Jackson Buick, Shailin Vaid, Tyler Hawes
December 4, 2022
ECON 3300
Professor Jain

The Effect of Fuel Export on Military Spending in the Post Cold-War Era

Research Question:

The research question of interest is: “How does the strength of a nation’s fuel export industry affect its amount of military expenditure relative to GDP in the post Cold-War era?” The motivation for this research question is to determine if countries with a greater fuel export industry have a larger focus on military expenditure to protect the country's wealth. We hypothesize that nations with a large fuel export suffer from a resource curse which leads to a heightened need to militarize. If this correlation is proven to exist, it would highlight a crucial cause of militarization: that nations with a fuel surplus are incentivized to militarize as a result of their export economies. Demilitarization is a crucial component of international collective security, and hence it is worth identifying the causes of militarization to diminish hostility. We have chosen to research the post-cold war era, starting in 1991, on until the year 2019, before the beginning of the pandemic.

Data Set:

The data being used in this research was sourced from The World Bank Group. The World Bank Group aims to “help developing countries improve the capacity, efficiency, and effectiveness of national statistical systems”. The data was collected through the statistical systems of member countries, with the oversight of the World Bank. Hence, the quality of this data is determined on how well this national system performs. There are many international statistical standards and regulations strictly followed by the World Bank, which makes available data quite strong, but there may be a non-random selection bias against countries without the

infrastructure and compliance to be included in the World Bank's database, which are disproportionately small. The World Bank Group operates in more than 170 countries utilizing information from partners in both the public and private sectors. Within the World Bank, the Development Data Group manages the statistical and data collection work for the World Bank Group. The Development Data Group works in close compliance with the banks of regions specified in the World Bank Group's outreach. The World Bank Group undergoes revisions each year to portray the most accurate data. Each new edition of the WDI (World Development Indicators) contains the "most complete time series" currently available. Undetermined data is represented as blank data since gap-filing for previous editions is unadvised within the World Bank Group since revisions to certain time series may cause "discontinuities" in the series. The data used in this research are from the years 1991 to 2019 to represent the post-cold war period, and the data is not available for years earlier than 1990 nor after 2019 for all variables used. The data used in this research only includes countries, and does not include data by geographic region or economic factor. Hence, this sample is representative of the population of countries in compliance with the World Bank's reporting standards from 1991 to 2019, and the external validity of these results to not expand beyond this. Additionally, the inclusion of control variables restricts the number of usable observations from 3476 observations with data for *Fuel Exports* and *Military Expenditure* to 1477 observations which additionally include all three controls. Each of the individual variables' data were sourced from different sectors as compiled by the World Bank, and will be detailed as they are introduced.

The dependent variable Y is *Military Expenditure*, measured in percentage points of national GDP for a given year. In the World Bank data, this was originally titled "Military expenditure (% of GDP)". This is a continuous numerical variable calculated as a proportion of

military spending divided by GDP as a measure of the relative importance of militarization to the greater economy of the nation. In other words, *Military Expenditure* represents how strongly a country militarizes relative to its own economic strength. This variable includes money spent on military training and planning, maintenance of equipment, and free military healthcare. The dependent variable data was sourced in partnership with the Stockholm International Peace Research Institute (SIPRI). *Military Expenditure* has a mean value of 2.246, a median value of 1.635, a minimum value of 0, and a maximum value of 117.350. We removed Kuwait in 1991 and Eritrea in 1999 from the data as outliers because of the abnormal nature of their sudden military expenditure for just those single years and we added 1e-10 to all data to avoid losing values of zero for our natural log regression. We also trimmed the data down to only countries and years that had data for all variables, though this process was not applied for Regression 6. The final result was a mean value of 1.694, a median value of 1.443, a minimum value of ~0, and a maximum value of 9.159.

The independent variable of interest X_1 is *Fuel Exports*, measured a percentage points of merchandise exports for a given year. In the World Bank data, this was originally titled "Fuel exports (% of merchandise exports)". This is a continuous numerical variable calculated as a proportion of fuel exports divided by total national merchandise trade export, or "the stock of material resources of a country leaving (as exports) its economic territory". In other words, *Fuel Exports* represents how important the export of fuel is to the entire merchandise export economy of a nation. The World Bank group estimated the data on *Fuel Exports* (as % of merchandise) using the World Integrated Trade Solution (WITS) platforms from the Comtrade database maintained by the United Nations Statistics Division. *Fuel Exports* has a mean value of 15.384, a median value of 3.246, a minimum value of 0, and a maximum value of 99.986. We trimmed the

data down to only countries and years that had data for all variables. The final result was a mean value of 13.434, a median value of 5.239, a minimum value of 0, and a maximum value of 99.950.

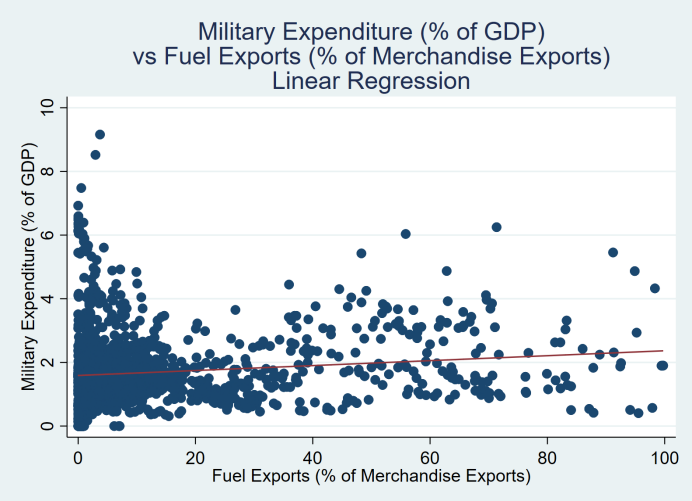
The control independent variable X_2 is *CO2 Emissions* in metric tons per capita within a nation. In the World Bank data, this was originally titled "CO2 emissions (metric tons per capita)". This is a continuous numerical variable representing national industrialization in unclean sectors. The World Bank Group allocated this data using a few sources, the majority of this data was collected from the Historical GHG emissions collected by the Climate watch group. *CO2 Emissions* have a mean value of 4.317, a median value of 2.379, a single minimum value of exactly 0, and a maximum value of 50.954. We trimmed the data down to only countries and years that had data for all variables. The final result was a mean value of 5.221, a median value of 4.062, a minimum value of 0.024, and a maximum value of 25.604.

The control variable X_3 is *FDI* (Foreign Direct Investment), which is represented by a country's balance of payments (BoP) net inflows in millions of current US dollars. In the World Bank data, this was originally titled "Foreign direct investment, net inflows (BoP, Current US$)". This is a continuous numerical variable determined by the difference of total value of payments into and out of a country, creating a tabulation of the total *FDI* for the nation. *FD*I is either positive or negative, representing the net flow of investment between countries. This data was allocated using the International Monetary Fund, Balance of Payments Database, with supplemented data from the United Nations Conference on Trade and Development and official national sources. FDI has a mean value of 7.691, a median value of 2.457, a minimum value of -1,303.131, and a maximum value of 1,709.766. We removed the entirety of the Cayman Islands and Liechtenstein from the data as outliers because they were yielding wildly varying data and as

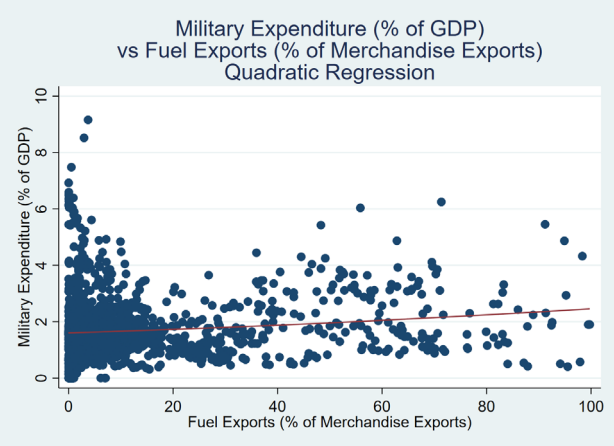
microstates for other countries likely functioned far atypical of any other data in the set, and we also trimmed the data down to only countries and years that had data for all variables. The final result was a mean value of 6.404, a median value of 2.910, a minimum value of -57.532, and a maximum value of 449.0828.

The control variable X_4 is a country's *Gini Index*. In the World Bank data, this was originally titled "Gini Index". The World Bank Poverty and Inequality Platform determined these figures based on primary household survey data obtained from government statistical agencies and World Bank country departments. The Gini index is used as a measure of statistical dispersion intended to portray the wealth inequality within a nation. *Gini Index* is a continuous numerical value measured between 0 and 1. A higher value represents a greater income inequality within that country. Research has shown that a greater income inequality has shown a higher rate of health and social issues, lower rates of social goods, and a lower overall satisfaction and happiness within a country. The *Gini Index* variable has a mean value of 38.146, a median value of 36, a minimum value of 20.7, and a maximum value of 65.8. We trimmed the data down to only countries and years that had data for all variables. The final result was a mean value of 38.041, a median value of 35.9, a minimum value of 22.9, and a maximum value of 65.8.

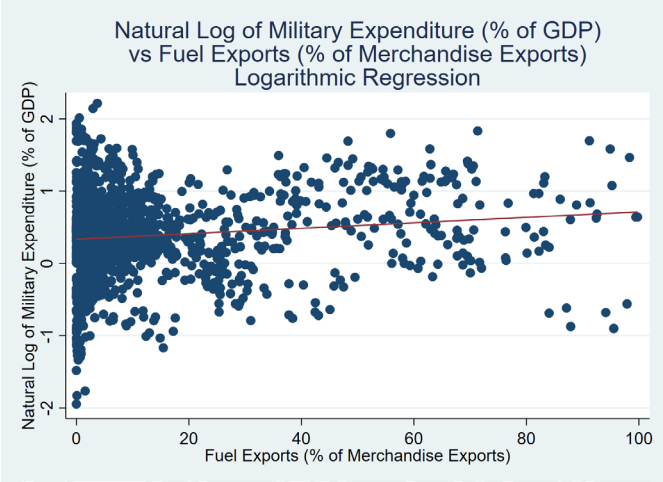
Empirical Specification and Analysis:



The coefficient of interest β_1 was expected to be a positive value, as we predicted the strength of a nation's fuel export industry to positively affect its amount of military expenditure relative to GDP in the post Cold-War era. This prediction is due to a perceived relationship between abundant natural resources, in this case fuel, and militarism. To examine this relationship, Model 1 is a naive regression of the variable *Military Expenditure* on *Fuel Exports*. The regression uses the following form: $MilitaryExpenditure = 1.589 + 0.008*FuelExports + u_i$. The intercept 1.589, is interpreted as the amount of military expenditure as a percentage of GDP when $FuelExports = 0$. This is interpreted that fuel exports as a percentage of total merchandise exports increasing by one percentage point is predicted to increase military expenditure as a percentage of GDP by 0.008 percentage points on average. In this naive linear regression, the effect of *Fuel Exports* on *Military Expenditure* is statistically significant at the 10%, 5%, and 1% significance levels. However, the economic significance of the coefficient of interest is low, as an increase of 0.008 percentage points of *Military Expenditure* is merely a 0.489% increase from the median value of *Military Expenditure*.



Model 2 is a quadratic regression that regresses *Military Expenditure* on *Fuel Exports*, with no controls. This model applies a quadratic function form to capture any nonlinearity in the data generating process. The regression uses the following form: *MilitaryExpenditure* = 1.600 + 0.006 * *FuelExports* + 2.79e-5 * *FuelExportsSquared* + u_i. The intercept 1.600, is interpreted as the amount of military expenditure as a percentage of GDP when *FuelExports* = 0. At the intercept, 1.600, an increase in fuel exports as a percentage of merchandise exports of one percentage point is predicted to yield a marginal increase of military expenditure as a percentage of GDP of 0.010 percentage points. Overall, this function shows increasing returns. In this quadratic regression the effect of *Fuel Exports Squared* on *Military Expenditure* is not statistically significant at the 10%, 5%, nor 1% significance levels. Similarly, the economic significance of the coefficient of interest is low, as an increase of 0.010 percentage points of *Military Expenditure* is merely a 0.625% increase from the intercept value of *Military Expenditure*.



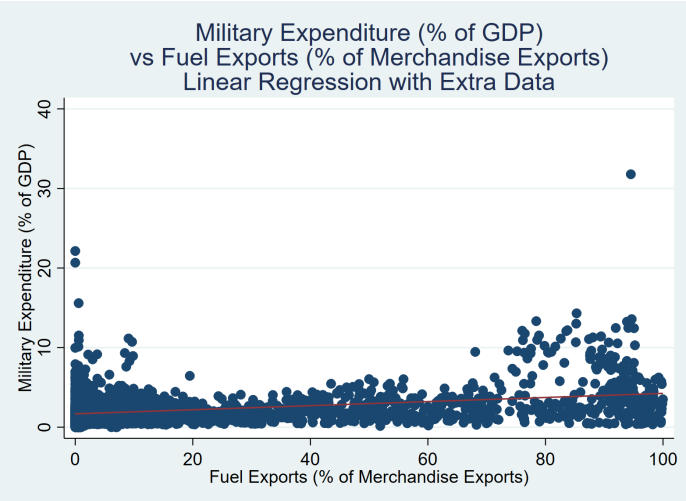
Model 3 is a logarithmic regression (log-linear) that regresses the natural logarithm of *Military Expenditure* on *Fuel Exports* with no controls. The regression uses the following form: Ln(*MilitaryExpenditure*) = -0.708 + 0.027 * *FuelExports* + u_i. The intercept is interpreted as the predicted percent of military expenditure as a percentage of GDP when *FuelExports* = 0. This regression is interpreted that fuel exports as a percentage of total merchandise exports increasing by one percentage point is predicted to increase military expenditure as a percentage of GDP by 2.7 percent on average. In this logarithmic regression, the effect of *Fuel Exports* on *Military Expenditure* is statistically significant at the 10%, 5%, and 1% significance levels. However, the economic significance of the coefficient of interest is low, as an increase of military expenditure as a percentage of GDP by 2.7 percent with a starting value of -0.708 percentage points will yield a very small overall influence.

Model 4 is a linear regression of *Military Expenditure* on *Fuel Exports* akin to Model 1 with the inclusion of three additional control regressors: *CO2 Emissions, Foreign Direct Investment,* and *Gini Index*. The regression uses the following form: *MilitaryExpenditure* = 1.107 + 0.007 * *FuelExports* + 0.042 * *CO2Emissions* - 0.003 * *FDI* + 0.008 * *Gini* + u_i . The intercept 1.107, is interpreted as the amount of Military Expenditure as a percentage of GDP when

FuelExports = 0, when holding constant *CO2 Emissions, Foreign Direct Investment,* and *Gini Index*. This is interpreted that an increase in fuel exports as a percentage of total merchandise exports by one percentage point is predicted to increase military expenditure as a percentage of GDP by 0.007 percentage points on average, holding constant *CO2 Emissions, Foreign Direct Investment,* and *Gini Index.* In this linear regression, the effect of *Fuel Exports* on *Military Expenditure* is statistically significant at the 10%, 5%, and 1% significance levels. However, the economic significance of the coefficient of interest is low, as an increase of 0.007 percentage points of *Military Expenditure* is merely a 0.428% increase from the median value of *Military Expenditure*.

Model 5 is a linear regression of *Military Expenditure* on *Fuel Exports* holding all regressors constant, using panel data to control for country fixed effects. The regression uses the following form: *MilitaryExpenditure* = 1.157 - 0.008 * *FuelExports* + 0.013 * *CO2Emissions* - 3.40e-4 * *FDI* + 0.007 * *Gini* + u_i , holding constant what country is being considered. The intercept 1.157, is interpreted as the amount of Military Expenditure as a percentage of GDP when *FuelExports* = 0, when holding constant *CO2 Emissions, Foreign Direct Investment,* and *Gini Index.* This is interpreted that an increase in fuel exports as a percentage of total merchandise exports by one percentage point is predicted to decrease military expenditure as a percentage of GDP by 0.008 percentage points on average, holding constant *CO2 Emissions, Foreign Direct Investment,* and *Gini Index*, and all controlling for all factors that vary across countries but are constant over time. In this linear regression, the effect of *Fuel Exports* on *Military Expenditure* is not statistically significant at the 10%, 5%, nor 1% significance levels. Additionally, the economic significance of the coefficient of interest is low, as the decrease of .008 percentage points of *Military Expenditure* is merely 0.489% decrease from the median

value of *Military Expenditure*. Notably, the adjusted R squared value of this regression is 1961% higher than that of Model 4, indicating a significant increase in the relationship after controlling for country fixed effects.



Model 6 is a linear naive regression of *Military Expenditure* on *Fuel Exports*. Model 6 mirrors Model 1 with the exception of including all data points containing both *Fuel Exports* and *Military Expenditure*, without removing any data points missing control data. This increases the number of observations from 1,477 to 3,476, dramatically increasing the adjusted R squared from Model 1 by 682%. We chose to include this regression to demonstrate the overwhelming effect that trimming data to match our controls had on our regression. The regression uses the following form: $MilitaryExpenditure = 1.679 + 0.026*FuelExports + u_i$. The intercept 1.679 is interpreted as the amount of military expenditure as a percentage of GDP when $FuelExports = 0$. This regression is interpreted that fuel exports as a percentage of total merchandise exports increasing by one percentage point is predicted to increase military expenditure as a percentage of GDP by 0.026 percentage points on average. In this naive linear regression, the effect of *Fuel Exports* on *Military Expenditure* is statistically significant at the 10%, 5%, and 1% significance levels. The economic significance of the coefficient of interest is still low as the decrease of

0.026 percentage points of *Military Expenditure* is merely 1.59% decrease from the median value of *Military Expenditure*. However, the effect is 225% larger than the coefficient of interest in Model 1, suggesting a significantly stronger relationship exists in the data which is not filtered to include controls.

	Dependent Variable: *Military Expenditure*					
	(1) Military Expenditure	(2) Military Expenditure	(3) Ln(Military Expenditure)	(4) Military Expenditure	(5) Military Expenditure	(6) Military Expenditure
Fuel Exports (X_1)	0.008***	0.006	0.027***	0.007***	-0.008	0.026***
	(0.002)	(0.005)	(0.004)	(0.002)	(0.003)	(0.002)
Fuel Exports Squared (X_2)		2.79e-5				
		(6.81e-5)				
CO2 Emissions per capita (X_3)				0.042***	0.013	
				(0.010)	(0.020)	
Foreign Direct Investment (X_4)				-0.003***	-3.40e-4	
				(0.001)	(-3.48e-4)	
GINI Index (X_5)				0.008**	0.007	
				(0.004)	(0.006)	
Constant/Intercept	1.589***	1.600***	-0.708***	1.107***	1.157***	1.679***
	(0.038)	(0.049)	(0.151)	(0.176)	(0.205)	(0.032)
Country Fixed					Yes	

Effects						
Sample size (n)	1,477	1,477	1,477	1,477	1,477	3,476
Adjusted R^2	0.017	0.017	0.017	0.041	0.845	0.133

Each column represents a separate regression. The entries in the first 5 rows are estimated regression coefficients, with standard errors below them in parenthesis. In Column (5), standard errors are clustered at the country level. The asterisks indicate whether the coefficient is statistically significant at the 10% level (*), 5% level (**) or the 1% level (***).

Discussion:

Beginning with Model 1, we analyzed the naive effect of *Fuel Export* on *Military Expenditure*, finding a statistically significant effect at the 1% level. Model 2 included a quadratic term to analyze the added value of nonlinearity to the relationship. We found that this model's β_1 and β_2 terms were statistically insignificant at all levels, and hence continued using the linear model. Model 3 applied a log-linear transformation to interpret our data as percentages, allowing us to analyze the relationship in relative terms. Model 4 expands upon Model 1 by including controls for *CO2 Emission per Capita*, *Forign Direct Investment*, and *GINI Index* to reduce omitted variable bias. This minimally changed β_1, but resulted in a 141% increase in adjusted R squared, and hence the omitted variables improved the model. Model 5 builds upon Model 4 by including country fixed effects through the use of panel data, which removed statistical significance from all β values in the regression, and even inverted the sign of β_1. With a 1961% increase in adjusted R squared after the inclusion of country fixed effects, we conclude that controlling for all factors that vary across countries but remain constant over time is a positive addition to the regression due to the dramatic decrease in omitted variable bias, and makes this model our preferred model. Model 6 demonstrates the sample selection bias contributing to the research by refraining from filtering for data points that include the control

variables. This resulted in a 135% increase in observations, a 225% increase in β_1, and 682% increase in adjusted R squared from Model 1, which is filtered for observations with control data.

There is additional concern for uncontrolled omitted variable bias in the research. A potential omitted variable contributing bias could be democratization. We expect that nations with more democratic governments may be more willing to decrease military expenditures than authoritarian governments, and would also export more fuel because they are more integrated into the global free market economy. This poses a positive correlation between *Fuel Export* and *Democracy*, and a negative correlation between *Military Expenditure* and *Democratization*, contributing a negative bias upon the positive effect of *Fuel Export* on *Military Expenditure*.

Sample selection bias is a strong concern, as was demonstrated by the inclusion of Model 6. Many countries did not report data for certain variables in many years, and this exclusion was not random. We expect that countries less involved in the international system were excluded, which tend to be less involved in exporting resources and more likely to be authoritarian and militaristic. This leads to an underestimate in *Military Expenditure*, as well as overall raising standard error and lowering the reliability of the data, affecting internal validity. Furthermore, the exclusion of certain countries from the World Bank entirely has a very similar effect, leading to a reduced external validity of the data as well.

A potential source of bias that could result in measurement error is from misreporting the exact *Military Expenditure*, which is largely based on estimates. *Fuel Exports* and *Military Expenditure* may suffer from random measurement error due to misestimation or miscalculation, but the rigorous standards of the World Bank likely avoided the vast majority of miscalculation. This would minimally underestimate the coefficients on all these variables, increasing variance and having an unknown effect upon the standard error. *Military Expenditure* likely faces

nonrandom measurement error, as it is easier to underreport with more incentive to do so. This would cause an underestimate of the effect of *Military Expenditure*, as the countries with larger spending may be underestimating/underreporting their true militarization.

There is a concern for simultaneous causality in our regression. Military expenditure leads to a greater ability to control territory rich with natural resources, causing a greater fuel export industry. Additionally, military expenditure suggests that the nation is more economically developed, increasing the nation's ability to access its fuel reserves due to its industrialization. Adversely, countries which export lots of fuel have reason to defend their natural resources, and will hence militarize. Additionally, countries with large quantities of fuel domestically to sell can cheaply and readily afford to militarize and industrialize.

In conclusion, the external validity of this study is damaged by the need to filter many observations to include our control variables. This greatly damages our sample's ability to represent the population parameter and the true data generating process, as we cannot claim to represent all countries from 1991-2019, and do not have all years for all included countries. The results of this study are only generalizable to countries who are economically developed enough to report to the World Bank with quite robust data, because those are the observations with control variables. Additionally, by restricting ourselves to the post-Cold-War to present day era, the external validity of our results into the Cold-War are weak, especially due to dramatic international economic changes from 1991 onward. Similarly, with the COVID-19 pandemic starting after 2019, greatly damaging the global supply chain and leading to a period of less energy trade, our conclusions about years after 2019 will be somewhat weaker as well. In 2022 we see heightened international military tensions which would greatly increase international

military spending, which may further decrease our ability to extrapolate this research into the present day.

Data Citations:

World Bank. “C02 Emissions (Metric Tons Per Capita).” *World Development Indicators*. The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC. Accessed 12 Dec. 2022.

World Bank. “Foreign direct investment, net inflows (BoP, current US$).” *World Development Indicators*. The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC. Accessed 12 Dec. 2022.

World Bank. “Fuel exports (% of merchandise exports).” *World Development Indicators*. The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC. Accessed 12 Dec. 2022.

World Bank. “Gini index.” *World Development Indicators*. The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC. Accessed 12 Dec. 2022.

World Bank. “Military expenditure (% of GDP).” *World Development Indicators*. The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC. Accessed 12 Dec. 2022.