Analysis

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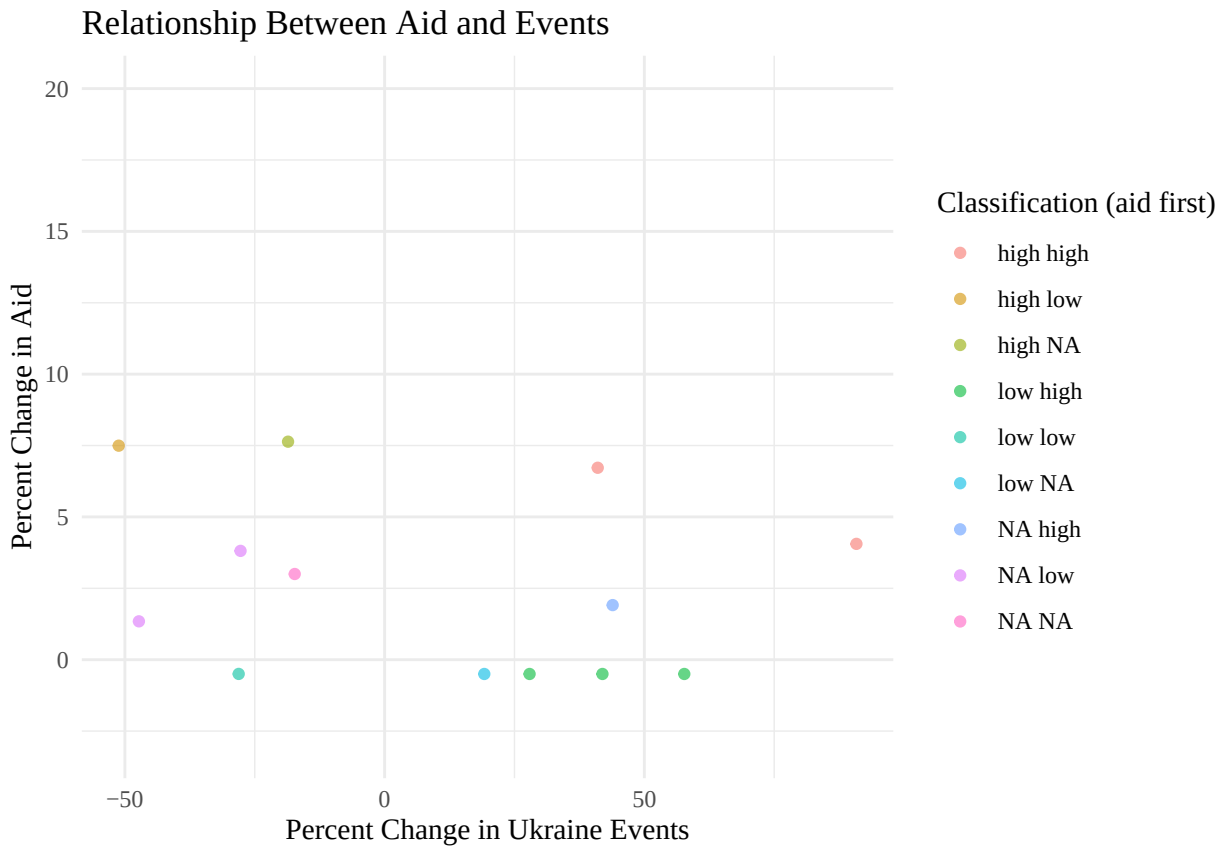
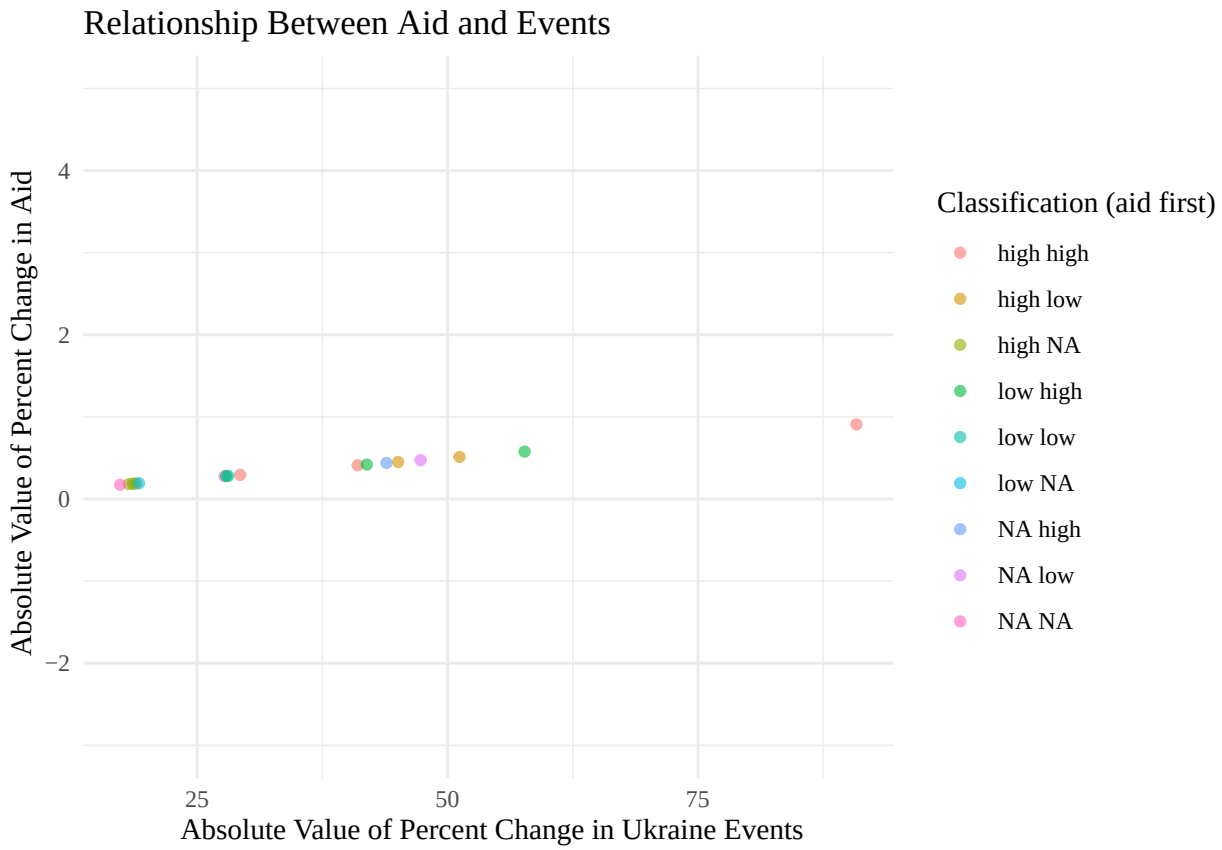
Data structuring

```
## 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

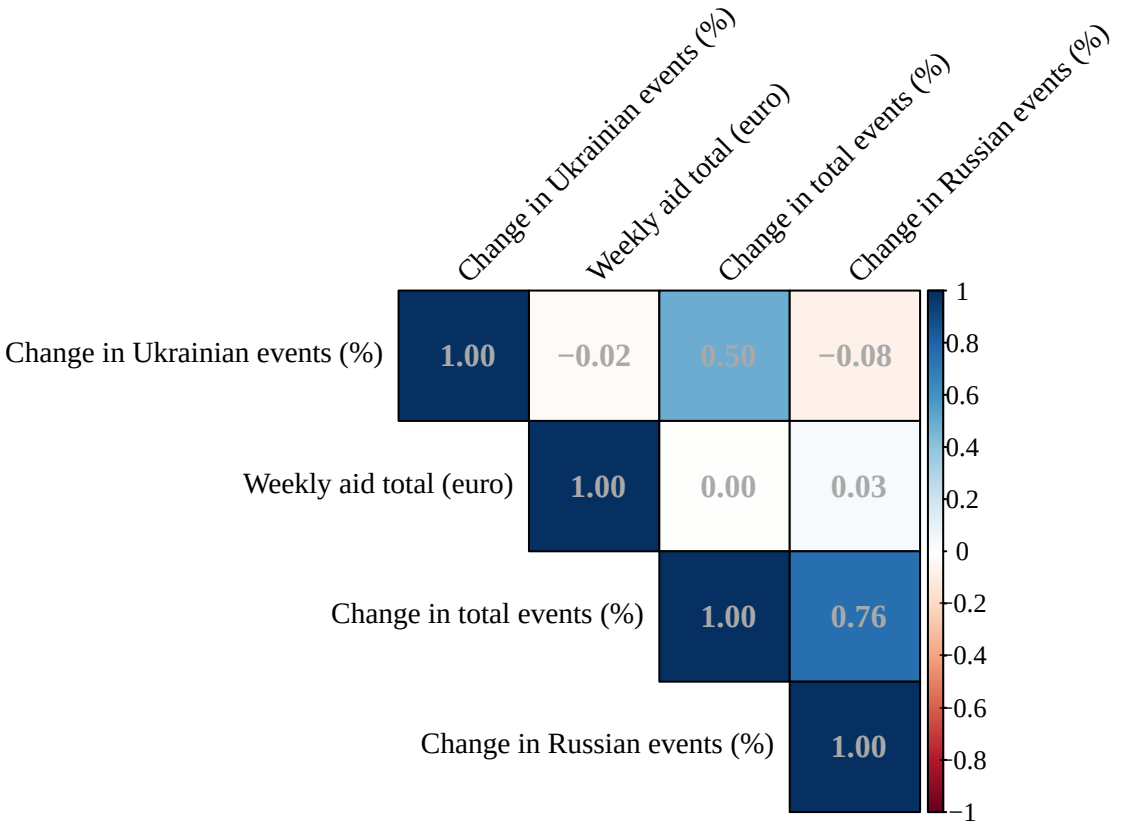
Summary Statistics

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Mon, Apr 07, 2025 - 20:52:14

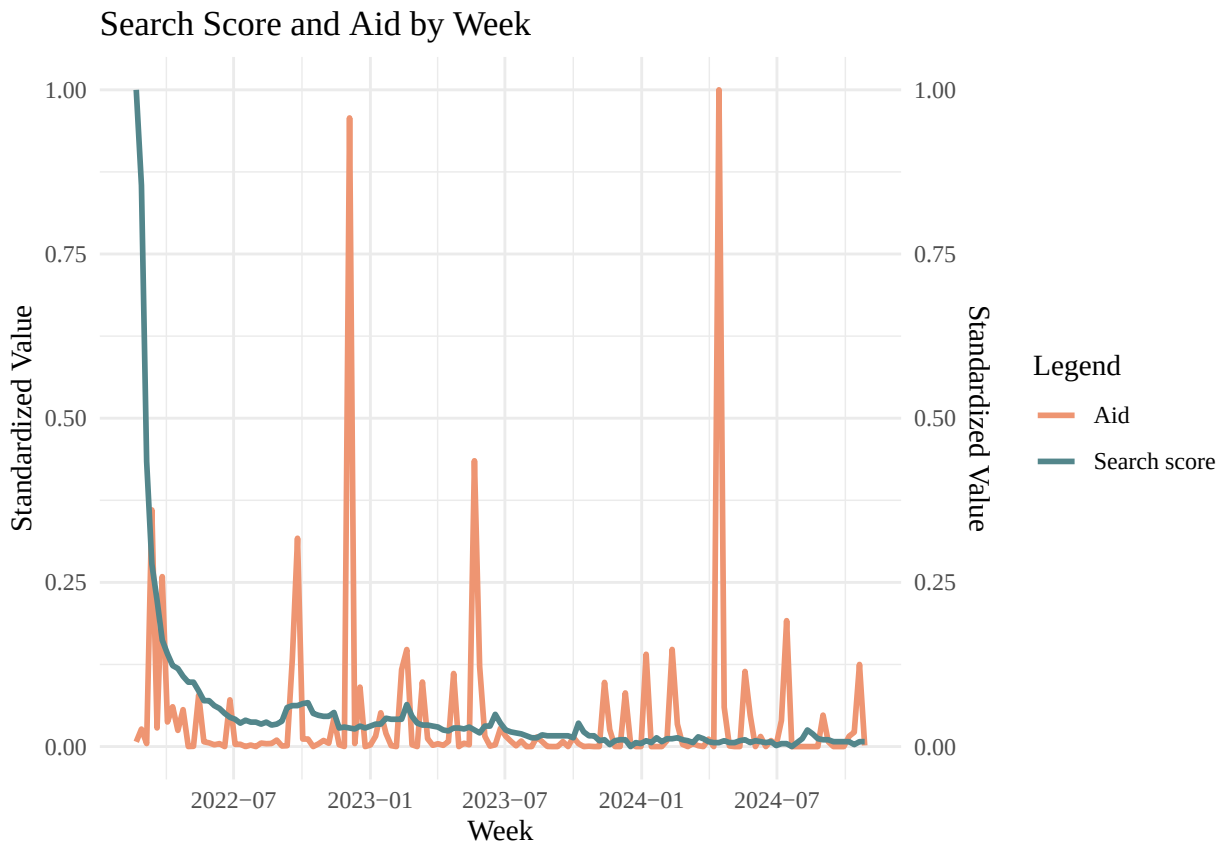
Table 1: Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Weekly aid total (euro)	141	834,605,790.000	2,474,692,804.000	0	791,674	489,242,572	18,926,299,908
Change in aid (%)	141	5,636.104	47,871.480	−100.000	−94.014	25.993	546,163.600
Weekly event total	141	466.043	76.734	268	412	513	638
Ukrainian instigated events	141	153.149	66.723	34	106	207	289
Russian instigated events	141	312.894	92.741	138	250	344	566
Change in total events (%)	141	0.444	11.954	−28.868	−7.882	8.382	64.183
Change in Ukrainian events (%)	141	1.065	22.569	−51.190	−14.103	13.084	90.826
Change in Russian events (%)	141	1.305	15.822	−32.143	−9.470	9.355	67.568
Search score	141	7.379	11.326	2.710	3.710	6.710	98.860

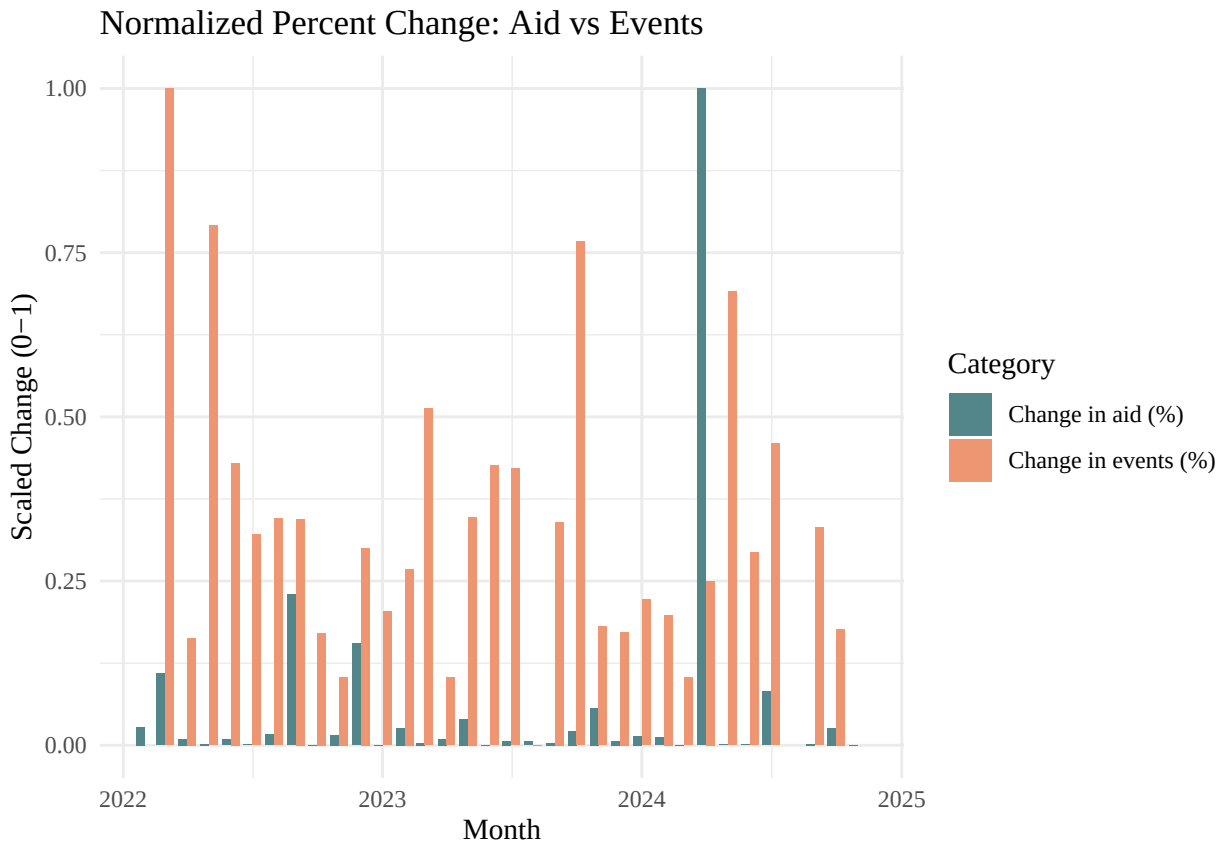
Correlation matrix

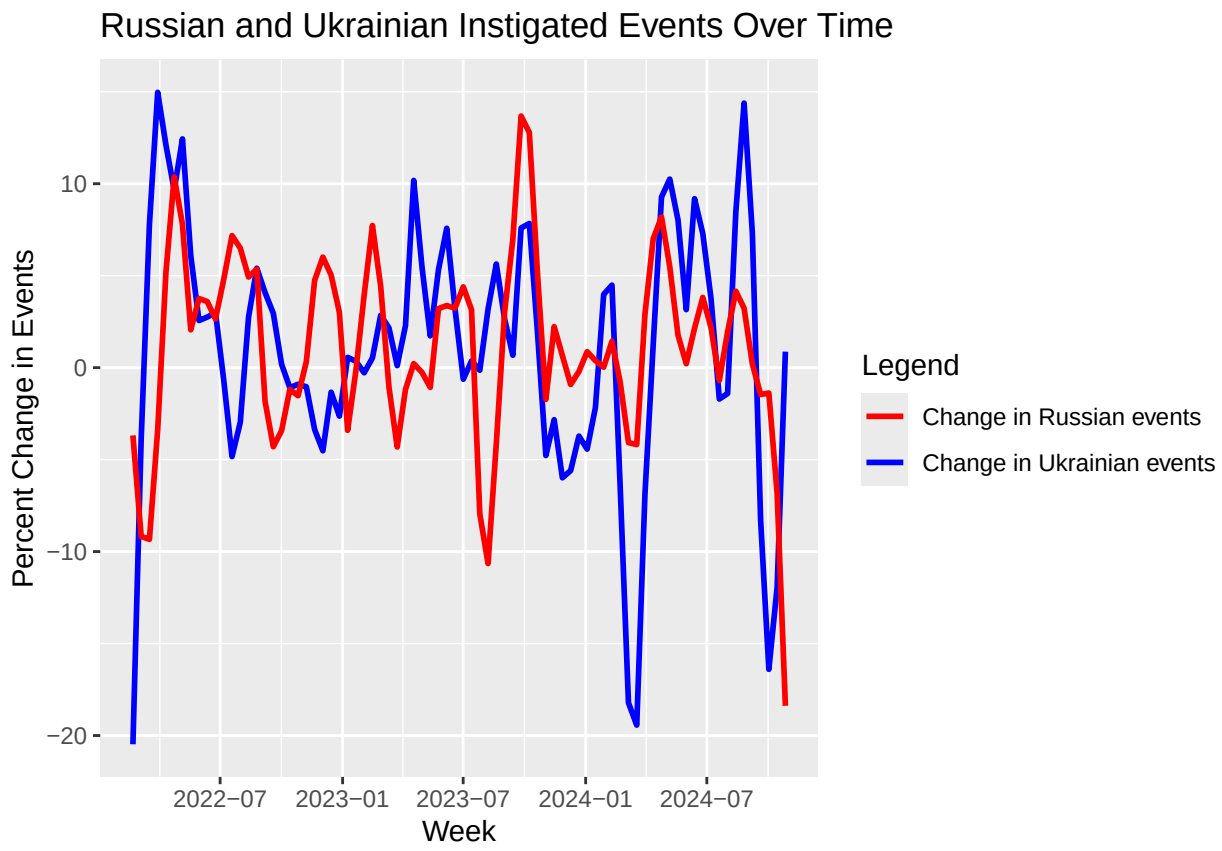


Visualizations




```
## 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
```

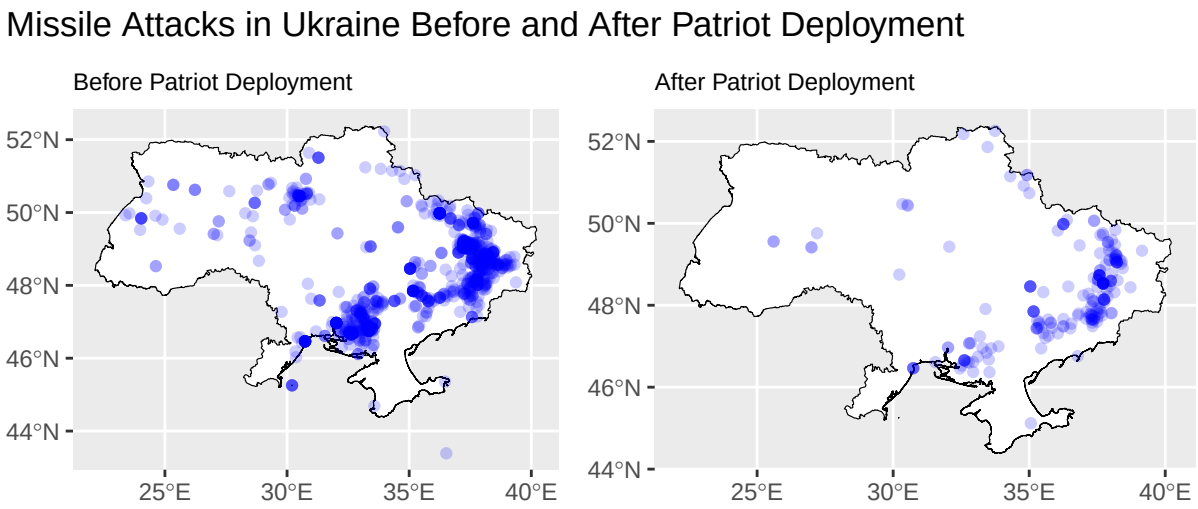
```
missiles_sf <- st_as_sf(missile_events, coords = c("longitude", "latitude"), crs = 4326)

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))

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(plot.title = element_text(size = 9))

(missile_map_before1 + missile_map_after1) +
   plot_annotation(
    title = "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-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

T-tests

Regressions on Ukraine

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
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_ukrain

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
```

```
# 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 =
```

Table 2: 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 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
```

Table 3: 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.

Regressions on missiles

```
# Missiles regressions

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

```
##
## Call:
## lm(formula = russian_missiles ~ patriot_aid, data = byweek_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -12.611  -7.611  -2.611   3.992  44.389
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  13.6105     0.9794  13.897   <2e-16 ***
## patriot_aid  -4.6027     1.7945  -2.565   0.0114 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.71 on 139 degrees of freedom
```

Table 4: 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.

```
## Multiple R-squared:  0.04519,    Adjusted R-squared:  0.03832
## F-statistic: 6.579 on 1 and 139 DF,  p-value: 0.01138
```

```
# 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
```

Table 5: 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.

```
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
```

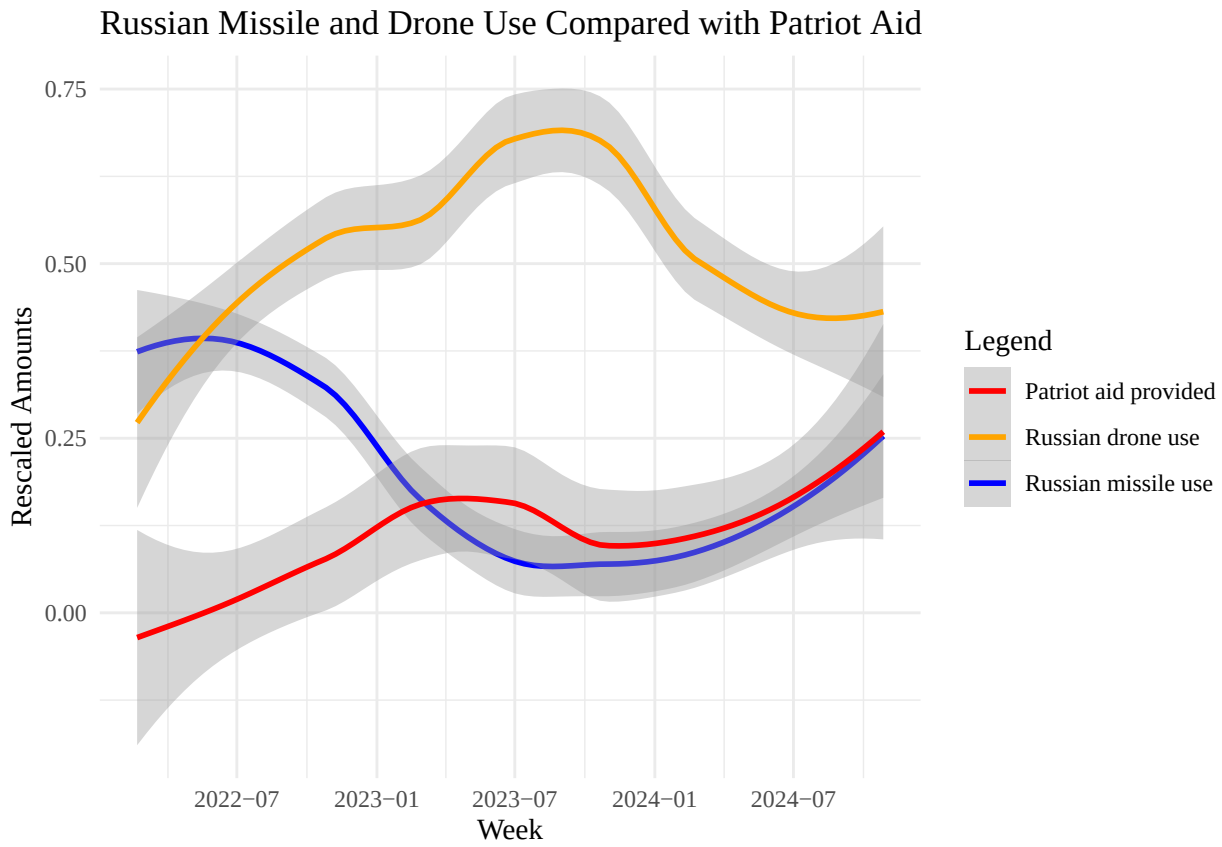
```
# Drone regressions (russian drone activity on anti drone aid)
antidrone_reg <- lm(russian_drones ~ week_lag_aid, data = drones_dataset)
```

```r
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'
```


Russian Missile and Drone Use Compared with Patriot Aid
0.75
0.50
0.25
0.00
Rescaled Amounts
2022−07
2023−01
2023−07
2024−01
2024−07
Week
Legend
Patriot aid provided
Russian drone use
Russian missile use