AAEC 6311

LAB #5

Objectives:

1) Learn to estimate panel data models

Cornell and Rupert (1988) analyzed the returns to schooling in a balanced panel of 595 observations on heads of households. The sample data are drawn from years 1976-1982 from the Panel Study of Income Dynamics.

The estimating equation is:

$$lnWage_{it} = \beta_1 + \beta_2 Exp_{it} + \beta_3 Exp_{it}^2 + \beta_4 Wks_{it} + \beta_5 Occ_{it} + \beta_6 Ind_{it} + \beta_7 South_{it} + \beta_8 SMSA_{it} + \beta_9 MS_{it} + \beta_{10} Union_{it} + \beta_{11} Ed_i + \beta_{12} Fem_i + \beta_{13} Bl_i + \varepsilon_{it}$$

Exp_{it} = Years of full time work experience

Wks_{it_t} = Weeks worked

Occ_{it} = 1 if blue-collar occupation, 0 if not.

Ind_{it} = 1 if the individual works in a manufacturing industry, 0 if not.

$South_{it}$= 1 if the individual lives in the South, 0 if not.

$SMSA_{it}$ = 1 if the individual resides in an SMS, 0 if not.

MS_{it} = 1 if the individual is married, 0 if not.

$Union_{it}$= 1 if the individual wage is set by a union contract, 0 if not.

Ed_i = years of education

Fem_i = 1 if the individual is female, 0 if not.

Bl_i = 1 if the individual is black, 0 if not.

Note that Ed_i, Fem_i and Bl_i are time invariant. The main interest of the study was β_{11}. Since Ed is time invariant, fixed effects model cannot estimate this.

Part 1. Basic Operations Using SAS

1.1. Import and manipulate the data

1.2. Calculate basic summary statistics and report results for all variables included in the model:

2. The SAS System

The MEANS Procedure

Variable	Label	N	Mean	Std Dev	Minimum	Maximum
T	**T**	4165	4.0000000	2.0002401	1.0000000	7.0000000
ID	**ID**	4165	298.0000000	171.7820858	1.0000000	595.0000000
EXP	**EXP**	4165	19.8537815	10.9663702	1.0000000	51.0000000
WKS	**WKS**	4165	46.8115246	5.1290982	5.0000000	52.0000000
OCC	**OCC**	4165	0.5111645	0.4999354	0	1.0000000
IND	**IND**	4165	0.3954382	0.4890033	0	1.0000000
SOUTH	**SOUTH**	4165	0.2902761	0.4539442	0	1.0000000
SMSA	**SMSA**	4165	0.6537815	0.4758210	0	1.0000000
MS	**MS**	4165	0.8144058	0.3888256	0	1.0000000
FEM	**FEM**	4165	0.1126050	0.3161473	0	1.0000000
UNION	**UNION**	4165	0.3639856	0.4812023	0	1.0000000
ED	**ED**	4165	12.8453782	2.7879950	4.0000000	17.0000000
BLK	**BLK**	4165	0.0722689	0.2589637	0	1.0000000
LWAGE	**LWAGE**	4165	6.6763464	0.4615122	4.6051700	8.5370000

Part 2. Write the three panel data models discussed in class using mathematical notation:

Pooled Model

OLS on the following:

$$\begin{aligned}\ln Wage_{it} - \ln \bar{Wage}_{i\bullet} = (\alpha - \alpha) &+ (Exp_{it} - \bar{Exp}_{i\bullet})'\beta_2 + (Exp_{it}^2 - \bar{Exp}_{i\bullet}^2)'\beta_3 + (Wks_{it} - \bar{Wks}_{i\bullet})'\beta_4 \\ &+ (Occ_{it} - \bar{Occ}_{i\bullet})'\beta_5 + (Ind_{it} - \bar{Ind}_{i\bullet})'\beta_6 + (South_{it} - \bar{South}_{i\bullet})'\beta_7 \\ &+ (SMSA_{it} - \bar{SMSA}_{i\bullet})'\beta_8 + (MS_{it} - \bar{MS}_{i\bullet})'\beta_9 + (Union_{it} - \bar{Union}_{i\bullet})' \\ &+ (Ed_i - \bar{Ed}_i)'\beta_{11} + (Fem_i - \bar{Fem}_i)'\beta_{12} + (Bl_i - \bar{Bl}_i)'\beta_{13} + (\epsilon_{it} - \bar{\epsilon}_{i\bullet})\end{aligned}$$

FE Model

OLS on the following:

$$\begin{aligned}\ln Wage_{it} - \ln \bar{Wage}_{i\bullet} = (\alpha_i - \alpha_i) &+ (Exp_{it} - \bar{Exp}_{i\bullet})'\beta_2 + (Exp_{it}^2 - \bar{Exp}_{i\bullet}^2)'\beta_3 + (Wks_{it} - \bar{Wks}_{i\bullet})'\beta_4 \\ &+ (Occ_{it} - \bar{Occ}_{i\bullet})'\beta_5 + (Ind_{it} - \bar{Ind}_{i\bullet})'\beta_6 + (South_{it} - \bar{South}_{i\bullet})'\beta_7 \\ &+ (SMSA_{it} - \bar{SMSA}_{i\bullet})'\beta_8 + (MS_{it} - \bar{MS}_{i\bullet})'\beta_9 + (Union_{it} - \bar{Union}_{i\bullet})' \\ &+ (\epsilon_{it} - \bar{\epsilon}_{i\bullet})\end{aligned}$$

RE Model

OLS on the following:

$$\begin{aligned}\ln Wage_{it} - \ln \bar{Wage}_{i\bullet} = (\alpha - \alpha) &+ (Exp_{it} - \bar{Exp}_{i\bullet})'\beta_2 + (Exp_{it}^2 - \bar{Exp}_{i\bullet}^2)'\beta_3 + (Wks_{it} - \bar{Wks}_{i\bullet})'\beta_4 \\ &+ (Occ_{it} - \bar{Occ}_{i\bullet})'\beta_5 + (Ind_{it} - \bar{Ind}_{i\bullet})'\beta_6 + (South_{it} - \bar{South}_{i\bullet})'\beta_7 \\ &+ (SMSA_{it} - \bar{SMSA}_{i\bullet})'\beta_8 + (MS_{it} - \bar{MS}_{i\bullet})'\beta_9 + (Union_{it} - \bar{Union}_{i\bullet})' \\ &+ (Ed_i - \bar{Ed}_i)'\beta_{11} + (Fem_i - \bar{Fem}_i)'\beta_{12} + (Bl_i - \bar{Bl}_i)'\beta_{13} + (\mu_i - \mu_i) + (\epsilon_{it} - \bar{\epsilon}_{i\bullet})\end{aligned}$$

Part 3. Estimation of Panel data Models using Pooled OLS.

3.1. Of the three panel data models discussed in class (Pooled Model, FE model and RE model), which ones can be consistently estimated using pooled OLS?

Using pooled OLS, only the pooled model and random effects model can be consistently used to estimate β. Pooled OLS is inconsistent if the model is a fixed effects model.

3.2. Use the proc reg procedure to estimate the model using pooled OLS. Report estimation results.

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: LWAGE LWAGE

Number of Observations Read 4165

Number of Observations Used 4165

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	380.13925	31.67827	259.54	<.0001
Error	4152	506.76569	0.12205		
Corrected Total	4164	886.90494			

Root MSE	0.34936	**R-Square**	0.4286
Dependent Mean	6.67635	**Adj R-Sq**	0.4270
Coeff Var	5.23282		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Heteroscedasticity Consistent		
							Standard Error	t Value	Pr > |t|
Intercept	Intercept	**1**	5.25112	0.07129	73.66	<.0001	0.07435	70.63	<.0001
EXP	EXP	**1**	0.04010	0.00216	18.57	<.0001	0.00216	18.59	<.0001
EXP2		**1**	-0.00067338	0.00004744	-14.19	<.0001	0.00004789	-14.06	<.0001
WKS	WKS	**1**	0.00422	0.00108	3.90	<.0001	0.00114	3.69	0.0002
OCC	OCC	**1**	-0.14001	0.01466	-9.55	<.0001	0.01494	-9.37	<.0001
IND	IND	**1**	0.04679	0.01179	3.97	<.0001	0.01199	3.90	<.0001
SOUTH	SOUTH	**1**	-0.05564	0.01253	-4.44	<.0001	0.01274	-4.37	<.0001
SMSA	SMSA	**1**	0.15167	0.01207	12.57	<.0001	0.01208	12.56	<.0001
MS	MS	**1**	0.04845	0.02057	2.36	0.0185	0.02049	2.36	0.0181
FEM	FEM	**1**	-0.36779	0.02510	-14.65	<.0001	0.02310	-15.92	<.0001
UNION	UNION	**1**	0.09263	0.01280	7.24	<.0001	0.01233	7.51	<.0001
ED	ED	**1**	0.05670	0.00261	21.70	<.0001	0.00273	20.80	<.0001
BLK	BLK	**1**	-0.16694	0.02204	-7.57	<.0001	0.02075	-8.05	<.0001

3.3. Use the proc panel procedure to estimate the model using pooled OLS. Report estimation results and compare them with the model estimated using proc reg?

The PANEL Procedure
Pooled (OLS) Estimates
Model: POOLED1
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	POOLED1
Estimation Method	Pooled
Number of Cross Sections	595
Time Series Length	7

Fit Statistics

SSE	506.7657	**DFE**	4152
MSE	0.1221	**Root MSE**	0.3494
R-Square	0.4286		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.251124	0.0713	73.66	<.0001	Intercept
EXP	1	0.040105	0.00216	18.57	<.0001	EXP
EXP2	1	-0.00067	0.000047	-14.19	<.0001	
WKS	1	0.004216	0.00108	3.90	<.0001	WKS
OCC	1	-0.14001	0.0147	-9.55	<.0001	OCC
IND	1	0.046789	0.0118	3.97	<.0001	IND
SOUTH	1	-0.05564	0.0125	-4.44	<.0001	SOUTH
SMSA	1	0.151667	0.0121	12.57	<.0001	SMSA
MS	1	0.048449	0.0206	2.36	0.0185	MS
FEM	1	-0.36779	0.0251	-14.65	<.0001	FEM
UNION	1	0.092627	0.0128	7.24	<.0001	UNION
ED	1	0.056704	0.00261	21.70	<.0001	ED
BLK	1	-0.16694	0.0220	-7.57	<.0001	BLK

Using proc model and proc model gives us the same estimates and standard errors, save for small rounding errors.

3.4. Using proc panel and the pooled estimator, estimate, report results and COMPARE parameter and standard errors estimated using: a) the standard var-cov matrix obtained using OLS, b) White's HCCCM, and c) Panel Robust HCCME.

More information about HCCMEs for panel data model can be found here:

http://documentation.sas.com/doc/en/pgmsascdc/9.4_3.3/etsug/etsug_panel_details38.htm

Proc panel pooled estimator

	OLS		White's HCCM		Panel Robust HCCME	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	5.25112	0.0713	5.25112	0.0744	5.25112	0.1233
EXP	0.04011	0.00216	0.04011	0.00216	0.04011	0.00407
EXP2	-0.0007	4.7E-05	-0.0007	4.8E-05	-0.0007	9.1E-05
WKS	0.00422	0.00108	0.00422	0.00114	0.00422	0.00154
OCC	-0.14	0.0147	-0.14	0.0149	-0.14	0.0272
IND	0.04679	0.0118	0.04679	0.012	0.04679	0.0236
SOUTH	-0.0556	0.0125	-0.0556	0.0127	-0.0556	0.0261
SMSA	0.15167	0.0121	0.15167	0.0121	0.15167	0.024
MS	0.04845	0.0206	0.04845	0.0205	0.04845	0.0409
FEM	-0.3678	0.0251	-0.3678	0.0231	-0.3678	0.0455
UNION	0.09263	0.0128	0.09263	0.0123	0.09263	0.0236
ED	0.0567	0.00261	0.0567	0.00273	0.0567	0.00555
BLK	-0.1669	0.022	-0.1669	0.0207	-0.1669	0.0442

As we can see, the estimates obtained from OLS, White's HCCM, and panel robust HCCME results in the same coefficients. The standard errors, however, differ based on whether or not we assume homoskedasticity.

a. The SAS System

The PANEL Procedure
Pooled (OLS) Estimates
Model: POOLED1
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label POOLED1

Estimation Method Pooled

Model Description

Number of Cross Sections	595
Time Series Length	7

Fit Statistics

SSE	506.7657	**DFE**	4152
MSE	0.1221	**Root MSE**	0.3494
R-Square	0.4286		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.251124	0.0713	73.66	<.0001	Intercept
EXP	1	0.040105	0.00216	18.57	<.0001	EXP
EXP2	1	-0.00067	0.000047	-14.19	<.0001	
WKS	1	0.004216	0.00108	3.90	<.0001	WKS
OCC	1	-0.14001	0.0147	-9.55	<.0001	OCC
IND	1	0.046789	0.0118	3.97	<.0001	IND
SOUTH	1	-0.05564	0.0125	-4.44	<.0001	SOUTH
SMSA	1	0.151667	0.0121	12.57	<.0001	SMSA
MS	1	0.048449	0.0206	2.36	0.0185	MS
FEM	1	-0.36779	0.0251	-14.65	<.0001	FEM
UNION	1	0.092627	0.0128	7.24	<.0001	UNION
ED	1	0.056704	0.00261	21.70	<.0001	ED
BLK	1	-0.16694	0.0220	-7.57	<.0001	BLK

b. The SAS System

The PANEL Procedure
Pooled (OLS) Estimates
Model: POOLED2
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	POOLED2
Estimation Method	Pooled

Model Description

Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	0

Fit Statistics

SSE	506.7657	**DFE**	4152
MSE	0.1221	**Root MSE**	0.3494
R-Square	0.4286		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.251124	0.0744	70.63	<.0001	Intercept
EXP	1	0.040105	0.00216	18.59	<.0001	EXP
EXP2	1	-0.00067	0.000048	-14.06	<.0001	
WKS	1	0.004216	0.00114	3.69	0.0002	WKS
OCC	1	-0.14001	0.0149	-9.37	<.0001	OCC
IND	1	0.046789	0.0120	3.90	<.0001	IND
SOUTH	1	-0.05564	0.0127	-4.37	<.0001	SOUTH
SMSA	1	0.151667	0.0121	12.56	<.0001	SMSA
MS	1	0.048449	0.0205	2.36	0.0181	MS
FEM	1	-0.36779	0.0231	-15.92	<.0001	FEM
UNION	1	0.092627	0.0123	7.51	<.0001	UNION
ED	1	0.056704	0.00273	20.80	<.0001	ED
BLK	1	-0.16694	0.0207	-8.05	<.0001	BLK

c. The SAS System

The PANEL Procedure
Pooled (OLS) Estimates
Model: POOLED3
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	POOLED3

Model Description

Estimation Method	Pooled
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	4

Fit Statistics

SSE	506.7657	**DFE**	4152
MSE	0.1221	**Root MSE**	0.3494
R-Square	0.4286		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.251124	0.1233	42.60	<.0001	Intercept
EXP	1	0.040105	0.00407	9.86	<.0001	EXP
EXP2	1	-0.00067	0.000091	-7.39	<.0001	
WKS	1	0.004216	0.00154	2.74	0.0062	WKS
OCC	1	-0.14001	0.0272	-5.15	<.0001	OCC
IND	1	0.046789	0.0236	1.98	0.0476	IND
SOUTH	1	-0.05564	0.0261	-2.13	0.0331	SOUTH
SMSA	1	0.151667	0.0240	6.31	<.0001	SMSA
MS	1	0.048449	0.0409	1.19	0.2357	MS
FEM	1	-0.36779	0.0455	-8.09	<.0001	FEM
UNION	1	0.092627	0.0236	3.92	<.0001	UNION
ED	1	0.056704	0.00555	10.21	<.0001	ED
BLK	1	-0.16694	0.0442	-3.77	0.0002	BLK

Part 4. Estimation of the Panel data Models using the Between Estimator.

4.1. Of the three panel data models discussed in class (Pooled Model, FE model and RE model), which ones can be consistently estimated using the Between Estimator?

The between estimator can only be used to consistently estimate the pooled model and random effects model. The between estimator is inconsistent in estimating the fixed effects model.

4.2. Using proc panel and the Between estimator, estimate, report and **COMPARE** parameter and standard errors using: a) the standard var-cov matrix obtained using OLS, b) White's HCCCM, and c) Panel Robust HCCME.

Proc panel between estimator

	OLS		White's HCCM		Panel Robust HCCME	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	5.12143	0.2042	5.12143	0.2078	5.12143	0.2078
EXP	0.0319	0.00478	0.0319	0.0046	0.0319	0.0046
EXP2	-0.0006	0.00011	-0.0006	0.0001	-0.0006	0.0001
WKS	0.00919	0.0036	0.00919	0.00358	0.00919	0.00358
OCC	-0.1676	0.0338	-0.1676	0.0334	-0.1676	0.0334
IND	0.05792	0.0255	0.05792	0.0264	0.05792	0.0264
SOUTH	-0.0571	0.026	-0.0571	0.0266	-0.0571	0.0266
SMSA	0.17578	0.0258	0.17578	0.0254	0.17578	0.0254
MS	0.11478	0.0477	0.11478	0.0499	0.11478	0.0499
FEM	-0.3171	0.0547	-0.3171	0.051	-0.3171	0.051
UNION	0.10907	0.0292	0.10907	0.0283	0.10907	0.0283
ED	0.05144	0.00555	0.05144	0.00586	0.05144	0.00586
BLK	-0.1578	0.045	-0.1578	0.0435	-0.1578	0.0435

Again, like in the proc panel pooled estimator, the estimates for our coefficients between OLS, White's HCCM, and the panel robust HCCME remains the same. However, the standard errors differ depending on whether or not we assume homoskedasticity.

a.)

The SAS System

The PANEL Procedure
Between-Groups Estimates
Model: BTWNG1
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	BTWNG1
Estimation Method	BtwGrps
Number of Cross Sections	595

Model Description

Time Series Length	7

Fit Statistics

SSE	42.0726	**DFE**	582
MSE	0.0723	**Root MSE**	0.2689
R-Square	0.5443		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.121431	0.2042	25.07	<.0001	Intercept
EXP	1	0.031901	0.00478	6.68	<.0001	EXP
EXP2	1	-0.00057	0.000105	-5.39	<.0001	
WKS	1	0.009189	0.00360	2.55	0.0110	WKS
OCC	1	-0.16762	0.0338	-4.96	<.0001	OCC
IND	1	0.057918	0.0255	2.27	0.0237	IND
SOUTH	1	-0.05705	0.0260	-2.20	0.0284	SOUTH
SMSA	1	0.175775	0.0258	6.82	<.0001	SMSA
MS	1	0.114782	0.0477	2.41	0.0164	MS
FEM	1	-0.31706	0.0547	-5.79	<.0001	FEM
UNION	1	0.109069	0.0292	3.73	0.0002	UNION
ED	1	0.051436	0.00555	9.26	<.0001	ED
BLK	1	-0.1578	0.0450	-3.51	0.0005	BLK

b.)

The SAS System

The PANEL Procedure
Between-Groups Estimates
Model: BTWNG2
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	BTWNG2

Model Description

Estimation Method	BtwGrps
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	0

Fit Statistics

SSE	42.0726	**DFE**	582
MSE	0.0723	**Root MSE**	0.2689
R-Square	0.5443		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.121431	0.2078	24.65	<.0001	Intercept
EXP	1	0.031901	0.00460	6.94	<.0001	EXP
EXP2	1	-0.00057	0.000102	-5.55	<.0001	
WKS	1	0.009189	0.00358	2.57	0.0105	WKS
OCC	1	-0.16762	0.0334	-5.02	<.0001	OCC
IND	1	0.057918	0.0264	2.20	0.0284	IND
SOUTH	1	-0.05705	0.0266	-2.14	0.0324	SOUTH
SMSA	1	0.175775	0.0254	6.92	<.0001	SMSA
MS	1	0.114782	0.0499	2.30	0.0218	MS
FEM	1	-0.31706	0.0510	-6.21	<.0001	FEM
UNION	1	0.109069	0.0283	3.85	0.0001	UNION
ED	1	0.051436	0.00586	8.77	<.0001	ED
BLK	1	-0.1578	0.0435	-3.63	0.0003	BLK

c.)

The SAS System

The PANEL Procedure
Between-Groups Estimates
Model: BTWNG3

Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	BTWNG3
Estimation Method	BtwGrps
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	0

Fit Statistics

SSE	42.0726	**DFE**	582
MSE	0.0723	**Root MSE**	0.2689
R-Square	0.5443		

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.121431	0.2078	24.65	<.0001	Intercept
EXP	1	0.031901	0.00460	6.94	<.0001	EXP
EXP2	1	-0.00057	0.000102	-5.55	<.0001	
WKS	1	0.009189	0.00358	2.57	0.0105	WKS
OCC	1	-0.16762	0.0334	-5.02	<.0001	OCC
IND	1	0.057918	0.0264	2.20	0.0284	IND
SOUTH	1	-0.05705	0.0266	-2.14	0.0324	SOUTH
SMSA	1	0.175775	0.0254	6.92	<.0001	SMSA
MS	1	0.114782	0.0499	2.30	0.0218	MS
FEM	1	-0.31706	0.0510	-6.21	<.0001	FEM
UNION	1	0.109069	0.0283	3.85	0.0001	UNION
ED	1	0.051436	0.00586	8.77	<.0001	ED
BLK	1	-0.1578	0.0435	-3.63	0.0003	BLK

Part 5. Estimation of the Panel data Models using the FE (or Within) Estimator.

5.1. Of the three panel data models discussed in class (Pooled Model, FE model and RE model), which ones can be consistently estimated using the FE Estimator?

The fixed effects estimator can consistently estimate β for all three models: pooled model, fixed effects model, and random effects model.

5.2. Is it possible to estimate all the model parameters using the FE estimator?

No, the fixed effect estimator cannot estimate the parameters of time invariant variables.

5.2. Using proc panel and the FE estimator, estimate, report results and **COMPARE** parameters and standard errors using: a) the standard var-cov matrix obtained using OLS, b) White's HCCCM, and c) Panel Robust HCCME.

Proc panel fixed effects estimator

	OLS		White's HCCM		Panel Robust HCCME	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	5.61891	0.0681	5.61891	0.0468	5.61891	0.0551
EXP	0.11321	0.00247	0.11321	0.0026	0.11321	0.00404
EXP2	-0.0004	5.5E-05	-0.0004	5.4E-05	-0.0004	8.2E-05
WKS	0.00084	0.0006	0.00084	0.00075	0.00084	0.00086
OCC	-0.0215	0.0138	-0.0215	0.0128	-0.0215	0.019
IND	0.01921	0.0154	0.01921	0.0159	0.01921	0.0226
SOUTH	-0.0019	0.0343	-0.0019	0.058	-0.0019	0.0891
SMSA	-0.0425	0.0194	-0.0425	0.024	-0.0425	0.0294
MS	-0.0297	0.019	-0.0297	0.0164	-0.0297	0.0268
UNION	0.03279	0.0149	0.03279	0.0158	0.03279	0.025

Like in our previous two estimators, the fixed effects estimator results in the same coefficients using OLS, White's HCCM, and the panel robust HCCME. The standard errors, again, differ depending on whether or not we assume homoskedasticity.

a.)

The SAS System

The PANEL Procedure
Fixed One-Way Estimates
Model: FE1
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label FE1

Model Description

Estimation Method	FixOne
Number of Cross Sections	595
Time Series Length	7

Fit Statistics

SSE	82.2673	**DFE**	3561
MSE	0.0231	**Root MSE**	0.1520
R-Square	0.9072		

F Test for No Fixed Effects

Num DF	Den DF	F Value	Pr > F
594	3561	38.25	<.0001

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.618905	0.0681	82.49	<.0001	Intercept
EXP	1	0.113208	0.00247	45.81	<.0001	EXP
EXP2	1	-0.00042	0.000055	-7.66	<.0001	
WKS	1	0.000836	0.000600	1.39	0.1634	WKS
OCC	1	-0.02148	0.0138	-1.56	0.1193	OCC
IND	1	0.01921	0.0154	1.24	0.2137	IND
SOUTH	1	-0.00186	0.0343	-0.05	0.9567	SOUTH
SMSA	1	-0.04247	0.0194	-2.19	0.0289	SMSA
MS	1	-0.02973	0.0190	-1.57	0.1175	MS
UNION	1	0.032785	0.0149	2.20	0.0281	UNION

b.)

The SAS System

The PANEL Procedure
Fixed One-Way Estimates
Model: FE2
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	FE2
Estimation Method	FixOne
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	0

Fit Statistics

SSE	82.2673	**DFE**	3561
MSE	0.0231	**Root MSE**	0.1520
R-Square	0.9072		

F Test for No Fixed Effects

Num DF	Den DF	F Value	Pr > F
594	3561	38.25	<.0001

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.618905	0.0468	120.15	<.0001	Intercept
EXP	1	0.113208	0.00260	43.54	<.0001	EXP
EXP2	1	-0.00042	0.000054	-7.74	<.0001	
WKS	1	0.000836	0.000752	1.11	0.2662	WKS
OCC	1	-0.02148	0.0128	-1.67	0.0945	OCC
IND	1	0.01921	0.0159	1.21	0.2273	IND
SOUTH	1	-0.00186	0.0580	-0.03	0.9744	SOUTH
SMSA	1	-0.04247	0.0240	-1.77	0.0770	SMSA
MS	1	-0.02973	0.0164	-1.81	0.0701	MS
UNION	1	0.032785	0.0158	2.07	0.0384	UNION

c.)

The SAS System

The PANEL Procedure

Fixed One-Way Estimates
Model: FE3
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	FE3
Estimation Method	FixOne
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	4

Fit Statistics

SSE	82.2673	**DFE**	3561
MSE	0.0231	**Root MSE**	0.1520
R-Square	0.9072		

F Test for No Fixed Effects

Num DF	Den DF	F Value	Pr > F
594	3561	38.25	<.0001

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	5.618905	0.0551	101.89	<.0001	Intercept
EXP	1	0.113208	0.00404	28.01	<.0001	EXP
EXP2	1	-0.00042	0.000082	-5.08	<.0001	
WKS	1	0.000836	0.000864	0.97	0.3334	WKS
OCC	1	-0.02148	0.0190	-1.13	0.2574	OCC
IND	1	0.01921	0.0226	0.85	0.3962	IND
SOUTH	1	-0.00186	0.0891	-0.02	0.9833	SOUTH
SMSA	1	-0.04247	0.0294	-1.44	0.1490	SMSA
MS	1	-0.02973	0.0268	-1.11	0.2678	MS
UNION	1	0.032785	0.0250	1.31	0.1901	UNION

5.3. Interpret the results of the F-test testing the significance of individual (or group effects).

H_0: All fixed effects are jointly zero

H_a: All fixed effects are not jointly zero

Since the f-statistic is 38.25, which is a p-value of less than 0.0001, we have evidence to rejected our null hypothesis and conclude that all fixed effects are not jointly zero, and that there is evidence to use the fixed effects model.

Part 6. Estimation of the Panel data Models using the RE Estimator.

6.1. Of the three panel data models discussed in class (Pooled Model, FE model and RE model), which ones can be consistently estimated using the RE Estimator?

Only the pooled and random effects model can be consistently estimated using the random effects estimator. The fixed effects model cannot be estimated using the random effects estimator.

6.2. Using proc panel and the RE estimator, estimate, report results and **COMPARE** parameter estimates and standard errors using: a) the standard var-cov matrix obtained using OLS, b) White's HCCCM, and c) Panel Robust HCCME.

Proc panel random effects estimator

	OLS		White's HCCM		Panel Robust HCCME	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	3.03059	0.2089	3.03059	0.2193	3.03059	0.202
EXP	0.10915	0.00241	0.10915	0.00263	0.10915	0.00397
EXP2	-0.0005	5.3E-05	-0.0005	5.6E-05	-0.0005	8.2E-05
WKS	0.00084	0.00059	0.00084	0.0008	0.00084	0.00086
OCC	-0.0239	0.0135	-0.0239	0.0131	-0.0239	0.0187
IND	0.01545	0.015	0.01545	0.0161	0.01545	0.0222
SOUTH	0.0042	0.0317	0.0042	0.053	0.0042	0.0802
SMSA	-0.0464	0.0187	-0.0464	0.0234	-0.0464	0.0291
MS	-0.0377	0.0186	-0.0377	0.0172	-0.0377	0.026
FEM	-0.1611	0.136	-0.1611	0.1269	-0.1611	0.109
UNION	0.03678	0.0145	0.03678	0.0162	0.03678	0.0248
ED	0.13846	0.0152	0.13846	0.0161	0.13846	0.0132
BLK	-0.2657	0.166	-0.2657	0.1533	-0.2657	0.1575

The coefficients obtained for the random effects estimator is consistent throughout using OLS, White's HCCM, and the panel robust HCCME. The standard errors differ depending on whether or not we assume homoskedasticity.

a.)

The PANEL Procedure
Wansbeek and Kapteyn Variance Components (RanOne)
Model: RE1
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	RE1
Estimation Method	RanOne
Number of Cross Sections	595
Time Series Length	7

Fit Statistics

SSE	92.8739	**DFE**	4152
MSE	0.0224	**Root MSE**	0.1496
R-Square	0.6172		

Variance Component Estimates

Variance Component for Cross Sections	1.064748
Variance Component for Error	0.023102

Hausman Test for Random Effects

Coefficients	DF	m Value	Pr > m
9	9	303.40	<.0001

Breusch Pagan Test for Random Effects (One Way)

DF	m Value	Pr > m
1	3497.02	<.0001

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	3.03059	0.2089	14.50	<.0001	Intercept
EXP	1	0.109147	0.00241	45.37	<.0001	EXP

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
EXP2	1	-0.00048	0.000053	-9.11	<.0001	
WKS	1	0.000838	0.000589	1.42	0.1553	WKS
OCC	1	-0.02385	0.0135	-1.77	0.0769	OCC
IND	1	0.015445	0.0150	1.03	0.3034	IND
SOUTH	1	0.004196	0.0317	0.13	0.8948	SOUTH
SMSA	1	-0.0464	0.0187	-2.48	0.0131	SMSA
MS	1	-0.03769	0.0186	-2.03	0.0424	MS
FEM	1	-0.16106	0.1360	-1.18	0.2365	FEM
UNION	1	0.036783	0.0145	2.53	0.0114	UNION
ED	1	0.138457	0.0152	9.09	<.0001	ED
BLK	1	-0.26569	0.1660	-1.60	0.1096	BLK

b.)

The SAS System

The PANEL Procedure
Wansbeek and Kapteyn Variance Components (RanOne)
Model: RE2
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	RE2
Estimation Method	RanOne
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	0

Fit Statistics

SSE	92.8739	**DFE**	4152
MSE	0.0224	**Root MSE**	0.1496
R-Square	0.6172		

Variance Component Estimates

Variance Component for Cross Sections	1.064748
Variance Component for Error	0.023102

Hausman Test for Random Effects

Coefficients	DF	m Value	Pr > m
9	9	25.76	0.0022

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	3.03059	0.2193	13.82	<.0001	Intercept
EXP	1	0.109147	0.00263	41.44	<.0001	EXP
EXP2	1	-0.00048	0.000056	-8.66	<.0001	
WKS	1	0.000838	0.000795	1.05	0.2922	WKS
OCC	1	-0.02385	0.0131	-1.82	0.0692	OCC
IND	1	0.015445	0.0161	0.96	0.3367	IND
SOUTH	1	0.004196	0.0530	0.08	0.9369	SOUTH
SMSA	1	-0.0464	0.0234	-1.98	0.0479	SMSA
MS	1	-0.03769	0.0172	-2.20	0.0281	MS
FEM	1	-0.16106	0.1269	-1.27	0.2045	FEM
UNION	1	0.036783	0.0162	2.27	0.0231	UNION
ED	1	0.138457	0.0161	8.62	<.0001	ED
BLK	1	-0.26569	0.1533	-1.73	0.0832	BLK

c.)

The SAS System

The PANEL Procedure
Wansbeek and Kapteyn Variance Components (RanOne)
Model: RE3
Dependent Variable: LWAGE (LWAGE)

Model Description

Model Statement Label	RE3

Model Description

Estimation Method	RanOne
Number of Cross Sections	595
Time Series Length	7
Hetero. Corr. Cov. Matrix Estimator	4

Fit Statistics

SSE	92.8739	**DFE**	4152
MSE	0.0224	**Root MSE**	0.1496
R-Square	0.6172		

Variance Component Estimates

Variance Component for Cross Sections	1.064748
Variance Component for Error	0.023102

Hausman Test for Random Effects

Coefficients	DF	m Value	Pr > m
9	9	.	.

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
Intercept	1	3.03059	0.2020	15.00	<.0001	Intercept
EXP	1	0.109147	0.00397	27.52	<.0001	EXP
EXP2	1	-0.00048	0.000082	-5.94	<.0001	
WKS	1	0.000838	0.000861	0.97	0.3307	WKS
OCC	1	-0.02385	0.0187	-1.28	0.2023	OCC
IND	1	0.015445	0.0222	0.70	0.4861	IND
SOUTH	1	0.004196	0.0802	0.05	0.9583	SOUTH
SMSA	1	-0.0464	0.0291	-1.59	0.1108	SMSA
MS	1	-0.03769	0.0260	-1.45	0.1469	MS
FEM	1	-0.16106	0.1090	-1.48	0.1395	FEM

Parameter Estimates

Variable	DF	Estimate	Standard Error	t Value	Pr > |t|	Label
UNION	1	0.036783	0.0248	1.48	0.1386	UNION
ED	1	0.138457	0.0132	10.49	<.0001	ED
BLK	1	-0.26569	0.1575	-1.69	0.0917	BLK

6.3. Interpret the results of the Breusch Pagan test for Random Effects and the Hausman test for the RE model.

BP test:

H_0: $\sigma_\mu^2 = 0$

H_a: $\sigma_\mu^2 \neq 0$

Since our m-value is 3479 and is significant, we have evidence to reject our null hypothesis and to conclude there is evidence to suggest that there is heterogeneity and that we should use the random effects model.

Hausman Test

H_0: $\text{plim}\left(\widehat{\beta_{RE}} - \widehat{\beta_{FE}}\right) = 0$

H_a: $\text{plim}\left(\widehat{\beta_{RE}} - \widehat{\beta_{FE}}\right) \neq 0$

Since our m-value is 303.40 and is significant, we have evidence to reject our null hypothesis and to conclude there is evidence that the estimates for our random effects and fixed effects estimators are different. We have evidence to suggest that we should use the fixed effects model.

Part 7. Overall Comparison of Models and Conclusions

7.1. Construct a Table that includes the parameter estimates and panel robust standard errors of models estimated using Pooled, FE and RE estimators. Evaluate the overall robustness of the results (i.e., evaluate changes in parameter estimates and standard error values).

	Pooled		FE		RE	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	5.25112	0.1233	5.61891	0.0551	3.03059	0.202
EXP	0.04011	0.00407	0.11321	0.00404	0.10915	0.00397
EXP2	-0.0007	9.1E-05	-0.0004	8.2E-05	-0.0005	8.2E-05
WKS	0.00422	0.00154	0.00084	0.00086	0.00084	0.00086
OCC	-0.14	0.0272	-0.0215	0.019	-0.0239	0.0187
IND	0.04679	0.0236	0.01921	0.0226	0.01545	0.0222
SOUTH	-0.0556	0.0261	-0.0019	0.0891	0.0042	0.0802

SMSA	0.15167	0.024	-0.0425	0.0294	-0.0464	0.0291
MS	0.04845	0.0409	-0.0297	0.0268	-0.0377	0.026
FEM	-0.3678	0.0455			-0.1611	0.109
UNION	0.09263	0.0236	0.03279	0.025	0.03678	0.0248
ED	0.0567	0.00555			0.13846	0.0132
BLK	-0.1669	0.0442			-0.2657	0.1575

As we can see, depending on the estimators we used, the coefficients and standard errors obtained vary across every variable. Generally, the random effects estimator obtains consistently smaller coefficients for our estimates. This theoretically makes sense, since we are separating individual specific random effects μ.

On a related note, the estimates obtained from the fixed effects estimator is generally larger than the other two estimators since we have removed 3 variables since they were time invariant. This could mean that the remaining variables explain more of the effect on wages or that the unobservable error term ϵ term would be larger.

7.2. Based on the three specification tests performed previously, what would be your preferred model?

From our three tests, if we do not care about the time invariant variables, we should use the fixed effects models for this panel data. From our Hausman test, we had evidence to conclude that the probability limits of our estimates from the random effects estimator and fixed effects estimator are not the same.

However, if the main interest of this study is still on the effects of education (β_{11}), then we must choose between pooled and random effects model in order to obtain the coefficient of the effects of education on wages. From our BP test, since we rejected the null, we find there is evidence of heterogeneity, therefore, the random effects model is better than the pooled model, and that the random effects model would be appropriate for capturing this heterogeneity.

7.3. Use the parameters of YOUR PREFFERRED model to:

a) Sketch the relationship between experience and wages

Because our model includes both exp and exp^2, our model predicts decreasing returns for experience, therefore we must calculate the following change in wage from a change in experience:

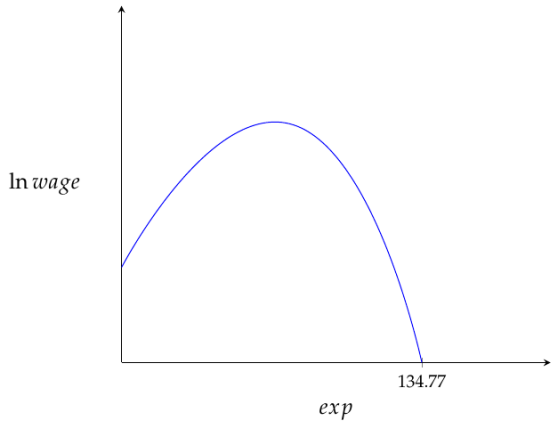
For the fixed effects model:

$$\frac{\partial \ln wage}{\partial exp} = \beta_2 + 2\beta_3 exp \underset{F.O.C.}{=} 0$$

$$0.113208 + 2(-0.00042)exp = 0$$

$$exp = 134.77$$

Therefore, on average, we expect the effect of experience on wages to increase from years 0-134.77, then decrease thereafter, ceteris paribus. Graphically, the effect of experience on wages should look something like the following:



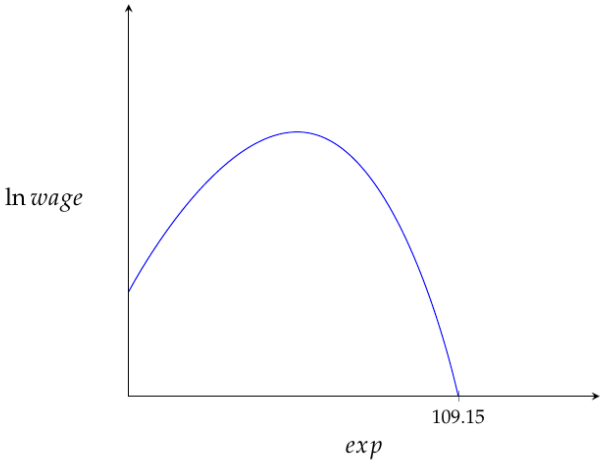
For the random effects model:

$$\frac{\partial \ln wage}{\partial exp} = \beta_2 + 2\beta_3 exp \underset{F.O.C.}{=} 0$$

$$0.10915 + 2(-0.0005)exp = 0$$

$$exp = 109.15$$

Therefore, on average, we expect the effect of experience on wages to increase from years 0-109.15, then decrease thereafter, ceteris paribus. And graphically, the effect of experience on wages would look similar to the fixed effects model:



b) Estimate the effect on wages of an additional year of experience

- For the fixed effect model, on average, every additional year of experience increases wages by 0.11321 percent, ceteris paribus.
- For the random effects model, on average, every additional year of experience increases wages by 0.10915 percent, ceteris paribus.

c) Interpret the coefficient related to Education.

- If we are using the fixed effects model, we cannot estimate the effect of education on wages because education is time invariant.
- If we are using the random effects model, on average, for every additional year of education, we expect a 0.13846 percent increase in wages, ceteris paribus.

d) Interpret the coefficient related to Marriage

- For the fixed effects model, on average, if the head of the household is married, there will be a 0.0297 percent decrease in wages, ceteris paribus.
- For the random effects model, on average, if the head of the household is married, there will be a 0.0377 percent decrease in wages, ceteris paribus.