EPPS 7316 Final Paper: The Effect of Military Fatalities on Trade Between Ukraine and Russia

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Ukrainian trade with Russia, evaluated as the share of Ukrainian imports that came from Russia and the share of Ukrainian exports that went to Russia, changed as a result of the war in Ukraine. Both the elapsed months since the start of the war in March 2014 and conflict intensity, measured by monthly Ukrainian military fatalities, were found to be significant and associated with decreases in Ukrainian trade with Russia, relative to its overall trade.

This project will examine the effect of the progression of the conflict in eastern Ukraine on the trade relationship between Ukraine and Russia.

I. Review of Literature

As trade continues to grow more globalized in nature, it is necessary to determine the new costs of conflict on modern economies. In the past, two nations at war could not engage in open legal trade, especially at the height of their conflict; now, however, it appears that economic considerations may outweigh nationalistic concerns, and what happens on the battlefield might not significantly disrupt trade.

The most relevant paper investigating the impact of war on international trade, published in 2005 by Reuven Glick and Alan M. Taylor, uses 251,905 bilateral trade observations from 1870 to 1997 involving 11,535 distinct country pairs from the Correlates of War (COW) database. Glick and Taylor use the widely-accepted gravity model to estimate both the contemporaneous and lagged effects of war on trade. The inclusion of lagged variables is noteworthy in that previous studies of its kind had only considered contemporaneous effects.

Furthermore, papers typically focus on the direct costs of war, traditionally casualties and wartime resources. The connection of war to interstate trade is logical in theory but messy in execution, and studies, such as that by Pollins (1989), van Bergeijk (1994), and Mansfield and Bronson (1997), that have attempted to test that relationship largely have failed to find clear results and come to a definite conclusion. One salient problem in these studies is the paradox that inclusion of so many country pairs necessarily introduces innumerable extraneous variables that dilute the efficacy of tests and confuse results. On the other hand, the exclusion of country pairs that are unlikely to engage in trade, such as Ukraine and Guyana, can introduce bias into the data samples.

My paper will attempt to circumvent that paradox by conducting an analysis focusing on the trade of material goods for one country pair, Ukraine and Russia, from 2006 through 2018. In that way, the scope of the analysis will match the sampling of data, which should avoid introducing bias. Additionally, by focusing on a particular channel of trade, more recent data is available than that from multinational sources such as the Correlates of War and the International Monetary Fund. Instead, this paper will use data on Ukrainian military fatalities, collected in the Ukrainian National Military History Museum's Memory Book, and Ukrainian foreign trade in goods, managed by the Ukrainian State Statistical Service, both of which are available through December 2018.

Glick and Taylor found that the indirect costs of war may roughly echo the direct costs of war, although an analysis of magnitude was not possible due to the scale of their panel data; instead, they used case studies for World War I and World War II. Because of the smaller scale of my project, it should be possible to run models that will consider the magnitude rather than only the presence of effects.

II. Data and Methodology

The chosen data sources are complete from at least March 2014 to December 2018 and are generally considered accurate. Ukrainian military fatalities from the Ukrainian National Military History Museum's Memory Book will serve as a proxy for the intensity of the conflict, as information on separatist and Russian military fatalities is limited. Bilateral trade in goods data from the Ukrainian Statistical Service extends from 2006 to 2018. I will use the value of Ukraine's trade with Russia as a percentage of the value of its global trade that month both to remove the effects of Ukrainian and global national macroeconomic volatility and to avoid the issue of inconsistent currency units from year to year. Russian macroeconomic volatility caused by factors such as oil price fluctuations and sanctions will be accounted for in separate Russian global imports and exports variables using data from the Russian Federal State Statistic Service.

My first two hypotheses are that since the beginning of the conflict in March 2014, Ukraine has found substitute sources of imports and destinations for exports, which has allowed it to curtail its trade in goods with Russia. Thus, during the war, the shares of (1a) Ukrainian imports from Russia as a percentage of all Ukrainian imports and (1b) Ukrainian exports to Russia as a percentage of all Ukrainian exports will be smaller than before the war. A second set of hypotheses will consider the interaction between time (measured in the number of months since the start of the war) and conflict intensity as a predictor for (2a) imports and (2b) exports.

I will conduct a test for war as a dummy variable (March 2014 to the end of the data series in December 2018) to verify that Ukrainian trade behavior toward Russia was significantly different since the outset of the conflict. I will run these tests for imports from Russia and exports to Russia because Ukraine's ability and willingness to find new sources of imports likely varied from its ability and willingness to find new destinations for its exports. The second set of hypotheses will treat the data as a time series, with the addition of the conflict intensity component and interaction terms.

TABLE 1—DESCRIPTION OF VARIABLES

Variable Name	Description
Russia.Imp.Share	Imports from Russia as share of all Ukrainian imports
Russia.Exp.Share	Exports to Russia as share of all Ukrainian exports
Russia.Imp.Share.SA	Imports share, seasonally adjusted
Russia.Exp.Share.SA	Exports share, seasonally adjusted
war	Indicator variable; 1 if date is after February 2014, 0 otherwise
war.months	Months since start of war in March 2014
ros.World.Exp	Total value of all exported Russian goods
ros.World.Imp	Total value of all imported Russian goods
fatalities	Ukrainian military fatalities
fatalities.lag	Ukrainian military fatalities, lagged one month

III. Results

The first model (1a) will predict the effect of the presence of the war on imports to Ukraine from Russia, i.e. $Russia.Imp.Share = \beta_0 + \beta_1 war$, where war = 0 from January 2006 through February 2014, and 1 from March 2014 through December 2018, the last month for which data are available. Table 2 shows

TABLE 2—MODEL 1A: WAR AND IMPORTS

	Russia.Imp.Share	
	Estimate	Pr(>|t|)
(Intercept)	0.3053	0.0000
war	-0.1401	0.0000
Observations	156	
R^2	0.593	
Adjusted R^2	0.591	
Residual Std. Error	0.056 (df = 154)	
F Statistic	224.717 (df = 1; 154)	0.0000

the results of the regression. *war* is significant, with a p-value of 0, and has a negative effect such that the average share of total Ukrainian imports that came from Russia was -0.14 less across months during the war compared to before the war. Model (1a) explains only 59.3% of the total variation in Russian import share, so other variables not included in the model also hold explanatory power.

The second part of this model (1b) will predict the effect of the presence of the war on exports from Ukraine to Russia as a share of all Ukrainian exports, i.e. $Russia.Exp.Share = \beta_0 + \beta_1 war$. Table 3 shows the results of the regression.

Table 3—Model 1b: War and Exports

	Russia.Exp.Share	
	Estimate	Pr(>|t|)
(Intercept)	0.2451	0.0000
war	-0.1326	0.0000
Observations	156	
R^2	0.779	
Adjusted R^2	0.777	
Residual Std. Error	0.034 (df = 154)	
F Statistic	541.609 (df = 1; 154)	0.0000

war is again significant, with a p-value of 0 and a negative effect of reducing the Russian share of Ukrainian exports by -0.13 across the war period. The presence of war alone explains 77.9% of the total variation in Russian export share, which, while considerable and worth noting for future inquiry, leaves room for other explanatory variables.

Next, we try a pair of more complex models, restricting the data to the war period ($war = 0$) and testing two separate measures of fatalities. The first uses contemporaneous fatalities, which notes the intensity of the war during the month of trade; the second uses fatalities lagged one month, which considers the effect of conflict intensity the previous month on trade, logistically and patriotically, during the current month. Both models use *war.months* to account for the number of months since the start of the conflict and $ros.World.Exp$ to account for variations in global Russian trade.

Therefore, in the first model (1), $Russia.Imp.Share = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities) + \beta_3 log(ros.World.Exp)$. In model (2), $Russia.Imp.Share = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities.lag) + \beta_3 log(ros.World.Exp)$. Table 4 shows the results of both regressions. All variables are significant at the 2 percent level or better. In both models, *war.months* has a negative effect such that each additional month into the war is associated with a decrease of -0.002 in the Russian share of Ukrainian imports. As expected, an increase in Russian global exports has a positive correlation with Ukrainian imports of Russian goods (a one-

Table 4—Russia Share of All Ukrainian Imports

	Dependent variable:	
	Russia.Imp.Share	
	(1)	(2)
war.months	−0.002	−0.002
	p = 0.000	p = 0.000
log(fatalities)	−0.012	
	p = 0.023	
log(fatalities.lag)		−0.022
		p = 0.00003
log(ros.World.Exp)	0.080	0.073
	p = 0.00004	p = 0.00004
Constant	−0.558	−0.442
	p = 0.005	p = 0.014
Observations	58	57
R^2	0.606	0.668
Adjusted R^2	0.584	0.649
Residual Std. Error	0.030 (df = 54)	0.027 (df = 53)
F Statistic	27.717 (df = 3; 54)	35.535 (df = 3; 53)

percent increase in Russian global exports corresponds to an increase in import share of roughly 0.08). The lagged fatalities measure has a larger coefficient (a one-percent increase in fatalities is associated with a decrease in import share of -0.022 compared to -0.012) and a smaller p-value. Additionally, model (2)'s R^2 is larger, indicating that the model with lagged fatalities does a better job of explaining the total variation in Russian import share. However, the R^2 is still only 0.668, meaning that further analysis will be necessary.

The next set of models repeat Table 4's calculations with Russian share of exports as the dependent variable and $ros.World.Imp$ to account for variations in global Russian trade. In the model (1), $Russia.Exp.Share = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities) + \beta_3 log(ros.World.Imp)$, and in model (2), $Russia.Exp.Share = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities.lag) + \beta_3 log(ros.World.Imp)$. Table 5 shows the results of both regressions. All variables are significant at the 7 percent level or better. As in the imports models, both exports models show that *war.months* has

Table 5—Russia Share of All Ukrainian Exports

	Dependent variable:	
	Russia.Exp.Share	
	(1)	(2)
war.months	−0.002	−0.002
	p = 0.000	p = 0.000
log(fatalities)	−0.005	
	p = 0.064	
log(fatalities.lag)		−0.005
		p = 0.069
log(ros.World.Imp)	0.073	0.070
	p = 0.000	p = 0.000
Constant	−0.524	−0.502
	p = 0.00000	p = 0.00000
Observations	58	57
R^2	0.870	0.859
Adjusted R^2	0.863	0.851
Residual Std. Error	0.015 (df = 54)	0.014 (df = 53)
F Statistic	120.957 (df = 3; 54)	107.562 (df = 3; 53)

a negative effect of -0.002 in the Russian share of Ukrainian imports. An increase in Russian global imports has a positive correlation with exports of Ukrainian goods to Russia (a one-percent increase in Russian global imports is associated with an increase in export share of 0.07). The lagged and not lagged fatalities measures have the same coefficient (here, a one-percent increase in fatalities corresponds to a decrease in export share of -0.005) and nearly the same p-values. Additionally, model (1)'s R^2 is slightly larger, indicating that the model with lagged fatalities does a better job of explaining the total variation in Russian import share. The R^2 is higher than the imports models, at 0.87.

Plotting the data across time (Figure 1) reveals a possible source of missing explanatory power in the earlier models. The share of Ukrainian imports that come from Russia appears to follow seasonal patterns. One possible explanation for this seasonality is that imported goods includes imported natural gas, for which Ukraine relies heavily on Russian imports during cold winter months, a relationship which continued despite the war due to limited alternative sources of natural gas.

Ukrainian exports to Russia (Figure 2) likewise appear to follow a seasonal pattern.

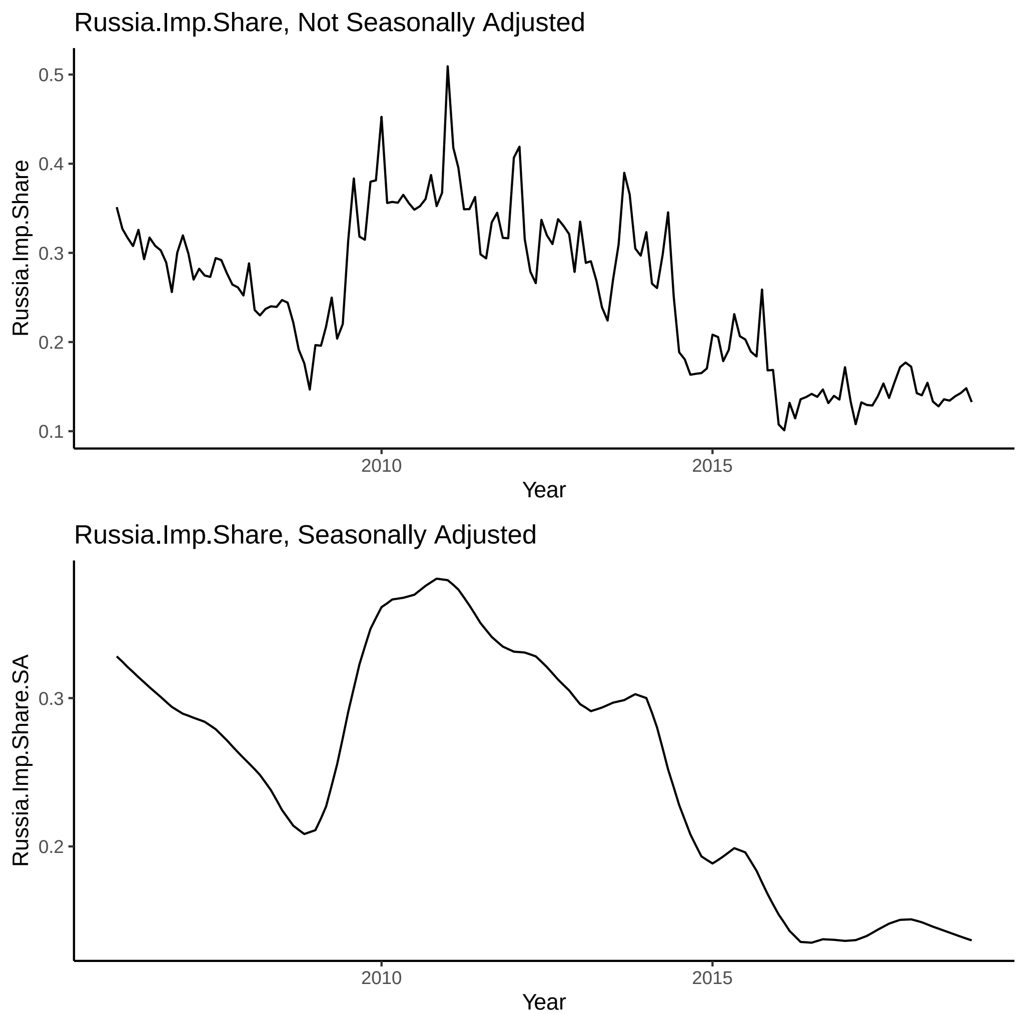

Figure 1. Seasonality of Imports Share

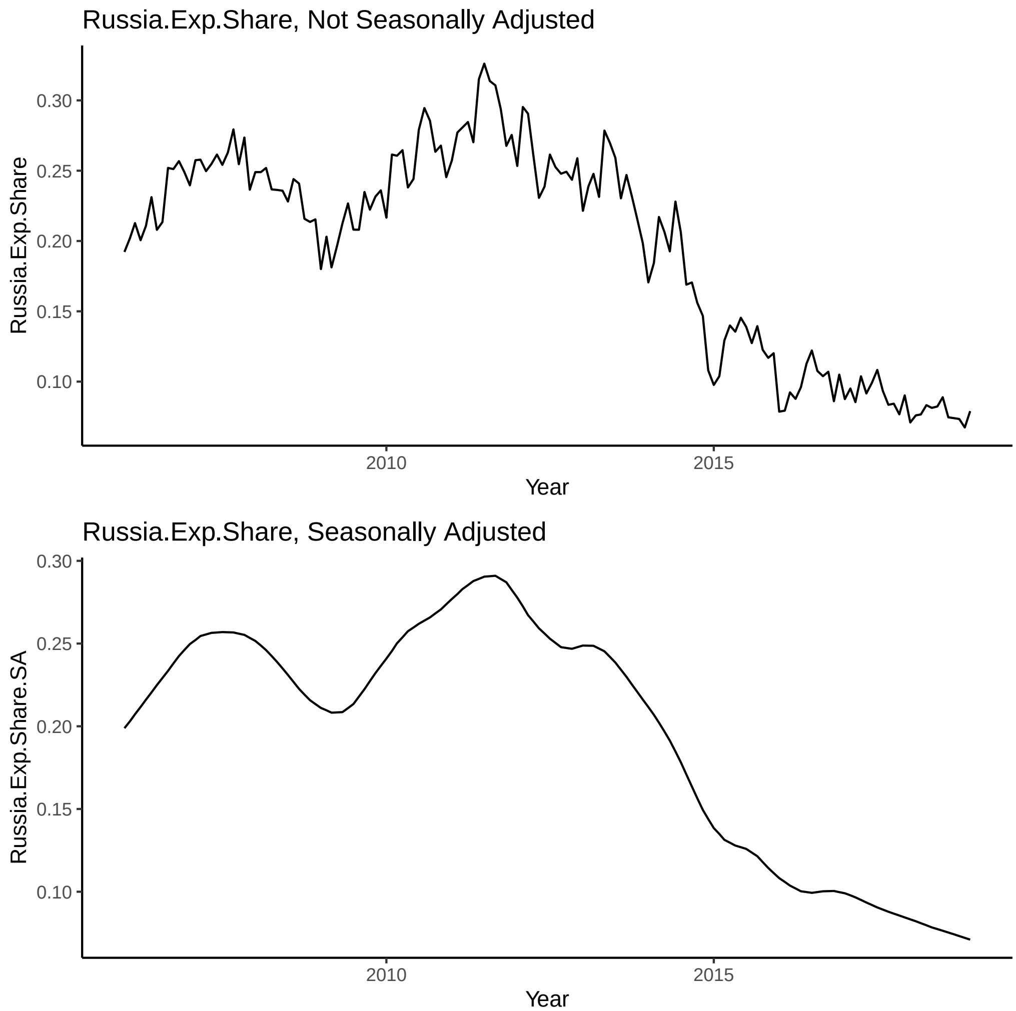

Figure 2. Seasonality of Exports Share

As the Ukrainian imports and exports data do not specify which goods are traded, it is not possible to identify the cause of seasonality in the share of Ukrainian exports that go to Russia. The full models from Tables 4 and 5 will be repeated using seasonally-adjusted Russia share of all Ukrainian imports and Russia share of all Ukrainian exports as dependent variables, respectively.

The models in Table 6 repeat Table 4's calculations with the seasonally-adjusted dependent variable. In the model (1), $Russia.Imp.Share.SA = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities) + \beta_3 log(ros.World.Exp)$, and in model (2), $Russia.Imp.Share.SA = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities.lag) + \beta_3 log(ros.World.Exp)$. The models using the seasonally-adjusted dependent variable find the same effect of $war.months$.

TABLE 6—RUSSIA SHARE OF ALL UKRAINIAN IMPORTS, SEASONALLY ADJUSTED

	Dependent variable:	
	Russia.Imp.Share.SA	
	(1)	(2)
war.months	−0.002	−0.002
	p = 0.000	p = 0.000
log(fatalities)	−0.008	
	p = 0.0001	
log(fatalities.lag)		−0.006
		p = 0.001
log(ros.World.Exp)	0.074	0.070
	p = 0.000	p = 0.000
Constant	−0.516	−0.479
	p = 0.000	p = 0.000
Observations	58	57
R^2	0.919	0.911
Adjusted R^2	0.915	0.906
Residual Std. Error	0.011 (df = 54)	0.010 (df = 53)
F Statistic	205.394 (df = 3; 54)	180.786 (df = 3; 53)

All else equal, each additional month since the start of the war corresponds to a -0.002 decrease in the share of Ukrainian imports that came from Russia. This coefficient indicates that the structure of Ukrainian trade changed progressively throughout the war; over time, Ukraine found alternative sources of imports and restructured its trade dynamics.

A one-percent increase in contemporaneous fatalities is associated with a -0.008 reduction in the Russian share of Ukrainian imports, a slightly larger coefficient than lagged fatalities, meaning that current conflict intensity might be a slightly better predictor than conflict intensity the previous month of Ukrainian import behavior. This result suggests that the effect of conflict intensity on Ukrainian imports could be logistical in nature, involving obstacles such as closed borders and destroyed infrastructure rather than retaliatory consumer behavior such as boycotts.

As in the non-seasonally adjusted-trade model, a one-percent increase in Russian global exports is associated with a 0.07 increase in the share of Ukrainian imports that come from Russia.

The first model (1) has slightly better overall predictive power than model (2), explaining 91.9% of the total variation in seasonally-adjusted Russia share of Ukrainian imports. In comparison, the best non-seasonally adjusted model explained only 66.8% of the variation. Removing the seasonality component of the dependent variable considerably increased the explanatory power of the models in Table 6.

Table 7—Russia Share of Ukrainian Exports, Seasonally Adjusted

	Dependent variable:	
	Russia.Exp.Share.SA	
	(1)	(2)
war.months	−0.002	−0.002
	p = 0.000	p = 0.000
log(fatalities)	−0.003	
	p = 0.013	
log(fatalities.lag)		−0.004
		p = 0.001
log(ros.World.Imp)	0.043	0.041
	p = 0.000	p = 0.000
Constant	−0.245	−0.216
	p = 0.00001	p = 0.00001
Observations	58	57
R^2	0.955	0.960
Adjusted R^2	0.952	0.958
Residual Std. Error	0.007 (df = 54)	0.007 (df = 53)
F Statistic	377.635 (df = 3; 54)	422.377 (df = 3; 53)

The models in Table 7 repeat Table 5's calculations with the seasonally-adjusted dependent variable. In the model (1), $Russia.Exp.Share.SA = \beta_0+\beta_1 war.months+\beta_2 log(fatalities)+\beta_3 log(ros.World.Imp)$, and in model (2), $Russia.Exp.Share.SA = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities.lag) + \beta_3 log(ros.World.Imp)$.

These find the same effect of *war.months*, a -0.002 decrease per month in the share of Ukrainian exports that went to Russia.

A one-percent increase in lagged fatalities is associated with a -0.004 reduction in the Russian share of Ukrainian exports, a slightly larger coefficient than contemporaneous fatalities, with a slightly better p-value, indicating that Ukrainian export behavior might be more greatly affected by the previous month's conflict intensity than by the current month's conflict intensity.

Compared to the non-seasonally adjusted-trade model, a one-percent increase in Russian global imports is associated with a smaller increase in the share of Ukrainian exports that go to Russia (0.04 rather than 0.08). This result indicates that some part of the other model's $ros.World.Imp$ coefficient was explained by seasonality.

Both models in Table 7 have high explanatory power, with the better, model (2), accounting for 96% of the total variation in seasonally-adjusted Russia share of Ukrainian exports. In comparison, the best non-seasonally adjusted model explained 87% of the variation. While not as dramatic as the differences between the import models, removing the seasonality component of the dependent variable notably increased the explanatory power of the export models.

Therefore, the best models for Russia share of Ukrainian imports and Russia share of Ukrainian exports are reprinted side by side in Table 8. $Russia.Imp.Share.SA = \beta_0+\beta_1 war.months+\beta_2 log(fatalities)+\beta_3 log(ros.World.Exp)$ and $Russia.Exp.Share.SA = \beta_0 + \beta_1 war.months + \beta_2 log(fatalities.lag) + \beta_3 log(ros.World.Imp)$.

Table 8—Best Models

	Dependent variable:	
	Russia.Imp.Share.SA	Russia.Exp.Share.SA
	(1)	(2)
war.months	−0.002	−0.002
	p = 0.000	p = 0.000
log(fatalities)	−0.008	
	p = 0.0001	
log(ros.World.Exp)	0.074	
	p = 0.000	
log(fatalities.lag)		−0.004
		p = 0.001
log(ros.World.Imp)		0.041
		p = 0.000
Constant	−0.516	−0.216
	p = 0.000	p = 0.00001
Observations	58	57
R^2	0.919	0.960
Adjusted R^2	0.915	0.958
Residual Std. Error	0.011 (df = 54)	0.007 (df = 53)
F Statistic	205.394 (df = 3; 54)	422.377 (df = 3; 53)

To verify that the inputs for these models are correctly specified, I next plot the residuals against the independent variables in figures 3 (imports) and 4 (exports). Visually, it is clear that the residuals have the same scatter across all values of the independent variables.

To be certain, Table 9 displays the results of two models regressing the errors on the independent variables. In model (1), $\epsilon = \beta_0 + \beta_1 war.months + \beta_2 ros.World.Exp + \beta_3 fatalities$, and in model (2), $\epsilon = \beta_0 + \beta_1 war.months + \beta_2 ros.World.Imp + \beta_3 fatalities.lag$. All coefficients are insignificant at a p-value of 0.7 or better.

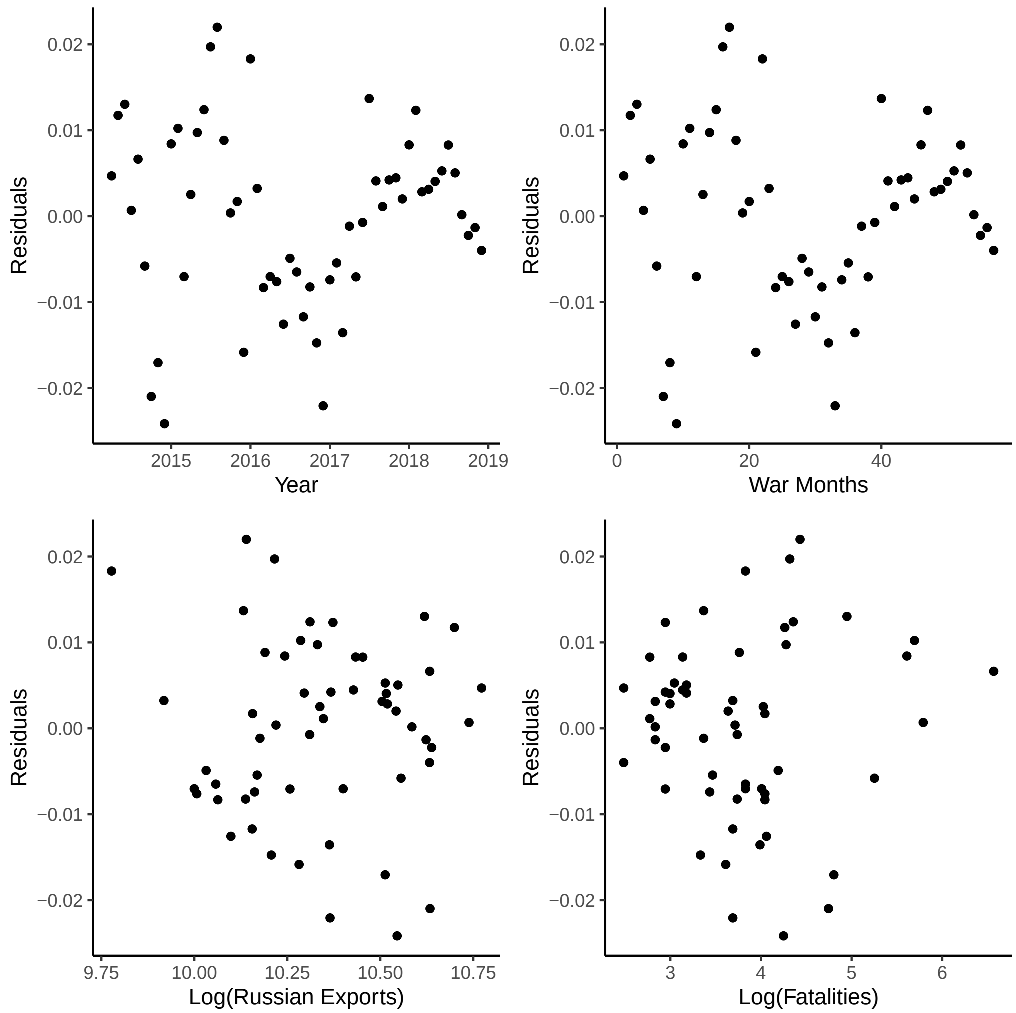

Figure 3. Test for Heteroskedasticity: Imports

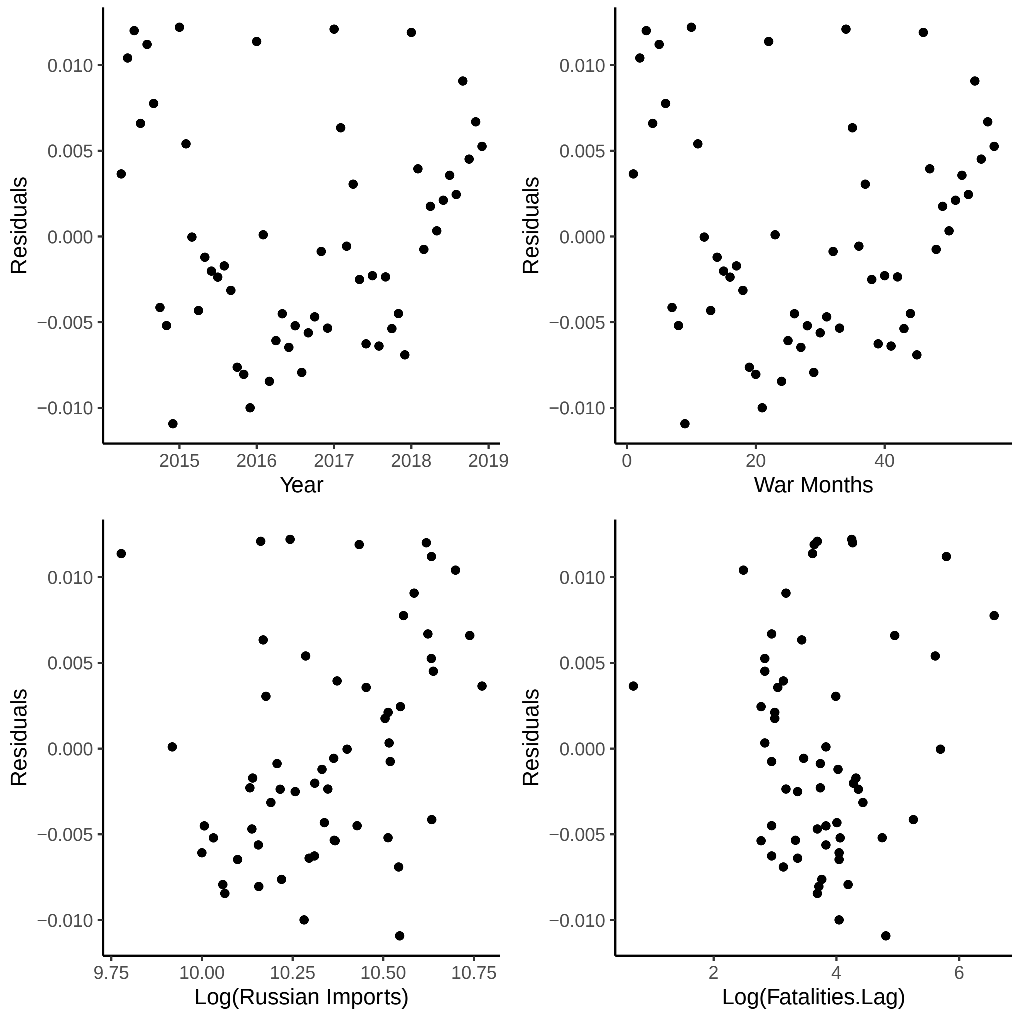

Figure 4. Test for Heteroskedasticity: Exports

Table 9—Heteroskedasticity Tests: Final Models

	Dependent variable:	
	Imports Model Residuals	Exports Model Residuals
	(1)	(2)
war.months	0.00005	0.000
	p = 0.727	p = 1.000
ros.World.Exp	−0.001	
	p = 0.918	
fatalities	0.001	
	p = 0.705	
ros.World.Imp		−0.000
		p = 1.000
fatalities.lag		0.000
		p = 1.000
Constant	0.002	0.000
	p = 0.981	p = 1.000
Observations	57	57
R^2	0.003	0.000
Adjusted R^2	−0.053	−0.057
Residual Std. Error (df = 53)	0.011	0.007
F Statistic (df = 3; 53)	0.054	0.000

IV. Conclusion

The war in Ukraine significantly impacted bilateral trade between Ukraine and Russia from March 2014 to December 2018. With each month that passed from the onset of the war, trade with Russia became an increasingly smaller portion of Ukraine's worldwide imports and exports.

The original hypotheses — that the presence of war itself was significant, and that a combination of the passage of time and intensity of conflict was significant — were both supported by these results. The final "best" models explained 92% and 96% of total variation in import share and export share, respectively.

With the negative effect of the war clear, analysis has raised a few more questions. There is significant seasonality in both Ukrainian imports from Russia as a share of its overall imports and exports to Russia as a share of its overall exports, and that seasonality persisted through the war. Where does that seasonality come from? It is likely that at least some of the seasonality in the import share is due to natural gas imports in the winter, which are difficult for Ukraine to substitute or import from other countries. Future research could use product-specific trade data to evaluate this hypothesis and to determine which goods account for the seasonality in export share.

Furthermore, it appears that in some circumstances, contemporaneous fatalities affect trade more than lagged fatalities, while in other circumstances the reverse is true. Future research could investigate the separate effects of conflict on consumer purchasing habits versus transportation logistics and infrastructure.

Finally, if Ukraine has found other countries to substitute certain classes of its imports and exports, which countries are they? Did policy changes, such as visa-free travel to Europe, provide additional inducement to import goods from Europe rather than Russia?

As the war continues and Ukraine further distances itself from Russia, understanding the effects of conflict on trade between Ukraine and Russia will help to assess its costs and illuminate the path forward.

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