Separation and Rare Events

Supplementary Materials

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This document contains supplementary information related to the main text.

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1 *Replicating Figure 3 using Stata*

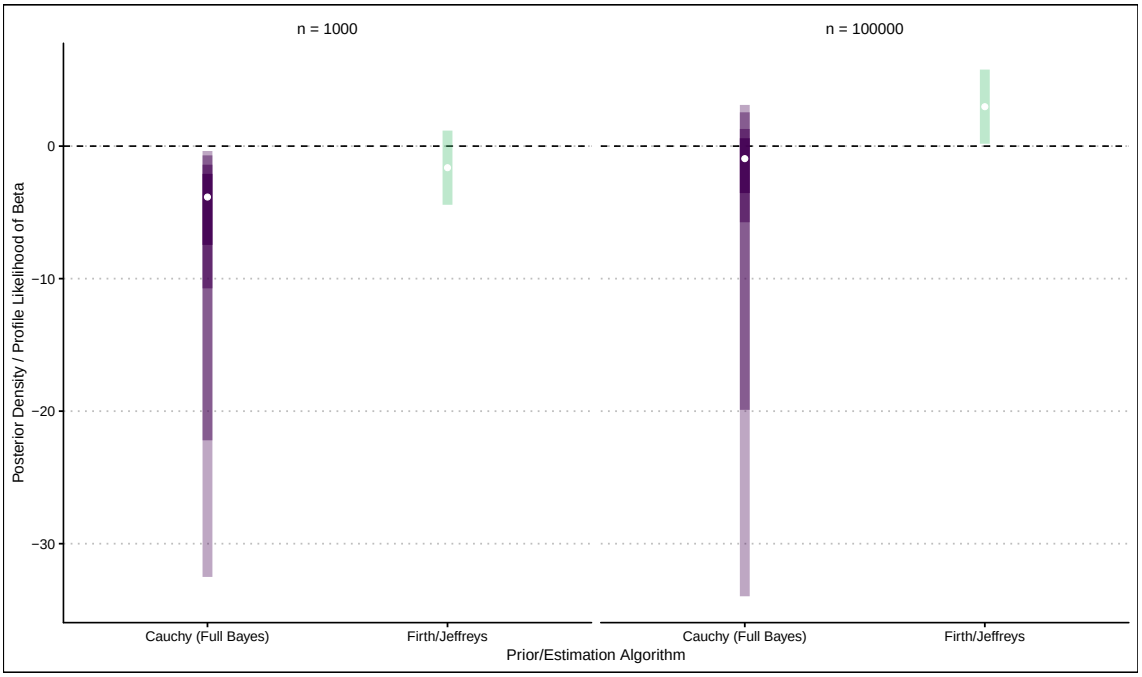

Figure A1: *Estimated coefficients, with measures of uncertainty, for two scenarios using Firth's penalised maximum likelihood and Gelman et. al's Cauchy prior when x and y are rare events and there is negative quasi-complete separation. The shaded areas indicate the central 50%, 68%, 90%, and 95% areas of the posterior density (Cauchy prior) for estimated effect of x (β). Only 95% confidence intervals are available for Firth's PMLE/Jeffreys Prior in Stata. Each panel indicates how these distributions change when increasing the number of observations, where $x = 0 \wedge y = 0$ (n1), from 1000 to 100,000. The number of observations where $x = 1 \wedge y = 0$ (n2) and $x = 0 \wedge y = 1$ (n3) are held constant at 50.*

2 *Descriptive Statistics for Empirical Illustration*

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
War	368,539	0.0001	0.009	0	0	0	1
Sanction Onset	368,539	0.0001	0.008	0	0	0	1
logCapabilityRatio	368,539	1.877	1.369	0.000	0.760	2.736	8.184
Ally	368,539	0.067	0.250	0	0	0	1
SmlDemocracy	368,539	−4.579	5.712	−10	−8	−3	10
SmlDependence	368,539	0.001	0.004	0.000	0.000	0.0001	0.261
logDistance	368,539	8.230	0.779	1.609	7.862	8.786	9.421
Contiguity	368,539	0.039	0.193	0	0	0	1
NIGOs	368,539	22.746	11.457	0	15	29	108
MajorPower	368,539	0.037	0.189	0	0	0	1

3 *Full Regression Table for Empirical Illustration*

	Jeffreys/PMLE	Cauchy (EM)	Cauchy (Stan Optim.)	Cauchy (Full Bayes)	Jeffreys/PMLE	Cauchy (EM)	Cauchy (Stan Optim.)	Cauchy (Full Bayes)
Constant	-9.34***	-9.35***	-9.35***	-9.36***	-3.55***	-11.62***	-11.76***	-11.8***
	[-9.7,-9.01]	[-12.51,-10.76]	[-9.69,-9]	[-9.72,-9.03]	[-7.48,-2.98]	[-12.51,-10.76]	[-12.97,-10.96]	[-12.85,-10.97]
Onset of Sanctions	5.37**	-0.01	-0.2	-0.1	4.07*	-0.03	-0.05	-0.11
	[0.52,7.37]	[-4.06,3.56]	[-4.96,4.75]	[-4.9,4.32]	[-2.69,4.94]	[-4.06,3.56]	[-4.59,4.03]	[-4.98,4.11]
logCapabilityRatio					-0.57***	-1.91***	-2.02***	-2.07***
					[-0.64,-0.24]	[-2.76,-0.92]	[-3.01,-1.17]	[-3.21,-1.07]
Ally					-1.46***	-1.5**	-1.55***	-1.61***
					[-3.49,-1.26]	[-2.6,-0.56]	[-2.69,-0.39]	[-2.97,-0.51]
SmlDemocracy					-0.03**	-0.49	-0.6	-0.55
					[-0.19,-0.02]	[-1.41,0.57]	[-1.87,0.44]	[-1.8,0.46]
SmlDependence					-100.34	-1.33*	-1.63**	-1.71***
					[-108.16,-92.53]	[-2.51,0.08]	[-3.96,-0.26]	[-3.74,-0.32]
logDistance					-0.73***	-1.23***	-1.27***	-1.25***
					[-0.8,-0.36]	[-1.72,-0.78]	[-1.67,-0.8]	[-1.69,-0.77]
Contiguity					3.25***	3.71***	3.68***	3.71***
					[2.27,3.48]	[2.73,4.56]	[2.68,4.93]	[2.66,4.92]
NIGOs					-0.02***	-0.39	-0.36	-0.38
					[-0.06,-0.02]	[-1.05,0.2]	[-1.06,0.41]	[-1.13,0.32]
MajorPower					2.77***	3.02***	3.1***	3.04***
					[1.77,2.94]	[2.13,4.03]	[2.04,4.03]	[2.01,4.03]
n	368539	368539	368539	368539	368539	368539	368539	368539

*** $p < 0.005$, ** $p < 0.05$, * $p < 0.1$

Based upon p-value, or whether zero falls into the associated credible interval. For models using Cauchy priors, all variables are centred. These are further divided by two times their standard deviation if continuous.

4 *Empirical Illustration Estimated in Stata*

	Firth/Jeffreys	Cauchy (Full Bayes)	Firth/Jeffreys	Cauchy (Full Bayes)
Onset of Sanctions	5.37***	-0.88	4.2**	-2.06
	[2.55,8.18]	[-103.67,4.64]	[0.83,7.57]	[-7.89,3.9]
logCapabilityRatio			-0.74***	-1.89***
			[-1.13,-0.35]	[-3.04,-0.94]
Ally			-1.5**	-1.46***
			[-2.65,-0.34]	[-2.95,-0.42]
SmlDemocracy			-0.03	-0.62
			[-0.13,0.06]	[-1.94,0.33]
SmlDependence			-169.76	-1.28**
			[-389.67,50.15]	[-3.16,-0.17]
logDistance			-0.82***	-1.19***
			[-1.11,-0.52]	[-1.64,-0.69]
Contiguity			3.69***	3.65***
			[2.59,4.79]	[2.53,4.68]
NIGOs			-0.02	-0.44
			[-0.05,0.01]	[-1.25,0.37]
MajorPower			3.22***	2.89***
			[2.24,4.21]	[1.79,3.88]
Constant	-9.34***	-9.34***	-3.29**	-11.66***
	[-9.68,-8.99]	[-9.71,-9.04]	[-6.12,-0.47]	[-12.51,-10.82]
n	368539	368539	368539	368539

*** $p < 0.005$, ** $p < 0.05$, * $p < 0.1$

Based upon p-value, or whether zero falls into the associated credible interval.

For models using Cauchy priors, all variables are centred.

These are further divided by two times their standard deviation if continuous.