Analysis

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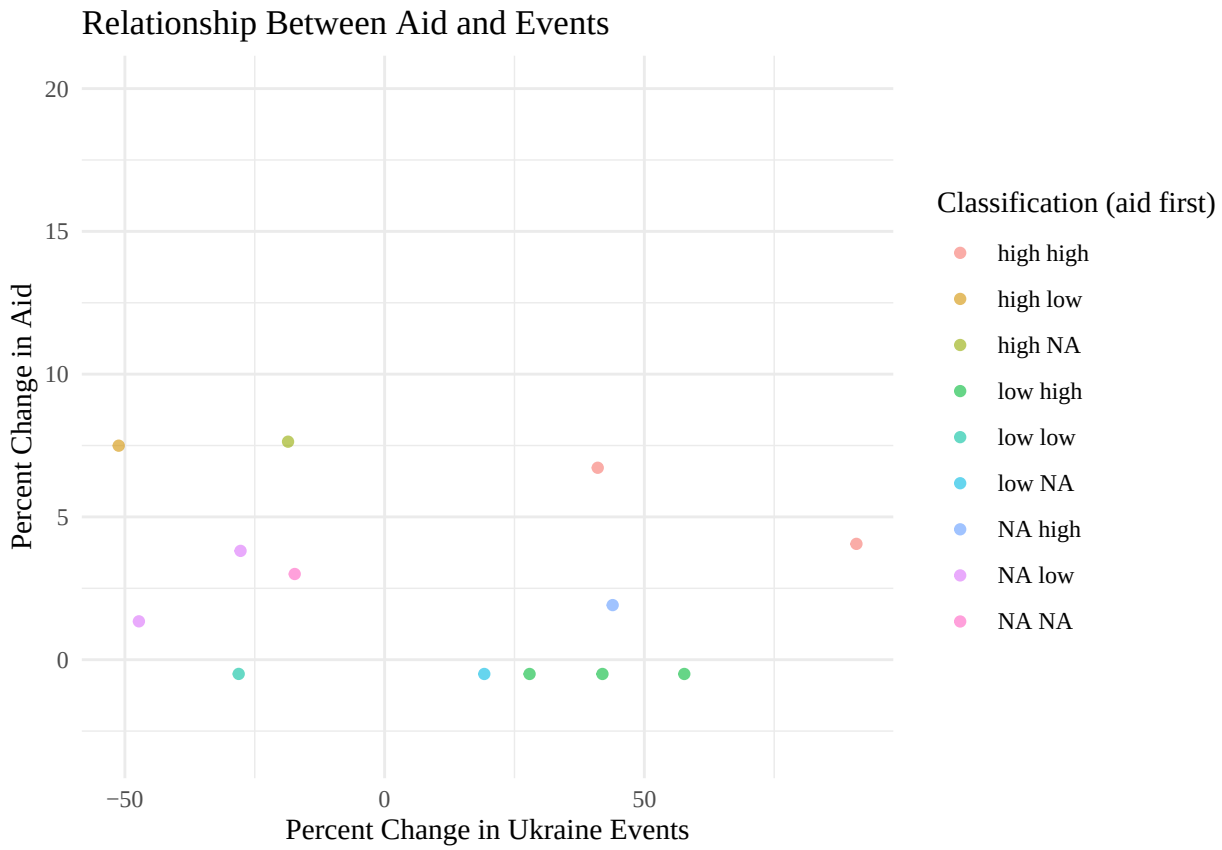
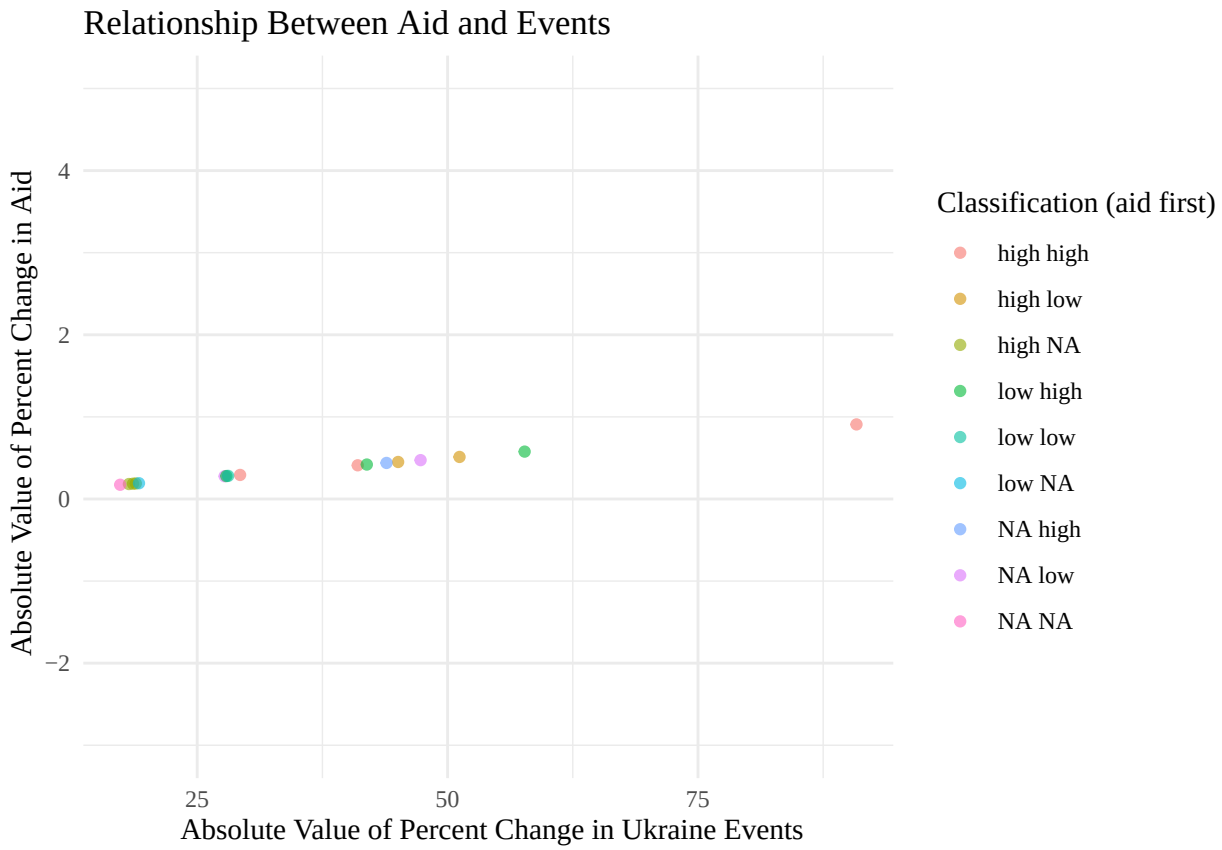
Data structuring

```
## Warning in full_join(drones_dataset[, c(1, 13, 14, 24)], antidrone_aid_df, : Detected an unexpected r
## i Row 1 of `x` matches multiple rows in `y`.
## i Row 1619 of `y` matches multiple rows in `x`.
## i If a many-to-many relationship is expected, set `relationship =
##   "many-to-many"` to silence this warning.
```

Top/bottom analysis

Top/bottom 25 aid and events percent changes (only rows with data in both columns)





Summary stats

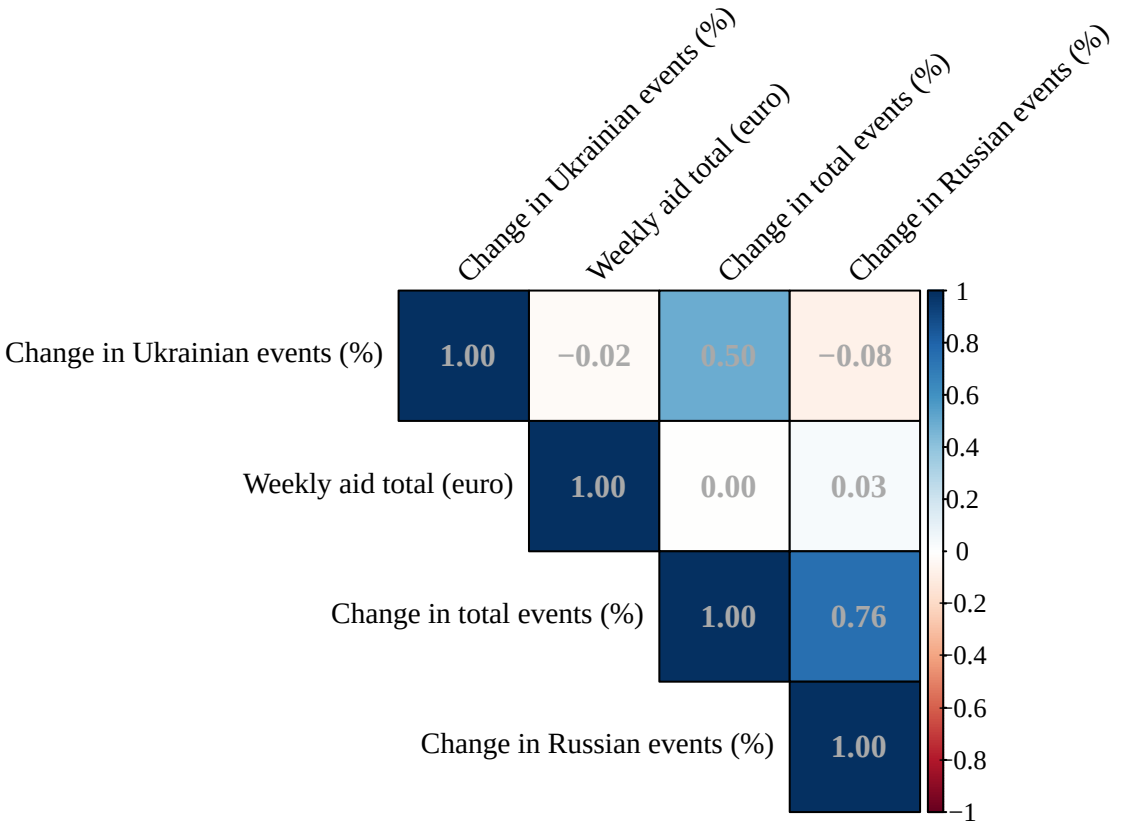
Summary Statistics

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Thu, Apr 10, 2025 - 09:31:42

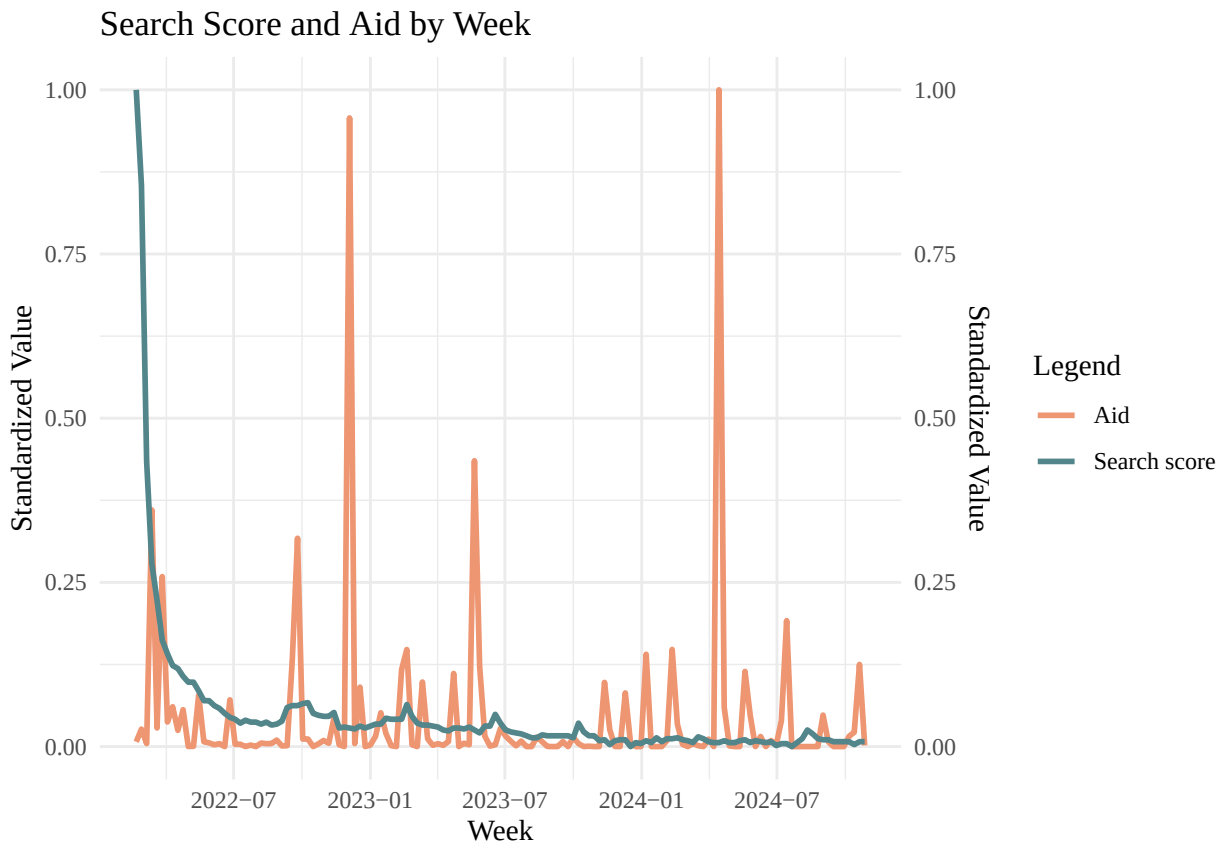
Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
Weekly aid total (euro)	141	834,605,790.00	2,474,692,804.00	0	18,926,299,908
Change in aid (%)	141	5,636.10	47,871.48	−100.00	546,163.60
Weekly event total	141	466.04	76.73	268	638
Russian missile use	141	12.63	10.92	1	58
Russian drone use	141	39.21	16.71	1	75
Change in total events (%)	141	0.44	11.95	−28.87	64.18
Change in Ukrainian events (%)	141	1.07	22.57	−51.19	90.83
Change in Russian events (%)	141	1.30	15.82	−32.14	67.57
Search score	141	7.38	11.33	2.71	98.86

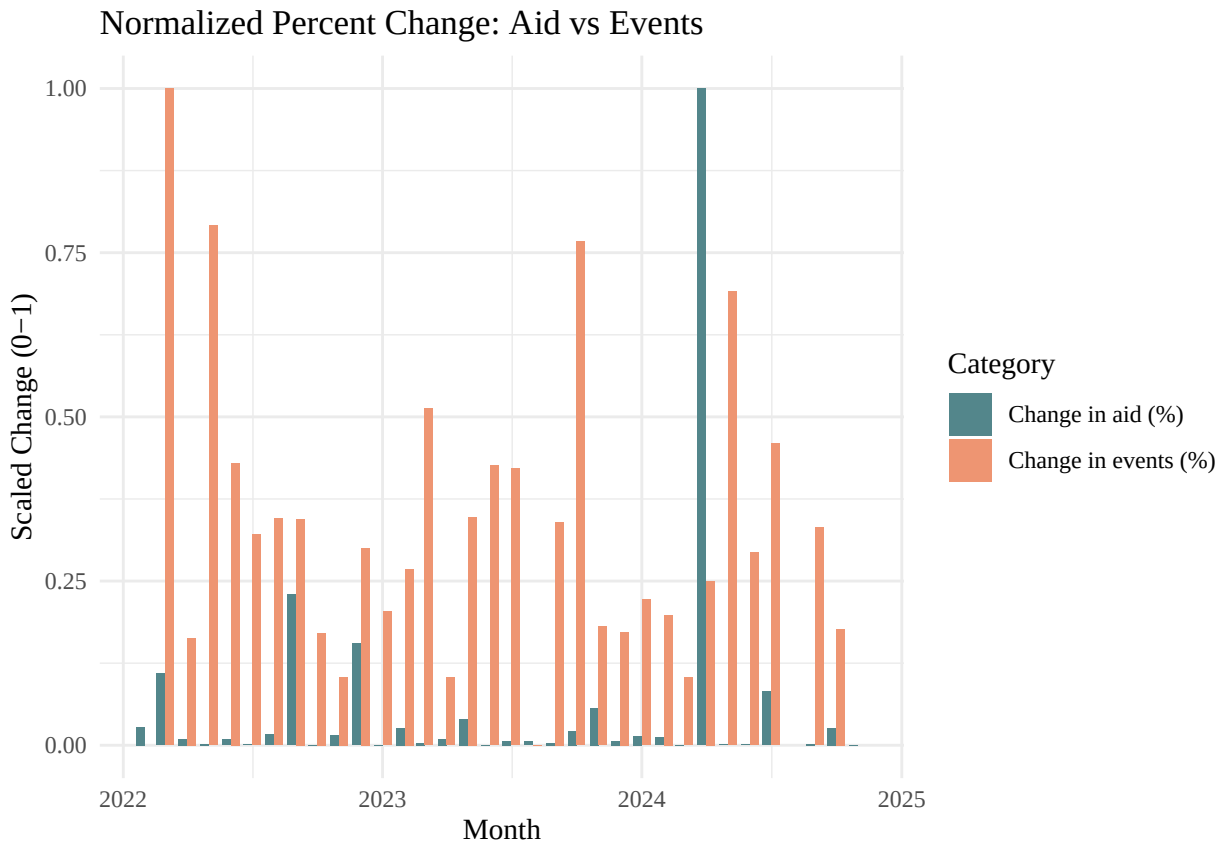
Correlation matrix

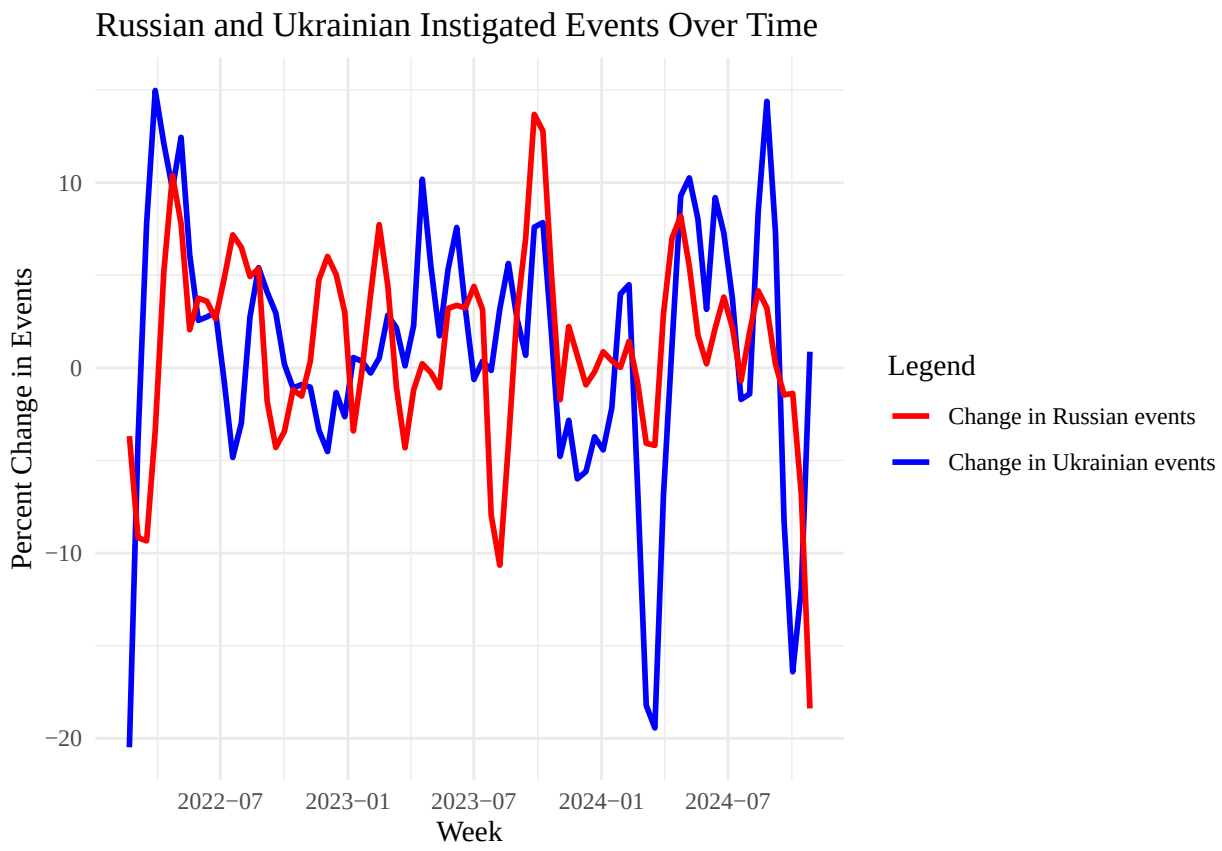


Visualizations




```
## Warning: Removed 2 rows containing missing values or values outside the scale range
## (`geom_bar()`).
```


Normalized Percent Change: Aid vs Events
Scaled Change (0–1)
1.00
0.75
0.50
0.25
0.00
2022
2023
2024
2025
Month
Category
Change in aid (%)
Change in events (%)



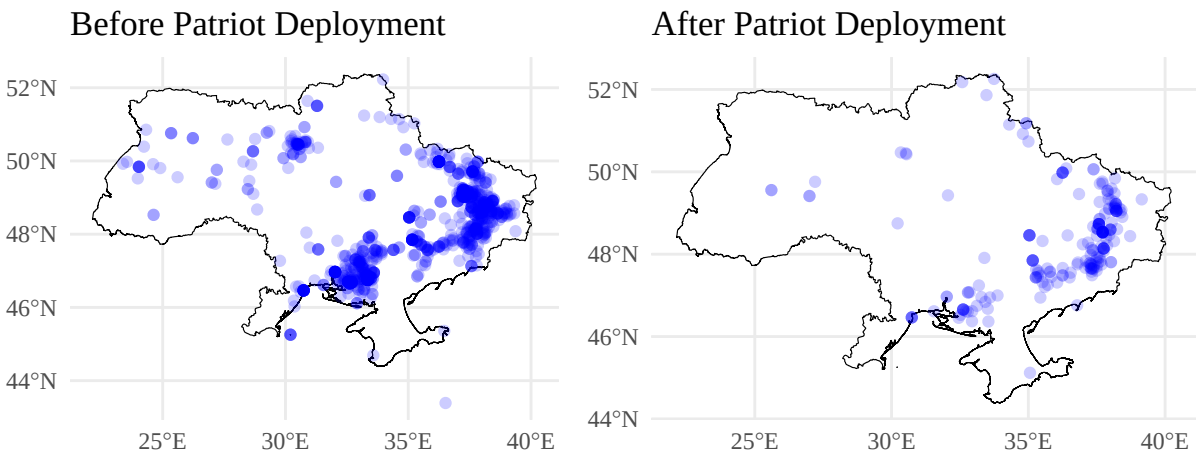

```
# Map of missile attacks

ukraine <- st_read("/Users/briannapenkala/Downloads/Capstone/gadm41_UKR_shp")
```

```
## Multiple layers are present in data source /Users/briannapenkala/Downloads/Capstone/gadm41_UKR_shp, r
## Use `st_layers' to list all layer names and their type in a data source.
## Set the `layer' argument in `st_read' to read a particular layer.

## Warning in CPL_read_ogr(dsn, layer, query, as.character(options), quiet, :
## automatically selected the first layer in a data source containing more than
## one.

## Reading layer `gadm41_UKR_0' from data source
##   `/Users/briannapenkala/Downloads/Capstone/gadm41_UKR_shp' using driver `ESRI Shapefile'
## Simple feature collection with 1 feature and 2 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 22.14045 ymin: 44.38597 xmax: 40.21807 ymax: 52.37503
## Geodetic CRS:  WGS 84
```

```
missiles_sf <- st_as_sf(missile_events, coords = c("longitude", "latitude"), crs = 4326)

missile_before1 <- missiles_sf %>% filter(date < as.Date("2022-12-21"))
missile_after1 <- missiles_sf %>% filter(date >= as.Date("2022-12-21") & date < as.Date("2023-06-01"))
```

```r
missile_map_before1 <- ggplot() +
  geom_sf(data = ukraine, fill = "white", color = "black") +
  geom_sf(data = missile_before1 , color = "blue", alpha = 0.2) +
  ggtitle("Before Patriot Deployment") +
  theme(plot.title = element_text(size = 9)) +
  theme_minimal(base_family = "Times New Roman") +
  theme(
    text = element_text(family = "Times New Roman"),
    axis.title = element_text(family = "Times New Roman"),
    axis.text = element_text(family = "Times New Roman"),
    plot.title = element_text(family = "Times New Roman"))

missile_map_after1 <- ggplot() +
  geom_sf(data = ukraine, fill = "white", color = "black") +
  geom_sf(data = missile_after1 , color = "blue", alpha = 0.2) +
  ggtitle("After Patriot Deployment") +
  theme_minimal(base_family = "Times New Roman") +
  theme(
    text = element_text(family = "Times New Roman"),
    axis.title = element_text(family = "Times New Roman"),
    axis.text = element_text(family = "Times New Roman"),
    plot.title = element_text(family = "Times New Roman"))

(missile_map_before1 + missile_map_after1) +
   plot_annotation(
    title = "Missile Attacks in Ukraine Before and After Patriot Deployment",
    theme = theme(plot.title = element_text(family = "Times New Roman")))
```

Missile Attacks in Ukraine Before and After Patriot Deployment




```
#caption = "Before = 02/22/2022 - 12/21/2022. After = 12/21/2022 - 06/21/2023"
```

T-tests

T-statistic	Degrees of Freedom	P-value	95% Confidence Interval
-28.3	218	< 2.2e-16	-294.746 - (-221.623)

Comparison of Mean Ukrainian and Russian-Instigated Events

T-statistic	Degrees of Freedom	P-value	95% Confidence Interval
-28.3	218	< 2.2e-16	-294.746 - (-221.623)

T-statistic	Degrees of Freedom	P-value	95% Confidence Interval
-0.351	4	0.743	-45.597 - 35.363

Comparison of Mean Ukrainian Event Percent Changes in High and Low Aid Periods

T-statistic	Degrees of Freedom	P-value	95% Confidence Interval
-0.351	4	0.743	-45.597 - 35.363

Percent Change Aid

	OLS	OLS	OLS	2SLS
Aid	-0.000			0.006
	(0.000)			(0.083)
Russian-instigated events change (%)	-0.096	-0.107	-0.106	-1.896
	(0.121)	(0.121)	(0.122)	(26.045)
Aid lagged one week		0.000		
		(0.000)		
Aid lagged two weeks			-0.000	
			(0.000)	
N	141	141	141	141
R2	0.011	0.006	0.006	-145.614
logLik	-638.223	-638.602	-638.602	
AIC	1284.445	1285.204	1285.203	

*** p < 0.001; ** p < 0.01; * p < 0.05.

Regressions on Ukraine

First stage:

$$MilitaryAid_W = \beta_0 + \beta_1 \text{SearchScore}_W + u_W$$

Second stage:

$$UVE_W = \beta_0 + \beta_1 \text{MilitaryAid}_{W-lag} + \beta_2 \text{RVE}_W + u_W$$

Where UVE shows Ukrainian-instigated events; RVE shows Russian-instigated events

Regressions on Russia

```
# Russia regressions no lag
basic_reg_russia <- lm(percent_change_russia ~ percent_change_aid + percent_change_ukraine, data = bywe

# Regressions one week lag
```

Aid as a Dummy Variable

	OLS	OLS	OLS	2SLS
Aid	-2.481			-23.808
	(4.504)			(30.696)
Russian-instigated events change (%)	-0.108	-0.110	-0.122	-0.115
	(0.121)	(0.122)	(0.120)	(0.131)
Aid lagged one week		1.275		
		(4.539)		
Aid lagged two weeks			1.691	
			(4.470)	
N	141	140	139	141
R2	0.008	0.006	0.009	-0.153
logLik	-638.452	-634.534	-627.990	
AIC	1284.903	1277.068	1263.979	

*** p < 0.001; ** p < 0.01; * p < 0.05.

```
basic_reg_lag1_russia <- lm(percent_change_russia ~ week_lag_percent_aid + percent_change_ukraine, data

# Regressions two week lag
basic_reg_lag2_russia <- lm(percent_change_russia ~ twoweek_lag_percent_aid + percent_change_ukraine, da

# Instrument
inst_basic_russia <- ivreg(formula = percent_change_russia ~ percent_change_aid + percent_change_ukraine

output_russia <- huxreg(basic_reg_russia,
                basic_reg_lag1_russia,
                basic_reg_lag2_russia,
                inst_basic_russia,
                 coefs = c("Aid" = "percent_change_aid",
                           "Ukrainian-instigated events change (%)" = "percent_change_ukraine",
                           "Aid lagged one week" = "week_lag_percent_aid",
                           "Aid lagged two weeks" = "twoweek_lag_percent_aid")) %>%
  set_caption("Percent Change Aid Russia") %>%
  set_markdown_contents(1, 2, "OLS") %>%
  set_markdown_contents(1, 3, "OLS") %>%
  set_markdown_contents(1, 4, "OLS") %>%
  set_markdown_contents(1, 5, "2SLS")
output_russia
```

Percent Change Aid Russia

	OLS	OLS	OLS	2SLS
Aid	0.000			0.001
	(0.000)			(0.006)
Ukrainian-instigated events change (%)	-0.047	-0.053	-0.051	0.188
	(0.059)	(0.059)	(0.059)	(1.107)
Aid lagged one week		0.000		
		(0.000)		
Aid lagged two weeks			0.000	
			(0.000)	
N	141	141	141	141
R2	0.015	0.006	0.018	-17.080
logLik	-587.836	-588.494	-587.655	
AIC	1183.673	1184.987	1183.310	

*** p < 0.001; ** p < 0.01; * p < 0.05.

```
# Russia dummy variable regressions

# Regressions dummy no lag
basic_dummy_russia <- lm(percent_change_russia ~ aidgiven + percent_change_ukraine, data = byweek_data)

# Regressions one week lag
basic_dummy_lag1_russia <- lm(percent_change_russia ~ aidgiven_week_lag + percent_change_ukraine, data =

# Regressions two week lag
basic_dummy_lag2_russia <- lm(percent_change_russia ~ aidgiven_twoweek_lag + percent_change_ukraine, da

# Instrument
inst_dummy_russia <- ivreg(formula = percent_change_russia ~ aidgiven + percent_change_ukraine | search_

output_dummy_russia <- huxreg(basic_dummy_russia,
                        basic_dummy_lag1_russia,
                        basic_dummy_lag2_russia,
                        inst_dummy_russia,
                  coefs = c("Aid" = "aidgiven",
                            "Ukrainian-instigated events change (%)" = "percent_change_ukraine",
                            "Aid lagged one week" = "aidgiven_week_lag",
                            "Aid lagged two weeks" = "aidgiven_twoweek_lag")) %>%
  set_caption("Aid as a Dummy Variable Russia") %>%
  set_markdown_contents(1, 2, "OLS") %>%
  set_markdown_contents(1, 3, "OLS") %>%
```

```
  set_markdown_contents(1, 4, "OLS") %>%
  set_markdown_contents(1, 5, "2SLS")
output_dummy_russia
```

Aid as a Dummy Variable Russia

	OLS	OLS	OLS	2SLS
Aid	-0.591			-19.304
	(3.164)			(22.677)
Ukrainian-instigated events change (%)	-0.053	-0.054	-0.062	-0.069
	(0.060)	(0.060)	(0.061)	(0.069)
Aid lagged one week		2.542		
		(3.169)		
Aid lagged two weeks			-0.639	
			(3.183)	
N	141	140	139	141
R2	0.006	0.010	0.008	-0.246
logLik	-588.506	-584.516	-580.760	
AIC	1185.012	1177.033	1169.520	

*** p < 0.001; ** p < 0.01; * p < 0.05.

Regressions on missiles

```
# Missiles regressions

# Patriot aid on missile use (expect to decrease)
missile_reg <- lm(russian_missiles ~ patriot_aid, data = byweek_data)

missile_reg_controlled <- lm(russian_missiles ~ patriot_aid + russian_drones, data = byweek_data)

missile_reg_inst <- ivreg(russian_missiles ~ patriot_aid + russian_drones | search_score + russian_drone

output_missile <- huxreg(missile_reg,
                missile_reg_controlled,
                coefs = c("Patriot aid" = "patriot_aid",
                          "Russian drones" = "russian_drones")) %>%
  set_caption("Russian Missile Use on Patriot Aid") %>%
  set_markdown_contents(1, 2, "OLS") %>%
```

```
  set_markdown_contents(1, 3, "OLS")
output_missile
```

Russian Missile Use on Patriot Aid

	OLS	OLS
Patriot aid	-4.603 *	-4.598 *
	(1.794)	(1.808)
Russian drones		0.002
		(0.055)
N	141	141
R2	0.045	0.045
logLik	-533.392	-533.392
AIC	1072.784	1074.783

*** p < 0.001; ** p < 0.01; * p < 0.05.

$$RussianMissileUse_W = \beta_0 + \beta_1 \text{PatriotAid}_W + \beta_2 \text{RussianDroneUse}_W + u_W$$

```
# Patriot aid on drone use (expect to increase)
missile_reg_drone <- lm(russian_drones ~ patriot_aid, data = byweek_data)
summary(missile_reg_drone)
```

```
##
## Call:
## lm(formula = russian_drones ~ patriot_aid, data = byweek_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -38.848 -10.848   2.152  12.139  35.152
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   39.848      1.527  26.088   <2e-16 ***
## patriot_aid   -2.987      2.799  -1.067    0.288
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16.7 on 139 degrees of freedom
## Multiple R-squared:  0.008128,   Adjusted R-squared:  0.0009918
## F-statistic: 1.139 on 1 and 139 DF,  p-value: 0.2877
```

```r
ex <- lm(russian_missiles ~ russian_drones, data = byweek_data)
summary(ex)
```

```
##
## Call:
## lm(formula = russian_missiles ~ russian_drones, data = byweek_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -11.742  -7.685  -3.500   3.514  44.988
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)    12.07448    2.36086   5.114 1.02e-06 ***
## russian_drones  0.01420    0.05542   0.256    0.798
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.96 on 139 degrees of freedom
## Multiple R-squared:  0.000472,   Adjusted R-squared:  -0.006719
## F-statistic: 0.06564 on 1 and 139 DF,  p-value: 0.7982
```

```r
# Drone regressions (russian drone activity on anti drone aid)
antidrone_reg <- lm(russian_drones ~ week_lag_aid, data = drones_dataset)
summary(antidrone_reg)
```

```
##
## Call:
## lm(formula = russian_drones ~ week_lag_aid, data = drones_dataset)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -9.000e-16 -9.000e-16 -9.000e-16 -9.000e-16  1.384e-11
##
## Coefficients:
##                Estimate Std. Error    t value Pr(>|t|)
## (Intercept)   1.000e+00  8.383e-16  1.193e+15   <2e-16 ***
## week_lag_aid -8.637e-16  3.482e-15 -2.480e-01    0.804
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.061e-13 on 17006 degrees of freedom
##   (707 observations deleted due to missingness)
## Multiple R-squared:    0.5,  Adjusted R-squared:    0.5
## F-statistic: 1.701e+04 on 1 and 17006 DF,  p-value: < 2.2e-16
```

```r
ggplot(aes(x = week), data = byweek_data) +
  geom_smooth(aes(y = rescale(russian_missiles), color = "Russian missile use")) +
  geom_smooth(aes(y = rescale(russian_drones), color = "Russian drone use")) +
  geom_smooth(aes(y = rescale(patriot_aid), color = "Patriot aid provided")) +
  scale_color_manual(values = c("Russian missile use" = "blue", "Russian drone use" = "orange", "Patriot
  labs(title = "Russian Missile and Drone Use Compared with Patriot Aid",
```

```
      x = "Week",
      y = "Rescaled Amounts",
      color = "Legend") +
  theme_minimal(base_family = "Times New Roman") +
  theme(
    text = element_text(family = "Times New Roman"),
    axis.title = element_text(family = "Times New Roman"),
    axis.text = element_text(family = "Times New Roman"),
    plot.title = element_text(family = "Times New Roman"))
```

```
## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
```