Cramér V Goodness-of-Fit Test (es_cramer_v_gof)

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Introduction

The *es_cramer_v_gof* function (and *es_cramer_v_gof_arr* in VBA) calculates the effect size Cramér's V for a goodness-of-fit test.

This document contains the details on how to use the functions, and formulas used in them.

1 About the Function

1.1 Input parameters:

- **chi2**
  the chi-square test statistic.

- **n**
  the sample size

- **k**
  the number of categories

- *Optional parameters*
  - **bergsma** (default is false)
    Boolean (true/false) to indicate the use of the Bergsma correction.

  - **out** (default is "value") – only applies to VBA *es_cramer_v_gof*
    Choice what to show as result. Either:
    - "value": the effect size value
    - "qual": the qualification/classification of the value

1.2 Output:

- **Value**
  The Cramer's V value

- Qualification
  The qualification/classification of the effect size using a rule of thumb

- The array version in VBA (*es_cramer_v_gof_arr*) requires **two rows** and **four columns**.

1.3 Dependencies

- **Excel**
  None.
  You can run the **es_cramer_v_gof_addHelp** macro so that the function will be available with some help in the ‘User Defined’ category in the functions overview.

- **Python**
  The following additional libraries will have to be installed/loaded:
  - *pandas*
    the data input needs to be a pandas data series, and the output is also a pandas dataframe.

- **R**
  No other libraries required.

2 Examples

2.1 Excel

	A	B	C	D	E	F	G
1							
2							
3		chi-square value:	3,105263				
4		sample size:	19				
5		number of categories:	4				
6							
7			**Bergsma**				
8		**out**	*FALSE*	*TRUE*			
9		*value*	0,233406	0			
10		*qual*	small	negligible			
11							
12		C9 =>	=es_cramer_v_gof(C3;C4;C5;C$8;$B9)				
13							
14		Cramer's V (GoF)	Qualification				
15		0,233405866	small				
16							
17		B14:C15 =>	=es_cramer_v_gof_arr(C3;C4;C5)				
18							
19		Cramer's V (GoF), with Bergsma correction	Qualification				
20		0	negligible				
21							
22		B19:C20 =>	=es_cramer_v_gof_arr(C3;C4;C5;TRUE)				
23							

2.2 Python

```
[2]: chi2 = 3.105263
     n = 19
     k = 4

     es_cramer_v_gof(chi2, n, k)
```

[2]:

	Cramer's V	Classification
0	0.233406	small

```
[3]: es_cramer_v_gof(chi2, n, k, True)
```

[3]:

	Cramer's V	Classification	comment
0	0.0	negligible	with Bergsma correction

2.3 R

```
> chi2Value <- 3.105263
> n <- 19
> k <- 4
> es_cramer_v_gof(chi2Value, n, k)
          v  qual
1 0.2334059 small
> es_cramer_v_gof(chi2Value, n, k, TRUE)
  v       qual                comment
1 0 negligible with Bergsma correction
> 
```

3 Details of Calculations

3.1 The Original Test

$$V = \sqrt{\frac{\chi^2_{GoF}}{n \times (k - 1)}}$$

Symbols used:

- k the number of categories
- n the sample size, i.e. the sum of all frequencies
- χ^2_{GoF} chi-square value of a Goodness-of-Fit test

3.2 Bergsma Correction

A correction can be applied using the procedure proposed by Bergsma (2013). This is actually for a Cramér's V with a chi-square test of independence, but adapting it for a goodness-of-fit will give:

$$V = \sqrt{\frac{\tilde{\varphi}^2}{\tilde{k} - 1}}$$

With

$$\tilde{\varphi}^2 = max\left(0, \varphi^2 - \frac{k-1}{n-1}\right)$$

$$\tilde{k} = k - \frac{(k-1)^2}{n-1}$$

$$\varphi^2 = \frac{\chi^2_{GoF}}{n}$$

3.3 Interpretation

This uses the interpretation of Cohen's w and converts them to Cramér's V depending on the number of categories.

Table 1

Rule-of-thumb for Cramér's V

k	*Negligible*	*Small*	*Medium*	*Large*
2	0 < 0.100	0.100 < 0.300	0.300 < 0.500	≥ 0.500
3	0 < 0.071	0.071 < 0.212	0.212 < 0.354	≥ 0.354
4	0 < 0.058	0.058 < 0.173	0.173 < 0.289	≥ 0.289
5	0 < 0.050	0.050 < 0.150	0.150 < 0.250	≥ 0.250
k	0.1 / √(k – 1)	0.3 / √(k – 1)	0.5 / √(k – 1)	

Note. Adapted from Cohen (1988, p. 227)

4 Sources

Cramér's V is described in *Mathematical methods of statistics* (Cramér, 1946, p. 282).

> function of the other. Thus $0 \leqq \frac{\varphi^2}{q-1} \leqq 1$, and the quantity $\frac{\varphi^2}{q-1}$ may be used as a measure, on a standardized scale, of the degree of dependence between the variables.

(Cramér, 1946, p. 282)

This measure is actually designed for the chi-square test for independence but can be adjusted for the goodness-of-fit test (Kelley & Preacher, 2012, p. 145; Mangiafico, 2016, p. 474).

> modeling context. Examples of other omnibus effect sizes are squared multiple correlation, Cramér's *V* in a chi-square goodness-of-fit context, the Mahalanobis distance for a standardized measure

(Kelley & Preacher, 2012, p. 145)

The Bergsma correction is found as:

> we propose to use
>
> $$\tilde{V} = \sqrt{\frac{\tilde{\phi}_+^2}{\min(\tilde{r}-1, \tilde{c}-1)}}$$

> sense, we will instead use the nonnegative estimator
>
> $$\tilde{\phi}_+^2 = \max(0, \tilde{\phi}^2).$$

(Bergsma, 2013, pp. 324–325)

Cohen's conversion from Cohen w to Cramer V

> ***Cramér's*** ϕ'. **A useful generalization of ϕ for contingency tables of any dimensionality is provided by Cramér's statistic ϕ' (Hays, 1981, p. 557; Blalock, 1972, p. 297);**
>
> (7.2.6) $$\phi' = \sqrt{\frac{\chi^2}{\mathbf{N}(\mathbf{r}-1)}} = \frac{\mathbf{w}}{\sqrt{\mathbf{r}-1}},$$

(Cohen, 1988, p. 223)

Cohen's classification for his w:

> **small:** $\mathbf{w} = .10$,
> **medium:** $\mathbf{w} = .30$,
> **large:** $\mathbf{w} = .50$.

(Cohen, 1988, p. 227)

References

Bergsma, W. (2013). A bias-correction for Cramér’s and Tschuprow’s. *Journal of the Korean Statistical Society*, *42*(3), 323–328. https://doi.org/10.1016/j.jkss.2012.10.002

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates.

Cramér, H. (1946). *Mathematical methods of statistics*. Princeton University Press.

Kelley, K., & Preacher, K. J. (2012). On effect size. *Psychological Methods*, *17*(2), 137–152. https://doi.org/10.1037/a0028086

Mangiafico, S. S. (2016). *Summary and analysis of extension program evaluation in R* (1.15). Rutger Cooperative Extension.