Carl von Ossietzky Universität Oldenburg

Power to the people: Distributive justice for agent-based load management in low-voltage grids

Supplementary information

submitted by

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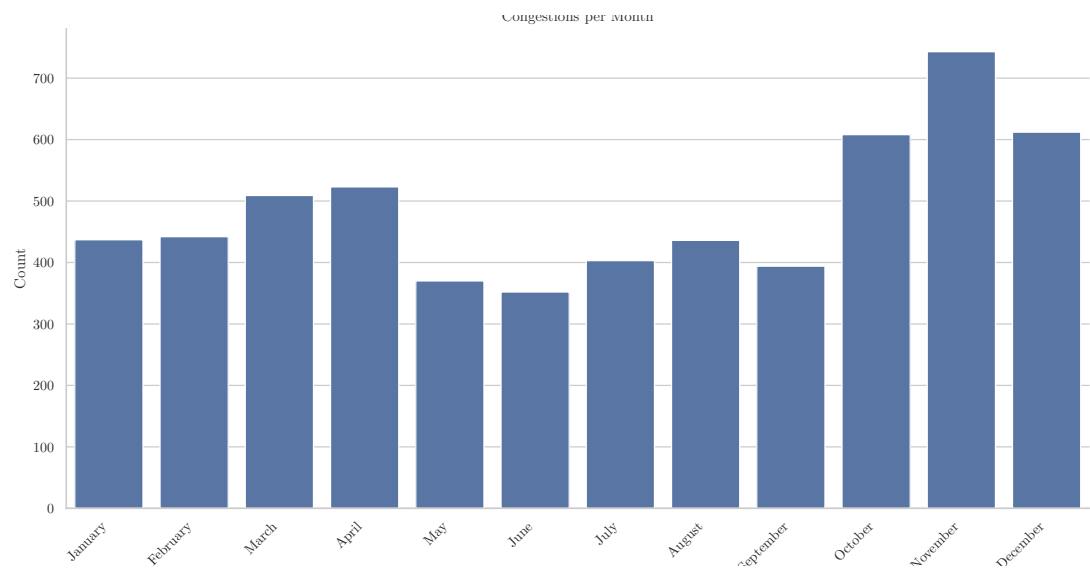# 1 Transformer loading percentages

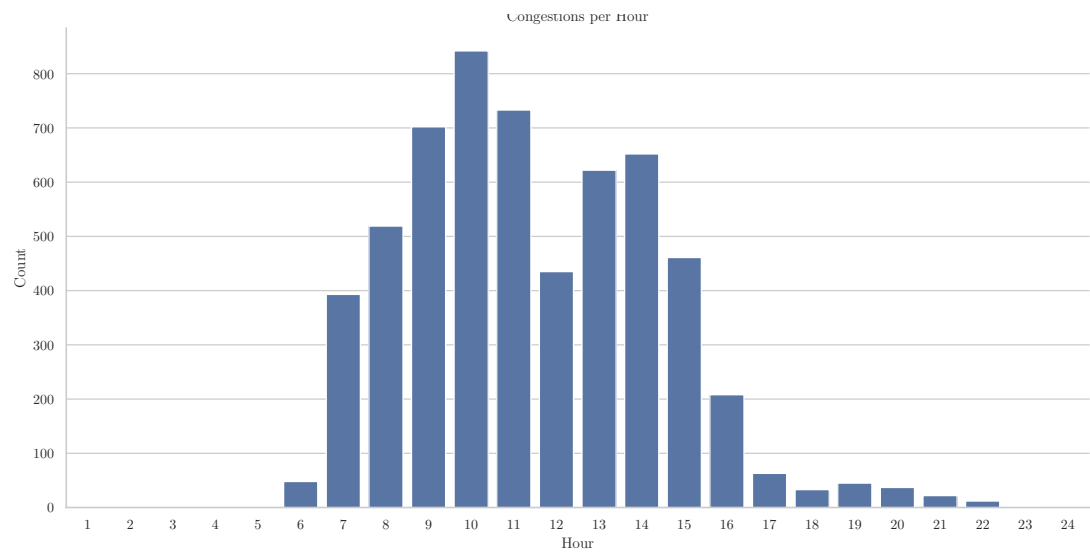

Figure 1.1: Transformer congestions per month.

Figure 1.2: Transformer congestions per hour.

2 Beta regressions for each canon

2.1 Effort

Dep. Variable:	outcome_adjusted	Log-Likelihood:	5.6580e+05
Model:	BetaModel	AIC:	-1.132e+06
Method:	Maximum Likelihood	BIC:	-1.132e+06
Date:	Sun, 05 Jan 2025		
Time:	14:24:17		
No. Observations:	647018		
Df Residuals:	647011		
Df Model:	5		

	coef	std err	z	P> |z|	[0.025	0.975]
const	-1.1339	0.005	-211.096	0.000	-1.144	-1.123
household	-0.5028	0.004	-135.368	0.000	-0.510	-0.496
charging_station	-0.3883	0.003	-111.899	0.000	-0.395	-0.382
heatpump	-0.0956	0.002	-47.185	0.000	-0.100	-0.092
PV	-0.4257	0.002	-265.433	0.000	-0.429	-0.423
lag_outcome	4.0306	0.005	738.592	0.000	4.020	4.041
precision	2.5615	0.002	1483.600	0.000	2.558	2.565

Table 2.1: Effort: Regression results for demand shares according to the canon of effort.

	Variable	VIF
0	const	49.939606
1	household	1.692808
2	charging$_s$tation	1.637288
3	heatpump	1.045405
4	PV	1.074722
5	lag$_o$utcome	1.030451

Table 2.2: Effort: Variance inflation factor to check for collinearity of predictors.

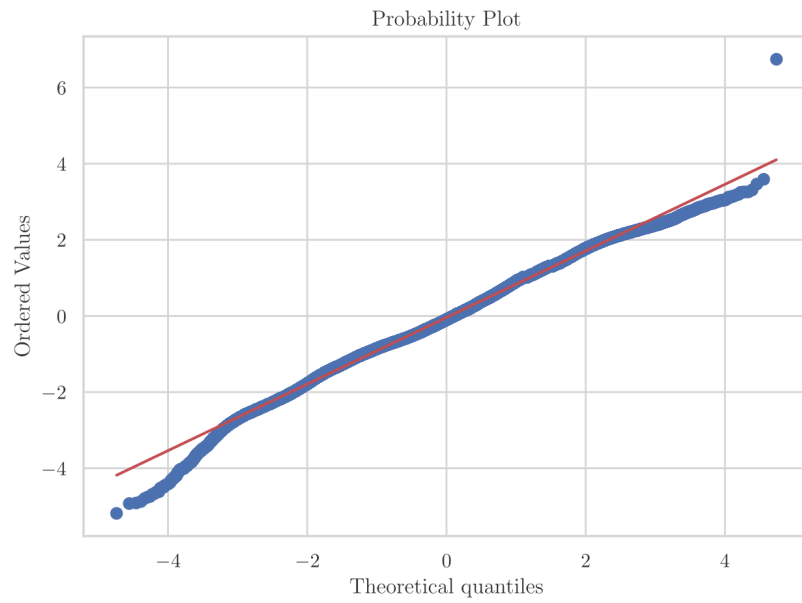Durbin-Watson statistic for autocorrelation: 2.3970245265452776

Figure 2.1: Effort: Distribution of residuals vs. normal distribution.
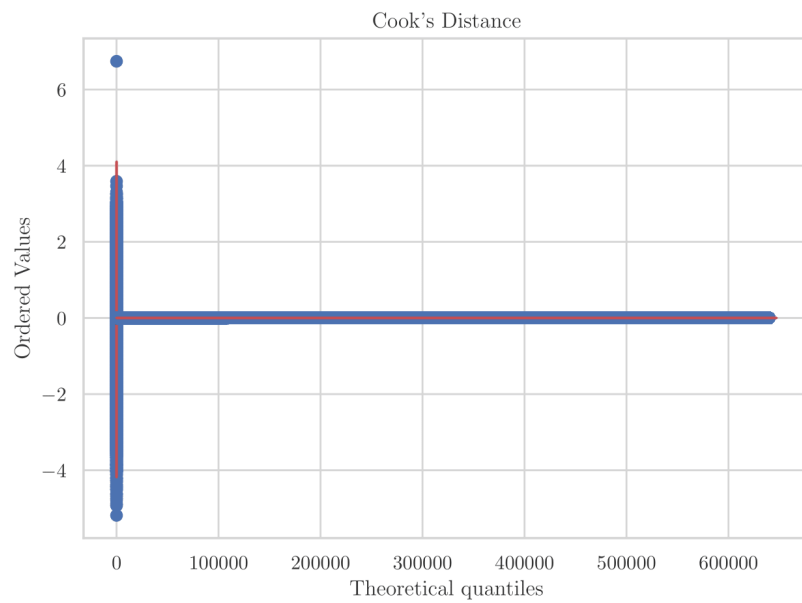

Figure 2.2: Effort: Outliers.

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2.2 Equality

Dep. Variable:	outcome_adjusted	Log-Likelihood:	1.3034e+06
Model:	BetaModel	AIC:	-2.607e+06
Method:	Maximum Likelihood	BIC:	-2.607e+06
Date:	Sun, 05 Jan 2025		
Time:	14:54:36		
No. Observations:	647018		
Df Residuals:	647011		
Df Model:	5		

	coef	std err	z	P> |z|	[0.025	0.975]
const	-3.4658	0.002	-1539.380	0.000	-3.470	-3.461
household	-0.0186	0.001	-14.171	0.000	-0.021	-0.016
charging_station	-0.0116	0.001	-9.450	0.000	-0.014	-0.009
heatpump	0.0001	0.001	0.161	0.872	-0.001	0.002
PV	0.0002	0.001	0.310	0.757	-0.001	0.001
lag_outcome	6.2634	0.002	2606.991	0.000	6.259	6.268
precision	4.8522	0.002	2766.335	0.000	4.849	4.856

Table 2.3: Equality: Regression results for demand shares according to the canon of equality.

	Variable	VIF
0	const	72.175634
1	household	1.690134
2	$charging_station$	1.626748
3	heatpump	1.024041
4	PV	1.073379
5	$lag_outcome$	1.000000

Table 2.4: Equality: Variance inflation factor to check for collinearity of predictors.

Durbin-Watson statistic for autocorrelation: 0.23918120007709764

2.3 Needs

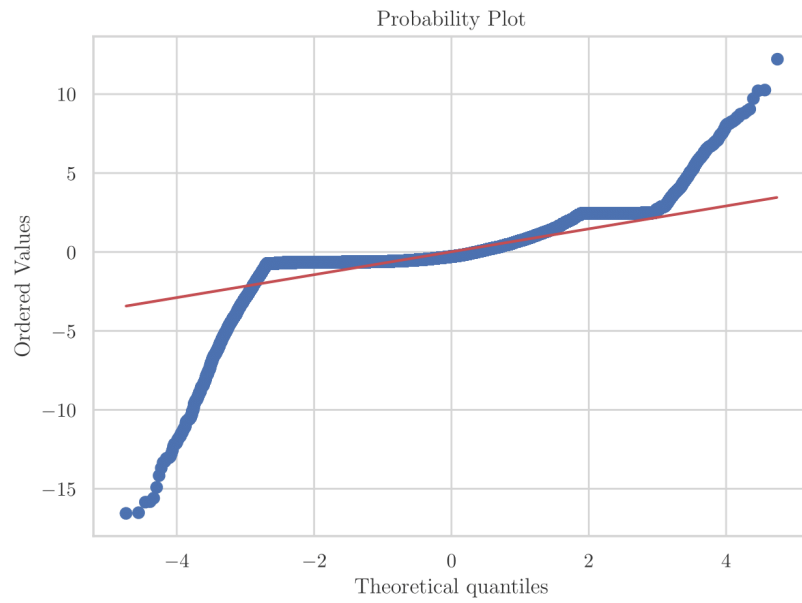Durbin-Watson statistic for autocorrelation: 2.0162657283185323

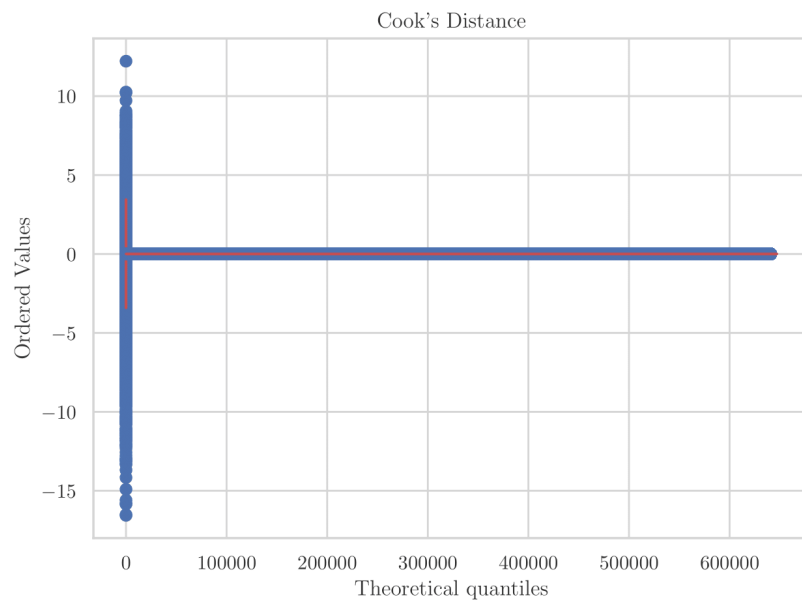Figure 2.3: Equality: Distribution of residuals vs. normal distribution.
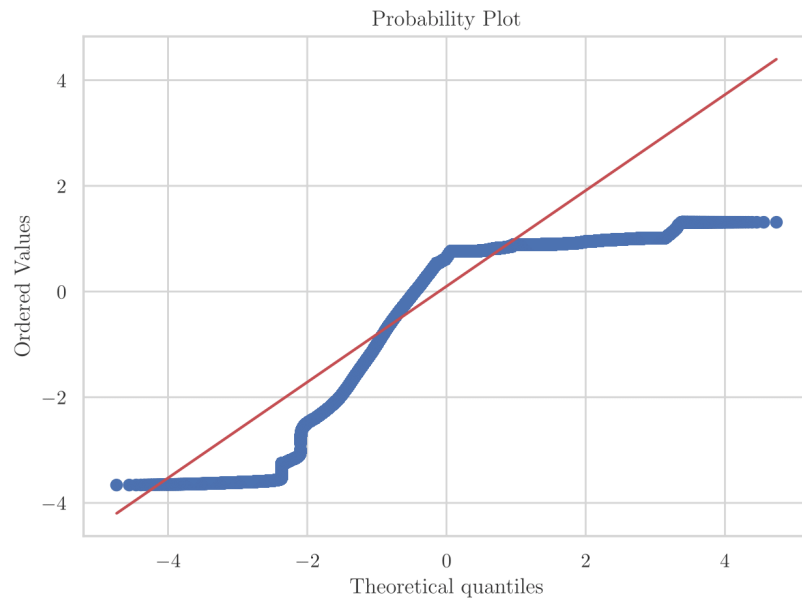

Figure 2.4: Equality: Outliers.

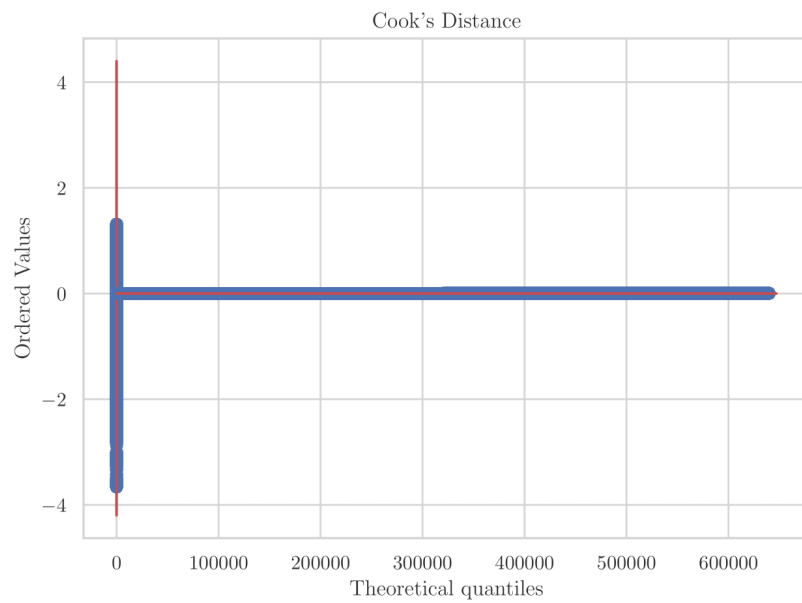Figure 2.5: Needs: Distribution of residuals vs. normal distribution.

Figure 2.6: Needs: Outliers.

	coef	std err	z	P> |z|	[0.025	0.975]
Dep. Variable: outcome_adjusted						

Dep. Variable:	outcome_adjusted
Model:	BetaModel
Method:	Maximum Likelihood
Date:	Sun, 05 Jan 2025
Time:	14:30:56
No. Observations:	647018
Df Residuals:	647011
Df Model:	5

	Log-Likelihood:	6.0138e+05
	AIC:	-1.203e+06
	BIC:	-1.203e+06

	coef	std err	z	P> |z|	[0.025	0.975]
const	0.5131	0.009	57.884	0.000	0.496	0.530
household	0.7496	0.007	112.355	0.000	0.737	0.763
charging_station	0.6194	0.006	98.574	0.000	0.607	0.632
heatpump	-0.0207	0.004	-5.415	0.000	-0.028	-0.013
PV	-0.2733	0.003	-93.972	0.000	-0.279	-0.268
lag_outcome	0.2796	0.006	46.576	0.000	0.268	0.291
precision	0.7186	0.002	406.188	0.000	0.715	0.722

Table 2.5: Needs: Regression results for demand shares according to the canon of needs.

	Variable	VIF
0	const	41.810614
1	household	1.701861
2	$charging_station$	1.645004
3	heatpump	1.163640
4	PV	1.088349
5	$lag_outcome$	1.175762

Table 2.6: Needs: Variance inflation factor to check for collinearity of predictors.

2.4 Productivity

Durbin-Watson statistic for autocorrelation: 2.0162657283185323

2.5 Social utility

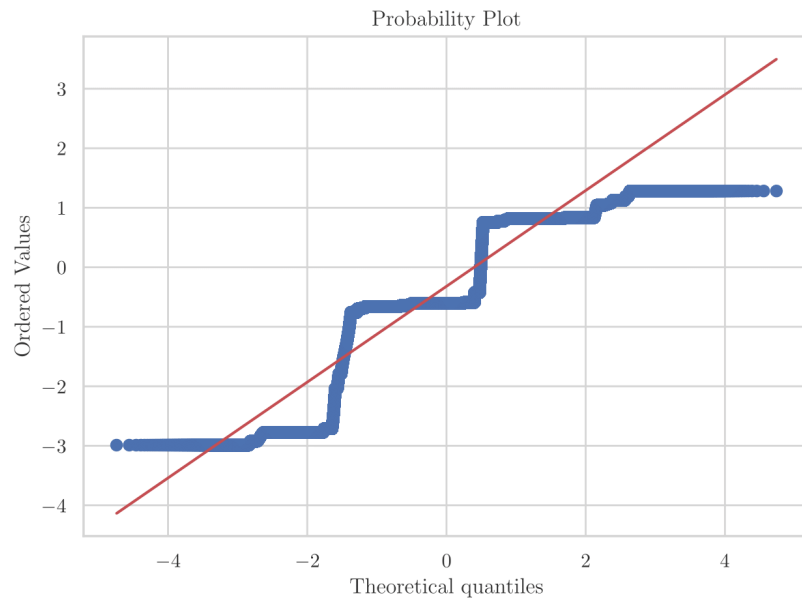Durbin-Watson statistic for autocorrelation: 2.063690331689273

Figure 2.7: Productivity: Distribution of residuals vs. normal distribution.
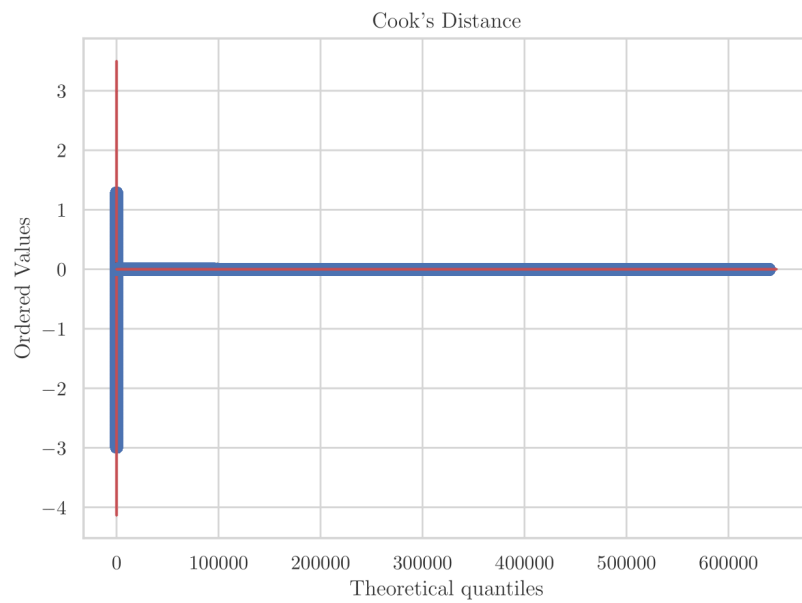

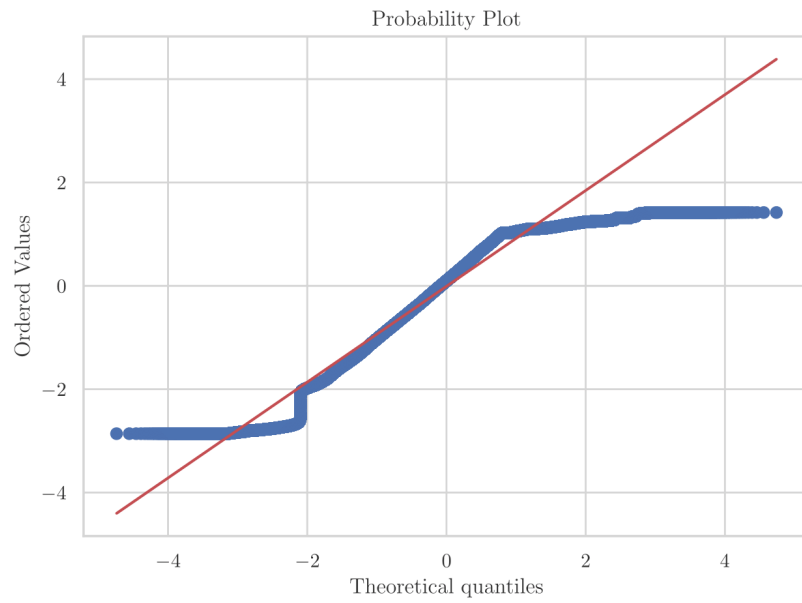Figure 2.8: Productivity: Outliers.

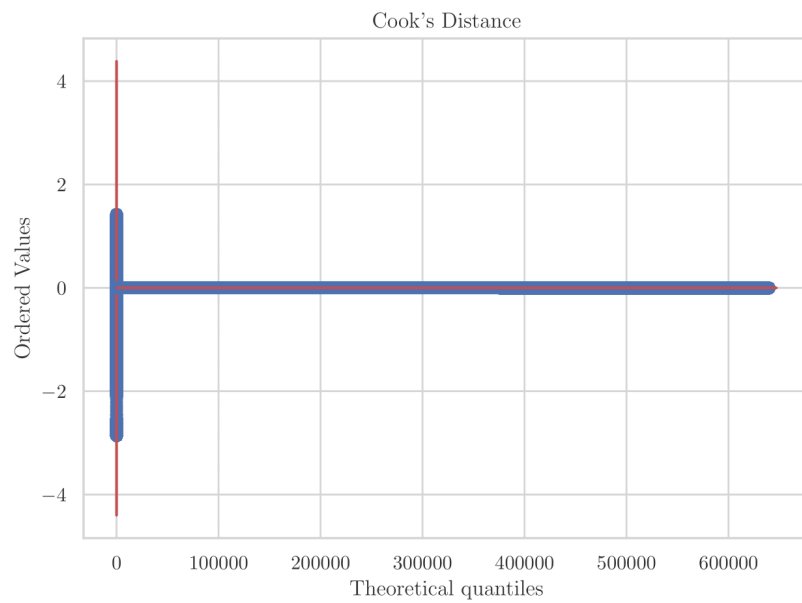Figure 2.9: Social utility: Distribution of residuals vs. normal distribution.

Figure 2.10: Social utility: Outliers.

	coef	std err	z	P> |z|	[0.025	0.975]
Dep. Variable:	outcome_adjusted		**Log-Likelihood:**		1.1399e+06	
Model:	BetaModel		**AIC:**		-2.280e+06	
Method:	Maximum Likelihood		**BIC:**		-2.280e+06	
Date:	Sun, 05 Jan 2025					
Time:	14:44:28					
No. Observations:	647018					
Df Residuals:	647011					
Df Model:	5					

	coef	std err	z	P> |z|	[0.025	0.975]
const	-2.6012	0.008	-332.299	0.000	-2.617	-2.586
household	0.8658	0.007	120.812	0.000	0.852	0.880
charging_station	0.2524	0.006	41.074	0.000	0.240	0.264
heatpump	-0.0443	0.004	-12.179	0.000	-0.051	-0.037
PV	2.9282	0.004	740.111	0.000	2.920	2.936
lag_outcome	0.1507	0.003	48.740	0.000	0.145	0.157
precision	0.3325	0.002	178.929	0.000	0.329	0.336

Table 2.7: Productivity: Regression results for demand shares according to the canon of productivity.

	Variable	VIF
0	const	25.094197
1	household	1.693167
2	$charging_{s}tation$	1.628072
3	heatpump	1.026517
4	PV	1.073610
5	$lag_{o}utcome$	1.004889

Table 2.8: Needs: Variance inflation factor to check for collinearity of predictors.

2.6 Supply and demand

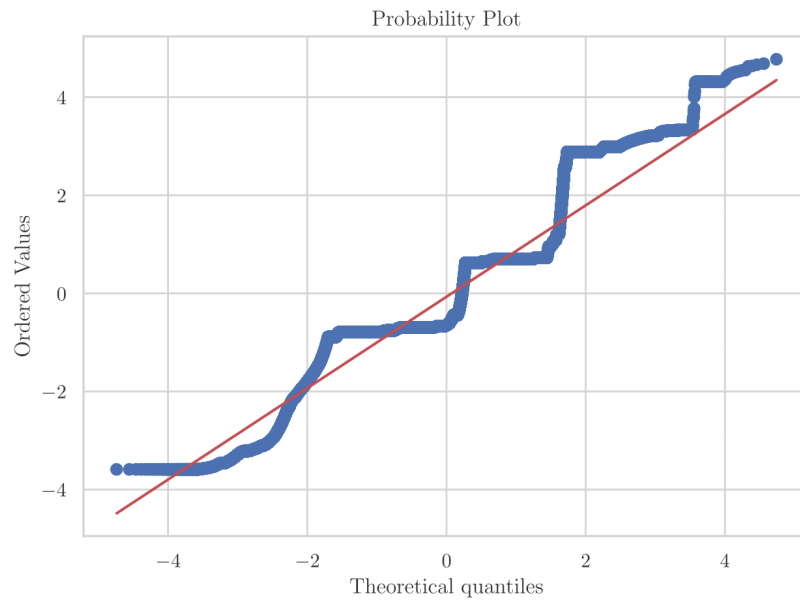Durbin-Watson statistic for autocorrelation: 1.4676094718163968

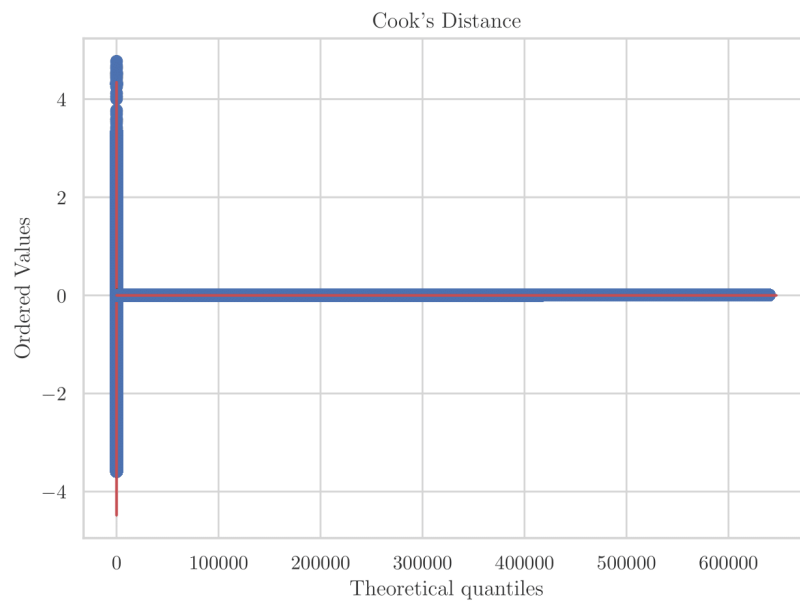Figure 2.11: Supply and demand: Distribution of residuals vs. normal distribution.

Figure 2.12: Supply and demand: Outliers.

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	coef	std err	z	P> |z|	[0.025	0.975]
Dep. Variable:	outcome_adjusted		**Log-Likelihood:**	1.9566e+05		
Model:	BetaModel		**AIC:**	-3.913e+05		
Method:	Maximum Likelihood		**BIC:**	-3.912e+05		
Date:	Sun, 05 Jan 2025					
Time:	14:38:34					
No. Observations:	647018					
Df Residuals:	647011					
Df Model:	5					

	coef	std err	z	P> |z|	[0.025	0.975]
const	0.7630	0.008	94.578	0.000	0.747	0.779
household	-0.1666	0.006	-27.836	0.000	-0.178	-0.155
charging_station	-0.2729	0.006	-47.250	0.000	-0.284	-0.262
heatpump	-0.0096	0.004	-2.736	0.006	-0.017	-0.003
PV	-0.1374	0.003	-49.006	0.000	-0.143	-0.132
lag_outcome	0.4802	0.006	83.852	0.000	0.469	0.491
precision	0.8495	0.002	531.985	0.000	0.846	0.853

Table 2.9: Social utility: Regression results for demand shares according to the canon of social utility.

	Variable	VIF
0	const	39.769136
1	household	1.718670
2	$charging_station$	1.721934
3	heatpump	1.068725
4	PV	1.073726
5	$lag_outcome$	1.105709

Table 2.10: Social utility: Variance inflation factor to check for collinearity of predictors.

3 Normative canon analysis

	coef	std err	z	P> |z|	[0.025	0.975]
Dep. Variable: outcome_adjusted **Log-Likelihood:** 1.0154e+06						

Dep. Variable:	outcome_adjusted	**Log-Likelihood:**	1.0154e+06
Model:	BetaModel	**AIC:**	-2.031e+06
Method:	Maximum Likelihood	**BIC:**	-2.031e+06
Date:	Sun, 05 Jan 2025		
Time:	14:49:37		
No. Observations:	647018		
Df Residuals:	647011		
Df Model:	5		

	coef	std err	z	P> |z|	[0.025	0.975]
const	-2.5211	0.008	-319.711	0.000	-2.537	-2.506
household	1.0326	0.007	142.431	0.000	1.018	1.047
charging_station	0.2317	0.006	36.938	0.000	0.219	0.244
heatpump	-0.0703	0.004	-19.342	0.000	-0.077	-0.063
PV	2.9668	0.004	753.588	0.000	2.959	2.975
lag_outcome	0.2242	0.003	73.163	0.000	0.218	0.230
precision	0.3417	0.002	186.920	0.000	0.338	0.345

Table 2.11: Supply and demand: Regression results for demand shares according to the canon of supply and demand.

	Variable	VIF
0	const	25.359748
1	household	1.692577
2	$charging_{s}tation$	1.627919
3	heatpump	1.025920
4	PV	1.073388
5	$lag_{o}utcome$	1.003825

Table 2.12: Supply and demand: Variance inflation factor to check for collinearity of predictors.
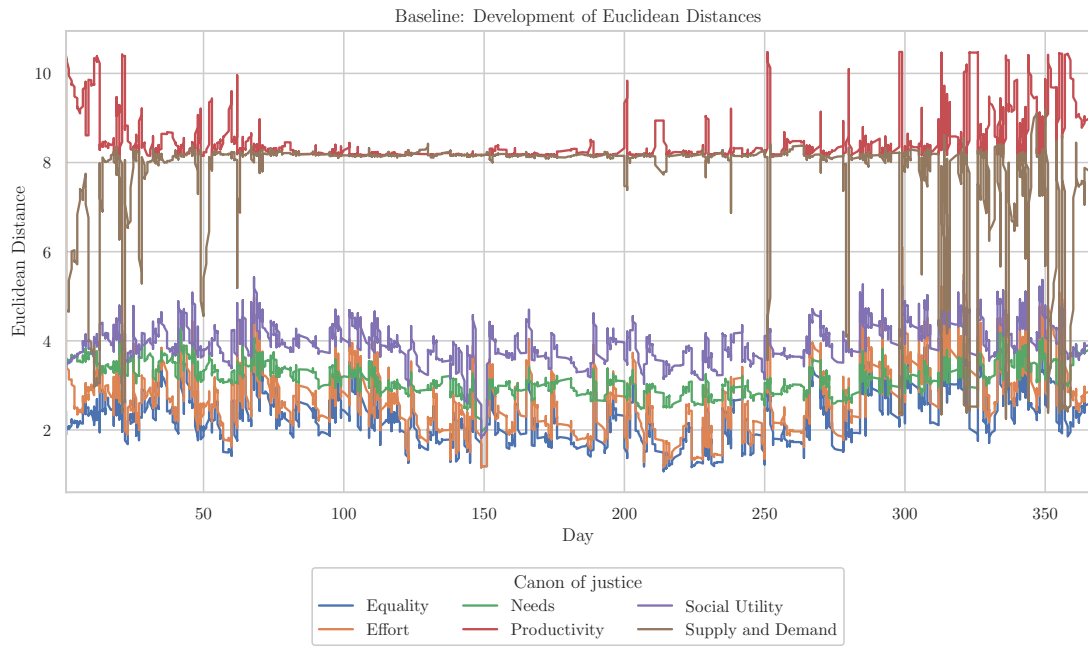
4 Voting analysis

Figure 3.1: Baseline: Development of Euclidean distances between the share of demand according to each canon and the share of demand according to the baseline condition.
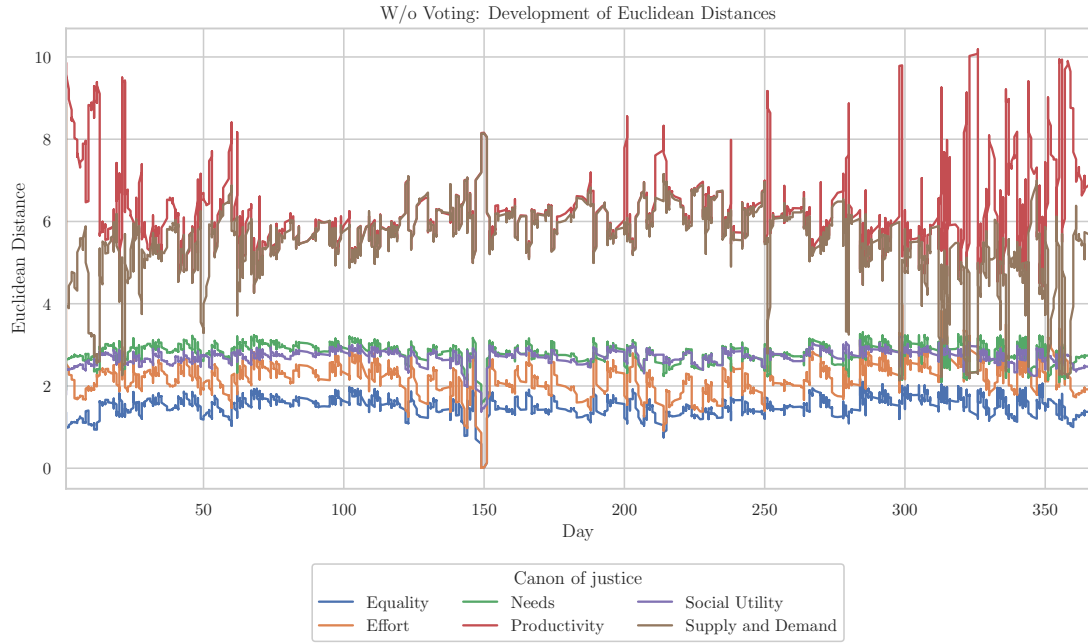
Figure 3.2: No voting: Development of Euclidean distances between the share of demand according to each canon and the share of demand according to the no voting condition.
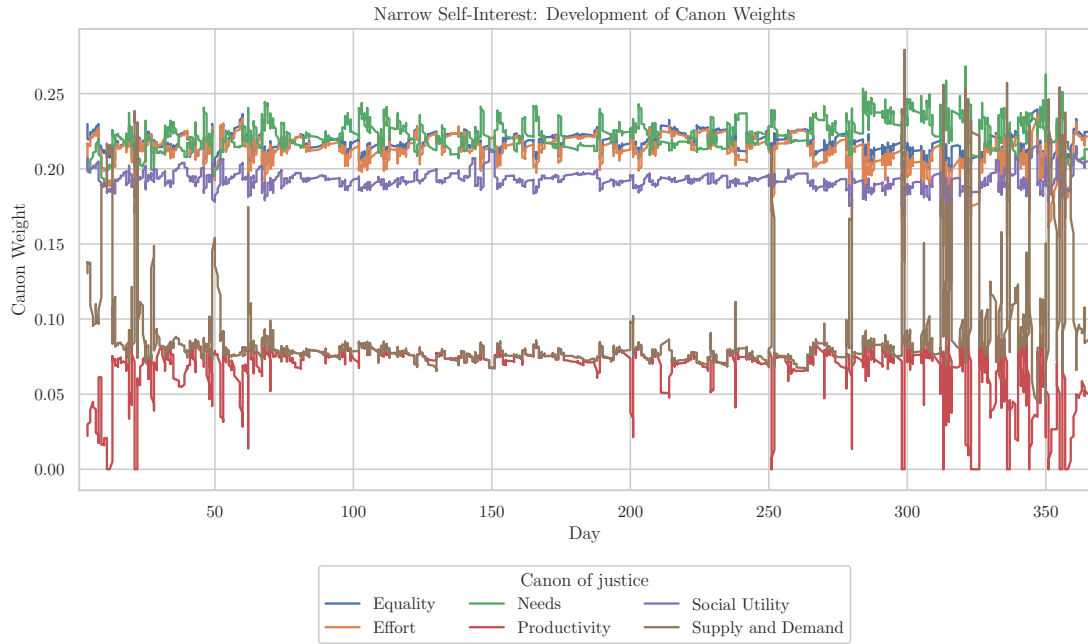

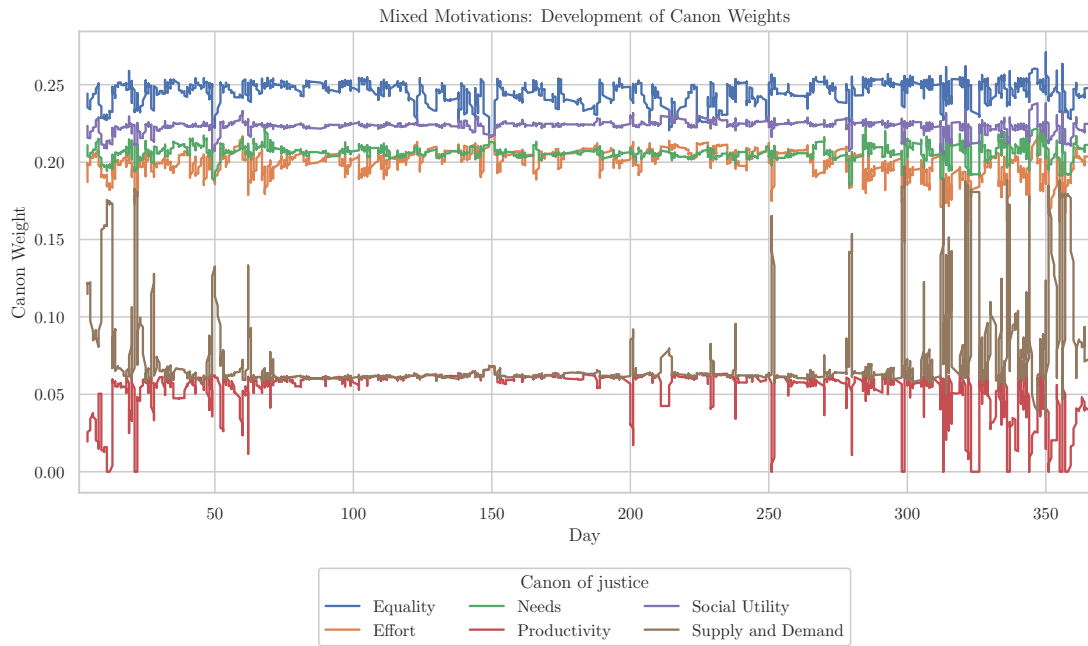Figure 4.1: Narrow self-interest: Development of canon weights over time.

Figure 4.2: Mixed motivations: Development of canon weights over time.
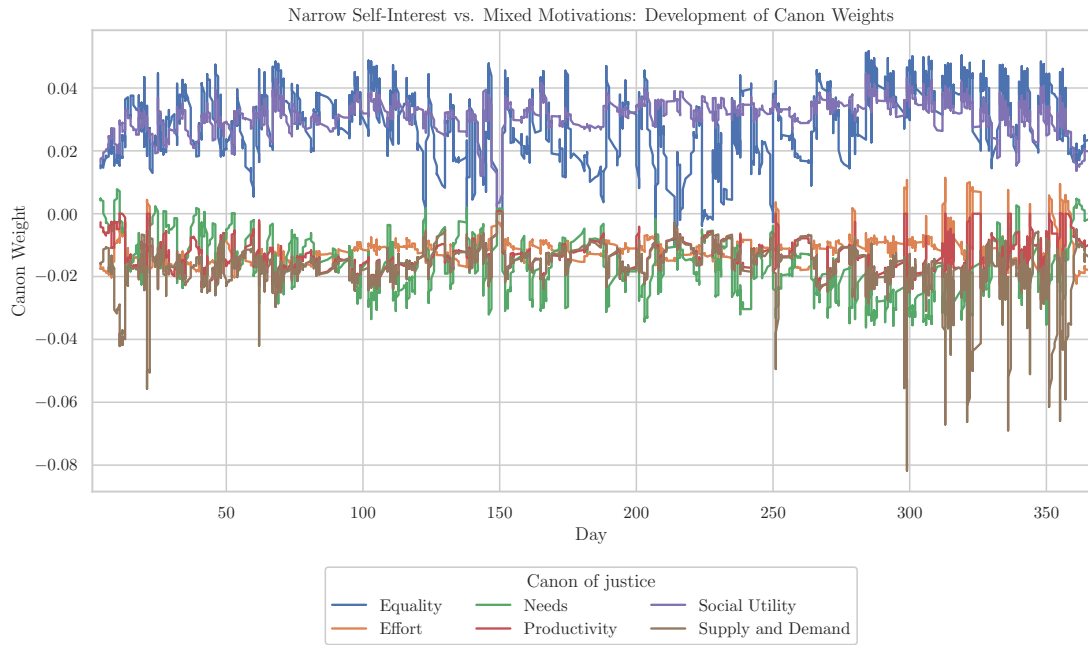

Figure 4.3: Narrow self-interest vs. mixed motivations: Development of canon weights over time.