

The Geopolitical Externalities of Climate Policy*

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Abstract

This paper formalizes the geopolitical externalities of climate policy. Lower fossil fuel demand depresses global prices, thereby reducing export revenues and fiscal resources in resource-rich countries and potentially lowering security burdens on fuel-importing countries. We quantify this mechanism in a case study linking the European Union’s (EU) oil consumption to Russia’s war in Ukraine. Our central estimate suggests that a one-euro reduction in EU oil consumption lowers EU security-related costs linked to Russia’s war effort by about 32 cents (plausible range: 1 cent to 4.64 euros). Internalized with a carbon price on oil, this corresponds to roughly 54 euros per tonne of CO₂ – before accounting for mitigated climate damages and other co-benefits of climate policy. Even under cautious assumptions, the geopolitical externalities appear quantitatively relevant and strengthens the case for unilateral efforts to reduce fossil-fuel demand in the EU.

Keywords: Geopolitical externalities; climate policy; fossil fuel markets; geoeconomics; security dividend; war economics

JEL-Classification: F18; F51; F52; H23; H56

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1 Introduction

Climate policy seeks to address the market failure of global warming caused by greenhouse gas emissions, primarily by reducing the use of fossil fuels. A substantial body of literature has emphasized the non-climate related externalities, or co-benefits, of these policies (Karlsson et al., 2020) – including improved public health (e.g. Gao et al., 2018), increased energy security (e.g. Kim et al., 2025; Kruse-Andersen, 2023; Schwanitz et al., 2015), and fiscal benefits from recycling revenues generated by climate policies (e.g. Bento & Jacobsen, 2007; Bento et al., 2018; Siegmeier et al., 2018). Beyond these well-documented co-benefits, climate policy also has a geopolitical externality.

At the end of the Cold War, Ward and Davis (1992) coined the concept of a “peace dividend”, describing how reduced geopolitical tensions lower military spending and free public budgets for civil society. Here, we demonstrate that climate policy can similarly create a security dividend. A significant share of the world’s fossil fuel resources is concentrated in a few countries, sometimes with high military expenditures (Do, 2021; Edenhofer et al., 2023; Ross, 2012), which contribute to imposing security and military costs on all other countries (e.g. Hauenstein et al., 2021; Rohner, 2025). By reducing dependence on fossil fuels, climate policy has the potential to diminish these costs, generating what we define as the geopolitical externality of climate policy.

Previous work has qualitatively identified the overlap between climate policy and geopolitics (Block et al., 2025; Charbonnier, 2024; Kim et al., 2025; Meckling, 2025; Mercure et al., 2021; Moore, 2024; Rohner, 2025) and quantitatively shown that geopolitical risks already drive renewable energy adoption (He et al., 2025; Zhang et al., 2024). Our paper extends this literature by explicitly modelling the relation between a country’s climate policy and the security-related costs it bears, mediated through global fuel markets and exporter rents. Practically, we formalize the geopolitical externality of fossil-fuel consumption and decompose it in four quantifiable causal steps (Section 2). This breakdown provides a structure for what research and data are needed to assess the geopolitical externality quantitatively. We also provide a tentative estimation in a case study analysing the rela-

tionship between the EU’s oil consumption and the security costs incurred from the start of the 2022 Russian war in Ukraine (Section 3).

Our analysis illustrates how reduced fossil fuel demand in the EU lowers oil revenues for Russia and, through this channel, reduce security-related expenditures borne by the EU. Our central estimate suggests that a one-euro reduction in EU oil consumption lowers EU expenditures linked to Russia’s war effort in Ukraine by about 0.32 euros, with a plausible range from 0.01 to 4.64 euros. If policymakers were to internalize this cost, our central estimate would justify a carbon price of 54 euros per tonne of CO₂ (assuming a benchmark oil price of 70 euros per barrel), before accounting for climate damages and other co-benefits. These findings suggest that the geopolitical externality can be quantitatively relevant, strengthening the EU’s unilateral incentives to reduce fossil-fuel demand.

We then highlight unaccounted mechanisms that may affect magnitude and sign of the geopolitical externality and discuss external validity across commodities, time horizons, and geopolitical contexts (Section 4).

Beyond formalizing the geopolitical externality of climate policy, our paper also contributes to the literature on relative-gains maximization in international relations (Burilkov & Wolff, 2025a; Fearon, 1998; Grieco et al., 1993; Powell, 1991; Snidal, 1991). In a setting where an adversary may use the income from trade to finance military aggression (Garfinkel et al., 2022; Powell, 1993), a country must account for how much its actions enrich that adversary and adopt policies that maximize its own income net of the opponent’s weight-adjusted income (Spiro, 2025). Recent studies have applied this relative-gains maximizing concept to trade and economic warfare between the West and Russia (De Souza et al., 2024; Sturm et al., 2022; Wachtmeister et al., 2024), but without providing a microfoundation. In the EU-Russia context, our benchmark implies a relative-gains weight of about 1.8: one additional euro of Russian government budget translates into about 1.82 euros of security-related costs for the EU in our central estimate (Steps 3-4). Put differently, the security cost of enriching Russia is roughly twice as large as the direct value the economic interaction creates for the EU. By quantifying the link between the EU oil imports and

Russia’s ability to wage war, our study also helps bridge the gap between geoeconomics and conflict studies (McGuirk & Trebesch, 2025).

We next define the geopolitical externality and lay out the four-step decomposition underlying our benchmark.

2 Conceptual definition

We define the geopolitical externality of climate policy as the indirect impact the climate policy in one country contributes to its own national security, mediated through fossil fuel markets. This externality arises because ambitious climate policies lower global demand for fossil fuels, thereby reducing fossil fuel prices. In turn, this diminishes the economic resources – and, thus, the military power – of fuel-exporting countries. Ultimately, climate policy could generate a security dividend by decreasing geopolitical and military risks.

The geopolitical externality of climate policy unfolds through four causal steps, as illustrated in Figure 1.

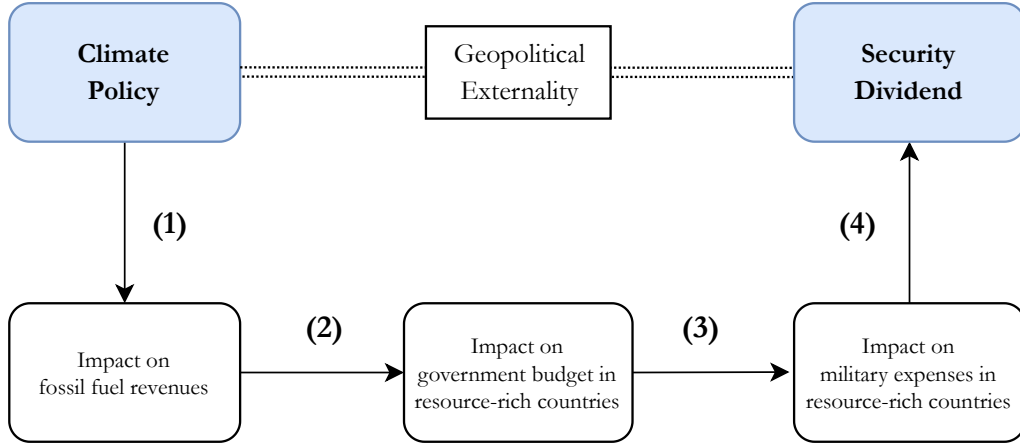


Figure 1: Conceptual steps of the geopolitical externality

Mathematically, we denote the geopolitical externality for country A , mediated by an oil-producing country B , as $\beta_{A \rightarrow B}$ ¹. We define it as the marginal change in country A ’s

¹More generally, the total geopolitical externality of climate policy in country A is the sum of the

security expenditures SE_A , in response to a marginal change in its fossil fuel consumption X_A :

$$\beta_{A \rightarrow B} \equiv \frac{\Delta(SE_A)}{\Delta(X_A)}. \quad (1)$$

Following Figure 1, we decompose Equation (1) into four ratios:

$$\beta_{A \rightarrow B} = \frac{\Delta(W_B)}{\Delta(X_A)} \times \frac{\Delta(GOV_B)}{\Delta(W_B)} \times \frac{\Delta(ME_B)}{\Delta(GOV_B)} \times \frac{\Delta(SE_A)}{\Delta(ME_B)}. \quad (2)$$

The first ratio relates a change in fossil fuel consumption within country A , $\Delta(X_A)$ to a reduction in country B 's fossil fuel rent $\Delta(W_B)$, as detailed in Section 2.1. The second ratio converts the change in fossil fuel rent, $\Delta(W_B)$, into a change in government budget, $\Delta(GOV_B)$, covered in Section 2.2. Third, the changes in country B 's government budget, $\Delta(GOV_B)$, influence its military expenses, $\Delta(ME_B)$, discussed in Section 2.3. Fourth, the additional military expenses of country B , $\Delta(ME_B)$, raise the security costs for country A , $\Delta(SE_A)$, as presented in Section 2.4. As illustrated in Section 3, combining estimates for the four ratios allows quantifying the geopolitical externality of fossil fuel consumption. This framework provides structure for which data and estimates are necessary to have in order to assess the geopolitical externality.

2.1 From climate policy to fossil fuel rents

The first link in this causal chain is the climate policy-induced reduction in global demand for fossil fuels, which exerts downward pressure on fossil fuel prices. This combination of reduced demand and lower prices results in decreased fossil fuel revenues for resource-rich countries. This effect is well documented and poses two primary challenges for ambitious climate policy: carbon leakage, where reduced domestic consumption is partially offset by increased consumption in countries without stringent climate policies (Grubb et al., 2022; Jakob, 2021); and the difficulty of securing an international climate agreement with disproportionately affected resource-rich countries (Kalkuhl & Brecha, 2013).

geopolitical externalities mediated through all other countries B : $\beta_A = \sum_B \beta_{A \rightarrow B}$.

In this paper, however, we emphasize a potential benefit of reduced fossil fuel revenues, contrasting these challenges. In addition to a terms-of-trade improvement – where fuel-importing countries like the EU benefit from lower global fossil-fuel prices driven by their own demand reduction (see Section 3.6) – the decline in fossil-fuel revenues of resource-rich countries marks the first step toward a geopolitical externality of climate policy.

2.2 From fossil fuel rents to state budgets

The second link in the causal chain is the reduction of government budgets in resource-rich countries, driven by declining fossil fuel revenues. Figure 2 illustrates that a few countries concentrate high shares of resource rents. These high resource-rent countries are mainly located in the Middle-East and North African (MENA) regions. These countries rely heavily on revenues from resource extraction and export revenues to fund their budgets, drawing income through profit taxes, royalties, and, more directly, state-owned enterprises (Nan Tian, 2017).

2.3 From state budgets to military spending

The third link in this chain driving the geopolitical externality is the induced decrease in military expenditures, which constrains these countries’ abilities to pursue aggressive geopolitical strategies. Levels of military expenditures derive from a complex interaction of factors (Bachtar et al., 2024) and only indirectly relate to the political nature of the regimes and their resource rent (Do, 2021; Rohner, 2025). Nonetheless, figure 2 highlights that countries with high resource rents often exhibit important military expenditures. Reductions in government budgets due to lower resource income significantly impact the military capacity of states involved in open conflicts (Federle et al., 2025; Spiro, 2025; Vandenbroucke, 2024) and more broadly the geopolitical ambitions of fuel-exporting countries (Nan Tian, 2017).

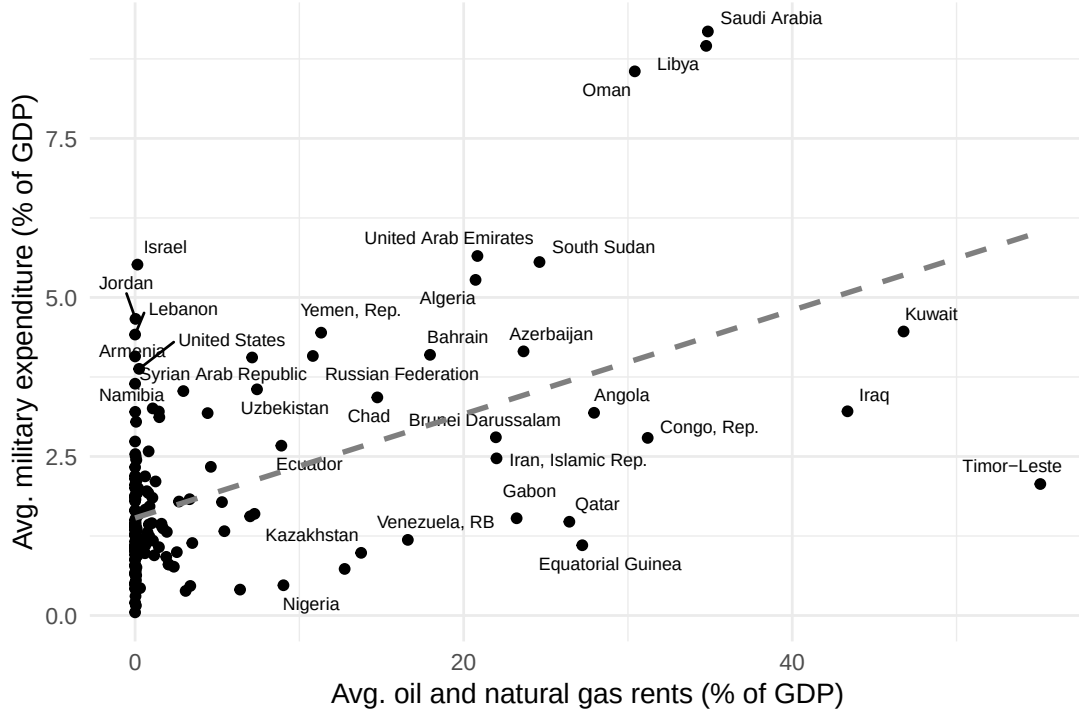


Figure 2: Correlation between military expenditures and oil and natural gas rents as a share of GDP (in %)

Note: Shares represent the averages values within the 2010-2019 time period, based on available data for each country. The dashed line represent the linear trend between fuel resource rents and military expenditures. Source: Own illustration based on World Bank (2025a), *World Development Indicators*.

2.4 From military spending to global security costs

The final link in this chain is the diminished geopolitical influence or threat posed by fossil-fuel-rich countries, enabling fuel- importing countries to reduce their own expenditures on geostrategic security (Hauenstein et al., 2021; Yesilyurt and Elhorst, 2017). This may include reduced military spending and decreased financial support – covering military, economic, and reconstruction efforts – for allies directly at war with resource-rich countries. This argument also applies in the absence of open conflicts, by reducing the costs of deterrence (Powell, 1991). By alleviating these security burdens, climate policy can generate a peace dividend, allowing resources to be redirected away from costly arms races. In addition, the effects extend beyond direct military threats, impacting international trade, the stability of global supply chains, and migration flows – including refugees from conflict

zones (Federle et al., 2024).

3 Quantifying the geopolitical externality

Since Russia’s illegal occupation of Crimea in 2014, the EU and Russia have been in conflict over Ukraine’s territorial integrity (Meister, 2022). Despite these tensions, Russia remained the EU’s largest oil supplier until its full-scale invasion of Ukraine in February 2022 (Eurostat, 2024a). The implications of the EU’s ambitious climate targets (European Commission, 2021), which necessitate a significant reduction in oil consumption, for Russia’s military spending offers a compelling case study on the intersection of climate policy and geopolitical risks.

In this section, we assess the geopolitical externality associated with the EU’s oil consumption in relation to the Russian war in Ukraine. We provide range estimates for the four ratios defined in Equation (2), and subsequently contextualize our estimate of the geopolitical externality within the range of other well-documented (co-)benefits of climate policy in Section 3.6.

3.1 Estimating Russia’s revenue losses from oil exports

First, we quantify how reduced oil consumption by the EU translates into rent losses for Russian exporters. Employing supply and demand elasticities (ϵ_S and ϵ_D , respectively), we estimate that for every euro reduction in oil demand in the EU, the market value of global oil production decreases by $1/[\epsilon_S - (1 - \mu_{EU})\epsilon_D]$ euro, where μ_{EU} is the EU share in global oil use.² For a competitive global oil market, the loss for Russian producers is calculated by weighting this price reduction by Russia’s share in global oil production, χ_{RUS} .

This yields:

$$\frac{\Delta(W_{RUS})}{\Delta(X_{EU})} = \frac{\chi_{RUS}}{\epsilon_S - (1 - \mu_{EU})\epsilon_D}. \quad (3)$$

² A formal proof of this relationship is provided in Appendix A, where we employ a static demand-supply model similar to Gars et al. (2022).

Global long-run elasticities are estimated to be between -0.23 and -1.1 on the demand side, with a central estimate of -0.45; on the supply side, estimates range from 0.05 to 0.2, with a central estimate of 0.13 (Caldara et al., 2019; Gars et al., 2022; Kilian, 2022). Russian oil production and EU oil consumption each account for approximately 11% of the world oil supply (EIA, 2024)³.

Using these values, each euro reduction in EU oil consumption leads to proportional profit losses for Russian producers, given by

$$\frac{\Delta(W_{RUS})}{\Delta(X_{EU})} = \mathbf{0.20} [0.09; 0.42], \quad (4)$$

where the numbers in brackets constitute the upper and lower bound attained by using alternative elasticities.

3.2 Effect on the government budget

The second causal link examines the relationship between Russian oil rents and the Russian government budget. Empirically, the Russian government heavily relies on tax revenue from the oil and gas sectors. In 2023, these sectors generated approximately \$108 billion in taxes, accounting for up to 32% of the Russian state budget (Yermanokov, 2024, p. 9). Notably, 80% of this fiscal revenue is derived from oil rents, mainly through the Mineral Resource Extract Tax (MRET) and an export tax on oil (Yermanokov, 2024).

The operating costs of the Russian fuel industry are largely fixed, such that the revenue loss for fuel exporters directly translates into profit losses. According to public figures (Spiro et al., 2025), 88% of the profits from oil extraction accrue to the Russian government.⁴

Given the autocratic nature of the Russian regime, the Russian government might eventually raise the profit tax on oil extraction to fully capture the oil rent if the situation

³ The exact data used for the calibration and the calculation spreadsheet are available as online supplementary information

⁴ The different profit taxes on privately-owned oil companies add to 77%, but the government directly owns 50% of the oil production capacity, on which it collects the full profits.

requires it, yielding a multiplier of 1. We use this case as an upper bound for our estimate and the observed effective tax rate of 88% as our lower bound and central estimate.

Under these assumptions, each euro lost in oil revenue translates into the following reduction in the government budget:

$$\frac{\Delta(GOV_{RUS})}{\Delta(W_{RUS})} = \mathbf{0.88} [0.88; 1]. \quad (5)$$

3.3 Linking the Russian government budget to military expenses

The third step examines the share of the Russian government budget allocated to military spending. In 2023, Russian security expenditures were estimated at 9.6 trillion rubles, accounting for about 30% of the total government spending (Cooper, 2023). Our analysis focuses on how an additional ruble of Russian fiscal revenue, $\Delta(GOV_{RUS})$, is allocated to military expenditures, $\Delta(ME_{RUS})$. As this ratio is hard to quantify, we propose three separate approaches to assess this relationship

Proportional expenses:

Here, we assume a direct linear relationship between the total government budget and military spending. Under this assumption, reductions in the Russian government budget are evenly distributed across all public expenditures. Thus, a one-ruble decrease in government revenue translates into a 0.3-ruble reduction in military expenses, corresponding to the military's 30% share of the budget.

One-to-one reduction:

Here, we assume that every additional ruble of oil export revenue is allocated entirely to military expenditures. This assumption is motivated by the fact that oil exports generate foreign currency needed to import dual-use goods and technical equipment necessary for the military but unavailable domestically. Under this approach, the military budget decreases in direct proportion to the Russian government budget.

Intertemporal budget:

It might also be that a loss in Russian governmental income has a multiplier effect on the intertemporal military expenditure. Russia benefits from vast stocks of Soviet-era military equipment, available at a negligible price. As a result, the Russian war effort may depend more on these material stocks than on the current government resources (Vandenbroucke, 2024).

However, in an intertemporal perspective, government revenue constraints ultimately become binding: a reduction of the Russian government budget hastens the depletion of available resources, thereby shortening the war and, in turn, the intertemporal military spending in Ukraine. In that perspective, if the reduced government income shortens the war, the corresponding reduction in cumulative spending does not only entail this reduction, but also the total budget that would otherwise have been spent during the time of war that has been avoided.

Appendix B formalizes this mechanism using a stock-flow modelling approach that includes spending on the war in Ukraine, stock depletion and government revenues. Calibrating the model on the difference between the reported Russian war spending and the rate of equipment losses observed on the battlefield (Seohina, 2024; Wrating & Reynolds, 2024), this approach yields a multiplier of 4.

Based on the different approaches, we get the following range of estimates linking marginal Russian military expenditures to marginal changes in the government budget:

$$\frac{\Delta(ME_{RUS})}{\Delta(GOV_{RUS})} = \begin{cases} 0.3 & \text{(proportional)} \\ 1 & \text{(one-to-one)} \\ 4 & \text{(intertemporal)} \end{cases} . \quad (6)$$

We use the one-to-one estimate as our central value, reflecting that Russia is engaged in a costly war of attrition in Ukraine that has priority over all other government expenses.

3.4 EU spending in reaction to the Russian war in Ukraine

As the final step in our causal chain, we assess the European security expenditures $\Delta(SE_{EU})$ in response to Russian military expenses in Ukraine, $\Delta(ME_{RUS})$. This scaling factor is affected both by measurement uncertainties and by the scope of expenses considered on both sides.

Between 2022 and 2024, the Russian government allocated 29,215 trillion rubles – about 350 billion USD – to its military. However, the fraction of this budget directly allocated to the war in Ukraine is largely unknown (Cooper, 2023). In September 2023, the RAND research center projected that direct Russian war spending would reach at least 131 billion USD by the end of 2024 (Shatz & Reach, 2023), while statements at the end of 2024 from US Defense Secretary Lloyd Austin suggested a figure “above 200 billion USD” (Kosoy, 2024). Based on available information, we thus estimate Russian spending on the war in Ukraine at 131 to 350 billion USD, with a central estimate of 200 billion USD.

From the onset of the war, the EU has provided Ukraine with direct financial, humanitarian, and military support. As of December 2024, EU member countries and institutions had allocated a total of 113 billion euros (122.5 billion USD) in such assistance (Trebesch et al., 2024). However, this figure significantly understates the overall cost of Russia’s war for the EU. Reconstruction needs following the large-scale damages to Ukraine’s infrastructure and economy are currently estimated to 524 billion USD (Becker et al., 2025; World Bank, 2025b). Assuming that reconstruction costs are shared between the EU and other European allies in proportion to their relative contributions to support Ukraine, we estimate the EU’s additional burden to be 241 billion USD. Adding this to the 122.5 billion USD in already allocated direct support yields a total EU cost of about 364 billion USD.

Taken together, this yields the following range of the ratio between the EU’s military expenditures and support to Ukraine and Russian military expenditures:

$$\frac{\Delta(SE_{EU})}{\Delta(ME_{RUS})} = \mathbf{1.82} [0.35; 2.78]. \quad (7)$$

Depending on the scope of Russia’s military effort in Ukraine and the range of costs included on the EU side, each euro of Russian military spending imposes between 35 cents and 2.8 euros in costs on the EU.

Using our central estimates – 200 billion USD in Russian military spending and 364 billion USD in total EU support to Ukraine – we derive a central ratio of 1.82. This estimate is larger than 1, capturing the fact that the destruction caused by a military conflict largely exceed the direct spending on the war: a bomb creates more damages than it costs to manufacture.

Importantly, the upper bound of this estimate is highly sensitive to the geopolitical context. In the case of a complete withdrawal of US support, preliminary estimates suggest that EU countries would need to increase their annual military spending by an additional 250 billion euros (Burilkov & Wolff, 2025b), substantially increasing the multiplier. Moreover, our estimate does not account for other indirect costs of Russia’s war in Ukraine, such as the strong reduction in EU economic growth (Gorodnichenko & Vasudevan, 2025).

3.5 Total geopolitical externality

In the previous four subsections, we quantified the individual steps required to estimate the geopolitical externality in the context of the EU’s oil consumption and its connection to the Russian war in Ukraine. Combining the four components of the analysis – as detailed in Equation (2) and summarized in Table 1 – yields a central estimate of the marginal geopolitical externality of 32 cents per euro of EU oil consumption, with a plausible range between 1 cent and 4.64 euros.⁵ This range reflects uncertainty at each step of the decomposition: the estimates depend on assumptions about supply and demand elasticities (Section 3.1), Russian taxation system and effectiveness (Section 3.2), Russian military expenditures as a function of the government budget (Section 3.3), and the scope of EU expenses in response to Russia’s invasion of Ukraine (Section 3.4). The latter two estimates

⁵ Appendix C presents all possible combinations of the lower, central, and upper estimates for each step and the contribution of each step to the overall range.

appear as the most difficult to quantify, with estimates in both cases spanning a full order of magnitude (see Figure C.2 in the Appendix).

Table 1: Geopolitical externality from EU oil consumption.

Causal step	Ad-valorem estimate		
	Low	Central	High
(1) Impact on Russian oil revenues	0.09	0.20	0.42
(2) Impact on Russian government budget	0.88	0.88	1
(3) Impact on Russian military expenses	0.3	1	4
(4) Cost of the war for the EU	0.35	1.82	2.78
Total geopolitical externality	0.01	0.32	4.64

Note: Ad-valorem estimates are expressed in monetary cost per monetary unit of oil used. Number in parenthesis indicate the range of estimate.

Overall, each euro spent on oil in the EU generates 32 cents (central estimate) in indirect geopolitical costs for the EU, stemming from Russia’s aggression. Assuming that the marginal geopolitical costs of EU oil consumption scale linearly, the 282 billion EUR spent on oil in 2023 in the EU (Eurostat, 2024b) are estimated to result in indirect geopolitical costs of 54 billion euros (with a range of 2.4 to 775 billion euros taking into account all possible combinations of parameters).

We can also express the geopolitical externality relative to the carbon content of oil, which can be interpreted as the required carbon price to internalize the geopolitical externality on oil consumption in the EU. Assuming a benchmark oil price of 70 euros per barrel and standard assumptions on oil’s carbon intensity, our central estimate implies a geopolitical externality equivalent to 54 euros per tonne of CO₂.⁶ Notably, this falls close to the range of EU ETS allowance prices observed in recent years. Even before accounting for climate damages and other co-benefits of reduced oil use (see next section), relatively conservative estimates of the geopolitical externality alone justify policies to reduce oil

⁶ This calculation uses a carbon intensity of 2.65 kgCO₂ per liter of oil and a barrel volume of 158 liters (Freund et al., 2018). Under our assumptions, each euro reduction in EU oil consumption results in approximately 6 kg of avoided CO₂ emissions within the EU. For a given ad valorem estimate, the corresponding implicit carbon price scales proportionally with the assumed oil price (e.g., about 76 EUR/tCO₂ at 100 euros per barrel).

consumption in the EU.

3.6 The geopolitical externality in perspective

The geopolitical externality complements other externalities associated with the consumption of oil. In this section, we compare the geopolitical benefits of reducing the EU’s domestic oil consumption to the terms-of-trade effect of reduced oil imports, the benefit of improved local air quality and to the benefits of climate mitigation.

As a net importer of fossil fuels, the EU benefits from lower world market prices resulting from reduced fossil fuel consumption through changes in terms-of-trade. We quantify this terms-of-trade externality by applying the reasoning of section 3.1 (see Appendix A for the proof):

$$\text{terms-of-trade externality} = \frac{\chi_{EU} - \mu_{EU}}{\epsilon_S - (1 - \mu_{EU})\epsilon_D}. \quad (8)$$

Using an EU consumption share of about 11% and a production share of about 1% in global oil supply (EIA, 2024), and applying the demand and supply elasticities from Section 3.1, we estimate the terms-of-trade benefits of reducing EU oil consumption by one euro to range between 8 and 38 cents, with a central estimate at 18 cents.

Oil combustion also generates local air pollution. Black et al. (2023) estimate that a liter of gasoline used in the EU causes an average 0.07 USD in health damages – equivalent to 15 cents per euro of oil used.

Our central estimate of the geopolitical externality (32 cents per euro spent on oil) is of a magnitude similar to other externalities that have been highlighted as important motivations for unilateral EU climate policy (see Table D.1 for a direct comparison with the terms-of-trade and air pollution externalities). The geopolitical benefits of lowering oil consumption should thus be considered as part of a comprehensive assessment of the benefits of reducing oil consumption. Taken together, the geopolitical, terms-of-trade and air pollution externalities of oil use justify an ad-valorem tax of 0.65 – equivalent to a carbon price of 109 EUR/tCO₂ – even without taking into account climate damages.

In comparison, the US Environmental Protection Agency (EPA) estimated the Social Cost of Carbon (SCC) at 190 euros per tonne of CO₂ for 2020, using a 2% discount rate (EPA, 2023). The SCC captures the global damages caused by one additional tonne of CO₂ emissions – only a fraction of which will accrue to the EU. While this argument is sometimes used against unilateral climate mitigation, the geopolitical, terms-of-trade and air pollution externalities quantified here are EU-specific co-benefits. These effects constitute strong arguments for unilateral climate action, even before accounting for the broader global climate damages.

4 Discussion

This study makes two contributions. First, we provide a structured way to assess the geopolitical externality of fossil-fuel consumption by systematically breaking the underlying mechanism into four causal steps (Section 2). The purpose of this decomposition is to identify quantifiable components: any empirical or quantitative assessment of how reduced fossil fuel consumptions affects security spending needs to include these linkages – from fossil fuel demand to exporter rents and public budgets, from fiscal resources to military capacity and expenditures, and from military capacity to the security-related costs borne by the fossil fuel importers. Making these links explicit also yields a simple policy implication: efficient climate policies should account for the associated marginal security benefit (or cost) in addition to the benefits of mitigating climate damages. Second, we provide a policy-relevant *order-of-magnitude benchmark* for a salient case – EU oil use and Russia’s military capacity in its invasion of Ukraine. This benchmark is not meant to be read as a literal point estimate. Rather, the main object of interest is the range implied by plausible assumptions along the four steps. Accordingly, we approach “robustness” by identifying uncertainty by step, highlighting which links drive the quantitative range, and indicating where additional evidence and future research would be most valuable.

In this section, we examine key mechanisms and sources of uncertainty underlying

the benchmark. We also discuss how the framework generalizes across commodities, time horizons, and geopolitical contexts.

4.1 Mechanisms and uncertainty

Several mechanisms and higher-order effects may affect the magnitude of our benchmark estimate of the geopolitical externality.

A first issue concerns the functioning of the fossil-fuel markets. In Step 1, we simplify the quantification by assuming a perfectly competitive market structure. However, in practice, both the exercise of market power, dynamic effects and geostrategic considerations can affect supply responses (Johnson et al., 2023a; Kilian, 2008; Nigmatulina, 2021). These effects can be particularly relevant in the case of oil, whose supply is concentrated in relatively few countries (notably the Organization of the Petroleum Exporting Countries – OPEC) and prone to market manipulation (Baumeister & Kilian, 2016). While oil supply decisions may amplify or dampen the price effects of oil demand reduction, the fundamental market mechanism described in Step 1 remains valid: oil exporters generally sustain income losses when oil demand diminishes.

Similarly, our benchmark focuses on implications via the global oil market and does not examine targeted trade reductions. In particular, we assume that oil trade can be redirected at low cost, abstracting from Russia-specific trade frictions, including infrastructure constraints (Farrokhi, 2020) and trade sanctions targeted at Russian oil, such as the EU/G7 price cap (Becker et al., 2024; Egorov et al., 2025; Johnson et al., 2023b). In practice, revenue losses from reduced purchases by the EU could be amplified by a weaker Russian bargaining position, a thinner buyer pool and thus larger discounts, as well as by re-routing and transport costs when exports are redirected (see Babina et al., 2026; Cardoso et al., 2025; Johnson et al., 2023b; Kilian et al., 2026; Spiro et al., 2025).

A second issue concerns the mapping from public finances to security outcomes in our EU–Russia example. Our benchmark is anchored in an active-conflict episode, where short-run financing needs and wartime constraints shape how the Russian government budget

translates into military capacity (Step 3). However, if the conflict in Ukraine is financed through buffers (e.g., by depleting the Russian wealth fund) and budget reallocation (e.g., from social spending to military expenditure), it might be that the Russian military capacity is unaffected by the government budget in the short run. Still, the constraints on the Russian budget remain binding in the long term (Vandenbroucke, 2024), as illustrated in Appendix B: reducing the current revenues of Russia accelerates the depletion of available resources, thereby reinforcing the attrition of the Russian capacity.

Beyond the capacity channel, reduced import dependence may also generate strategic effects. In particular, lowering the EU’s dependence on Russian oil strengthens the EU’s outside option and can increase bargaining power in future negotiations with Russia - or conversely reduce the opportunity cost of a direct military confrontation for Russia (Mayer et al., 2025). Such bargaining effects are difficult to quantify, but they plausibly reinforce the direction of our EU–Russia benchmark irrespective of whether the EU would actively use this leverage.

Another consideration is that Russia may anticipate that future climate policies will ultimately reduce their future revenues, thus projecting its military ambitions while fossil fuel incomes are still high – essentially extending the concept of the Green Paradox to war preparation. Still, this second-order effect would not change the sign of the geopolitical externality for the EU: reducing fossil fuel demand still allows limiting the Russian military capability.

Besides the channel we quantify – income declines leading to lower military capacity – large income shocks may trigger regime instability with uncertain and potentially costly fallout, and policy actions may have signalling or deterrence effects toward current or future adversaries. We cannot rule out these channels; they are complementary mechanisms outside our benchmark.

Taken together, these considerations underscore that our EU–Russia benchmark is best regarded as an order-of-magnitude exercise and indicate where additional evidence would be most valuable. They also motivate our discussion of external validity below.

4.2 External validity

While our quantitative benchmark is case-specific, the underlying four-step logic provides a general framework that can be applied across commodities, time horizons, and geopolitical contexts. Both the sign and the magnitude of the implied security component may vary systematically along these dimensions.

Over commodity. Our benchmark in Section 3 focuses on the impact of reduced oil consumption in the EU, abstracting from the impact of EU climate policy on other fossil fuels, particularly coal and natural gas. While the conceptual decomposition introduced in Section 2 applies to other fossil fuels too, key market features differ and Step 1 of the analysis would need to be adjusted accordingly. For natural gas, segmented markets, infrastructure constraints (pipelines and LNG capacity), and contract structures affect the price response to location-specific demand reductions and, hence, the pass-through to exporter rents (Alessandri & Gazzani, 2023).

Accordingly, bilateral trade frictions are likely more relevant for natural gas than for oil, so targeted trade disruptions may generate additional revenue effects beyond the global price channel emphasized in our benchmark. The link between revenue changes and fiscal resources (and, ultimately, security outcomes) can also differ for both coal and natural gas relative to oil (Step 2), reflecting differences in taxation, ownership structures, and the importance of coal/natural gas rents for state capacity.

More broadly, as the energy transition reshapes resource demands and dependencies, related geopolitical externalities may arise for other strategic materials, such as critical minerals (Berman et al., 2017; van der Ploeg & Rohner, 2012) or green technologies, through channels beyond the fossil-rent mechanism studied here. Again, while our four-step decomposition framework would remain generally valid for such commodity, a quantification of the geopolitical externality for other commodities would require adjustments to the structure of the commodity markets and institutional details.

Over time. The benchmark is best interpreted as a current snapshot in a specific security and decarbonization context. As decarbonization progresses and import dependence declines, the marginal geopolitical externality of fossil consumption may shrink “by design” as exposure and, hence, leverage diminish.

The value of the geopolitical externality also depends on the state of international relations and burden-sharing. Changes in the extent and duration of financial and security support provided by the EU and its allies can shift the security costs borne by the EU and, in turn, the implied value of the externality. Conversely, an improvement in diplomatic relations between the EU and Russia would dampen it. However, as long as Russia and the EU remain international rivals, the sign of the geopolitical externality in this setting remains positive: even in peace time, reductions in Russian oil rents can constrain military buildup and thereby reduce the cost of deterrence for the EU.⁷

Establishing the time profile of the geopolitical externality therefore remains an important direction for future work.

Over space. The implied geopolitical externality depends on the specific geoeconomic context, in particular on which suppliers are affected, by how much, and on how changes in resource rents translate into outcomes that are relevant for security from the perspective of the importers.

A general quantification of the geopolitical externality should in particular capture how the geopolitical externality impacts third countries. Fuel exporters are negatively affected by a reduction in fuel demand, while all fuel importers benefit from the reduced prices (Edenhofer et al., 2025). Depending on their strategic alignment, these indirect effects can positively or negatively affect the security environment of the country implementing the demand reduction measures.

Finally, lower fossil-fuel demand and the associated decline in resource rents can have

⁷ Relatedly, Yesilyurt and Elhorst (2017) provide evidence on post-Cold War military budget spillovers, showing that a 1% increase in military spending by one country induces a 0.24% increase in neighboring countries in the short term.

distributional consequences, including potentially substantial impacts on poorer resource-dependent countries. Whether such rent declines raise or reduce long-run security risks depends on institutional settings – for example, through *resource-curse* channels whereby resource rents shape governance, corruption, and conflict risks (e.g. Collier & Hoeffler, 2005; Ross, 2015; van der Ploeg, 2011). Evaluating the security implications of fossil-fuel demand reductions across suppliers and institutional environments is therefore an exercise that extends beyond the specific benchmark evaluated here.

5 Conclusions

This paper formalizes and quantifies the geopolitical externality of climate policy. By reducing fossil-fuel demand and import dependence, climate policy can lower exporter rents and constrain the fiscal resources available for military activity in resource-rich states, ultimately lowering security-related costs borne by importers. We develop a four-step decomposition of the underlying channel that makes the links transparent and quantifiable, and we implement it in a case study of EU oil consumption and Russia’s war in Ukraine.

Applied to this EU–Russia setting, our central estimate suggests that a one-euro reduction in EU oil consumption lowers EU security-related costs linked to Russia’s war effort by about 0.32 euros, with a plausible range from 0.01 to 4.64 euros. Internalized by a carbon price on oil, the central estimate corresponds to about 54 EUR per tonne of CO₂ (assuming a benchmark oil price of 70 euros per barrel) before accounting for climate damages and other co-benefits. These magnitudes indicate that, even under cautious assumptions, the geopolitical externality can be quantitatively relevant for unilateral policy incentives and strengthen the case for ambitious EU climate policy.

A key takeaway is conceptual: fossil-fuel consumption can generate a geopolitical externality through the channel we formalize, implying a security component alongside climate damages in efficient policy. At the same time, our EU–Russia estimate is context-specific and best read as an order-of-magnitude benchmark.

While our quantification is anchored in a particular active-conflict episode, the framework generalizes. Applying it to other settings requires adapting the four-step decomposition to commodity-specific market structure (e.g., for natural gas), the relevant time horizon, and institutional and geopolitical heterogeneity across suppliers. Establishing these extensions with additional evidence are important directions for future research.

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Appendix

A Price effects of a demand reduction in fuels

This appendix derives the effects of an exogenous demand change in Europe on oil revenues in Russia and on the EU's terms of trade.

A.1 Definitions

We consider a perfectly competitive and frictionless global oil market. We note Ω the ensemble of countries, $D_i(p)$ the demand for oil in country i at price p and $S_i(p)$ its oil production. The market is at equilibrium, such that:

$$\sum_{i \in \Omega} D_i(p) = \sum_{i \in \Omega} S_i(p). \quad (\text{A.1})$$

In Russia, the producers' surplus $\pi_{RUS}(p)$ is generally defined as:

$$\pi_{RUS}(p) = \int_{\rho=S_{RUS}^{-1}(0)}^p S_{RUS}(\rho) d\rho. \quad (\text{A.2})$$

The EU welfare is noted W_{EU} and is the combination of the consumers' and producers' surplus:

$$W_{EU} = \int_{\rho=p}^{\infty} D_{EU}(\rho) d\rho + \int_{\rho=S_{EU}^{-1}(0)}^p S_{EU}(\rho) d\rho \quad (\text{A.3})$$

The demand and supply elasticities, noted ϵ^D and ϵ^S , are assumed equal everywhere and defined as:

$$\begin{cases} \epsilon^D = \frac{\partial(D(p))}{\partial p} \frac{p}{D(p)} \\ \epsilon^S = \frac{\partial(S(p))}{\partial p} \frac{p}{S(p)} \end{cases} \quad (\text{A.4})$$

A.2 Profit losses for the Russian producers

We want to derive, for an exogenous demand change in Europe, $\partial(D_{EU}(p))$, the relative change in Russian profit $\partial(\pi_{RUS}(p))$. This ratio should be unitless, such that we need to divide the derived value by the oil price p . Using the notations of the main text, we can express the ratio $\frac{\Delta(W_{RUS})}{\Delta(X_{EU})}$ as:

$$\frac{\Delta(W_{RUS})}{\Delta(X_{EU})} = \frac{1}{p} \frac{\partial(\pi_{RUS}(p))}{\partial(D_{EU}(p))}. \quad (\text{A.5})$$

Using the chain rule, we can decompose this expression into the impact of a price change on the Russian oil rent ($\frac{\partial(\pi_{RUS}(p))}{\partial p}$) and the effect of a demand change in the EU on the

global price ($\frac{\partial p}{\partial(D_{EU}(p))}$):

$$\frac{\Delta(W_{RUS})}{\Delta(X_{EU})} = \frac{1}{p} \frac{\partial(\pi_{RUS}(p))}{\partial p} \frac{\partial p}{\partial(D_{EU}(p))}. \quad (\text{A.6})$$

We derive the first term directly from Equation (A.2), using that Russian producers extract as much oil as possible with their given equipment:

$$\frac{\partial(\pi_{RUS}(p))}{\partial p} = S_{RUS}(p). \quad (\text{A.7})$$

For the second term $\frac{\partial p}{\partial(D_{EU}(p))}$, we start from the market clearing condition, Equation (A.1):

$$\sum_{i \in \Omega} \frac{\partial(D_i(p))}{\partial p} = \sum_{i \in \Omega} \frac{\partial(S_i(p))}{\partial p}. \quad (\text{A.8})$$

Isolating the European oil demand change $\partial D_{EU}(p)$, we get:

$$\frac{\partial D_{EU}(p)}{\partial p} = \sum_{i \in \Omega} \frac{\partial(S_i(p))}{\partial p} - \sum_{i \neq EU} \frac{\partial(D_i(p))}{\partial p}. \quad (\text{A.9})$$

This equation relates marginal changes in consumption and production around the world. The terms on the right hand side reflect changes in production and consumption *induced* by changes in the world market price. The term on the left hand side means a net change in consumption, capturing both a direct demand reduction and the change in consumption induced by the resulting change in world market price.⁸

Introducing the elasticities from Equation (A.4) into the marginal market clearing condition, Equation (A.9), we find:

$$\frac{\partial D_{EU}(p)}{\partial p} = \frac{1}{p} [\epsilon^S S(p) - \epsilon^D (D(p) - D_{EU}(p))]; \quad (\text{A.10})$$

where $S(p)$ is the global oil production and $D(p)$ the global oil demand.

Now, using the market clearing condition, Equation (A.1), and introducing $\mu_{EU} = \frac{D_{EU}}{D}$ the share of Europe in global oil demand, we have:

$$\frac{\partial D_{EU}(p)}{\partial p} = \frac{S(p)}{p} [\epsilon^S - (1 - \mu_{EU})\epsilon^D]. \quad (\text{A.11})$$

Finally, by inserting Equation (A.7) and the inverse of Equation (A.11) into Equa-

⁸ On the left hand-side, we can view the price p as parameterizing the change in demand whose effect we are trying to analyze. The right hand-side features standard partial derivatives.

tion (A.12), we find:

$$\frac{\Delta(W_{RUS})}{\Delta(X_{EU})} = \frac{S_{RUS}(p)}{S(p)} \frac{1}{\epsilon^S - (1 - \mu_{EU})\epsilon^D}. \quad (\text{A.12})$$

By posing $\chi_{RUS} = \frac{S_{RUS}(p)}{S(p)}$ the fraction of Russia in total oil production, we get Equation (3) from the main text.

A.3 Terms-of-trade effect

The terms of trade effect for the EU, η_E^{tot} derives from the change in the aggregated EU surplus $-\partial W_{EU}$, Equation (A.3) – caused by the change in exogenous demand $\partial(D_{EU}(p))$:

$$\eta_E^{tot} = \frac{1}{p} \frac{\partial(W_{EU}(p))}{\partial(D_{EU}(p))}. \quad (\text{A.13})$$

Again, we use the chain rule and decompose this equation into a price effect on the EU aggregated surplus ($\frac{\partial(W_{EU}(p))}{\partial p}$) and the price change provoked by the change in EU oil demand ($\frac{\partial p}{\partial(D_{EU}(p))}$):

$$\eta_E^{tot} = \frac{1}{p} \frac{\partial(W_{EU}(p))}{\partial p} \frac{\partial p}{\partial(D_{EU}(p))}. \quad (\text{A.14})$$

This time, the first term of the derivation is deduced from Equation (A.3):

$$\frac{\partial(W_{EU}(p))}{\partial p} = S_{EU}(p) - D_{EU}(p). \quad (\text{A.15})$$

Now, combining Equation (A.15) and the inverse of Equation (A.11) and inserting into Equation (A.14), we find the following expression for quantifying the terms-of-trade effect of a change in EU oil demand:

$$\eta_E^{tot} = \frac{\chi_{EU} - \mu_{EU}}{\epsilon^S - (1 - \mu_{EU})\epsilon^D}. \quad (\text{A.16})$$

B On the long term sensitivity of military expenses

This appendix presents a model for estimating the cumulative spending on a war depending on current government resources and a stock of resource that the government can mobilize to fund the war effort. Section B.1 introduces a basic formulation of the model with constant spending and a fixed stock of resources. Section B.2 introduces an alternative formulation with an endogenous resource stock, while Section B.3 allows for time-varying military spending and government resources.

B.1 Baseline model

Let m_t denote the real Russian military expenditures for the war in Ukraine and g_t the fiscal resources that the Russian government can use for the war at time t . If the Russian resources do not fully cover the military expenses ($g_t < m_t$), the Russian government can draw on a stock of military equipment $S(t)$.⁹

The depletion of the stock S at time t is thus the quantity of military expenses not covered by the government's own resources:

$$\frac{dS_t}{dt} = (g_t - m_t). \quad (\text{B.1})$$

The war ends at time T , when the aggressor or the defender cannot sustain the war anymore because the military stock S is exhausted: $S(T) = 0$. By definition, we then have:

$$S(0) = \int_{t=0}^T m_t - g_t dt. \quad (\text{B.2})$$

Assuming the military expenditures $m_t = m$ and the government revenues $g_t = g$ are constant, the length of the war simplifies to ratio between the initial resource stock S_0 and the gap in military spending $m - g$. Accordingly,

$$T = \frac{S_0}{m - g}. \quad (\text{B.3})$$

The cumulative resources spent during the war M is given:

$$M = \int_{t=0}^T m_T dT = mT. \quad (\text{B.4})$$

In the main text (Section 3.3), we are interested in the sensitivity of the annual military spending, $\frac{1}{T}dM(T)$, to a marginal change in government budget dg_t . We derive this multiplier using the chain rule:

⁹ We present and calibrate this model based on military stocks. A similar argument can apply to other exhaustible resources such as fiscal space or human resources.

$$\frac{1}{T} \frac{dM}{dg_t} = \frac{1}{T} \frac{dM}{dT} \frac{dT}{dg_t}. \quad (\text{B.5})$$

For the first term, equation (B.4) implies that a marginal increase in war duration increases the total cumulative expenditures by the value m :

$$\frac{dM}{dT} = m. \quad (\text{B.6})$$

For the second term, Equation (B.3) indicates that an additional unit of government budget increases the war duration by:

$$\frac{dT}{dg} = -\frac{S_0}{(m-g)^2}. \quad (\text{B.7})$$

Combining Equations (B.6) and (B.7) in equation (B.5), we get

$$\frac{1}{T} \frac{dM}{dg_t} = \frac{S_0}{T} \frac{m}{(m-g)^2}. \quad (\text{B.8})$$

The current military expenses thus increase by a coefficient $\frac{S_0}{T} \frac{m}{(m-g)^2}$ for each additional unit of income available.

Using Equation (B.3), we finally substitute $S_0/T = m - g$ to derive an expression of the end-of-war multiplier depending only on the share of military expenses covered by the current government budget:

$$\frac{1}{T} \frac{dM}{dg_t} = \frac{m}{m-g}. \quad (\text{B.9})$$

We find that the marginal yearly spending on the war ($\frac{1}{T}dM$) decreases proportionally to the inverse of the *funding gap* ($m - g$, the difference between the "budgeted" and the "real" military expenditures) for a marginal decrease in the government revenue. Figure B.1 provides a graphical interpretation of the model.

To quantify the potential magnitude of the end-of-war multiplier, we draw on publicly available data on Russian military spending and stock depletion. In the first six months of the war, Russia reportedly lost approximately 10.7 billion USD in military equipment (Shatz & Reach, 2023), with an estimated 80% replaced by depleting soviet equipment reserves (Seohina, 2024; Wrating & Reynolds, 2024). Over the course of one year, this translates into an estimated 18 billion USD in military equipment drawn from the stocks and unreported in the military budget. In addition, the Russian government reported a 17 billion USD fiscal deficit in 2023 (Cooper, 2023), further reducing its capacity of taking more debts in the future. These stocks depletion add to the 109 billion USD official defense budget, which thereby represent about 75% of the real military expenditures. Applying Equation (B.9), the implied end-of-war multiplier is: $dM/(Tdg_t) = 1/(1-0.75) = 4$. Thus, a unit decrease in the Russian government revenue translates into four units of reduced intertemporal military spending under these assumptions.

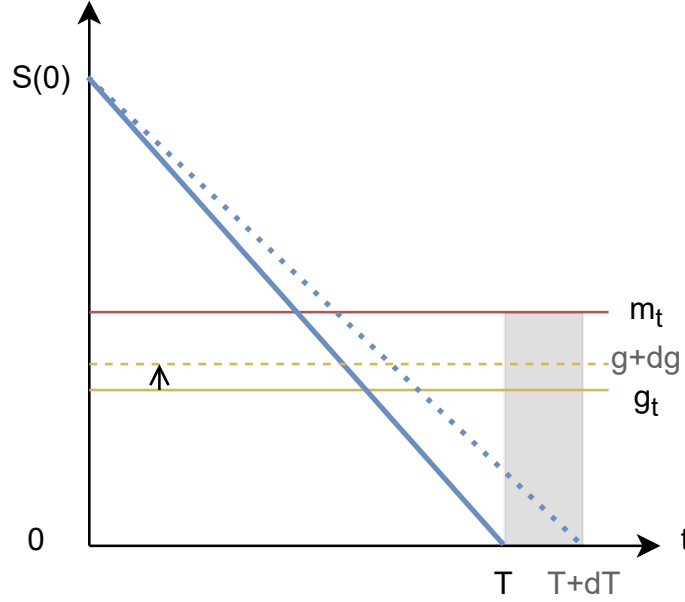


Figure B.1: Graphical representation of the end-of-war model.

Note: The yellow line g figures the current income the government can spend on the war, while the red line m is the effective war effort. The gap between the current government revenue and the real military effort is covered by withdrawing resources from a stock S , whose value is shown in blue, which is depleted at a rate $(m - g)$. The war ends at time T , when the resource stock is fully exhausted. The dotted lines represent the effect of an increase dg of the government revenues: increasing the current government revenue decreases the rate of the stock depletion (dotted blue curve), effectively delaying the end of the war ($T + dT$). The extension of the duration of the war dT allows an increase of $dT * m$ in inter-temporal military spending (grey area). Such marginal military spending do not depend on the size of the initial stock ($S(0)$) nor on the duration of the war (T), but only on the stock depletion rate.

B.2 Endogenous resource stock

The baseline model assumes that the “non-budgeted” resource stock $S(t)$ is fixed in quantity. By modifying Equation (B.1), the model can be extended to dynamic stocks, reflecting the progressive replenishment of the equipment stock, e.g. through repairing or modernizing damaged or deprecated equipment. If we denote r the rate at which Russia can replace its material losses, Equation (B.1) becomes:

$$\frac{dS_t}{dt} = (g_t - m_t) + rS_t. \quad (\text{B.10})$$

Solving this equation at the end-of-war T introduces an additional parameter e^{rT} reflecting the endogenous evolution of the stock. As a result, the multiplier expression generalizes to:

$$\frac{1}{T} \frac{dM}{dg_t} = \frac{m}{m - g} e^{rT}. \quad (\text{B.11})$$

B.3 Endogenous spending path

The formulation of Equation (B.3) assumes that government and military spending are constant over time. Our modeling approach also applies to other paths of spending over time. In that case, Equation (B.9) becomes:

$$\frac{1}{T} \frac{dM}{dg_t} = \frac{m_T}{m_T - g_T}. \quad (\text{B.12})$$

In this case, the change in intertemporal spendings only depends on the budget gap *at the time the war ends*. This approach allows for an alternative calibration of the model: from a fiscal perspective, we can estimate the current government deficit that would trigger a sovereign default – and, in turn, the end of the war. In 1998, the Russian government defaulted on its public debt with a fiscal deficit of 55% of its current revenues (Khara et al., 2001). Assuming the same level of fiscal deficit would trigger a default in contemporary Russia, the end-of-war multiplier would reach 1.8.

C Possible range and sensitivity of the geopolitical externality

In the main text, we highlight the lower and upper bounds as well as a central estimate for each of the four steps contributing to the geopolitical externality (see Table 1). Taken together, these yield a central estimate of approximately 0.32 for the geopolitical externality and a range of values resulting from the extreme combinations spanning three orders of magnitude.

However, when combining the lower, central, and upper values for each of the four steps, we obtain a total of $3^4 = 81$ possible combinations. While assigning probabilities to these individual estimates lies beyond the scope of this paper, the resulting distribution still conveys useful information about the possible value of the geopolitical externality.

Figure C.1 shows the occurrences of the geopolitical externality estimate across all possible combinations of the lower, higher and central estimates.

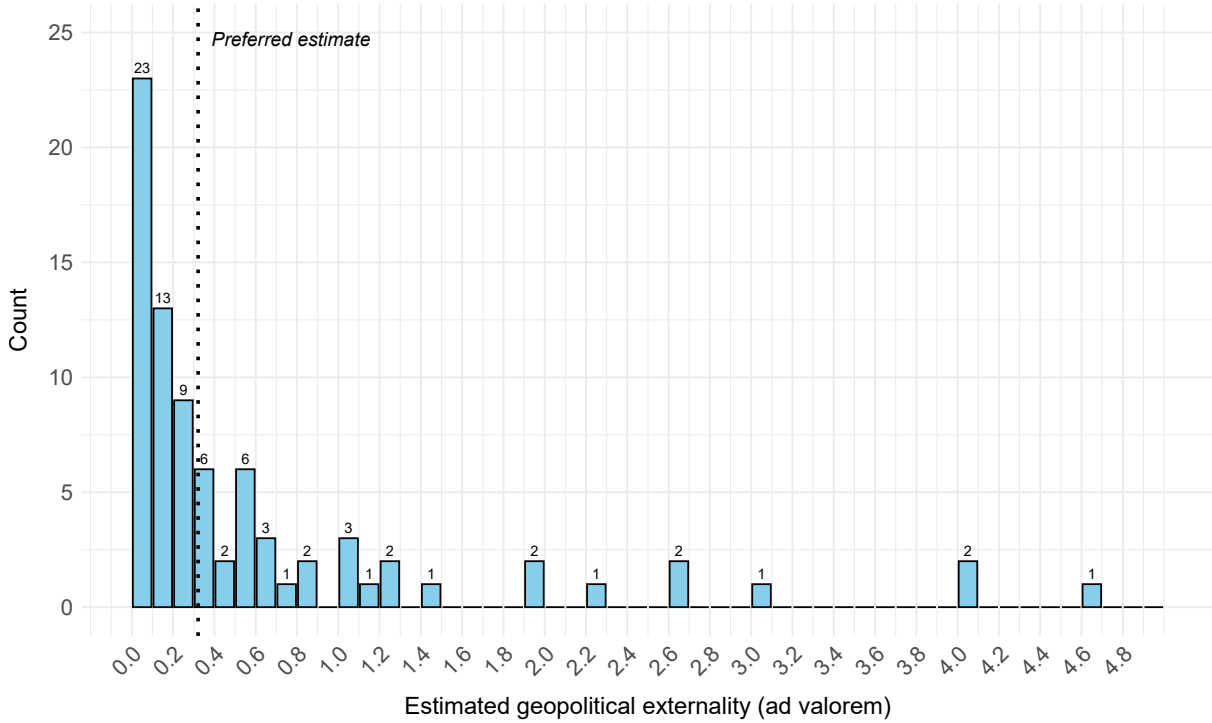


Figure C.1: Simulated distribution of the geopolitical externality.

Notes: Each bar reflects the number of occurrences from 81 scenario combinations, based on three value assumptions for each of the four steps contributing to the geopolitical externality. The central estimate (0.32) is shown as a dotted vertical line.

Out of the 81 possible, 47 yield a geopolitical externality below our central value, of which 36 are below 0.20. By contrast, 16 combinations exceed a value of 1. These

relatively rare but high-value combinations highlight the potentially high magnitude of the geopolitical externality.

To further illustrate the drivers of uncertainty, Figure C.2 shows the individual contribution of each causal step’s parameter uncertainty to the range of the geopolitical externality – i.e., varying the estimate of one causal step within its range while holding the other three at their central estimates. Uncertainty in the Russian military spending multiplier (Step 3) contributes most strongly to the overall range of the geopolitical externality, whereas uncertainty regarding the link between Russian oil rents and the Russian government budget (Step 2) has comparatively little impact.

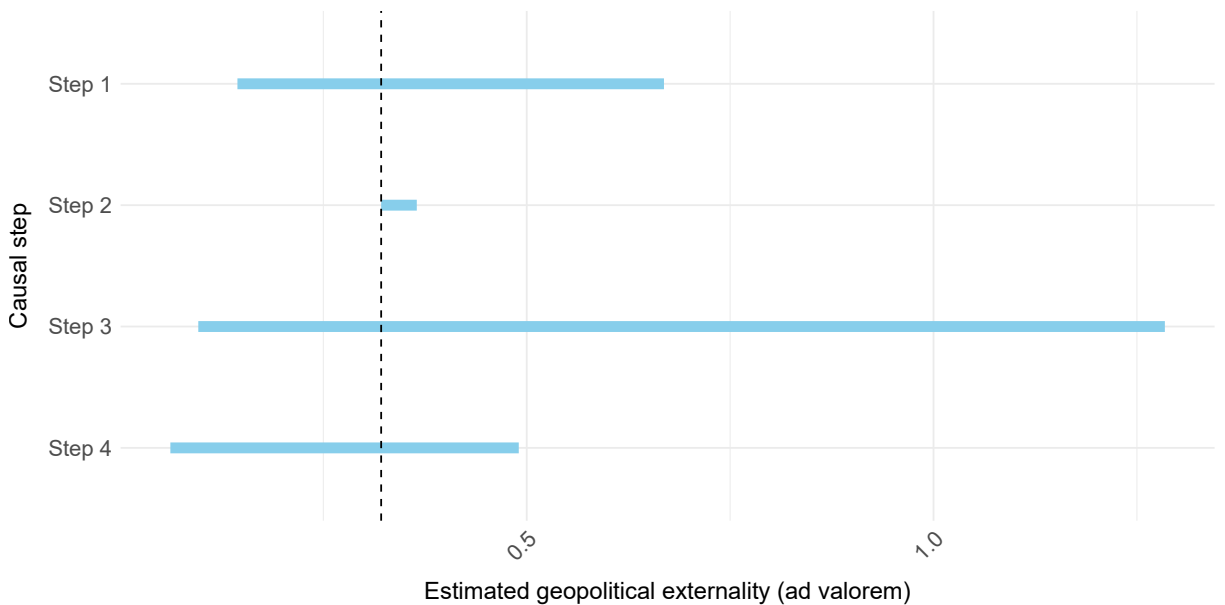


Figure C.2: Sensitivity of the geopolitical externality to individual causal steps.

Notes: Each bar reflects the range of estimates of the geopolitical externality that results from varying one causal step individually across its low and high estimate while holding the other steps at their central values. The central estimate of the geopolitical externality (0.32) is shown as a dotted vertical line.

D Additional table and figures

Table D.1: The geopolitical externality compared to other externalities of oil use in the EU.

Externality	Ad-valorem estimate			Social cost estimate (EUR/tCO ₂)		
	Low (1)	Central (2)	High (3)	Low (4)	Central (5)	High (6)
Geopolitical	0.01	0.32	4.64	1	54	775
Terms-of-trade	0.08	0.18	0.38	14	31	64
Air pollution	0.15	0.15	0.15	24	24	24
Total	0.24	0.65	5.17	40	109	864

Note: Ad-valorem estimates are expressed in monetary cost per monetary unit of oil used. The social cost equivalents are estimated using an oil price of 70 EUR and an emission intensity of 2.65 kgCO₂/l.