A Program for the Estimated Standard Error of the Difference in Slopes from Separate Regressions

David A. Walker
Northern Illinois University

The SPSS program provides an application for researchers and practitioners interested in two formulas for the standard error of the difference between regression slope coefficients per the discussion proffered recently in *Multiple Linear Regression Viewpoints* by Robinson, Tomek, and Schumacker (2013) and Hayes and Agler (2014).

The subsequent SPSS program (Walker, 2014) is intended to provide an application for researchers and practitioners interested in two formulas for the standard error of the difference between regression slope coefficients. In this particular area of methodology, described recently in *Multiple Linear Regression Viewpoints* by Robinson, Tomek, and Schumacker (2013) and Hayes and Agler (2014), a debate has ensued regarding which formula to employ when examining a regression research question such as "Is the relationship between X and Y (e.g., the relationship between risk of breast cancer and the intention to obtain breast cancer screening) the same or different between two groups (e.g., individuals at low risk versus high risk of breast cancer)?

The literature suggests that a specific formula (noted as Formula7 in part II of the subsequent SPSS program) for the standard error (SE) of the difference between two regression slopes from separate regressions (i.e., the SE of b2 – b1) advanced by studies such as Brame, Paternoster, Mazerolle, and Piquero (1998); Cohen (1983); Hayes and Agler (2014), and Paternoster, Brame, Mazerolle, and Piquero (1998) provides an unbiased estimate. Another formula (noted as Formula5 in part II of the following SPSS program) for the estimated standard error of the difference in slopes from separate regressions presented by Robinson et al. (2013), and based on work by Kleinbaum and Kupper (1978), facilitates a more powerful test of the difference in slopes, but has been noted in the literature as a biased estimate, for example, by Paternoster et al. who determined "… this to be an incorrect formula for the difference between two regression coefficients, because the estimated standard error of the difference is negatively biased" (p. 862).

Standard Error of the Difference in Slopes (SE of b2 – b1) from Separate Regressions Program

The heuristic example and data used in the current SPSS syntax program, and also employed in both the Robinson et al. (2013) and Hayes and Agler (2014) studies, provide results from the two formulas for the estimated standard error of the difference in slopes from separate regressions. The data were derived from Aiken (2006) (http://www.public.asu.edu/~atlsa/PSY531/home7dat.txt) and used to answer the previously-noted regression research question.

The SPSS program has two parts along with embedded instructions. Part I uses Aiken's (2006) raw data and produces results for the separate regression models fitted to each group separately. The first area of focus from part I are the sample sizes for the two groups, where the high risk group (coded as 1) had $n = 91$ and the low risk group (coded as 0) had $n = 96$. The second area of focus from the regression model results are the SEs for the slopes of each regression equation (SEb1 and SEb2), where SEb1 = 0.167 (group 1) and SEb2 = 0.141 (group 0). Additionally, for part II of the program, the user would enter the sample sizes for the two groups in the model as well as the SEs for b1 and b2. The results found in part II of the program show a comparison between the two formulas, where the estimated SE of b2 – b1 in separate regressions, per the Robinson et al. (2013) position, was 0.159 and the SE from the Hayes and Agler (2014) perspective was 0.221 as noted in Table 5 from the latter.

To restate, this SPSS program was presented as a readily-accessible and easily-implemented way, given a similar regression situation as described in this example, of determining the standard error of the difference between two slopes (SE of b2 – b1) from separate regressions. Of note, this program can be used with other raw data beyond the presented example.

****

Contact dawalker@niu.edu
Northern Illinois University, 204D Gabel, DeKalb, IL 60115
APA 6th Edition Citation
Walker, D. A. (2014). Standard error of the difference in slopes from separate regressions [Computer program]. DeKalb, IL: Author.
**.

```
DATA LIST LIST / Case Group Dummy (3F8.0) Risk Int2gr (2F9.4).
```

****

NOTE: Run the regression model first (PART I) to obtain samples sizes and standard errors for b1 and b2, which will then be entered into PART II of the program below
**.

****

PART I: Between BEGIN DATA and END DATA below, data come from Aiken (2006) (http://www.public.asu.edu/~atlsa/PSY531/home7dat.txt), where Case are the participants, Group 1 (dummy coded as 1) are at high risk of breast cancer, Group 3 (dummy coded as 0) are at low risk for breast cancer (Note: Group 2 was removed from the data set), and
with the question "Is the relationship between X and Y (e.g., the relationship between risk of breast cancer and the intention to obtain breast cancer screening) the same or different between two groups (e.g., individuals at low risk versus high risk of breast cancer)?
**.

```
BEGIN DATA
   6    1    1     5.8800    6.2723
   7    1    1     5.0800    5.6331
   8    1    1     5.6800     .1396
   9    1    1     5.6000    2.4134
  10    1    1     5.4000    4.9166
  11    1    1     5.8400    3.7166
  12    1    1     5.5200    5.8110
  13    1    1     5.8800    3.1764
  14    1    1     5.3200    6.0798
  15    1    1     5.7600    4.4524
  16    1    1     6.6400    3.8435
  17    1    1     5.9600    7.7328
  18    1    1     5.6800    2.8904
  19    1    1     6.7200    2.5417
  20    1    1     5.3200    5.6832
  21    1    1     6.9600    3.2330
  22    1    1     4.8800    5.9297
  23    1    1     6.4000     .9472
  24    1    1     6.0000    3.5944
  25    1    1     3.9600    5.8155
  26    1    1     5.5600    3.0541
  27    1    1     6.8000    3.9284
  28    1    1     5.8000    1.9755
  29    1    1     6.6800    1.4138
  30    1    1     6.8000    4.1887
  31    1    1     6.2400    7.0136
  32    1    1     5.1200    5.4981
  33    1    1     4.9600    5.4932
  34    1    1     5.6000    4.0277
  35    1    1     6.2800     .0201
  36    1    1     4.8000    4.8073
```

37	1	1	5.2800	4.1993
38	1	1	5.6800	3.6719
39	1	1	6.4400	1.7936
40	1	1	4.8400	4.0763
41	1	1	5.9600	2.5864
42	1	1	7.2800	1.0497
43	1	1	6.3600	1.6308
44	1	1	6.8400	2.9525
45	1	1	5.1200	4.7190
46	1	1	5.6400	3.7540
47	1	1	7.3200	1.6966
48	1	1	6.6400	2.8214
49	1	1	5.6400	2.5502
50	1	1	6.7600	6.4821
51	1	1	6.4400	2.8842
52	1	1	4.8800	5.5327
53	1	1	6.7200	4.8796
54	1	1	4.1600	8.8610
55	1	1	5.8800	3.2083
56	1	1	6.7600	3.6334
57	1	1	5.4000	5.7713
58	1	1	7.6800	3.7364
59	1	1	6.4000	1.2736
60	1	1	5.9600	6.1007
61	1	1	4.9200	3.4817
62	1	1	6.1200	3.1699
63	1	1	3.7200	6.6367
64	1	1	6.0400	4.4254
65	1	1	8.1200	1.7100
66	1	1	5.4000	2.7042
67	1	1	4.9600	.1000
68	1	1	7.7600	2.8558
69	1	1	7.6000	3.3786
70	1	1	6.6400	2.8434
71	1	1	5.5600	1.4464
72	1	1	5.9600	1.4819
73	1	1	6.0400	3.7199
74	1	1	5.7200	3.8526
75	1	1	4.8000	7.9103
76	1	1	7.8000	2.4874
77	1	1	7.1200	1.1212
78	1	1	4.5600	4.4132
79	1	1	6.7600	2.5265
80	1	1	4.8400	2.0525
81	1	1	3.7200	7.6633
82	1	1	6.5200	6.6017
83	1	1	5.2400	4.3401
84	1	1	8.4000	.1000
85	1	1	3.4800	4.4218
86	1	1	8.7200	1.3826
87	1	1	6.0000	2.9555
88	1	1	7.4400	2.2478
89	1	1	5.7200	7.5798
90	1	1	5.6800	5.6534
91	1	1	4.1600	5.9258
92	1	1	4.3600	4.8596
93	1	1	8.0400	1.5051
94	1	1	7.6000	4.5189
95	1	1	5.8800	4.2018

96	1	1	6.7600	1.5827
145	3	0	3.8000	6.9432
146	3	0	3.8100	3.8780
147	3	0	3.7000	5.0565
148	3	0	3.3300	6.8098
149	3	0	4.2300	6.8058
150	3	0	3.5000	7.1364
151	3	0	3.7500	5.7816
152	3	0	3.1300	3.1689
153	3	0	3.7400	7.4606
154	3	0	3.1300	8.0808
155	3	0	3.9700	8.5968
156	3	0	2.2500	7.8598
157	3	0	3.0900	5.0652
158	3	0	2.8100	2.0038
159	3	0	3.9100	6.1994
160	3	0	3.7100	7.9174
161	3	0	3.6300	7.7204
162	3	0	3.1000	5.0996
163	3	0	3.3300	2.6029
164	3	0	4.0700	7.5854
165	3	0	3.9400	7.3420
166	3	0	3.7400	5.3863
167	3	0	3.2900	4.2541
168	3	0	3.3900	2.4164
169	3	0	3.8100	7.7362
170	3	0	3.7000	7.8777
171	3	0	2.3300	6.5961
172	3	0	2.9600	4.5304
173	3	0	4.3700	5.8116
174	3	0	4.3600	5.2268
175	3	0	3.6800	5.9279
176	3	0	3.9300	5.3928
177	3	0	3.5900	8.5000
178	3	0	3.1000	3.7551
179	3	0	3.1800	5.9669
180	3	0	3.8700	6.2055
181	3	0	3.6200	7.6674
182	3	0	3.2000	7.1059
183	3	0	2.6800	1.9442
184	3	0	3.7800	6.6490
185	3	0	3.5400	3.9620
186	3	0	2.4800	2.8027
187	3	0	4.0600	7.3543
188	3	0	4.5600	4.0663
189	3	0	4.6700	4.3458
190	3	0	3.2500	4.5636
191	3	0	3.7400	5.7331
192	3	0	3.9700	6.5206
193	3	0	3.6500	5.7024
194	3	0	3.6800	5.0748
195	3	0	3.5800	4.0923
196	3	0	5.0000	6.8036
197	3	0	4.7200	5.9993
198	3	0	4.1400	4.2794
199	3	0	3.9600	8.8474
200	3	0	1.7500	5.7036
201	3	0	5.4300	8.2242
202	3	0	3.1200	5.7957
203	3	0	4.1200	7.8698

```
 204   3   0    2.8100    3.1160
 205   3   0    3.6800    6.0828
 206   3   0    2.4400    6.4699
 207   3   0    3.9900    5.2653
 208   3   0    4.0700    6.3213
 209   3   0    3.1900    5.2002
 210   3   0    4.4300    6.8410
 211   3   0    3.4600    7.0056
 212   3   0    3.8600    6.8389
 213   3   0    4.5000    6.6359
 214   3   0    3.9300    7.7443
 215   3   0    3.4400    6.5655
 216   3   0    4.3700    7.4891
 217   3   0    3.4500    6.1449
 218   3   0    5.1900    5.7520
 219   3   0    5.4000    4.4224
 220   3   0    4.8100    9.0037
 221   3   0    3.7800    6.2479
 222   3   0    4.7500    7.7820
 223   3   0    4.5400    8.0749
 224   3   0    5.7300    9.8735
 225   3   0    3.3700    8.3291
 226   3   0    3.6200    5.7143
 227   3   0    1.6900    3.8664
 228   3   0    4.2300    6.1701
 229   3   0    3.0100    5.0253
 230   3   0    1.0600    3.3323
 231   3   0    4.1700    7.4146
 232   3   0    4.0800    7.7898
 233   3   0    3.6700    5.9753
 234   3   0    3.6900    5.7857
 235   3   0    5.0400    6.0894
 236   3   0    6.1500   10.2023
 237   3   0    4.1000    6.3574
 238   3   0    5.6500    7.4785
 239   3   0    7.4700    8.6647
 240   3   0    9.9900   11.8612
END DATA.
SPLIT FILE By Dummy.
REGRESSION
 /DESCRIPTIVES MEAN STDDEV
  /DEPENDENT Int2gr
  /METHOD=ENTER Risk.
```

Descriptive Statistics

Dummy		Mean	Std. Deviation	N
1	Int2gr	3.779842	1.9673414	91
	Risk	5.970989	1.0709923	91
0	Int2gr	6.195198	1.8233778	96
	Risk	3.861875	1.1099742	96

Model Summary

Dummy	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1	.518[a]	.268	.260	1.6923175
0	1	.553[a]	.306	.298	1.5275103

a. Predictors: (Constant), Risk

ANOVA[a]

Dummy	Model		Sum of Squares	df	Mean Square	F	Sig.
1	1	Regression	93.448	1	93.448	32.629	.000[b]
		Residual	254.891	89	2.864		
		Total	348.339	90			
0	1	Regression	96.518	1	96.518	41.366	.000[b]
		Residual	219.329	94	2.333		
		Total	315.847	95			

a. Dependent Variable: Int2gr
b. Predictors: (Constant), Risk

Coefficients[a]

Dummy	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
			B	Std. Error	Beta		
1	1	(Constant)	9.461	1.010		9.365	.000
		Risk	-.951	.167	-.518	-5.712	.000
0	1	(Constant)	2.688	.567		4.740	.000
		Risk	.908	.141	.553	6.432	.000

a. Dependent Variable: Int2gr

```
SPLIT FILE OFF.

****************************************************************************.
DATA LIST LIST / N1 N2 (2F8.0) SEb1 SEb2 (2F9.3).
****************************************************************************
```

PART II: Below are the samples sizes from the example (N1 and N2) and the standard errors for b1 (SEb1) and b2 (SEb2), which are entered below between BEGIN DATA and END DATA for the second part of the program

```
****************************************************************************.

BEGIN DATA
91 96 .167 .141
END DATA.
COMPUTE  Formula5 = SQRT(((N1*SEb1**2+N2*SEb2**2)/((N1+N2)-2))).
COMPUTE Formula7 = SQRT((SEb1**2+SEb2**2)).
FORMAT Formula5 TO Formula7 (F8.3).
VARIABLE LABEL Formula5 'Estimated SE of the Difference in Slopes (Robinson
et al)'/Formula7 'Estimated SE of the Difference in Slopes (Hayes & Agler)'.
REPORT FORMAT=LIST AUTOMATIC ALIGN (CENTER)
  /VARIABLES= Formula5 Formula7
  /TITLE "Standard Error of the Difference in Slopes from Separate
Regressions".

Standard Error of the Difference in Slopes from Separate Regressions
                      Estimated SE             Estimated SE
                      of the                    of the
                      Difference in             Difference in
                      Slopes (Robinson et al)   Slopes (Hayes & Agler)

                      ___________              ___________
                         .155                     .219
```

References

Aiken, L. (2006). *PSY 531 multiple regression in psychological research*. Retrieved from http://www.public.asu.edu/~atlsa/PSY531/home7dat.txt

Brame, R., Paternoster, R., Mazerolle, P., & Piquero, A. (1998). Testing the equality of maximum-likelihood regression coefficients between two independent equations. *Journal of Quantitative Criminology*, *14*, 245-261.

Cohen, A. (1983). Comparing regression coefficients across subsamples: A study of the statistical test. *Sociological Methods & Research*, *12*, 77-94.

Hayes, A. F., & Agler, R. A. (2014). On the standard error of the difference between two independent regression coefficients in moderation analysis: A commentary on Robinson, Tomek, and Schumacker (2013). *Multiple Linear Regression Viewpoints*, *40(2)*, 16-27.

Kleinbaum, D. G., & Kupper, L. L. (1978). *Applied regression analysis and other multivariable methods*. North Scituate, MA: Duxbury Press.

Paternoster, R., Brame, R., Mazerolle, P., Piquero, A. (1998). Using the correct statistical test for the equality of regression coefficients. *Criminology*, *36*, 859-866.

Robinson, C. D., Tomek, S., & Schumacker, R. E. (2013). Tests of moderation effects: Difference in simple slopes versus the interaction term. *Multiple Linear Regression Viewpoints*, *39*(*1*), 16-24.

Walker, D. A. (2014). Standard error of the difference in slopes from separate regressions. [Computer program]. DeKalb, IL: Author.

Send correspondence to: David A. Walker
Northern Illinois University
Email: dawalker@uniu.edu