Government Spending

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Introduction

Textbook Exercise 9.5

9.5 Subjects in a GSS were asked their opinions about government spending on the environment (E), health (H), assistance to big cities (C), and law enforcement (L). The data are shown at the text website, with outcome categories 1 = too little, 2 = about right, 3 = too much. For the homogeneous association model, Table 9.19 shows some results, including the two-factor estimates for the EH association for coding by which estimates at category 3 of each variable equal 0.

a. Test the model goodness of fit, and interpret.

b. Report the estimated EH conditional odds ratio for the (i) too much and too little categories, (ii) too much and about right categories, and (iii) about right and too little categories.

c. Table 9.20 reports $\{\hat{\lambda}_{eh}^{EH}\}$ when parameters sum to zero within rows and within columns, and when parameters are zero in the first row and first column. Show how these yield the estimated EH conditional odds ratio for the too much and too little categories. Construct a confidence interval for that odds ratio. Interpret.

Parameter Information

Subject were asked their opinions on government spending.

- n=597 participants
- 4 categorical variables

Category	Rating
E=environment H=health C=big city assistance L=law enforcement	1=too little 2=about right 3=too much

Data

```
***** [Table9.5, page370]***** ;
data problem9_5;
input E C H L count  @@;
datalines;
1 1 1 1 62  1 1 2 1 90  1 1 3 1 74  1 2 1 1 11  1 2 2 1 22
1 2 3 1 19  1 3 1 1 2   1 3 2 1 2   1 3 3 1 1   2 1 1 1 11
2 1 2 1 21  2 1 3 1 20  2 2 1 1 1   2 2 2 1 6   2 2 3 1 6
2 3 1 1 1   2 3 2 1 2   2 3 3 1 4   3 1 1 1 3   3 1 2 1 2
3 1 3 1 9   3 2 1 1 1   3 2 2 1 2   3 2 3 1 4   3 3 1 1 1
3 3 2 1 0   3 3 3 1 1   1 1 1 2 17  1 1 2 2 42  1 1 3 2 31
1 2 1 2 7   1 2 2 2 18  1 2 3 2 14  1 3 1 2 3   1 3 2 2 0
1 3 3 2 3   2 1 1 2 3   2 1 2 2 13  2 1 3 2 8   2 2 1 2 4
2 2 2 2 9   2 2 3 2 5   2 3 1 2 0   2 3 2 2 1   2 3 3 2 3
3 1 1 2 0   3 1 2 2 1   3 1 3 2 2   3 2 1 2 0   3 2 2 2 1
3 2 3 2 2   3 3 1 2 0   3 3 2 2 0   3 3 3 2 2   1 1 1 3 5
1 1 2 3 3   1 1 3 3 11  1 2 1 3 0   1 2 2 3 1   1 2 3 3 3
1 3 1 3 1   1 3 2 3 1   1 3 3 3 1   2 1 1 3 0   2 1 2 3 2
2 1 3 3 3   2 2 1 3 0   2 2 2 3 0   2 2 3 3 2   2 3 1 3 1
2 3 2 3 1   2 3 3 3 1   3 1 1 3 0   3 1 2 3 0   3 1 3 3 1
3 2 1 3 0   3 2 2 3 0   3 2 3 3 0   3 3 1 3 0   3 3 2 3 0
3 3 3 3 3
;
```

The Homogeneous Association Model

$$\log\left(\mu_{hijk}\right) = \lambda + \lambda_h^E + \lambda_i^H + \lambda_j^C + \lambda_k^L + \lambda_{hi}^{EH} + \lambda_{hj}^{EC} + \lambda_{hk}^{EL} + \lambda_{ij}^{HC} + \lambda_{ik}^{HL} + \lambda_{jk}^{CL}$$

- Association between any 2 categories
- Model has no 3-factor or 4-factor interaction term

Conditional dependence of the variables indicated given two variables that are not present are held constant.

The Homogeneous Association Model

$$\log\left(\mu_{hijk}\right) = \lambda + \lambda_h^E + \lambda_i^H + \lambda_j^C + \lambda_k^L + \lambda_{hi}^{EH} + \lambda_{hj}^{EC} + \lambda_{hk}^{EL} + \lambda_{ij}^{HC} + \lambda_{ik}^{HL} + \lambda_{jk}^{CL}$$

- Used the 3rd level as the reference for the model
- We used the maximum likelihood parameter given by SAS
- The total amount of non-redundant parameters is 33

$$HIJK=1+(H-1)+(I-1)+(J-1)+(K-1)+(H-1)(I-1)+(H-1)(I-1)+(H-1)(J-1)$$
$$+(H-1)(K-1)+(I-1)(J-1)+(I-1)(K-1)+(J-1)(K-1)$$

```
*** Homogenous Association Model;
proc genmod data=problem9_5;
class E(ref='3') H(ref='3') C(ref='3') L(ref='3')/ param=ref;
model count = E C H L E*H E*C E*L H*C H*L C*L/ dist=poi lrci type3 residuals obstats;
title 'Homogenours Association Model';
output out=pred p=exp1;run;quit;
```

Testing the model goodness of fit (9.5a)

$$\begin{cases} H_0\text{: the fitted model fits well} \\ H_1\text{: the fitted model does not fit well} \end{cases}$$

- Deviance G^2=31.6695, df=48
- Pearson Chi-Squares X^2=26.5224, df=48

- p-values > α=0.05
- Fail to reject H_0. The model fits well.

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	48	31.6695	0.6598
Scaled Deviance	48	31.6695	0.6598
Pearson Chi-Square	48	26.5224	0.5526
Scaled Pearson X2	48	26.5224	0.5526
Log Likelihood		1284.9404	
Full Log Likelihood		-119.2515	
AIC (smaller is better)		304.5030	
AICC (smaller is better)		352.2477	
BIC (smaller is better)		383.5198	

Estimated EH conditional odds ratio (9.5b)

We are interested in the association between a subject rating about the government spending on the Environment and Health.

Table 9.19 Software Output (Based on SAS) for Fitting Model For Exercise 9.5

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	48	31.6695	0.6598
Pearson Chi-Square	48	26.5224	0.5526
Log Likelihood		1284.9404	

Parameter			DF	Estimate	Standard Error	Wald 95% Confidence	Limits	Chi-Square
e*h	1	1	1	2.1425	0.5566	1.0515	3.2335	14.81
e*h	1	2	1	1.4221	0.6034	0.2394	2.6049	5.55
e*h	2	1	1	0.7294	0.5667	−0.3813	1.8402	1.66
e*h	2	2	1	0.3183	0.6211	−0.8991	1.5356	0.26

EH part for the parameter estimates output

Estimated EH conditional odds ratio (9.5b)

Since we used the 3rd level as the reference, we are able to obtain estimates for

λ_{11}^{EH} λ_{12}^{EH} λ_{21}^{EH} λ_{22}^{EH}

All other parameters are redundant.

Analysis Of Maximum Likelihood Parameter Estimates

Parameter			DF	Estimate	Standard Error	Likelihood Ratio 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
E*H	1	1	1	2.1425	0.5566	1.0132	3.2209	14.81	0.0001
E*H	1	2	1	1.4221	0.6034	0.2148	2.6069	5.55	0.0184
E*H	1	3	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	2	1	1	0.7294	0.5667	-0.4194	1.8265	1.66	0.1980
E*H	2	2	1	0.3183	0.6211	-0.9248	1.5346	0.26	0.6084
E*H	2	3	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	3	1	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	3	2	0	0.0000	0.0000	0.0000	0.0000	.	.

EH part for the parameter estimates output from SAS

Estimated EH conditional odds ratio for the too much (3) and too little (1) (9.5b.i)

$$\log(\hat{\theta}_{13}) = \log\left(\frac{\hat{\mu}_{11jk}\hat{\mu}_{33jk}}{\hat{\mu}_{13jk}\hat{\mu}_{31jk}}\right) = \log(\hat{\mu}_{11jk}) + \log(\hat{\mu}_{33jk}) - \log(\hat{\mu}_{13jk}) - \log(\hat{\mu}_{31jk})$$

$$= \hat{\lambda} + \hat{\lambda}_1^E + \hat{\lambda}_1^H + \hat{\lambda}_j^C + \hat{\lambda}_k^L + \hat{\lambda}_{11}^{EH} + \hat{\lambda}_{1j}^{EC} + \hat{\lambda}_{1k}^{EL} + \hat{\lambda}_{1j}^{HC} + \hat{\lambda}_{1k}^{HL} + \hat{\lambda}_{jk}^{CL}$$

$$+\hat{\lambda} + \hat{\lambda}_3^E + \hat{\lambda}_3^H + \hat{\lambda}_j^C + \hat{\lambda}_k^L + \hat{\lambda}_{33}^{EH} + \hat{\lambda}_{3j}^{EC} + \hat{\lambda}_{3k}^{EL} + \hat{\lambda}_{3j}^{HC} + \hat{\lambda}_{3k}^{HL} + \hat{\lambda}_{jk}^{CL}$$

$$-(\hat{\lambda} + \hat{\lambda}_1^E + \hat{\lambda}_3^H + \hat{\lambda}_j^C + \hat{\lambda}_k^L + \hat{\lambda}_{13}^{EH} + \hat{\lambda}_{1j}^{EC} + \hat{\lambda}_{1k}^{EL} + \hat{\lambda}_{3j}^{HC} + \hat{\lambda}_{3k}^{HL} + \hat{\lambda}_{jk}^{CL})$$

$$-(\hat{\lambda} + \hat{\lambda}_3^E + \hat{\lambda}_1^H + \hat{\lambda}_j^C + \hat{\lambda}_k^L + \hat{\lambda}_{31}^{EH} + \hat{\lambda}_{3j}^{EC} + \hat{\lambda}_{3k}^{EL} + \hat{\lambda}_{1j}^{HC} + \hat{\lambda}_{1k}^{HL} + \hat{\lambda}_{jk}^{CL})$$

$$= \hat{\lambda}_{11}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{13}^{EH} - \hat{\lambda}_{31}^{EH}$$

Zero for Third Level

	H		
E	1	2	3
1	2.1425	1.4221	0
2	0.7294	0.3183	0
3	0	0	0

$$\hat{\theta}_{13} = e^{\hat{\lambda}_{11}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{13}^{EH} - \hat{\lambda}_{31}^{EH}} = e^{2.1425+0-0-0} = e^{2.1425} = 8.5207$$

Estimated EH conditional odds ratio for the too much (3) and too little (1) (9.5b.i)

$$\hat{\theta}_{13} = e^{\hat{\lambda}_{11}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{13}^{EH} - \hat{\lambda}_{31}^{EH}} = e^{2.1425+0-0-0} = e^{2.1425} = 8.5207$$

Zero for Third Level

	H		
E	1	2	3
1	2.1425	1.4221	0
2	0.7294	0.3183	0
3	0	0	0

Interpretation:

While holding the subject's opinions on government spending for big city assistance and law enforcement constant, participants are 8.5207 times more likely to agree that the government has been spending too little on the environment and health issue than the participants who think the government was spending too much.

Estimated EH conditional odds ratio for the too much (3) and about right (2) (9.5b.ii)

$$\log(\hat{\theta}_{23}) = \log\left(\frac{\hat{\mu}_{22jk}\hat{\mu}_{33jk}}{\hat{\mu}_{23jk}\hat{\mu}_{32jk}}\right) = \log(\hat{\mu}_{22jk}) + \log(\hat{\mu}_{33jk}) - \log(\hat{\mu}_{23jk}) - \log(\hat{\mu}_{32jk})$$

$$= \hat{\lambda}_{22}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{23}^{EH} - \hat{\lambda}_{32}^{EH}$$

$$\hat{\theta}_{23} = e^{\hat{\lambda}_{22}^{EH}+\hat{\lambda}_{33}^{EH}-\hat{\lambda}_{23}^{EH}-\hat{\lambda}_{32}^{EH}} = e^{0.3183+0-0-0} = e^{0.3183} = 1.3748$$

	Zero for Third Level		
	H		
E	1	2	3
1	2.1425	1.4221	0
2	0.7294	0.3183	0
3	0	0	0

Interpretation:

While holding the subject's opinions on government spending for big city assistance and law enforcement constant, participants are 1.3748 times more likely to agree that the government has been spending the right amount on the environment and health issue than the participants who think the government was spending too much.

Estimated EH conditional odds ratio for the about right (2) and too little (1) (9.5b.iii)

$$\log(\hat{\theta}_{12}) = \log\left(\frac{\hat{\mu}_{11jk}\hat{\mu}_{22jk}}{\hat{\mu}_{12jk}\hat{\mu}_{21jk}}\right) = \log(\hat{\mu}_{11jk}) + \log(\hat{\mu}_{22jk}) - \log(\hat{\mu}_{12jk}) - \log(\hat{\mu}_{21jk})$$

$$= \hat{\lambda}_{11}^{EH} + \hat{\lambda}_{22}^{EH} - \hat{\lambda}_{12}^{EH} - \hat{\lambda}_{21}^{EH}$$

$$\hat{\theta}_{12} = e^{\hat{\lambda}_{11}^{EH} + \hat{\lambda}_{22}^{EH} - \hat{\lambda}_{12}^{EH} - \hat{\lambda}_{21}^{EH}} = e^{2.1425+0.3183-1.4221-0.7294} = e^{0.3093} = 1.362$$

	Zero for Third Level		
	H		
E	1	2	3
1	2.1425	1.4221	0
2	0.7294	0.3183	0
3	0	0	0

Interpretation:

While holding the subject's opinions on government spending for big city assistance and law enforcement constant,participants are 1.362 times more likely to agree that the government has been spending too little on the environment and health issue than the participants who think the government the right amount

Estimated CL conditional odds ratio (extra)

From the same homogeneous association model, we can find the estimated conditional odds ratio between any pairs of variables (e.g.: big city assistance (C) & law enforcement (L), while holding E & H as constant)

	Zero for Third Level		
	L		
C	1	2	3
1	1.8741	1.0366	0
2	1.9371	1.823	0
3	0	0	0

$$\hat{\theta}_{13} = e^{\hat{\lambda}_{11}^{CL}+\hat{\lambda}_{33}^{CL}-\hat{\lambda}_{13}^{CL}-\hat{\lambda}_{31}^{CL}} = e^{1.8741+0-0-0} = e^{1.8741} = 6.515$$

$$\hat{\theta}_{23} = e^{\hat{\lambda}_{22}^{CL}+\hat{\lambda}_{33}^{CL}-\hat{\lambda}_{23}^{CL}-\hat{\lambda}_{32}^{CL}} = e^{1.823+0-0-0} = e^{1.823} = 6.1904$$

$$\hat{\theta}_{12} = e^{\hat{\lambda}_{11}^{CL}+\hat{\lambda}_{22}^{CL}-\hat{\lambda}_{12}^{CL}-\hat{\lambda}_{21}^{CL}} = e^{1.8741+1.823-1.0366-1.9371} = e^{0.7234} = 2.0801$$

More on the estimated EH odds ratio (9.5c)

Sum to Zero Constraints

Sum to Zero Constraints:
The parameter estimates sum to zero within rows and within columns.

The conditional odds ratio for too much (3) and too little (1) is same as the one we calculated before.

Sum to Zero Constraints

		H	
E	1	2	3
1	0.509	0.166	−0.676
2	−0.065	−0.099	0.163
3	−0.445	−0.068	0.513

$$\log\left(\hat{\theta}_{13}\right) = \hat{\lambda}_{11}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{13}^{EH} - \hat{\lambda}_{31}^{EH} = 0.509 + 0.513 - (-0.676) - (-0.445) = 2.143$$

$$\hat{\theta}_{13} = e^{2.143} = 8.5207$$

More on the estimated EH odds ratio (9.5c)
Sum to Zero Constraints

Similarly,
The conditional odds ratio for too much (3) and about right (2)

$$log\left(\hat{\theta}_{23}\right) = \hat{\lambda}_{22}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{23}^{EH} - \hat{\lambda}_{32}^{EH} = -0.099 + 0.513 - 0.163 - (-0.068) = 0.319$$

$$\hat{\theta}_{23} = e^{0.319} = 1.3748$$

The conditional odds ratio for about right (2) and too little (1)

$$log\left(\hat{\theta}_{12}\right) = \hat{\lambda}_{11}^{EH} + \hat{\lambda}_{22}^{EH} - \hat{\lambda}_{12}^{EH} - \hat{\lambda}_{21}^{EH} = 0.509 + (-0.099) - 0.166 - (-0.065) = 0.309$$

$$\hat{\theta}_{12} = e^{0.309} = 1.362$$

More on the estimated EH odds ratio (9.5c)
Zero for the First Level

Zero for the First Level:
= setting the 1st level as reference
(instead of 3rd level previously)

$$\hat{\theta}_{13} = e^{\hat{\lambda}_{33}^{EH}} = e^{2.142} = 8.5207$$
$$\hat{\theta}_{23} = e^{\hat{\lambda}_{22}^{EH}+\hat{\lambda}_{33}^{EH}-\hat{\lambda}_{23}^{EH}-\hat{\lambda}_{32}^{EH}} = e^{0.309+2.142-1.413-0.720} = e^{0.318} = 1.374$$
$$\hat{\theta}_{12} = e^{\hat{\lambda}_{22}^{EH}} = e^{2.309} = 1.362$$

Zero for First Level

	H		
E	1	2	3
1	0	0	0
2	0	0.309	1.413
3	0	0.720	2.142

```
*** Homogenous Association Model;
proc genmod data=problem9_5;
class E(ref='1') H(ref='1') C(ref='1') L(ref='1') / param=ref;
model count = E C H L E*H E*C E*L H*C H*L C*L/ dist=poi lrci type3 residuals obstats;
title 'Homogenours Association Model';
output out=pred p=exp1;run;quit;
```

More on the estimated EH odds ratio (9.5c)

Zero for the First Level

$$\hat{\theta}_{23} = e^{\hat{\lambda}_{22}^{EH} + \hat{\lambda}_{33}^{EH} - \hat{\lambda}_{23}^{EH} - \hat{\lambda}_{32}^{EH}} = e^{0.309+2.142-1.413-0.720} = e^{0.318} = 1.374$$

Recall that $\hat{\theta}_{23} = \dfrac{\hat{\pi}_{22}\hat{\pi}_{33}}{\hat{\pi}_{23}\hat{\pi}_{32}}$

$$\log(\hat{\theta}_{23}) = \log\left(\frac{\hat{\pi}_{22}\hat{\pi}_{33}}{\hat{\pi}_{23}\hat{\pi}_{32}}\right) + \log\left(\frac{\hat{\pi}_{11}\hat{\pi}_{33}}{\hat{\pi}_{13}\hat{\pi}_{31}}\right) - \log\left(\frac{\hat{\pi}_{11}\hat{\pi}_{32}}{\hat{\pi}_{12}\hat{\pi}_{31}}\right) - \log\left(\frac{\hat{\pi}_{11}\hat{\pi}_{23}}{\hat{\pi}_{13}\hat{\pi}_{21}}\right) = \log\left(\frac{\hat{\pi}_{22}\hat{\pi}_{33}}{\hat{\pi}_{23}\hat{\pi}_{32}}\right)$$

	$\log(\frac{\hat{\pi}_{22}\hat{\pi}_{33}}{\hat{\pi}_{23}\hat{\pi}_{32}})$	$\log(\frac{\hat{\pi}_{11}\hat{\pi}_{23}}{\hat{\pi}_{13}\hat{\pi}_{21}})$
	$\log(\frac{\hat{\pi}_{11}\hat{\pi}_{22}}{\hat{\pi}_{12}\hat{\pi}_{31}})$	$\log(\frac{\hat{\pi}_{11}\hat{\pi}_{33}}{\hat{\pi}_{13}\hat{\pi}_{31}})$

Local conditional odds ratio

Estimated Probability Cells

$\hat{\pi}_{11}$	$\hat{\pi}_{12}$	$\hat{\pi}_{13}$
$\hat{\pi}_{21}$	$\hat{\pi}_{22}$	$\hat{\pi}_{11}$
$\hat{\pi}_{31}$	$\hat{\pi}_{32}$	$\hat{\pi}_{33}$

Confidence Interval for EH conditional odds ratio for the too much (3) and too little(1) (9.5c continued)

Zero for the 3rd Level:

$\log(\hat{\theta}_{13}) = \hat{\lambda}_{11}^{EH}$

95% C.I. for $\hat{\theta}_{13}$ is $[e^{1.0132}, e^{3.2209}]$

$= [2.7544, 25.0507]$

Analysis Of Maximum Likelihood Parameter Estimates									
Parameter			DF	Estimate	Standard Error	Likelihood Ratio 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
E*H	1	1	1	2.1425	0.5566	$\boxed{1.0132}$	$\boxed{3.2209}$	14.81	0.0001
E*H	1	2	1	1.4221	0.6034	0.2148	2.6069	5.55	0.0184
E*H	1	3	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	2	1	1	0.7294	0.5667	-0.4194	1.8265	1.66	0.1980
E*H	2	2	1	0.3183	0.6211	-0.9248	1.5346	0.26	0.6084
E*H	2	3	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	3	1	0	0.0000	0.0000	0.0000	0.0000	.	.
E*H	3	2	0	0.0000	0.0000	0.0000	0.0000	.	.

Confidence Interval for EH conditional odds ratio for the too much (3) and too little(1) (9.5c continued)

Zero for the 3rd Level:

$$\log(\hat{\theta}_{13}) = \hat{\lambda}_{11}^{EH}$$

95% C.I. for $\hat{\theta}_{13}$ is $[e^{1.0132}, e^{3.2209}]$

$= [2.7544, 25.0507]$

Interpretation:

We are 95% confident the true conditional odds ratio between too little and too much lies between 2.7544 and 25.0507. Since the entire interval is greater than one, this means that the subjects are more likely to say the government is spending too little on the environment and health than say they are spending too much

Estimated Marginal Odds Ratio for EH using the marginal table with fitted values (Extra)

Marginal Table EH

show us how a subject's opinion on how much the government spends on the environment relates to how much the government spends on health given their opinions on government spending for big city assistance and law enforcement is held constant

		Health		
		Too Little	**About Right**	**Too Much**
Environment	**Too Little**	335	95	14
	About Right	81	33	14
	Too Much	18	10	7

$$\hat{\theta}_{EH_{13}} = \frac{335(7)}{14(18)} = \frac{2345}{112} = 20.94$$

$$\hat{\theta}_{EH_{23}} = \frac{33(7)}{14(10)} = \frac{231}{140} = 1.65$$

$$\hat{\theta}_{EH_{12}} = \frac{335(33)}{95(81)} = \frac{11055}{7695} = 1.44$$

Estimated Marginal Odds Ratio for EH using the marginal table with fitted values (Extra)

Marginal OR

$$\hat{\theta}_{EH_{13}} = \frac{335(7)}{14(18)} = \frac{2345}{112} = 20.94$$

		Health		
		Too Little	About Right	Too Much
Environment	Too Little	$\boxed{335}$	95	$\boxed{14}$
	About Right	81	33	14
	Too Much	$\boxed{18}$	10	$\boxed{7}$

Interpretation:

The odds of a participant claiming the government spent too little on health would also claim the government spent too little on the environment is 20.94 times the odds of claiming the government spent too little on health but spent too much on the environment.

Estimated Marginal Odds Ratio for EH using the marginal table with fitted values (Extra)

Marginal OR

$$\hat{\theta}_{EH_{23}} = \frac{33(7)}{14(10)} = \frac{231}{140} = 1.65$$

		Health		
		Too Little	**About Right**	**Too Much**
Environment	**Too Little**	335	95	14
	About Right	81	33	14
	Too Much	18	10	7

Interpretation:

The odds of a participant claiming the government spent right amount on health would also claim the government the right amount on the environment is 1.65 times the odds of claiming the government spent the right amount on health but spent too much on the environment

Estimated Marginal Odds Ratio for EH using the marginal table with fitted values (Extra)

Marginal OR

$$\hat{\theta}_{EH_{12}} = \frac{335(33)}{95(81)} = \frac{11055}{7695} = 1.44$$

		Health		
		Too Little	**About Right**	**Too Much**
Environment	**Too Little**	335	95	14
	About Right	81	33	14
	Too Much	18	10	7

Interpretation:

The odds of a participant claiming the government spent too little on health would also claim the government spent too little on the environment is 1.44 times the odds of claiming the government spent the too little on health but spent the right amount on the environment.

Looking for a better model (extra)

- Homogeneous Association Model:
  - (EH, EC, CL, EL, HC, HL, CL)
- Backward elimination to remove factor interactions
  - (EH, EC, CL, ~~EL,~~ HC, HL, CL)
  - (EH, EC, CL, ~~EL, HC,~~ HL, CL)
- No interaction term model
  - (E, H, C, L)
- Three-factor interactions terms
  - (EH, EC, CL, EL, HC, HL, CL, EHC, EHL, HCL, ECL)

Looking for a better model (extra)

- Compare models by AIC

Model	Homogenous Association -EL			Homogenous Association -EL -HC			No interaction			Three factor interaction		
Criterion	DF	Value	Value/DF	DF	Value	Value/DF	DF	Value	Value/DF	DF	Value	Value/DF
Deviance	52	34.1026	0.6558	56	39.4112	0.7038	72	124.3443	1.7270	16	8.5237	0.5327
Scaled Deviance	52	34.1026	0.6558	56	39.4112	0.7038	72	124.3443	1.7270	16	8.5237	0.5327
Pearson Chi-Square	52	29.1564	0.5607	56	34.0851	0.6087	72	281.9375	3.9158	16	6.8176	0.4261
Scaled Pearson X2	52	29.1564	0.5607	56	34.0851	0.6087	72	281.9375	3.9158	16	6.8176	0.4261
Log Likelihood		1283.7238			1281.0695			1238.6030			1296.5132	
Full Log Likelihood		-120.4680			-123.1224			-165.5889			-107.6786	
AIC (smaller is better)		298.9361			296.2447			349.1778			345.3573	
AICC (smaller is better)		333.0537			319.8811			351.7130			917.3573	
BIC (smaller is better)		368.3751			356.1059			370.7279			500.9965	

Conclusion

1. Homogeneous Association Model
2. Estimated EH conditional odds ratio won't change by different parameter estimations methods
3. 95% C.I. for the conditional odds ratio can be calculated from the 95% C.I of the estimated parameters.

Zero for Third Level

E	H 1	H 2	H 3
1	2.1425	1.4221	0
2	0.7294	0.3183	0
3	0	0	0

Sum to Zero Constraints

E	*H* 1	*H* 2	*H* 3
1	0.509	0.166	−0.676
2	−0.065	−0.099	0.163
3	−0.445	−0.068	0.513

Zero for First Level

E	*H* 1	*H* 2	*H* 3
1	0	0	0
2	0	0.309	1.413
3	0	0.720	2.142