Online Appendix to Estimating Dark Figures of Crime

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This online appendix contains additional results and figures for our paper "Estimating Dark Figures of Crime".

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A Additional Estimated Models

Table 1: Estimated Parameters Cybercrime Cantons St Gallen and Zug (Model III)

	St Gallen		Zug	
	Lower	Upper	Lower	Upper
Constant on Crime ($\hat{c}$)	(-3.4539	-2.8455)	(-4.0010	-3.7799)
IV on Crime ($\hat{\varphi}$)	(0.2088	0.2781)	(0.1266	0.1655)
R_{prev} on Crime ($\hat{\eta}$)	(2.1848	3.2685)	(1.0008	2.1779)
Constant on Enforcement ($\hat{d}$)	(-2.3977	-1.4127)	(-1.4390	-0.6813)
IV on Enforcement ($\hat{\xi}$)	(0.1379	0.2407)	(0.2966	1.4059)
R_{prev} on Enforcement ($\hat{\alpha}$)	(-0.4373	0.5471)	(-1.8563	0.3711)
$\hat{E}$ (Enforcement estimated on $\hat{\theta}$)	(0.0284	0.0634)	(0.1445	0.9324)
$\hat{C}$ (Cybercrime estimated on $\hat{\theta}$)	(0.0008	0.0206)	(0.0001	0.0004)
N	3'690'564		3'968'712	

Z (IV on Crime): Ln(*N_Emp*) + *Covid* + *Online* + *Retail*

W (IV on Reporting): *AG* + *DSG* + *Listed* + *NIS1* + *Not_Virtual*

This table shows for an additional Model III the confidence intervals of the estimated parameters in Equations 1 and 2 for St Gallen and Zug. The confidence intervals show the same direction and almost identical magnitude across model and canton. With the exception of α for Zug (change of sign), all parameters are significant.

Table 2: Estimated Parameters Cybercrime Cantons St Gallen and Zug (Model IV)

	St Gallen		Zug	
	Lower	Upper	Lower	Upper
Constant on Crime ($\hat{c}$)	(-2.2151	-1.8087)	(-3.1929	-2.1612)
IV on Crime ($\hat{\varphi}$)	(0.2707	0.3682)	(0.1570	0.2763)
R_{prev} on Crime ($\hat{\eta}$)	(1.5235	3.7571)	(0.9748	3.6283)
Constant on Enforcement ($\hat{d}$)	(-3.7372	-3.4322)	(-3.5717	-2.5880)
IV on Enforcement ($\hat{\xi}$)	(0.4552	0.5278)	(0.2931	0.4467)
R_{prev} on Enforcement ($\hat{\alpha}$)	(0.5090	0.8510)	(-0.4517	0.8486)
$\hat{E}$ (Enforcement estimated on $\hat{\theta}$)	(0.0002	0.0046)	(0.0010	0.0244)
$\hat{C}$ (Cybercrime estimated on $\hat{\theta}$)	(0.0221	0.2889)	(0.0037	0.0305)
N	3'690'564		3'968'712	

Z (IV on Crime): Ln(*N_Emp*) + *Covid* + *Online* + *Retail*

W (IV on Reporting): *AG* + *DSG* + *Listed* + *NIS1* + *Not_Virtual* + *Not_Canton*

This table shows for an additional Model IV the confidence intervals of the estimated parameters in Equations 1 and 2 for St Gallen and Zug. The confidence intervals show the same direction and almost identical magnitude across model and canton. With the exception of α for Zug (change of sign), all parameters are significant.

Table 3: Estimated Parameters Cybercrime Cantons St Gallen and Zug (Model V)

	St Gallen		Zug	
	Lower	Upper	Lower	Upper
Constant on Crime ($\hat{c}$)	(-2.4941	-1.6498)	(-3.7464	-3.4873)
IV on Crime ($\hat{\varphi}$)	(0.3470	0.5467)	(0.1385	0.2448)
R_{prev} on Crime ($\hat{\eta}$)	(1.4511	2.7542)	(1.2198	1.8599)
Constant on Enforcement ($\hat{d}$)	(-3.2544	-2.5938)	(-1.8626	-1.2700)
IV on Enforcement ($\hat{\xi}$)	(0.2552	0.3509)	(0.5287	1.3147)
R_{prev} on Enforcement ($\hat{\alpha}$)	(0.5499	1.2171)	(-1.0193	1.1251)
$\hat{E}$ (Enforcement estimated on $\hat{\theta}$)	(0.0017	0.0102)	(0.0586	0.8847)
$\hat{C}$ (Cybercrime estimated on $\hat{\theta}$)	(0.0191	0.1193)	(0.0001	0.0003)
N	3'690'564		3'968'712	

Z (IV on Crime): *Covid + Online + Retail*

W (IV on Reporting): *AG + DSG + Listed + NIS1 + Not_Virtual*

This table shows for an additional Model V the confidence intervals of the estimated parameters in Equations 1 and 2 for St Gallen and Zug. The confidence intervals show the same direction and almost identical magnitude across model and canton. With the exception of α for Zug (change of sign), all parameters are significant.

B Additional Results

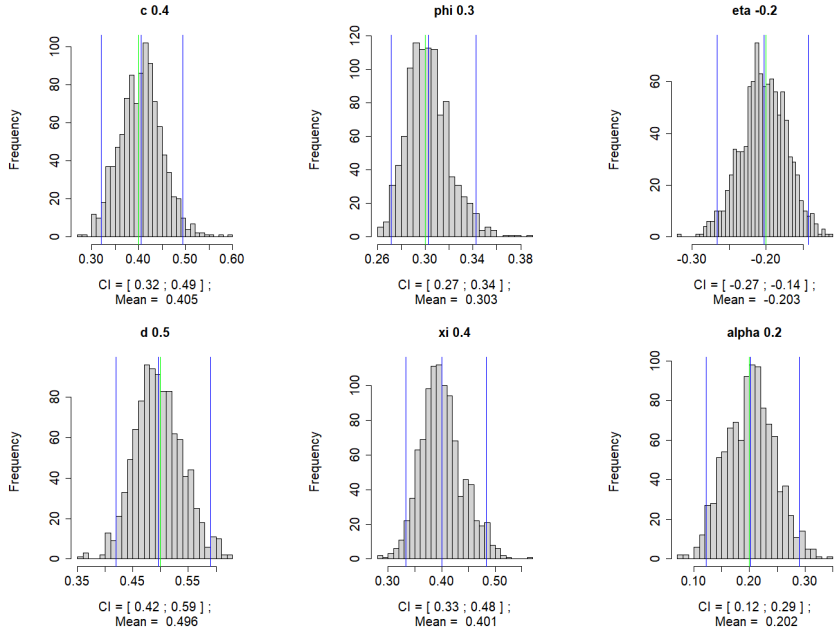

Figure 1: Bootstrapping estimated Parameters for 1000 Simulations
Note: This figure shows the distribution of all estimated parameters in 1000 simulations with 100'000 observations each. We show the confidence intervals below in each subplot, with the lower and upper bounds (thin blue vertical lines). The estimated mean is in the middle of the distribution (blue vertical line in the middle). The simulated (true) value is the green line.

Table 4: Parameter Estimations Cantons St Gallen and Zug

	St Gallen		Zug	
	Model I	Model II	Model I	Model II
Constant on Crime ($\hat{c}$)	-1.2123^{***}	-1.5848^{***}	-1.4772^{**}	-2.1919^{***}
	(0.1327)	(0.1123)	(0.4571)	(0.2960)
IV on Crime ($\hat{\varphi}$)	0.6765^{***}	0.6856^{***}	0.5327^{***}	0.4879^{***}
	(0.0705)	(0.0572)	(0.1543)	(0.0758)
R_{prev} on Crime ($\hat{\eta}$)	1.8558^{***}	2.1003^{***}	1.3675	1.4725^{**}
	(0.4172)	(0.4043)	(0.7405)	(0.5272)
Constant on Enforcement ($\hat{d}$)	-3.9609^{***}	-3.8014^{***}	-3.8162^{***}	-3.4472^{***}
	(0.0627)	(0.0674)	(0.2205)	(0.2106)
IV on Enforcement ($\hat{\xi}$)	0.5708^{***}	0.5668^{***}	0.3839^{***}	0.4299^{***}
	(0.0189)	(0.0187)	(0.0339)	(0.0387)
R_{prev} on Enforcement ($\hat{\alpha}$)	0.8975^{***}	0.7435^{***}	0.9133^{**}	0.6003^{*}
	(0.0793)	(0.0805)	(0.2859)	(0.2939)
$\hat{E}$ (Enforcement Estimated on $\hat{\theta}$)	0.0011	0.0016	0.0008	0.0033
	(0.0034)	(0.0039)	(0.0013)	(0.0040)
$\hat{C}$ (Cybercrime Estimated on $\hat{\theta}$)	0.1785	0.1076	0.0979	0.0235
	(0.1108)	(0.0917)	(0.0549)	(0.0218)
Observations	3′690′564	3′690′564	3′968′712	3′968′712

Note: Significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively.
Model I
Z (IV on Crime): *Covid + Online + Retail*
W (IV on Reporting): *AG + DSG + Listed + NIS1 + Not_Virtual + Not_Canton*
Model II
Z (IV on Crime): *Covid + Mid_Sized + Large_Sized + Online + Retail*
W (IV on Reporting): *AG + DSG + Listed + NIS1 + Not_Virtual + Not_Canton*
(Variable Values and Range see Table 22)

Table 5: Evaluation of Results (Model I)

Canton	κ	LM_C	p_C	LM_E	p_E
SG	7484.806	105.8112	0	93.33228	0
ZG	13505.54	31.40451	0	28.92275	1e-07

Z: *Covid + Online + Retail*
W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for the estimates in Table 4 the condition number and the Lagrange Multiplier statistics with p-values for the unrestricted Equations 6 and 7.

Table 6: Evaluation Values (Model II)

Canton	κ	LM_C	p_C	LM_E	p_E
SG	6650.83	116.9504	0	84.80163	0
ZG	6080.90	145.2108	0	1e-7	0.9998

Z: *Covid + Mid_Sized + Large_Sized + Online + Retail*
W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for the estimates in Table 4 the condition number and the Lagrange Multiplier statistics with p-values for the unrestricted Equations 6 and 7.

C Multiple Starting Points

Table 7: Different Initial Parameters Simulation

c	φ	η	d	ξ	α	Value	κ	$\bar{se}$	c_0	φ_0	η_0	d_0	ξ_0	α_0
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	-1.121	-0.460	3.117	0.141	0.259	3.430
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	0.922	-2.530	-1.374	-0.891	2.448	0.720
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	0.802	0.221	-1.112	3.574	0.996	-3.933
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	1.403	-0.946	-2.136	-0.436	-2.052	-1.458
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	-1.250	-3.373	1.676	0.307	-2.276	2.508
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	0.853	-0.590	1.790	1.756	1.643	1.377
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.98e+02	0.012	1.108	-0.124	-0.612	-0.761	-1.389	-0.416
0.422	0.305	-0.209	0.476	0.388	0.203	661165.7	6.95e+02	0.012	-2.531	4.338	2.416	-2.246	-0.806	-0.933
0.423	0.305	-0.210	0.475	0.387	0.203	661165.7	6.96e+02	0.012	1.560	-0.167	0.507	-0.057	-0.086	2.737
0.126	0.226	-0.068	0.905	32.269	0.143	662500.9	Inf	0.000	-0.452	3.033	-3.098	1.169	0.248	0.432
0.126	0.226	-0.068	0.905	8.173	0.143	662500.9	Inf	0.000	0.759	-1.005	-0.666	-2.037	-2.144	0.607
0.336	0.242	-0.351	0.596	0.498	8.001	663259.3	Inf	0.000	0.896	0.106	1.845	4.100	-0.982	-4.618
0.132	0.220	-0.126	0.906	9.665	6.236	664102.3	Inf	0.000	2.011	-1.418	-1.376	2.051	-0.570	-2.441
0.057	0.218	0.010	5.050	11.995	-4.001	665215.9	Inf	0.000	0.363	-0.278	0.012	0.771	-0.741	1.289
0.734	0.565	7.743	0.289	0.198	-0.264	665883.9	1.07e+18	0.000	-0.441	0.664	2.194	0.870	-0.652	2.298
0.062	0.213	-0.049	32.312	40.133	18.303	666804.3	Inf	0.000	1.987	1.097	0.477	-1.256	2.721	-1.201
0.062	0.213	-0.049	47.892	-18.403	-4.708	666804.3	3.78e+26	0.000	4.375	3.065	-0.471	-2.053	-1.421	0.514
0.062	0.213	-0.049	25.213	-5.708	-8.357	666804.3	3.33e+24	0.000	-0.493	-0.695	-1.903	-0.090	-1.570	-3.336
6.649	3.065	1.559	0.090	0.184	-0.050	668541.3	4.00e+17	0.000	-0.760	1.838	-1.151	1.216	-3.236	-0.111
46.643	-17.849	-2.765	0.090	0.184	-0.050	668541.3	Inf	0.000	1.039	0.602	0.211	-1.281	-1.699	-2.048

This table shows for the simulation 20 optimization runs with different starting points. The resulting estimates are in columns 1 to 6. The respective objective value, condition number κ and mean standard errors are in columns 7 to 9. The randomly set initial parameter values are shown in columns 10 to 15. The results are sorted by objective value and condition number. Confidence intervals of the best result are shown in Table **??**.

Table 8: Different Initial Parameter St Gallen (Model I)

c	φ	η	d	ξ	α	Value	κ	$\bar{se}$	c_0	φ_0	η_0	d_0	ξ_0	α_0
-1.212	0.677	1.856	-3.961	0.571	0.898	6902.927	7.48e+03	0.13	-1.121	-0.460	3.117	0.141	0.259	3.430
-1.212	0.677	1.856	-3.961	0.571	0.898	6902.927	7.48e+03	0.13	0.922	-2.530	-1.374	-0.891	2.448	0.720
-1.212	0.677	1.856	-3.961	0.571	0.898	6902.927	7.48e+03	0.13	0.802	0.221	-1.112	3.574	0.996	-3.933
-1.212	0.677	1.856	-3.961	0.571	0.898	6902.927	7.49e+03	0.13	1.403	-0.946	-2.136	-0.436	-2.052	-1.458
-1.170	0.709	4.356	-3.973	0.564	0.848	6904.291	7.35e+05		-1.250	-3.373	1.676	0.307	-2.276	2.508
-1.170	0.709	11.961	-3.973	0.564	0.848	6904.295	3.17e+18	0.00	0.853	-0.590	1.790	1.756	1.643	1.377
-1.170	0.709	7.117	-3.973	0.564	0.848	6904.295	9.54e+10		1.108	-0.124	-0.612	-0.761	-1.389	-0.416
-1.170	0.709	7.092	-3.973	0.564	0.848	6904.295	1.91e+11		-2.531	4.338	2.416	-2.246	-0.806	-0.933
-1.170	0.709	159.033	-3.973	0.564	0.848	6904.295	2.04e+18	0.00	1.560	-0.167	0.507	-0.057	-0.086	2.737
-0.276	17.433	2.072	-4.251	0.536	1.206	6936.584	1.74e+18	0.00	-0.452	3.033	-3.098	1.169	0.248	0.432
-0.276	6.913	3.428	-4.250	0.535	1.199	6936.642	1.09e+10		0.759	-1.005	-0.666	-2.037	-2.144	0.607
-0.276	4.813	107.814	-4.250	0.535	1.199	6936.644	1.29e+18	0.00	0.896	0.106	1.845	4.100	-0.982	-4.618
-0.276	32.754	14.960	-4.250	0.535	1.199	6936.644	6.04e+18	0.00	2.011	-1.418	-1.376	2.051	-0.570	-2.441
-2.013	0.280	-0.010	-3.698	0.771	9.100	6949.593	3.21e+09		0.363	-0.278	0.012	0.771	-0.741	1.289
-2.013	0.280	-0.010	-3.698	0.771	9.192	6949.593	5.05e+09		-0.441	0.664	2.194	0.870	-0.652	2.298
-2.013	0.280	-0.010	-3.698	0.771	20.178	6949.593	Inf	0.00	1.987	1.097	0.477	-1.256	2.721	-1.201
-2.013	0.280	-0.010	-3.698	0.771	54.504	6949.593	Inf	0.00	4.375	3.065	-0.471	-2.053	-1.421	0.514
-2.013	0.280	-0.010	-3.698	0.771	12.082	6949.593	Inf	0.00	-0.493	-0.695	-1.903	-0.090	-1.570	-3.336
-3.684	0.233	1.707	11.025	29.198	102.537	7544.701	Inf	0.00	-0.760	1.838	-1.151	1.216	-3.236	-0.111
-3.685	0.233	1.707	114.193	43.808	36.576	7545.091	Inf	0.00	1.039	0.602	0.211	-1.281	-1.699	-2.048

Z: *Covid + Online + Retail*

W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for St Gallen (Model I) 20 optimization runs with different starting points. The resulting estimates are in columns 1 to 6. The respective objective value, condition number κ and mean standard errors are in columns 7 to 9. The randomly set initial parameter values are shown in columns 10 to 15. The results are sorted by objective value and condition number. Confidence intervals of the best result are shown in Table **??**.

Table 9: Different Initial Parameter Zug (Model I)

c	φ	η	d	ξ	α	Value	κ	$\bar{se}$	c_0	φ_0	η_0	d_0	ξ_0	α_0
-1.477	0.533	1.367	-3.816	0.384	0.913	3145.263	1.35e+04	0.315	-1.121	-0.460	3.117	0.141	0.259	3.430
-1.477	0.533	1.367	-3.816	0.384	0.913	3145.263	1.35e+04	0.315	0.922	-2.530	-1.374	-0.891	2.448	0.720
-1.477	0.533	1.367	-3.816	0.384	0.913	3145.263	1.35e+04	0.315	0.802	0.221	-1.112	3.574	0.996	-3.933
-1.477	0.533	1.367	-3.816	0.384	0.913	3145.263	1.35e+04	0.315	1.403	-0.946	-2.136	-0.436	-2.052	-1.458
-1.514	0.521	1.387	-3.797	0.385	0.898	3145.268	1.28e+04	0.303	-1.250	-3.373	1.676	0.307	-2.276	2.508
-0.261	17.208	4.828	-4.223	0.344	1.197	3152.185	2.12e+18	0.000	0.853	-0.590	1.790	1.756	1.643	1.377
-2.093	0.344	-0.360	-3.452	0.426	40.910	3159.725	Inf	0.000	1.108	-0.124	-0.612	-0.761	-1.389	-0.416
-2.093	0.344	-0.361	-3.452	0.426	38.431	3159.725	Inf	0.000	-2.531	4.338	2.416	-2.246	-0.806	-0.933
-2.093	0.344	-0.361	-3.452	0.426	87.312	3159.725	Inf	0.000	1.560	-0.167	0.507	-0.057	-0.086	2.737
-2.093	0.344	-0.361	-3.452	0.426	24.588	3159.725	Inf	0.000	-0.452	3.033	-3.098	1.169	0.248	0.432
-2.093	0.344	-0.361	-3.452	0.426	79.309	3159.725	Inf	0.000	0.759	-1.005	-0.666	-2.037	-2.144	0.607
-2.093	0.344	-0.361	-3.452	0.426	57.065	3159.725	Inf	0.000	0.896	0.106	1.845	4.100	-0.982	-4.618
-2.093	0.344	-0.361	-3.452	0.426	41.746	3159.725	Inf	0.000	2.011	-1.418	-1.376	2.051	-0.570	-2.441
8.007	5.749	20.020	-4.305	0.301	1.386	3178.338	Inf	0.000	0.363	-0.278	0.012	0.771	-0.741	1.289
-3.813	0.166	1.509	-1.022	29.107	-8.313	3271.378	Inf	0.000	-0.441	0.664	2.194	0.870	-0.652	2.298
-3.813	0.167	1.494	-1.022	10.304	6.636	3273.136	Inf	0.000	1.987	1.097	0.477	-1.256	2.721	-1.201
-3.813	0.167	1.494	-1.022	144.463	12.040	3273.136	Inf	0.000	4.375	3.065	-0.471	-2.053	-1.421	0.514
-3.851	0.174	1.604	20.317	24.583	-45.485	3294.026	3.40e+10		-0.493	-0.695	-1.903	-0.090	-1.570	-3.336
-3.853	0.177	1.541	14.008	18.778	-18.672	3297.374	8.55e+10	1049	-0.760	1.838	-1.151	1.216	-3.236	-0.111
-3.858	0.181	1.529	10.164	3.652	-1.650	3303.203	Inf	0.000	1.039	0.602	0.211	-1.281	-1.699	-2.048

Z: *Covid + Mid_Sized + Large_Sized + Online + Retail*

W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for Zug (Model I) 20 optimization runs with different starting points. The resulting estimates are in columns 1 to 6. The respective objective value, condition number κ and mean standard errors are in columns 7 to 9. The randomly set initial parameter values are shown in columns 10 to 15. The results are sorted by objective value and condition number. Confidence intervals of the best result are shown in Table **??**.

Table 10: Different Initial Parameter St Gallen (Model II)

c	φ	η	d	ξ	α	Value	κ	$\bar{se}$	c_0	φ_0	η_0	d_0	ξ_0	α_0
-1.585	0.686	2.100	-3.801	0.567	0.743	6829.762	6.65e+03	0.123	-1.121	-0.460	3.117	0.141	0.259	3.430
-1.585	0.686	2.098	-3.801	0.567	0.744	6829.762	6.62e+03	0.123	0.922	-2.530	-1.374	-0.891	2.448	0.720
-1.553	0.713	35.371	-3.818	0.562	0.697	6831.324	1.74e+18	0.000	0.802	0.221	-1.112	3.574	0.996	-3.933
-1.553	0.713	17.927	-3.818	0.562	0.697	6831.324	7.87e+17	0.000	1.403	-0.946	-2.136	-0.436	-2.052	-1.458
-1.553	0.713	11.274	-3.818	0.562	0.697	6831.324	4.22e+19	0.000	-1.250	-3.373	1.676	0.307	-2.276	2.508
-1.553	0.713	146.155	-3.818	0.562	0.697	6831.324	8.33e+17	0.000	0.853	-0.590	1.790	1.756	1.643	1.377
-2.289	0.322	0.276	-3.520	0.794	2.439	6851.527	2.12e+03	0.107	1.108	-0.124	-0.612	-0.761	-1.389	-0.416
-2.309	0.321	0.147	-3.526	0.809	8.671	6872.163	1.07e+09		-2.531	4.338	2.416	-2.246	-0.806	-0.933
-2.309	0.321	0.147	-3.526	0.809	16.010	6872.163	Inf	0.000	1.560	-0.167	0.507	-0.057	-0.086	2.737
-2.309	0.321	0.147	-3.526	0.809	50.658	6872.163	Inf	0.000	-0.452	3.033	-3.098	1.169	0.248	0.432
-2.309	0.321	0.147	-3.526	0.809	202.076	6872.163	Inf	0.000	0.759	-1.005	-0.666	-2.037	-2.144	0.607
-2.309	0.321	0.147	-3.526	0.809	20.871	6872.163	Inf	0.000	0.896	0.106	1.845	4.100	-0.982	-4.618
-2.309	0.321	0.147	-3.526	0.809	10.818	6872.163	Inf	0.000	2.011	-1.418	-1.376	2.051	-0.570	-2.441
-2.309	0.321	0.147	-3.526	0.809	12.413	6872.163	Inf	0.000	0.363	-0.278	0.012	0.771	-0.741	1.289
-2.309	0.321	0.147	-3.526	0.809	52.685	6872.163	Inf	0.000	-0.441	0.664	2.194	0.870	-0.652	2.298
-0.506	6.322	2.211	-4.227	0.533	1.187	6896.476	1.79e+09		1.987	1.097	0.477	-1.256	2.721	-1.201
-0.506	12.427	15.543	-4.227	0.533	1.181	6896.549	1.48e+19	0.000	4.375	3.065	-0.471	-2.053	-1.421	0.514
5.448	33.236	0.224	-4.342	0.506	1.367	7006.910	2.02e+19	0.000	-0.493	-0.695	-1.903	-0.090	-1.570	-3.336
-3.738	0.295	1.611	16.370	30.059	36.271	7416.776	Inf	0.000	-0.760	1.838	-1.151	1.216	-3.236	-0.111
-3.738	0.295	1.612	401.311	52.476	56.489	7417.099	Inf	0.000	1.039	0.602	0.211	-1.281	-1.699	-2.048

Z: *Covid + Mid_Sized + Large_Sized + Online + Retail*

W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for St Gallen (Model II) 20 optimization runs with different starting points. The resulting estimates are in columns 1 to 6. The respective objective value, condition number κ and mean standard errors are in columns 7 to 9. The randomly set initial parameter values are shown in columns 10 to 15. The results are sorted by objective value and condition number. Confidence intervals of the best result are shown in Table **??**.

Table 11: Different Initial Parameter Zug (Model II)

c	φ	η	d	ξ	α	Value	κ	$\bar{se}$	c_0	φ_0	η_0	d_0	ξ_0	α_0
-2.192	0.488	1.473	-3.447	0.430	0.600	3105.311	6.08e+03	0.240	-1.121	-0.460	3.117	0.141	0.259	3.430
-2.192	0.488	1.472	-3.447	0.430	0.600	3105.311	6.08e+03	0.240	0.922	-2.530	-1.374	-0.891	2.448	0.720
-2.192	0.488	1.472	-3.447	0.430	0.600	3105.311	6.08e+03	0.240	0.802	0.221	-1.112	3.574	0.996	-3.933
-2.246	0.477	1.498	-3.409	0.435	0.565	3105.328	6.06e+03	0.245	1.403	-0.946	-2.136	-0.436	-2.052	-1.458
-2.618	0.370	0.015	-3.108	0.490	57.206	3118.793	Inf	0.000	-1.250	-3.373	1.676	0.307	-2.276	2.508
-2.618	0.370	0.015	-3.108	0.490	53.480	3118.793	Inf	0.000	0.853	-0.590	1.790	1.756	1.643	1.377
-2.618	0.370	0.015	-3.108	0.490	12.804	3118.793	Inf	0.000	1.108	-0.124	-0.612	-0.761	-1.389	-0.416
-2.618	0.370	0.015	-3.108	0.490	28.350	3118.793	Inf	0.000	-2.531	4.338	2.416	-2.246	-0.806	-0.933
-2.618	0.370	0.015	-3.108	0.490	29.276	3118.793	Inf	0.000	1.560	-0.167	0.507	-0.057	-0.086	2.737
-2.618	0.370	0.015	-3.108	0.490	79.254	3118.793	Inf	0.000	-0.452	3.033	-3.098	1.169	0.248	0.432
-2.618	0.370	0.015	-3.108	0.490	38.298	3118.793	Inf	0.000	0.759	-1.005	-0.666	-2.037	-2.144	0.607
-0.474	14.185	0.861	-4.208	0.350	1.232	3133.934	4.61e+18	0.000	0.896	0.106	1.845	4.100	-0.982	-4.618
-0.476	10.459	21.097	-4.210	0.351	1.165	3134.916	1.38e+18	0.000	2.011	-1.418	-1.376	2.051	-0.570	-2.441
-3.864	0.251	1.419	-0.973	6.830	-2.102	3227.574	8.82e+05		0.363	-0.278	0.012	0.771	-0.741	1.289
-3.865	0.252	1.406	-0.972	10.409	5.973	3228.900	Inf	0.000	-0.441	0.664	2.194	0.870	-0.652	2.298
-3.865	0.252	1.406	-0.972	12.632	49.145	3228.900	Inf	0.000	1.987	1.097	0.477	-1.256	2.721	-1.201
-3.902	0.260	1.447	3.576	166.363	-20.942	3250.866	Inf	0.000	4.375	3.065	-0.471	-2.053	-1.421	0.514
-3.902	0.260	1.447	6.537	107.889	-35.693	3250.872	Inf	0.000	-0.493	-0.695	-1.903	-0.090	-1.570	-3.336
-3.903	0.261	1.434	19.245	30.700	-3.741	3252.170	Inf	0.000	-0.760	1.838	-1.151	1.216	-3.236	-0.111
-3.907	0.263	1.436	33.857	18.235	11.453	3255.747	Inf	0.000	1.039	0.602	0.211	-1.281	-1.699	-2.048

Z: *Covid + Mid_Sized + Large_Sized + Online + Retail*

W: *AG + DSG + Listed + NIS1 + Not_Virtual Not_Canton*

This table shows for Zug (Model II) 20 optimization runs with different starting points. The resulting estimates are in columns 1 to 6. The respective objective value, condition number κ and mean standard errors are in columns 7 to 9. The randomly set initial parameter values are shown in columns 10 to 15. The results are sorted by objective value and condition number. Confidence intervals of the best result are shown in Table **??**.

D Correlation Tables

Table 12: Correlation Matrix Simulation

	R_{prev}	R	Z	W
R_{prev} (Recorded earlier Period)	1			
R (Recorded)	-0.0193	1		
Z (IV affecting Crime)	-0.0013	0.1179	1	
W (IV affecting Enforcement)	0.0025	0.1021	0.0008	1

This table shows the correlation matrix of the simulated values for 1 million observations (Section **??**). It indicates that there is no collinearity between Z and W, which requires strict exogeneity in theory. By construction, R correlates with W and Z in the simulation. Note that in our simulation, no observed variables experience a high level of correlation.

Table 13: Correlation Cybercrime Canton St Gallen (Model I)

	R_{prev}	R	Z	W
R_{prev} (Recorded earlier Period)	1			
R (Recorded)	0.1113	1		
Z (IV affecting Crime)	0.0378	0.0139	1	
W (IV affecting Enforcement)	0.0703	0.0269	0.1385	1

This table shows the correlation between the observed variables for cybercrime used for estimation in canton St Gallen (Model I): policy shock for cybercrime (W), external shock for reporting (Z), reporting in earlier time period (R_{prev}) and reporting (R).

Table 14: Correlation Cybercrime Canton St Gallen (Model II)

	R_{prev}	R	Z	W
R_{prev} (Recorded earlier Period)	1			
R (Recorded)	0.1113	1		
Z (IV affecting Crime)	0.0558	0.0208	1	
W (IV affecting Enforcement)	0.0703	0.0269	0.1569	1

This table shows the correlation between the observed variables for cybercrime used for estimation in canton St Gallen (Model II): policy shock for cybercrime (W), external shock for reporting (Z), reporting in earlier time period (R_{prev}) and reporting (R).

Table 15: Correlation Cybercrime Canton Zug (Model I)

	R_{prev}	R	Z	W
R_{prev} (Recorded earlier Period)	1			
R (Recorded)	0.0427	1		
Z (IV affecting Crime)	0.0158	0.0050	1	
W (IV affecting Enforcement)	0.0261	0.0097	0.0259	1

This table shows the correlation between the observed variables for cybercrime used for estimation in canton Zug (Model I): policy shock for cybercrime (W), external shock for reporting (Z), reporting in earlier time period (R_{prev}) and reporting (R).

Table 16: Correlation Cybercrime Canton Zug (Model II)

	R_{prev}	R	Z	W
R_{prev} (Recorded earlier Period)	1			
R (Recorded)	0.0427	1		
Z (IV affecting Crime)	0.0270	0.0090	1	
W (IV affecting Enforcement)	0.0261	0.0097	0.041	1

This table shows the correlation between the observed variables for cybercrime used for estimation in canton Zug (Model II): policy shock for cybercrime (W), external shock for reporting (Z), reporting in earlier time period (R_{prev}) and reporting (R).

Table 17: Correlation Cybercrime Canton SG

	R_{prev}	R	*N_Emp*	*Covid*	*Online*	*Retail*	*AG*	*Listed*	*NIS1*	*DSG*	*Not_V*	*Not_C*
R_{prev}	1	0.1113	0.0387	-0.0005	0.0577	0.0461	0.0375	0.0298	0.0054	0.0002	0.0040	0.3443
R	0.1113	1	0.0294	0.0011	0.0235	0.0178	0.0136	0.0100	0.0025	0.0007	0.0014	0.1328
N_Emp	0.0387	0.0294	1	-0.0013	-0.0012	-0.0024	0.0058	0.1400	-0.0010	-0.0004	0.0017	0.0795
Covid	-0.0005	0.0011	-0.0013	1	0.0059	0.0025	-0.0161	-0.0001	0.6230	0.1909	0.0017	-0.0027
Online	0.0577	0.0235	-0.0012	0.0059	1	0.3127	-0.0357	-0.0017	0.0045	0.0028	0.0021	0.1155
Retail	0.0461	0.0178	-0.0024	0.0025	0.3127	1	-0.0881	-0.0054	0.0016	0.0020	0.0171	0.1024
AG	0.0375	0.0136	0.0058	-0.0161	-0.0357	-0.0881	1	0.0220	-0.0111	-0.0057	-0.0390	0.0654
Listed	0.0298	0.0100	0.1400	-0.0001	-0.0017	-0.0054	0.0220	1	0.0000	-0.0001	0.0015	0.0519
NIS1	0.0054	0.0025	-0.0010	0.6230	0.0045	0.0016	-0.0111	0.0000	1	0.1190	0.0020	-0.0016
DSG	0.0002	0.0007	-0.0004	0.1909	0.0028	0.0020	-0.0057	-0.0001	0.1190	1	0.0000	-0.0011
Not_Virtual	0.0040	0.0014	0.0017	0.0017	0.0021	0.0171	-0.0390	0.0015	0.0020	0.0000	1	0.0069
Not_Canton	0.3443	0.1328	0.0795	-0.0027	0.1155	0.1024	0.0654	0.0519	-0.0016	-0.0011	0.0069	1

This table shows the correlation between all used observed variables for cybercrime in Canton St Gallen.

Table 18: Correlation Cybercrime Canton ZG

	R_{prev}	R	*N_Emp*	*Covid*	*Online*	*Retail*	*AG*	*Listed*	*NIS1*	*DSG*	*Not_V*	*Not_C*
R_{prev}	1	0.0427	0.0182	-0.0007	0.0207	0.0249	0.0148	0.0028	0.0014	-0.0032	0.0142	0.2378
R	0.0427	1	0.0053	0.0006	0.0074	0.0089	0.0047	0.0007	0.0016	0.0006	0.0044	0.0797
N_Emp	0.0182	0.0053	1	-0.0021	-0.0010	-0.0007	0.0032	0.1789	-0.0012	-0.0013	0.0083	0.1016
Covid	-0.0007	0.0006	-0.0021	1	0.0039	0.0088	-0.0217	0.0014	0.6441	0.3806	-0.0233	-0.0022
Online	0.0207	0.0074	-0.0010	0.0039	1	0.3693	-0.0376	-0.0021	0.0031	0.0029	-0.0089	0.0632
Retail	0.0249	0.0089	-0.0007	0.0088	0.3693	1	-0.0811	-0.0006	0.0071	0.0076	0.0096	0.0793
AG	0.0148	0.0047	0.0032	-0.0217	-0.0376	-0.0811	1	0.0246	-0.0179	-0.0146	-0.0100	0.0265
Listed	0.0028	0.0007	0.1789	0.0014	-0.0021	-0.0006	0.0246	1	0.0017	0.0003	0.0038	-0.0012
NIS1	0.0014	0.0016	-0.0012	0.6441	0.0031	0.0071	-0.0179	0.0017	1	0.2451	-0.0194	-0.0015
DSG	-0.0032	0.0006	-0.0013	0.3806	0.0029	0.0076	-0.0146	0.0003	0.2451	1	-0.0168	-0.0020
Not_Virtual	0.0142	0.0044	0.0083	-0.0233	-0.0089	0.0096	-0.0100	0.0038	-0.0194	-0.0168	1	0.0211
Not_Canton	0.2378	0.0797	0.1016	-0.0022	0.0632	0.0793	0.0265	-0.0012	-0.0015	-0.0020	0.0211	1

This table shows the correlation between all used observed variables for cybercrime in Canton Zug.

E Additional Summary Statistics

Table 19: Summary Statistics Simulated Data

	Mean	Median	SD	Min	Max	Skew	Obs
Z (IV affecting Crime)	0.9986	1	0.71	0	2	0	1'000'000
W (IV affecting Enforcement)	1.0009	1	0.71	0	2	0.00	1'000'000
R_{prev} (Recorded earlier period)	0.5005	1	0.50	0	1	0.00	1'000'000
R (Recorded)	0.5976	1	0.49	0	1	-0.40	1'000'000
E (Enforcement)	0.8306	1	0.38	0	1	-1.76	1'000'000
C (Crime)	0.7205	1	0.45	0	1	-0.98	1'000'000

This table provides summary statistics for the simulated variables. Here, both instruments, Z and W, independently take the binomial distributed values for 0, 1 and 2 as set in the simulation. Around 72% of all entities simulated in the population are subject to crime (C). About 83% of the entities experience high detection effort / reporting incentive (E). This gives a rate of recorded crime $R = C \cdot E$ of nearly 60%. Around 50% of all entities have been recorded in crime in a previous time period (R_{prev}).

Table 20: Summary Statistics Sample of Cybercrime Reporting Firms Canton St Gallen, registered in St Gallen (Upper Panel) and registered in other canton (Lower Panel)

	Mean	Median	SD	Min	Max	Skew	Obs
Mean(*N_Emp*)	49.6770	4	358.58	1	5820.8	15.48	270
Mid_Sized	0.1296	0.0	0.34	0	1.0	2.19	270
Large_Sized	0.0074	0.0	0.09	0	1.0	11.43	270
Retail	0.1407	0	0.35	0	1	2.05	270
Online	0.0333	0	0.18	0	1	5.17	270
Not_Virtual	0.0000	0.0	0	0	0.0		270
AG	0.6667	1	0.47	0	1	-0.70	270
Listed	0	0	0	0	0		270
Not_Canton	0.0000	0.0	0	0	0.0		270

	Mean	Median	SD	Min	Max	Skew	Obs
Mean(*N_Emp*)	517.4782	4	6583.73	1	106370.5	15.53	269
Mid_Sized	0.2156	0	0.41	0	1.0	1.38	269
Large_Sized	0.0223	0	0.15	0	1.0	6.43	269
Retail	0.4275	0	0.50	0	1	0.29	269
Online	0.1413	0	0.35	0	1	2.05	269
Not_Virtual	0.0000	0	0	0	0.0		269
AG	0.6989	1	0.46	0	1	-0.86	269
Listed	0.0112	0	0.11	0	1	9.26	269
Not_Canton	1.0000	1	0	1	1.0		269

This table provides summary statistics for the companies reporting cybercrime in Canton St Gallen. The Upper Panel shows the reporting companies registered in Canton St Gallen, the Lower Panel shows reporting companies registered in another canton.

Table 21: Summary Statistics Sample of Cybercrime Reporting Firms Canton Zug, registered in Zug (Upper Panel) and registered in other canton (Lower Panel)

	Mean	Median	SD	Min	Max	Skew	Obs
Mean(*N_Emp*)	27.6342	4	109.10	1	1'340	9.93	185
Mid_Sized	0.1081	0	0.31	0	1	2.50	185
Large_Sized	0.0108	0	0.10	0	1	9.38	185
Retail	0.0595	0	0.24	0	1	3.70	185
Online	0.0162	0	0.13	0	1	7.60	185
AG	0.7676	1	0.42	0	1	-1.26	185
Listed	0.0054	0	0.07	0	1	13.38	185
Not_Virtual	0.0000	0	0	0	0		185
Not_Canton	0.0000	0	0	0	0		185

	Mean	Median	SD	Min	Max	Skew	Obs
Mean(*N_Emp*)	1'411.5600	15	11'174.31	1	96'793	8.29	75
Mid_Sized	0.2933	0	0.46	0	1	0.89	75
Large_Sized	0.0533	0	0.23	0	1	3.90	75
Retail	0.3867	0	0.49	0	1	0.46	75
Online	0.1067	0	0.31	0	1	2.50	75
AG	0.8400	1	0.37	0	1	-1.82	75
Listed	0	0	0	0	0		75
Not_Virtual	0.0000	0	0	0	0		75
Not_Canton	1.0000	1	0	1	1		75

This table provides summary statistics for the companies reporting cybercrime in Canton Zug. The Upper Panel shows the reporting companies registered in Canton Zug, the Lower Panel shows reporting companies registered in another canton.

Table 22: Summary Statistics Cybercrime Population Canton St Gallen and Zug

	Mean	Median	SD	Min	Max	Skew	Obs
Year	2019.6	2020	2.30	2016	2023	-0.07	3'690'564
R	0.0003	0	0.02	0	1	61.41	3'690'564
R_{prev}	0.0023	0	0.05	0	1	20.74	3'690'564
N_Emp	11.7716	1	542.24	1	106'622	172.09	3'690'564
Mid_Sized	0.0192	0.0	0.14	0	1	7.01	3'690'564
Large_Sized	0.0006	0.0	0.02	0	1	40.85	3'690'564
Covid	0.2456	0	0.43	0	1	1.18	3'690'564
Retail	0.0849	0	0.28	0	1	2.98	3'690'564
Online	0.0090	0	0.09	0	1	10.41	3'690'564
AG	0.3368	0	0.47	0	1	0.69	3'690'564
Listed	0.0003	0	0.02	0	1	55.99	3'690'564
DSG	0.0341	0	0.18	0	1	5.14	3'690'564
NIS1	0.7137	1	0.45	0	1	-0.95	3'690'564
Not_Virtual	-0.0069	0	0.08	-1	0	-11.95	3'690'564
Not_Canton	0.0068	0	0.08	0	1	12.05	3'690'564
Both_Cantons	0.0009	0	0.03	0	1	33.40	3'690'564

	Mean	Median	SD	Min	Max	Skew	Obs
Year	2020.2	2020	2.59	2016	2024	-0.10	3'968'712
R	0.0001	0	0.01	0	1	108.03	3'968'712
R_{prev}	0.0009	0	0.03	0	1	33.51	3'968'712
N_Emp	12.8076	4	678.09	1	106'622	127.73	3'968'712
Mid_Sized	0.0150	0	0.12	0	1	7.99	3968712
Large_Sized	0.0006	0	0.02	0	1	40.83	3968712
Covid	0.2158	0	0.41	0	1	1.38	3'968'712
Retail	0.0392	0	0.19	0	1	4.75	3'968'712
Online	0.0055	0	0.07	0	1	13.34	3'968'712
AG	0.5493	1	0.50	0	1	-0.20	3'968'712
Listed	0.0008	0	0.03	0	1	35.83	3'968'712
DSG	0.1574	0	0.36	0	1	1.88	3'968'712
NIS1	0.7565	1	0.43	0	1	-1.20	3'968'712
Not_Virtual	-0.1847	0	0.39	-1	0	-1.62	3'968'712
Not_Canton	0.0020	0	0.04	0	1	22.54	3'968'712
Both_Cantons	0.0009	0	0.03	0	1	32.67	3'968'712

This table provides summary statistics for the population of all firms per month incorporated in Canton St Gallen (Upper Panel) and Zug (Lower Panel). It is a total of 3'690'564 firm months aggregated from 2015 to 2023 for St Gallen and 3'968'712 from 2016 to 2024 for Zug. It describes the data we use to estimate the monthly dark figure of cyberattacks. On average, firms employ 12 workers with with the same largest firm having 106'622 employees in both cantons. However, most companies in St Gallen have only one employee, and four employees in Zug. This makes the distribution of the number of employees highly skewed with a standard deviation of 542 and 678, respectively. Out of all companies incorporated in St Gallen, only 0.03% report per month. The monthly reporting rate in Zug is only half as high, at 0.01%. Reporting (R) is a binary variable being 0 most often. Relatively to reporting in a previous period (R_{prev}), a large share reports at least one more time in a later stage.