

Models In Epidemiology And Biostatistics
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Nitrogenous Fertilizer - Wheat Yield

From Fisher SMRW p136 : 'The yields of dressed grain in bushels per acre shown in [table below] were obtained from two plots on Broadbalk wheat field during thirty years; the only difference in manurial treatment was that "9a" received nitrate of soda, while "7b" received an equivalent quantity of nitrogen as sulphate of ammonia. In the course of the experiment, plot "9a" appears to be gaining in yield on plot "7b". Is this apparent gain significant?

A great part of the variation in yield from year to year is evidently similar in the two plots; in consequence, the series of differences will give the clearer result.'

```
. use fisher_smrw_p137.dta
```

```
. list
```

	y9a	y7b	diff	hy
1.	29.62	33	-3.38	1855
2.	32.38	36.91	-4.53	1856
3.	43.75	44.84	-1.09	1857
4.	37.56	38.94	-1.38	1858
5.	30	34.66	-4.66	1859
6.	32.62	27.72	4.9	1860
7.	33.75	34.94	-1.19	1861
8.	43.44	35.88	7.56	1862
9.	55.56	53.66	1.9	1863
10.	51.06	45.78	5.28	1864
11.	44.06	40.22	3.84	1865
12.	32.5	29.91	2.59	1866
13.	29.13	22.16	6.97	1867
14.	47.81	39.19	8.62	1868
15.	39	28.25	10.75	1869
16.	45.5	41.37	4.13	1870
17.	34.44	22.31	12.13	1871
18.	40.69	29.06	11.63	1872
19.	35.81	22.75	13.06	1873
20.	38.19	39.56	-1.37	1874
21.	30.5	26.63	3.87	1875
22.	33.31	25.5	7.81	1876
23.	40.12	19.12	21	1877
24.	37.19	32.19	5	1878
25.	21.94	17.25	4.69	1879
26.	34.06	34.31	-.25	1880
27.	35.44	26.13	9.31	1881
28.	31.81	34.75	-2.94	1882
29.	43.38	36.31	7.07	1883
30.	40.44	37.75	2.69	1884

```
. gen hyc=hy-1869.5
```

```
. regress diff hyc
```

Source	SS	df	MS	Number of obs	=	30
Model	159.972486	1	159.972486	F(1, 28)	=	5.20
Residual	860.591362	28	30.7354058	Prob > F	=	0.0303
				R-squared	=	0.1567
				Adj R-squared	=	0.1266
Total	1020.56385	29	35.1918568	Root MSE	=	5.544

diff	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
hyc	.266792	.1169418	2.28	0.030	.0272477	.5063363
_cons	4.467	1.012183	4.41	0.000	2.393638	6.540362

```
. predict yh
```

```
. gen hyc2=hyc*hyc
```

```
. regr diff hyc hyc2
```

Source	SS	df	MS	Number of obs	=	30
Model	428.245581	2	214.122791	F(2, 27)	=	9.76
Residual	592.318267	27	21.9377136	Prob > F	=	0.0006
				R-squared	=	0.4196
				Adj R-squared	=	0.3766
Total	1020.56385	29	35.1918568	Root MSE	=	4.6838

diff	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
hyc	.266792	.0987975	2.70	0.012	.0640763	.4695077
hyc2	-.0447023	.0127831	-3.50	0.002	-.0709312	-.0184735
_cons	7.815951	1.283896	6.09	0.000	5.181614	10.45029

```
. predict yh2
```

```
. twoway (scatter diff hy,msize(small) legend(off))(line yh hy)(line yh2 hy)
```

After reshaping to long and renaming :

```
. anova yield year treat treat#c.yrc,sequential
```

```
Number of obs =      60    R-squared      = 0.8880
Root MSE      =  3.92017    Adj R-squared = 0.7640
```

Source	Seq. SS	df	MS	F	Prob>F
Model	3411.9322	31	110.06233	7.16	0.0000
year	3032.6346	29	104.57361	6.80	0.0000
treat	299.31136	1	299.31136	19.48	0.0001
treat#yrc	79.986208	1	79.986208	5.20	0.0303
Residual	430.29566	28	15.367702		
Total	3842.2279	59	65.122506		

```
. anova yield year treat treat#c.yrc treat#c.yrc2,sequential
```

```
Number of obs =      60    R-squared      = 0.9229
Root MSE      =  3.31193    Adj R-squared = 0.8316
```

Source	Seq. SS	df	MS	F	Prob>F
Model	3546.0688	32	110.81465	10.10	0.0000
year	3032.6346	29	104.57361	9.53	0.0000
treat	299.31136	1	299.31136	27.29	0.0000
treat#yrc	79.986208	1	79.986208	7.29	0.0118
treat#yrc2	134.13655	1	134.13655	12.23	0.0016
Residual	296.1591	27	10.968856		
Total	3842.2279	59	65.122506		

```
. mixed yield i.treat##c.yrc || year:
```

Computing standard errors:

Mixed-effects ML regression
Group variable: year

Number of obs = 60
Number of groups = 30

Obs per group:

min = 2
avg = 2.0
max = 2

Log likelihood = -193.26173

Wald chi2(3) = 28.65
Prob > chi2 = 0.0000

yield	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
1.treat	4.467	.9778611	4.57	0.000	2.550428	6.383573
yrc	-.3482914	.1553723	-2.24	0.025	-.6528154	-.0437674
treat#c.yrc						
1	.2667919	.1129765	2.36	0.018	.0453622	.4882217
_cons	33.035	1.344815	24.56	0.000	30.39921	35.67079

Random-effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]	
year: Identity				
var(_cons)	39.91268	12.29732	21.81981	73.00806
var(Residual)	14.34318	3.703394	8.647017	23.79166

LR test vs. linear model: chibar2(01) = 23.37 Prob >= chibar2 = 0.0000

```
. drop yh
```

```
. predict yh
(option xb assumed)
```

```
. twoway (scatter yield year if treat==0,msize(small))(scatter yield year if
treat==1,msize(small))(line yh year if treat==0)(line yh year if treat==1),legend(label(1
"7b") label(2 "9a") label(3 "7b fit") label(4 "9a fit"))
```

```
. mixed yield i.treat##c.yrc i.treat##c.yrc2 || year:
```

Mixed-effects ML regression
Group variable: year

Number of obs = 60
Number of groups = 30

Obs per group:

min = 2

avg = 2.0
max = 2

Log likelihood = -187.65717

Wald chi2(5) = 54.22
Prob > chi2 = 0.0000

yield	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
1.treat	7.815951	1.21801	6.42	0.000	5.428695	10.20321
yr	-.3482914	.1521333	-2.29	0.022	-.6464672	-.0501156
treat#c.yr						
1	.2667919	.0937275	2.85	0.004	.0830894	.4504944
yr2	.0215466	.0196841	1.09	0.274	-.0170336	.0601267
treat#c.yr2						
1	-.0447023	.0121271	-3.69	0.000	-.0684711	-.0209336
_cons	31.4208	1.977008	15.89	0.000	27.54594	35.29567

Random-effects Parameters	Estimate	Std. Err.	[95% Conf. Interval]	
year: Identity				
var(_cons)	42.14539	12.22299	23.87179	74.40723
var(Residual)	9.871967	2.54893	5.951472	16.37506

LR test vs. linear model: chibar2(01) = 32.05 Prob >= chibar2 = 0.0000

. drop yh

. predict yh
(option xb assumed)

. twoway (scatter yield year if treat==0,msize(small))(scatter yield year if
treat==1,msize(small))(line yh year if treat==0)(line yh year if treat==1),legend(label(1
"7b") label(2 "9a") label(3 "7b fit") label(4 "9a fit"))