF	0.012607	0.010859
BANR	0.005162	0.007552
BOKF	0.011551	0.010390
CATY	0.011662	0.010440
CBU	0.012496	0.010810
CFR	0.012829	0.010958
CMA	0.010162	0.009773
COLB	0.010551	0.009946
SASR	0.010162	0.009773
SFNC	0.010829	0.010069
SNV	0.005718	0.007799
SSB	0.009662	0.009551
TCBI	0.008607	0.009082
TRMK	0.011273	0.010267
UBSI	0.012218	0.010686
UCBI	0.001885	0.006096
ZION	0.005885	0.007873

```
In [25]: # LM test for random effects versus OLS
n = pdata.index.levels[0].size
T = pdata.index.levels[1].size
D = np.kron(np.eye(n), np.ones(T)).T
e = pooled.resids
LM = (e.dot(D).dot(D.T).dot(e) / e.dot(e) - 1) ** 2 * n * T / 2 / (T - 1)
LM_pvalue = stats.chi2(1).sf(LM)
print("LM Test: chisq = {0}, df = 1, p-value = {1}".format(LM, LM_pvalue))

LM Test: chisq = 17.41855558550175, df = 1, p-value = 2.9988413156280707e-05
```

```
In [26]: # Hausman test for fixed versus random effects model
# null hypothesis: random effects model
psi = fixed.cov - random.cov.iloc[1:,1:]
diff = fixed.params - random.params[1:]
# psi = fixed1.cov.iloc[1:,1:] - random.cov.iloc[1:,1:]
# diff = fixed1.params[1:] - random.params[1:]
W = diff.dot(np.linalg.inv(psi)).dot(diff)
dof = random.params.size - 1
pvalue = stats.chi2(dof).sf(W)
print("Hausman Test: chisq = {0}, df = {1}, p-value = {2}".format(W, dof, pvalue))

Hausman Test: chisq = 0.10815956207802956, df = 6, p-value = 0.9999746858996604
```

```
In [27]: # panel robust hetero cov
fixed_robust = PanelOLS.from_formula('roa ~ 1 + de + df + ta + ffr +cc + lf + Ent
print(fixed_robust)
random_robust = RandomEffects.from_formula('roa ~ 1 + de + df + ta + ffr +cc + lf
print(random_robust)
```

PanelOLS Estimation Summary

```
=====
=
Dep. Variable:          roa    R-squared:          0.123
2
Estimator:              PanelOLS    R-squared (Between):    -0.009
7
No. Observations:      360    R-squared (Within):      0.123
2
Date:                  Tue, Jul 12 2022    R-squared (Overall):      0.108
2
Time:                  15:48:40    Log-likelihood            1251.
8
Cov. Estimator:        Clustered
                               F-statistic:          7.823
9
Entities:              20    P-value            0.000
0
Avg Obs:               18.000    Distribution:          F(6,33
4)
Min Obs:               18.000
Max Obs:               18.000    F-statistic (robust):      7.824
2
                               P-value            0.000
0
Time periods:          18    Distribution:          F(6,33
4)
Avg Obs:               20.000
Min Obs:               20.000
Max Obs:               20.000
```

Parameter Estimates

```
=====
Parameter  Std. Err.    T-stat    P-value    Lower CI    Upper CI
-----
Intercept    0.0079    0.0014    5.5236    0.0000    0.0051    0.0108
cc           -0.0066    0.0153   -0.4289    0.6683   -0.0367    0.0236
de            0.0010    0.0008    1.1717    0.2422   -0.0007    0.0027
df          -1.711e-06  4.526e-06  -0.3780    0.7057  -1.061e-05  7.193e-06
ffr           0.0011    0.0003    3.4584    0.0006    0.0005    0.0017
lf            0.0003    6.394e-05  4.3575    0.0000    0.0002    0.0004
ta            0.0016    0.0024    0.6578    0.5111   -0.0032    0.0064
=====
```

F-test for Poolability: 2.5609

P-value: 0.0004

Distribution: F(19,334)

Included effects: Entity

RandomEffects Estimation Summary

=====			
=			
Dep. Variable:	roa	R-squared:	0.118
Estimator:	RandomEffects	R-squared (Between):	-0.006
No. Observations:	360	R-squared (Within):	0.123
Date:	Tue, Jul 12 2022	R-squared (Overall):	0.108
Time:	15:48:40	Log-likelihood	1244.
Cov. Estimator:	Clustered	F-statistic:	7.939
Entities:	20	P-value	0.000
Avg Obs:	18.000	Distribution:	F(6,35
Min Obs:	18.000		
Max Obs:	18.000	F-statistic (robust):	7.901
		P-value	0.000
Time periods:	18	Distribution:	F(6,35
Avg Obs:	20.000		
Min Obs:	20.000		
Max Obs:	20.000		

Parameter Estimates

=====						
	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI

Intercept	0.0082	0.0019	4.3147	0.0000	0.0044	0.0119
cc	-0.0084	0.0153	-0.5466	0.5850	-0.0384	0.0217
de	0.0009	0.0008	1.1179	0.2644	-0.0006	0.0024
df	-1.629e-06	4.271e-06	-0.3814	0.7032	-1.003e-05	6.772e-06
ffr	0.0011	0.0003	3.7346	0.0002	0.0005	0.0017
lf	0.0003	6.451e-05	4.2841	0.0000	0.0001	0.0004
ta	0.0018	0.0024	0.7508	0.4533	-0.0029	0.0064
=====						




```
In [28]: # compare fixed effects and random effects models
res3 = {'Fixed (Panel-Robust)':fixed_robust,'Random (Panel-Robust)':random_robust}
print(compare(res3))
```

Model Comparison		
	Fixed (Panel-Robust)	Random (Panel-Robust)
Dep. Variable	roa	roa
Estimator	PanelOLS	RandomEffects
No. Observations	360	360
Cov. Est.	Clustered	Clustered
R-squared	0.1232	0.1189
R-Squared (Within)	0.1232	0.1232
R-Squared (Between)	-0.0097	-0.0060
R-Squared (Overall)	0.1082	0.1086
F-statistic	7.8239	7.9396
P-value (F-stat)	0.0000	0.0000
Intercept	0.0079 (5.5236)	0.0082 (4.3147)
cc	-0.0066 (-0.4289)	-0.0084 (-0.5466)
de	0.0010 (1.1717)	0.0009 (1.1179)
df	-1.711e-06 (-0.3780)	-1.629e-06 (-0.3814)
ffr	0.0011 (3.4584)	0.0011 (3.7346)
lf	0.0003 (4.3575)	0.0003 (4.2841)
ta	0.0016 (0.6578)	0.0018 (0.7508)
Effects	Entity	

T-stats reported in parentheses

In []:

