Trade Policy in the Shadow of Conflict: The Case of Dual-Use Goods*

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Abstract

Policymakers increasingly use trade instruments to address national security concerns. This paper studies optimal policy for dual-use goods, items with both military and civilian applications. We begin by empirically documenting that regulation and trade flows of dual-use goods respond to changes in the security environment over time. To put structure on the national security externality, we introduce military procurement into a multi-country general equilibrium network model and add a military contest to the national welfare function. In a simple two-country case, optimal export taxes depend on a trade-off between the good's military centrality and its distortion centrality. Military centrality is a network-adjusted sales share to the foreign military; distortion centrality reflects taxation misallocation in the domestic economy from roundabout imports. Using U.S. defense procurement data, we construct a measure of military use across goods, ranging from zero to one, by scaling the U.S. closed-economy military centrality by import demand elasticities. Our measure predicts policy targeting and trade responses around conflicts and allows us to evaluate the U.S. security restrictions and global sanctions against Russia. To quantify the macroeconomic magnitude of the consumption-security trade-off, we calibrate our model to a potential U.S.-China conflict. Our revealed preference estimate of the conflict prize amounts to 250% annual U.S. GDP.

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1 Introduction

A recent rise in geopolitical tensions has prompted policymakers to rethink trade policy in light of national security considerations. Evidence of the Russian war effort in Ukraine relying on imported manufacturing components emphasized trade in dual-use goods, items with both military and civilian applications.[1] Amid growing concerns about future military confrontations with China, the U.S. Department of Commerce introduced a pre-emptive export ban on advanced NVIDIA chips.[2] In policy discourse, a view that supply chains for goods of strategic importance should go only through friendly countries has been emerging as a new political consensus, gradually replacing previous free trade narratives.[3]

Despite the policy interest, the field of international trade still lacks a theory defining dual-use goods and their role in trade policy. Optimal tariff formulas have been derived for consumption goods for a variety of market structures (Helpman and Krugman, 1989). The literature has also explored how trade taxes should correct international externalities in the context of carbon emissions and climate change (e.g., Kortum and Weisbach, 2021). In response to the conflict in Ukraine, recent theoretical work has commented on the optimal sanctions design, drawing a parallel between sanctions and terms-of-trade manipulations (Becko, 2024). The quantitative treatment of the military externality, however, remains a gap in the literature, which we attempt to address.

Our paper characterizes the optimal trade policy for dual-use goods in a world with possible military conflicts. We motivate our inquiry by empirically documenting that regulation and trade flows of critical goods respond to changes in the security environment over time. Then we lay out a simple two-country model that formalizes our idea of a military contest and derive optimal tax formulas across goods in that setup. We bring our optimal tax formulas to the data and show that the resulting measure of military use, based on sufficient statistics for Pigouvian terms, predicts policy targeting and changes in trade flows around conflicts. To put numbers on the contest block, we extend our baseline model to a multi-country general equilibrium setup and calibrate it to a potential U.S.-China conflict.

We begin our paper by establishing three motivating facts about dual-use goods. First, goods, classified as dual-use by security authorities, are often intermediate inputs. They are concentrated in categories such as machine tools, aerospace, and chemicals, and are generally produced by industries located mid-stream in the U.S. input-output tables. Second, more policy attention has been directed towards those goods in recent years. The range of

[1] The FT article 'Type of Russian missile that struck Kyiv children's hospital uses western components" (Miller et al., 2024) provides one piece of anecdotal evidence.

[2] News coverage of the ban can be found in the article "U.S. Restricts Sales of Sophisticated Chips to China and Russia" in the New York Times (Clark & Swanson, 2022).

[3] See "What is Friendshoring?" in the New York Times (Kessler, 2022)

goods classified as dual-use for EU customs has doubled since 2007, with sharp increases around 2014 and 2022; security-related policy announcements targeting those goods have increased tenfold since 2019. Third, trade in dual-use goods responds to the security environment. The subsidy equivalent for dual-use trade within Cold War blocs peaked in 1990 with 40% and has been decreasing since then, but the Ukraine conflict reversed half of the post-1990 decrease in bloc importance.[4] During war episodes between 1960 and today, dual-use imports on average experienced a 10% subsidy equivalent for friends and a 10% tariff equivalent for enemies. Together these facts suggest that trade in certain goods responds to a time-varying national security externality and motivate our modeling approach that takes production networks into account.

We formalize our notion of the defense externality in a simple two-country model. We begin with an Armington (1969) setup with a freely tradable outside good and then expand the model to incorporate production networks in the spirit of Baqaee and Farhi (2024). To those setups, we add the defense department as a second final demand agent in addition to households. The defense department also buys physical goods and is financed by household taxes. The government chooses defense spending to balance household consumption (butter) with the expected payoff of a contest with the foreign military (guns). In the two-country case, the contest payoff is a function of a simple ratio of home military to foreign, but we generalize it later. We solve for the optimal taxes across goods, keeping in mind that the observed national security bans might be a second-best outcome if policy instruments are restricted to zero or infinite taxes only.

In this setup, optimal export taxes depend on a trade-off between foreign military centrality and domestic distortion centrality. Military centrality is a network- and taxation-adjusted sales share to the foreign military and is scaled by a macro shifter that captures the importance of winning the military contest relative to domestic consumption. Distortion centrality is a network- and taxation-adjusted domestic sales share via roundabout imports. The trade-off is divided by the import demand elasticity and, as such, matters more for less substitutable goods. It serves as a Pigouvian addition to standard terms-of-trade components in the optimal tax formulas. We later extend our model for our calibration exercise to feature production factors in fixed supply and find that the generalized optimal tax formulas feature a factor centrality trade-off that is scaled by the price reaction of each factor.

As an illustration of our model's primary mechanism, consider U.S. chip exports to China. Taxing chip exports increases their price for the Chinese military but also increases the price of re-imported electronics that contains those chips for American buyers. For $1 of U.S. export sales, foreign military centrality is roughly those 20 cents that go to the Chi-

[4] Here and henceforth, subsidy equivalent or tariff equivalent simply means the coefficient on the gravity equation right-hand-side indicator variable.

nese military and domestic distortion centrality is roughly the 10 cents that return to the U.S. via electronics.[5] The U.S. government would prefer higher export taxes on chips when military tensions with China are high relative to domestic needs. If China can easily substitute American chips with home-produced chips, the trade-off matters less, and the U.S. chip exports should be taxed less. If trade instruments for national security are limited to export bans, we would observe a chip ban as a second-best if the optimal export tax is high enough.[6]

To quantify which goods matter for defense in practice, we develop an empirical measure of military use between 0 and 1 by taking our optimal tax formulas to the data. We first provide some anecdotal and historical evidence that regulators take relative use by military and households into account. Then we construct our military use measure by calculating military centrality across goods for the U.S. closed-economy network and scaling it by import demand elasticities from the trade literature. The intuition for this statistic comes from our optimal tax formulas and consists in the trade-off between the size of the military externality and production base non-substitutability. The closed economy benchmark allows us to understand existing levels of trade regulation as opposed to prescribing where regulation should move next if we worked with endogeneous international centralities. The highest military use goods are aluminium, warships, tanks, aircraft engines, and various shipbuilding inputs.

Our measure of military use predicts targeting by trade policies, as well as changes in import flows around conflicts. For policy outcomes, we look at dual-use lists, U.S. export non-tariff measures after 2022, and global export policy announcements over time. We observe a striking change in the policy gradient: goods in the top percentile of our military use measure faced 40% less export policy announcements over 2018-2019 compared to goods in the bottom percentile, 7% more over 2020-2021, and 100% more over 2022-2023.[7] Military use is a strong and robust predictor of inclusion into trade restrictions. It also yields a better fit than a simple military sales share, wins a horserace against the latter, and stays of the same magnitude and significance conditional on sales share polynomials and other controls.

[5]The remaining 70 cents constitute foreign consumer centrality, which would appear in the trade-off alongside domestic distortion centrality if the U.S. government placed a positive weight on foreign consumption. All the sale cents mentioned should also be adjusted by taxation along the network in a way that the main text clarifies.

[6]For more concrete examples, we provide several firm-level case studies of critical supply chains in our motivating facts section.

[7]One potential reason why those goods have been targeted less before 2019 is that they are inputs; see Antràs et al. (2024). Another reason would be that the military domain lacked the need for adjustment close to the steady state relative to other domains in peacetime or, more behaviorally, had no salience for policymakers.

For trade flow outcomes, we look at conflict events and decompose changes in average military use of imports across source countries and individual goods. In the case of Ukraine, for a 1pp increase in military use, a good sees a 5% increase in imports after 2022. The leading military contributors are Poland (weapons), Slovakia (ammunition), and Canada (tanks), offset by Russia (fossil fuels), China (electrical apparatus, steel), and Belarus (petroleum). We perform similar decompositions for Russia after 2022 and China between 2016 and today. Intriguingly, we spot a trend in Chinese military-adjacent decoupling since 2016, driven by a decrease in imports of aerospace items, chips, and opticals from the West.

With our military use measure, we quantify to what extent various sanction lists target military enterprises. We find that the U.S. Bureau of Industry Security lists follow an intuitive pecking order from the Military End Use list (average centrality percentile 76%) to Denied Persons List (52%). There is also an intuitive clustering in terms of countries, with a targeted group (>75%: e.g., Latin America and Northern Europe), an expanded group (50%-75%: e.g., China, UAE, Turkey), and a blanket sanctions group (<50%: e.g., Armenia, Serbia, Iran). Similarly, we evaluate the EU dual-use lists, finding that in 2015 they were enhanced to incorporate more military-centric items, while in 2022 they were expanded on the extensive margin towards less military-centric items. For the EU critical goods lists, semiconductors (74%), listed as Tier 1 of battlefield items, score less on our measure than radioelectronics (95%), listed as Tier 2. We also develop an intuitive clustering for various sanctions against Russia, with Navalny-35 and UK HMT/OFSI Investment Bans having the best military precision.

In the final part of the paper, we evaluate the macroeconomic magnitude of the national security externality. To that end, we calibrate our model to a potential U.S.-China conflict with the rest of the world as a bystander country. We first extend our theory to a general equilibrium case, developing compact propagation matrix formulas for factor price changes. We also extend our data and assemble Chinese input-output tables, constructing final military demand based on the revenues of publicly-traded firms in the defense sector. We parametrize national welfare as domestic consumption, foreign consumption with a weight, and a generalized contest function of domestic and foreign militaries with a weight. The contest elasticity parameter γ captures the returns to scale to military when the latter converts to the probability of winning.

The structural parameters are disciplined using a revealed preference approach. The contest elasticity parameter γ rationalizes how much the U.S. adjusts its military spending in response to the evolution of the Eastern Bloc spending over time. We find that it equals $\gamma \approx 0.5$ across specifications, suggesting that the military advantage converts into the probability of winning with decreasing returns. The welfare weight on the military contest, or what we call the conflict prize, is estimated from the levels of military spending: a

marginal tax dollar going to the military should be as valuable as a marginal tax dollar left to households. Our estimate of the conflict prize amounts to 250% of the annual U.S. GDP. The estimate depends on our assumptions on existing military stockpiles, which we back out using book values from accounting statements. Indeed, when stockpiles decrease, military spending increases: during World War II, it reached 40% of domestic GDP for the U.S. (though separating stockpile effects from changes in the externality magnitude might require some causal inference in the future). The prize reflects a dynamic continuation value of winning the contest projected onto a static model, so the magnitude of 250% of the annual U.S. GDP is not as large as one might think.

Given our structural fit, we evaluate how home military advantage ($m_{\text{HOME}}/m_{\text{FRGN}}$) can be increased at the expense of consumption ratio ($c_{\text{FRGN}}/c_{\text{HOME}}$) across various scenarios. In the baseline with export taxes and zero welfare weights on foreign households, the U.S. increases its military advantage by 1.7% and decreases its consumption ratio by 1.5%; China does this by 2.1% (>1.7%) and -4.9% (<-1.5%), demonstrating a stronger export policy impact. Potential smuggling via the Rest of the World reduces those magnitudes by more than a half for both countries. When military stockpiles are gone, incentives to block exports increase, multiplying the U.S. numbers by $\approx$1.25. Import taxes are a stronger military deterrent for the U.S. compared to export policy, but the mechanism is through decreasing Chinese defense spending. For China, on the other hand, import policy has a near-zero impact because China does not import much of the American goods. Finally, the U.S. export policy jointly with the Western coalition has a five times stronger impact than the U.S. on its own; similar enforcement by the Eastern coalition moves the needle for China very modestly by 1.25. Those estimates capture orders of magnitudes based on our stylized calibration and, as such, are open to future refinement.

Our main takeaway is that military can be thought of as an interest group that shapes policy and trade outcomes in a way that is relevant on a macro scale. Future research can zoom in more on the production dynamics, uncertainty, behavioral responses, game theory, as well as better data; we discuss various follow-up questions in our conclusion. We hope that our paper will inspire more work on the economics of national security to help solve the issue of military conflicts.

This paper proceeds as follows. Section 2 contextualizes our contribution within the broader literature. Section 3 lays out motivating facts on trade in dual-use goods. Section 4 presents a simple two-country model to pin down our intuitions. Section 5 develops our empirical measure of military use. Section 6 extends and calibrates the model. Section 7 concludes.

2 Related literature

Our paper studies optimal trade policy for dual-use goods in the presence of a military contest externality. Thematically, it continues the line of work that studies the role of interest groups in international trade, this time with a national security angle. Theoretically, it contributes to the optimal tariff literature, as well as the literature on wedges in production networks. Empirically, it quantifies industry network positions by incorporating defense procurement into the input-output tables, and also looks at the associated trade and industrial policies.

We continue the tradition of research on interest groups in international trade starting from Grossman and Helpman (1994). The literature began with the influence of domestic lobbies on trade policy but has expanded to consider the influence of foreign lobbies (Antràs and Padró i Miquel, 2011, 2023); some recent quantitative treatments include Ossa (2014), Méndez and Van Patten (2022), Adão et al. (2023, 2024), Kleinman et al. (2023), Hsiao et al. (2024). We quantitively discipline military contests instead of domestic elections or other diplomatic actions.

More broadly, our paper is related to the work on geoeconomics. Earlier work in that area used parsimonious setups to understand price incentives relating conflict, production, and exchange (Skaperdas and Syropoulos, 2001, Kaempfer and Lowenberg, 2007, Acemoglu et al., 2012) and examine links between trade and conflicts empirically (Martin, Mayer, et al., 2008, 2012; Martin, Thoenig, et al., 2008, Acemoglu and Yared, 2010, Wen, 2012, Rohner et al., 2013, Chatagnier and Kavakl, 2017). Recent work deepens our understanding of mechanisms behind international coercion (Becko, 2023, Bianchi and Sosa-Padilla, 2023, Clayton et al., 2023, 2024, Becko and O'Connor, 2024, Itskhoki and Mukhin, 2022, 2023, Eichengreen et al., 2024, E. Liu and Yang, 2024) and delivers structural estimates of various conflict parameters (Kang, 2016, König et al., 2017, Couttenier et al., 2023, Thoenig, 2023). We do not model the game theory behind conflict realization but treat its probability as given, so consider our approach closer to the interest group literature.

We solve for optimal taxes in a multi-agent network economy with distortions and externalities. Optimal tariff formulas have been derived for consumption goods for a variety of market structures (Helpman and Krugman, 1989); most recently, for a Ricardian setup with a continuum of goods (Costinot et al., 2015), under monopolistic competition with firm heterogeneity (Costinot et al., 2020), and in the presence of the economies of scale (Lashkaripour & Lugovskyy, 2022). Becko (2024) showed that the optimal sanctions problem is a scaled terms-of-trade manipulation problem. An extensive literature has studied optimal trade taxes under climate production externalities (e.g., Farrokhi and Lashkaripour, 2021, Kortum and Weisbach, 2021; more broadly, Golosov et al., 2014, Conte et al., 2022, Cruz and Rossi-Hansberg, 2022, 2023, Hsiao, 2022, Acemoglu et al., 2023, Bilal and Rossi-

Hansberg, 2023). At the same time, the production networks literature starting from Long and Plosser (1983) has developed theoretical tools for input-output accounting and optimal wedge-setting on networks (e.g., E. Liu, 2019, Bigio and La'O, 2020, Galeotti et al., 2020, Lashkaripour and Beshkar, 2020, Wu, 2022, Baqaee and Farhi, 2024, E. Liu and Tsyvinski, 2024). To those lines of work, we contribute optimal tax expressions under arbitrary network distortions, compact formulas for factor price adjustments, as well as reformulations of centrality in terms of sales shares for multi-agent economies.

Our quantification of industry positions in input-output networks follows a long tradition starting from Leontief (1936), most recently exemplified by work on global value chains (Jones, 1976, Antràs et al., 2012, Antràs and Chor, 2013, 2018, Hausmann et al., 2014, Antràs, 2016, Grassi, 2018, Alfaro et al., 2019, Grassi and Sauvagnat, 2019). We also analyze applications of trade and industrial policies similar to Evenett (2019), Bai et al. (2022), Copeland et al. (2022), Juhász et al. (2022), Goldberg et al. (2024). Our contribution is that we do this for military goods by working with government procurement contracts following Auerbach and Gorodnichenko (2012), Belenzon and Cioaca (2021), Cox et al. (2023). Our conflict event studies speak to the analysis of the economic consequences of war and alliances (Chupilkin and Koczan, 2022, Davis et al., 2023, Federle et al., 2024, Neri-Laine, 2024, Horn et al., 2024, Gopinath et al., 2024). Our calibration exercises are similar to recent quantitative work on sanctions (e.g., Ghironi et al., 2023, de Souza et al., 2024); new studies also quantitatively estimate various elasticities of adjustment (e.g., Chupilkin et al., 2024, Egorov et al., 2024, Li et al., 2024, Teti et al., 2024). With that in mind, we are ready to proceed to the main text.

3 Motivating facts

What goods can be put to both military and civilian uses? Rare-earth magnets produced in Chengdu, China, are used as inputs into the U.S. F-35 fighter jet radars and Tesla car seats. Ship engines produced by a German Rolls-Royce subsidiary power the PLA Navy's missile destroyers and cruises across Lake Michigan. CNC machines are used to make parts for Iskander missiles and golf clubs. Inexpensive drones for amateur photography are repurposed for trench warfare in Ukraine. Examples of such manufacturing inputs and equipment are more than plentiful.[8]

Governments have historically intervened in the free exchange of dual-use items. Military considerations prevailed over the design of export control policies to the Soviet Union during the Cold War (Gustafson, 1981). The 1721 Naval Stores Act, passed by the British Parliament, incentivized the production and import of timber from the North American

[8] See Appendix B.1 for our firm-level supply chain reconstructions behind the examples in this paragraph.

colonies (Bowett, 1994). Cheap timber was a strategic input to bolster the British hegemony on the sea but as a by-product also spurred a boom in London furniture making. The 1076 Song court decree banned exports of gunpowder components, saltpeter and sulfur, to neighboring Liao and Western Xia to protect its military advantage (Andrade, 2016). The design of national security interventions becomes more challenging in the modern world of global value chains and reshipping, where imprecise policy tools affect third parties and generate adjustments (X. Liu et al., 2024, Iyoha et al., 2024, Itskhoki and Ribakova, 2024).

In this section, we document three stylized facts about dual-use goods, as classified by security experts, that will motivate our theoretical framework. First, dual-use goods are overwhelmingly intermediate inputs. Second, trade in dual-use goods is increasingly regulated. Third, trade responds to changes in the security environment. We elaborate on each of these facts below.

Fact #1. Dual-use goods are intermediate inputs

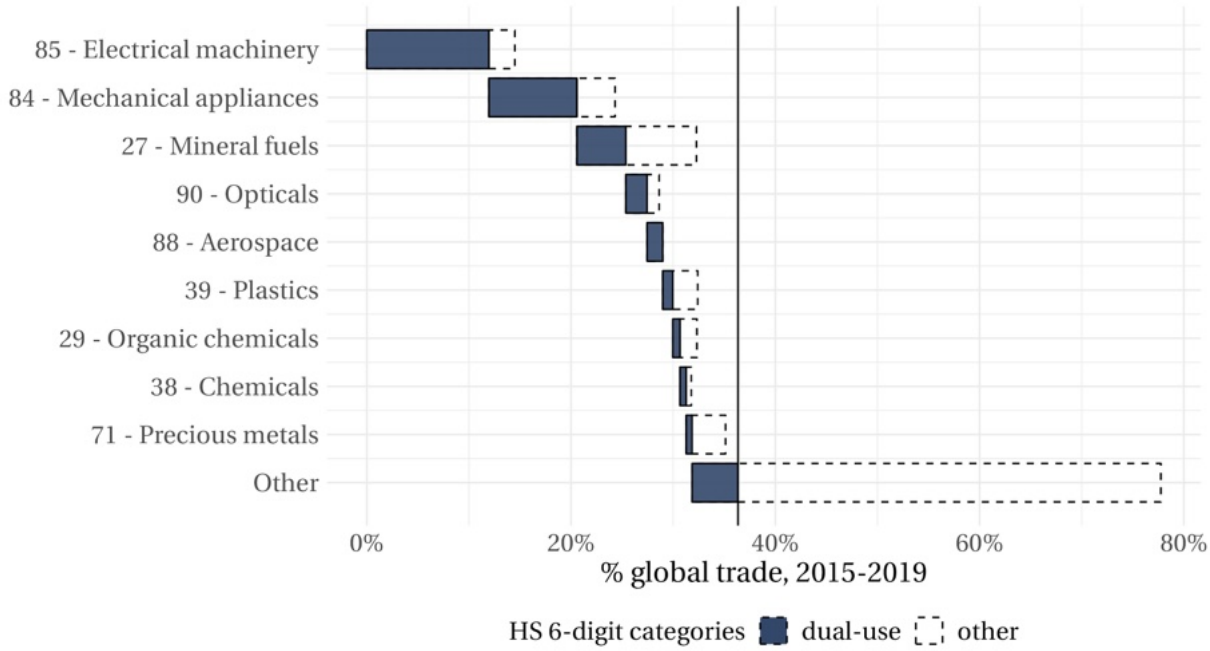
Customs authorities implement strategic trade control to ensure that goods critical to national security do not cross international borders. The EU TARIC correlation tables provide the link between traditional Harmonized System codes and the Export Control Classification Numbers (ECCN), flagging which goods should be subject to additional checks and licensing.[9] For the purposes of this section, we adopt a formal definition of dual-use goods as a set of HS 6-digit commodities listed in those tables.

Many commodities flagged as dual-use facilitate manufacturing production. Two main HS 2-digit categories containing dual-use goods are electrical equipment (85) and mechanical machinery (84). Dual-use goods within these categories jointly account for more than 20% of global trade between 2015 and 2019 (Figure 1). Other prominent buckets are opticals (90), aerospace (88), and mineral fuels (27) with 2% of global trade each, as well as plastics (39), organic chemicals (29), and chemicals (38) with 1% each. Together commodities flagged as dual-use cover 36.3% of global trade.[10]

To understand positioning of dual-use goods in production networks, we take the input-

[9] The EU ECCN lists largely mirror those developed by the U.S. Bureau of Industry Security.

[10] The reader should be careful in interpreting this number. First, this is not the same as saying that 36.3% of global trade is used in military production. These figures reflect commodities that might be used as military inputs, including raw materials such as oil and steel, but in practice are mostly used for civilian purposes. Second, it would also be incorrect to say that every item shipped within flagged categories could be used in military production. Not every chip crossing the border can be put into a missile. These dual-use classifications are developed with customs' goals in mind and as such exhibit type-I and type-II errors driven by institutional objectives. Chatelus and Heine (2016) presents a nuanced discussion of those issues. As such, the only way to treat our dual-use goods definition is to treat it in a formal sense. We will later demonstrate that this definition is helpful for policy analysis.



Notes: Data for dual-use categories is taken from the 2018 vintage of the EU TARIC dual-use correlation tables. Data on trade flows from 2015 to 2019 is coming from the CEPII BACI (HS Rev. 4, 2012) dataset (Gaulier & Zignago, 2010). Blue bars show the share of global trade accounted by the dual-use goods within broader 2-digit categories; those bars are stacked to resemble a cumulative distribution function. Larger dashed white bars reflect the trade share of all the goods within the category. As such, blue bars sum horizontally to the total dual-use share of 36.3%, but white bars do not sum to 100% because they are placed relatively to blue bars.

Figure 1: Dual-use goods (2018 vintage) breakdown by HS2 codes

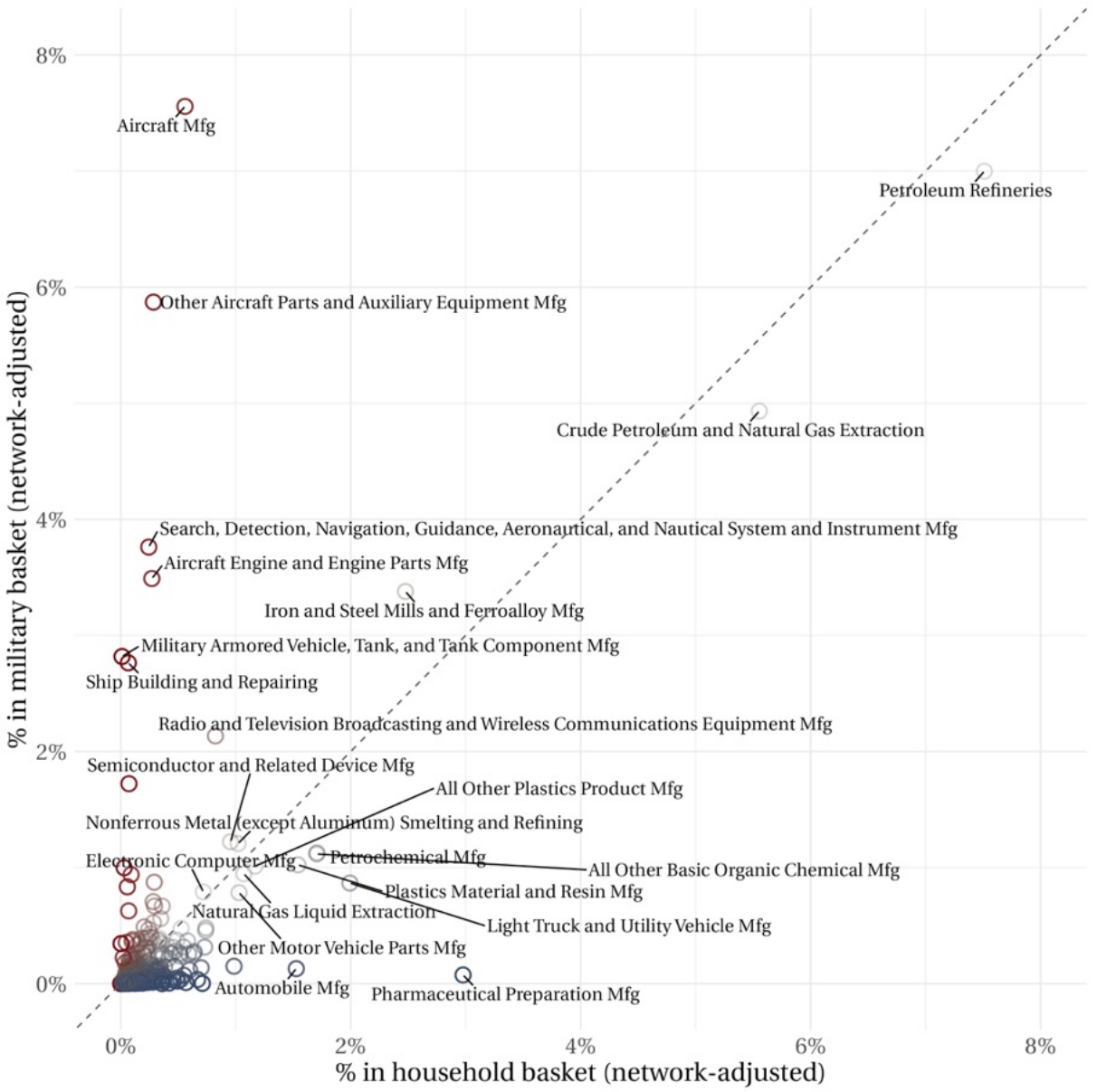
output tables for the U.S. economy. Figure 2 plots network-adjusted sales of various industries to the U.S. military and the U.S. households.[11] Some industries, such as missile production or tank manufacturing, sell primarily to the military. Others, like automobile manufacturing or pharmaceuticals, sell mostly to households. A range of input industries, such as semiconductors or production of plastics, sell to both.

We introduce some heuristic metrics to capture relevant industry characteristics. We define *Military-HH sales symmetry* as a scaled difference between network-adjusted military and households sales of an industry (or a measure of proximity to the 45-degree line in Figure 2):

$$\text{Military-HH sales symmetry}_i \equiv 1 - \frac{|\text{Military sales}_i - \text{Household sales}_i|}{\text{Military sales}_i + \text{Household sales}_i} \in [0,1]$$

The formula follows the logic of the Grubel-Lloyd intra-industry trade index (Grubel & Lloyd,

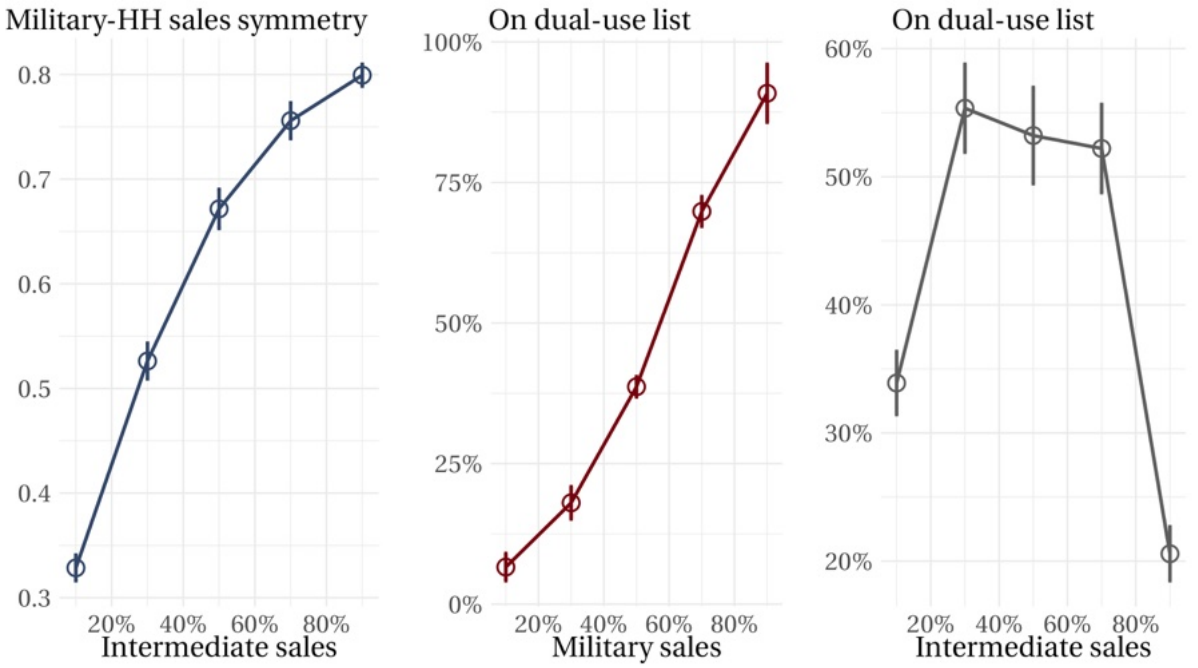
[11] The military and household network-adjusted sales are calculated using Leontief inverses as $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}]\prime\mathbf{1}}\right]$ and $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}]\prime\mathbf{1}}\right]$, where $\mathbf{\Omega}$ is an input-output expenditure matrix and $\mathbf{s}^{\mathbf{M}}$, $\mathbf{s}^{\mathbf{C}}$ are expenditure shares on goods of military and households.



Notes: Data for the U.S. input-output table is taken for 2018 from the Bureau of Economic Analysis, with additional information from the 2018 Survey of the U.S. Businesses by the U.S. Census. Data for the military final demand is coming from procurement contracts accessed via USASpending. As mentioned in footnote 11, the military and household network-adjusted sales are calculated using Leontief inverses as $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}]'\mathbf{1}}\right]$ and $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}]'\mathbf{1}}\right]$, where $\mathbf{\Omega}$ is an input-output expenditure matrix and $\mathbf{s}^{\mathbf{M}}$, $\mathbf{s}^{\mathbf{C}}$ are expenditure shares on goods of military and households.

Figure 2: 2018 U.S. input-output table

1975). Sales symmetry takes the value of 0 when an industry sells exclusively to households or exclusively to the military and the value of 1 when an industry has equal shares in the baskets of two groups. To measure the use of industry's output as an input into other industries' production, we take the ratio of intermediate sales to total sales. We also look at network-adjusted military sales as a share of total sales.



Notes: The figure presents binscatters with an x-axis split into five intervals of equal length. For clarity,

$$\text{Intermediate sales, } \%_i \equiv \frac{\text{Intermediate sales}_i}{\text{Total sales}_i}, \qquad \text{Military sales, } \%_i \equiv \frac{\text{Military sales}_i}{\text{Total sales}_i}.$$

The unit of observation is an HS six-digit category. Regressions are weighted by their respective trade shares. Supplementary Appendix Figure SA.B.1 presents some robustness checks.

Figure 3: Dual-use goods in production networks

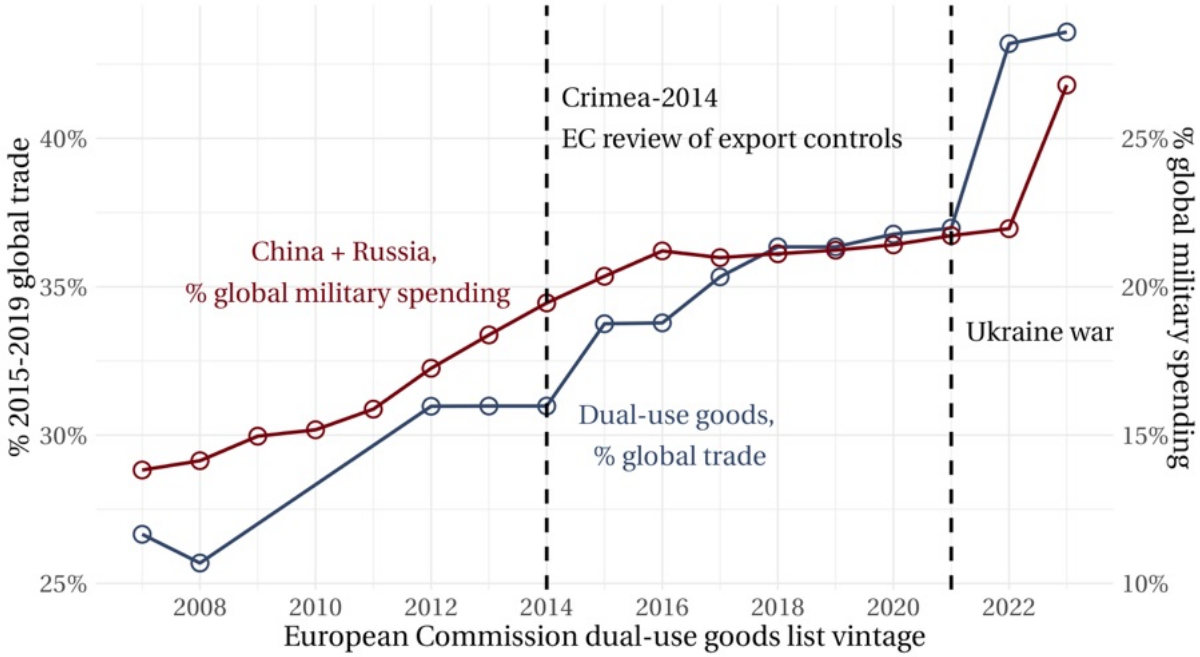
Figure 3 portrays three key relationships between our measures. First, our intermediate sales share and sales symmetry measure move together one-to-one. The more final sales the industry has, the more it sells to a specific final agent, and vice versa. Second, the probability of being on the dual-use list goes hand-in-hand with military sales share. If an industry sells exclusively to the military, it will be on the dual-use list, and vice versa. Finally, the relationship between the dual-use list inclusion and intermediate sales share is an inverse U-shape. Very downstream and very upstream industries are not on the dual-use list, while industries in the middle are, which will motivate our production networks modeling treatment.[12] Armed with that descriptive knowledge, we proceed with analyzing

[12]Note that very downstream final military items are not featured on the customs dual-use lists: HS codes

how trade policy behaved over time.

Fact #2. Trade in dual-use goods is increasingly regulated

The customs definition of dual-use goods that we have selected as our benchmark has been changing over time. The set of commodities classified as dual-use has been steadily growing since 2008, with sharp increases in 2015 and 2022 (Figure 4). The dual-use filter expanded from covering 25% of global trade in 2007 to 45% in 2023. If one expresses the same fact using the raw HS code count, the number of listed codes doubled from 600 to 1200 items (11.5% and 23% out of 5,205 goods in total; see Figure C.1).



Notes: Data for dual-use categories is taken from the EU TARIC dual-use correlation tables. Data on trade flows is coming from the CEPII BACI (HS Rev. 4, 2012) dataset (Gaulier & Zignago, 2010). Military spending data, which we use to measure military spending of China and Russia as a percent of global military spending, comes from SIPRI.

Figure 4: Dual-use goods coverage over time

The rise in dual-use coverage coincides with the rise in military spending of China and Russia, and the timing coincides with two acts of Russian aggression in Europe. In 2015, the European Commission ordered to review and modernize the export control system following increased national security threats; the list was updated to incorporate industrial

93XXXX (arms and ammunition), 8710XX (tanks), 890610 (warships) are not included. We add those manually as soon as monotonicity in regressions for military end use becomes important, but for descriptive plots we keep those out.

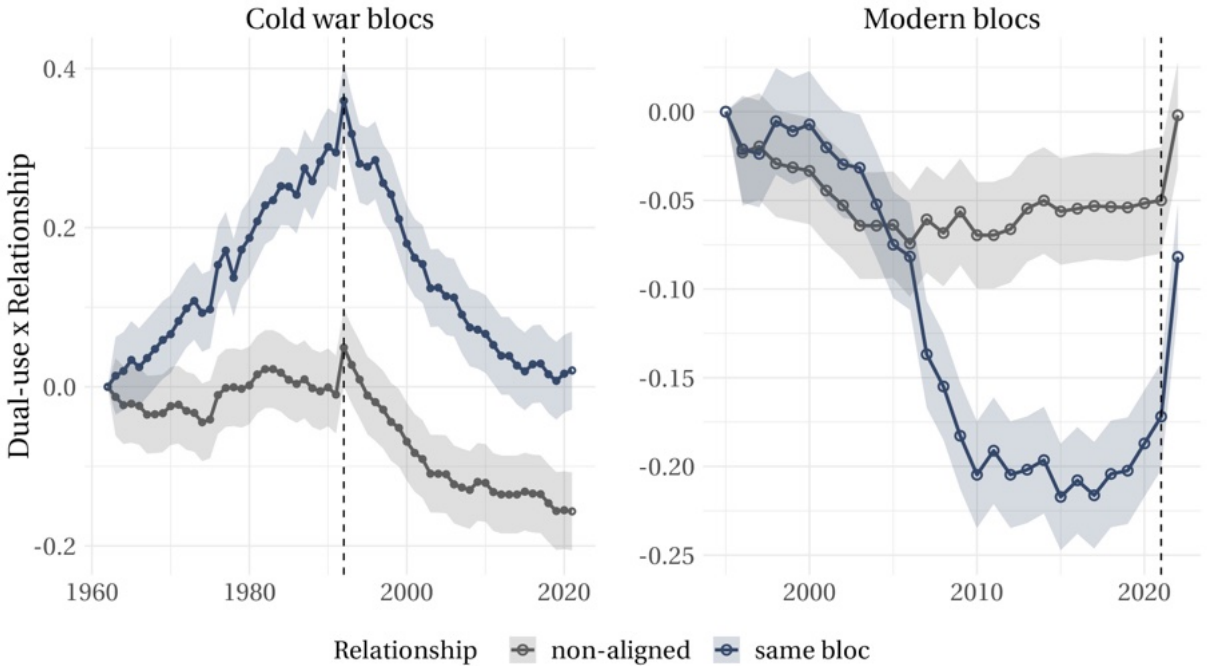
machinery. In 2022, following the start of the Ukraine war, the list extended the machinery restrictions but also incorporated more household-oriented items such as air-conditioners and refrigerators (Supplementary Appendix Tables S.A.B1, S.A.B2). Those facts make one conjecture that the classification threshold might expand towards more household-oriented items in response to changes in the national security externality; a conjecture that we will check in section 5.4 when discussing EU lists.

While the scope of customs controls has been expanding, the intensity of trade and industrial policies in this area has also been on the rise. In Appendix C.1.2, we document that "ringfencing" trade and industrial policies that restrict foreign access, such as foreign customer limit, local operations requirement, and intellectual property protection, disproportionately target dual-use goods relative to a random draw benchmark or standard market-based instruments such as import tariffs. We also show that such policies have been more popular since 2019, with a tenfold increase in new policy announcements in 2023 relative to the pre-pandemic period. Section 5 will look at policy targeting more formally; we will move on to understand whether policy targeting translates into changes in trade flows.

Fact #3. Dual-use trade responds to changes in the security environment over time

The state of international security has varied historically, and those variations are reflected in trade patterns of dual-use goods. In 1990, dual-use trade within Cold War blocs had a 40% subsidy equivalent compared to all other trade links, as captured by a gravity equation at the exporter-importer-product-year level with a rich set of fixed effects (Figure 5; for details of the gravity specification and definitions of country blocs, please refer to the note below the figure). The importance of the Cold War blocs has been gradually decreasing since then, and by 2019 the relative subsidy on the same-bloc$\times$dual-use trade links has vanished altogether. Increasing trade irrelevance of country blocs has been partially reversed by the Ukraine war, which has rolled back half of the implicit subsidy decrease for same-bloc$\times$dual-use trade links for modern geopolitical blocs since 1995. The Ukraine war has also emphasized the importance in dual-use trade between aligned/non-aligned country pairs: those trade links have witnessed a 5% subsidy equivalent. Our findings add detail to the results by Gopinath et al. (2024), who have established similar patterns for aggregate trade flows.

In Appendix C.1.3, we show that shocks to the national security environment makes trade in dual-use goods react in the short run. For wars between 1960 and today, dual-use imports for war participants experience a 10% subsidy equivalent shock for their diplomatic friends and 10% tariff equivalent shock for their diplomatic enemies. This is on top of a 30% subsidy shock and 30% tariff shock for all imports. The results suggest that following national security shocks, trade in certain goods can adjust along geopolitical lines



Notes: The trade data for the Cold War (1962-2021) comes from the Atlas of Economic Complexity and is at the SITC Rev. 2 (1975) level. The trade data for the modern period (1995-2022) comes from the UNComtrade database via BACI CEPII and is at the HS Rev. 0 (1992) level.
Our specification of choice is a triple-difference regression at the exporter-importer-product-year level that compares (1) trade in dual-use goods to trade in other goods, (2) within links of a given country-to-country relationship type to all other trade links, and (3) in years with high bloc tension compared to other years. The regression equation is

$$\log y_{ijkt} = \alpha^{\mathcal{T}}_{ijk} + \alpha^{\mathcal{X}}_{ikt} + \alpha^{\mathcal{M}}_{jkt} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{Relationship}_{ij} \times \text{Dual-use}_{k} + \varepsilon_{ijkt},$$

where $\alpha^{\mathcal{T}}_{ijk}$, $\alpha^{\mathcal{X}}_{ikt}$, and $\alpha^{\mathcal{M}}_{jkt}$ are a set of exporter-importer-product, exporter-product-time, and importer-product-time fixed effects. Relationship_{ij} captures the diplomatic relationship between country i and country j. Year 1960 serves as a baseline; we place no weight on extensive margin when $y_{ijkt} = 0$ by setting left-hand side to zero following Chen and Roth (2024). An $ijkt$ observation is included in the regression as long as both country i and country j have some data for year t.
Country classifications into the Western and Eastern blocs during the Cold War and in the modern times are listed in Table SA.B.4. Same bloc links are defined as links within the Western bloc and links within the Eastern bloc. Non-aligned links are defined as links between the Western bloc countries and the Rest of the World, as well as the Eastern bloc and the Rest of the World, with flows in both directions. Same bloc and non-aligned links are included in gravity regressions simultaneously.
Figures plot triple-difference coefficients $\beta_{t,R}$ with heteroskedasticity-robust standard errors at 95% confidence intervals. Figure C.4 plots $\gamma_{t,R}$; Figures SA.B.3 and SA.B.4 present some robustness checks.

Figure 5: Trade in dual-use goods by diplomatic relationship

pretty quickly; we will analyze conflict shocks more in section 5.

Together our three facts suggest an existence of a time-varying national security externality, for which trade in goods with military uses responds stronger than trade in other goods. The next section will formalize this externality in a simple theoretical framework.

4 A simple two-country model

To capture our notion of the national security externality, we build a simple two-country model. We begin with a standard Armington (1969) setup with a freely tradable outside good that serves as a numeraire. Additional model components are a tax-financed defense department that buys goods and a military contest in the welfare function, which is a function of the ratio of home military to foreign one. We first consider a game where home and foreign governments pick trade taxes and defense spending simultaneously in a unilateral way to maximize domestic welfare. Then we consider a variation when trade policy moves before defense spending for both countries, adding a precautionary motive similar to Becko and O'Connor (2024). We end the section with a full setup that incorporates production networks in the spirit of Baqaee and Farhi (2024).

For every setup, we solve for the optimal taxes across goods. With no welfare weight on national security, the optimal export tax equals the monopoly markup, or an inverse demand elasticity, while the optimal import tariff is flat and equal to zero.[13] Once security begins to matter, an export tax formula gains an additional Pigouvian term that multiplies a sales share going to foreign military by a country-level macro shifter. When the game becomes two-stage, the macro shifter starts featuring an additional dynamic term that depends on the behavioral response of countries' defense spending in the second period. Due to that new dynamic component, domestic and import subsidies become positive and start playing a deterrence role. Once we extend the model to production networks, instead of a simple foreign military sales share, optimal tax formulas include a trade-off between network-adjusted sales share to foreign military and domestic sales share coming from roundabout imports. In section 6, we dispense with the freely tradable outside good and show that an additional factor centrality trade-off, scaled by the factor price response, emerges.

[13] The level of import tariffs and export taxes is pinned down by the existence of a freely tradable outside good. In its absence, the Lerner symmetry would hold and the flat level of import tariffs and export taxes would hold up to a constant (Itskhoki & Mukhin, 2023).

4.1 Armington setup

Our baseline model features a minimalist environment that keeps things tractable. We consider a world with two countries, home (H) and foreign (F). There are six agents in every country: a local representative firm, two local aggregators, one for a local consumption good and one for the military, a representative household, the defense department, and the government. (Figure D.1 portrays the structure schematically.) The firm uses local labor to produce a local variety; the remainder of the labor not used by the firm is automatically converted into a homogenous freely tradable outside good. The aggregators combine home and foreign varieties into a local consumption good and the military. The household buys the local consumption good and a freely tradable outside good with its income, derived from its labor income and trade tax revenues net of a military lump-sum tax. The defense department spends government lump-sum taxes on the military. The government chooses trade policy and defense spending to maximize welfare, a sum of household utility and a national security term.

Firms. Every country has one firm producing a local variety with a constant-returns-to-scale labor technology $q_k = z_k^q L_k$, $k \in \{H, F\}$. Here z_k^q is a technology shifter. Firm prices are

$$p_k = w_k / z_k^q. \tag{1}$$

Every country-variety on the supply side will be later combined into a local consumption good and military good via demand aggregators, mirroring Armington (1969) model structure.

In addition to varieties produced by firms, there is also one freely tradable outside good that is produced only with labor: $B = L^B$. We normalize its price to 1, $p^B = 1$. If both countries produce the freely tradable outside good, labor wages are pinned down by $w_H = w_F = 1$, which shuts down general equilibrium wage effects. Later assumptions on household utility and labor endowments will ensure that would indeed be the case.

Aggregators. In every country $i \in \{H, F\}$, there is a consumption aggregator and a military aggregator. These aggregators transform varieties produced by firms into a final consumption good and the military. To buy from firm k, aggregator in country i pays the price

$$p_{ik} = \tau_{ik}^{\mathcal{X}} \tau_{ik}^{\mathcal{M}} d_{ik} p_k, \tag{2}$$

where $(\tau_{ik}^{\mathcal{X}} - 1)$ is an export tax (or subsidy) by a country k, $(\tau_{ik}^{\mathcal{M}} - 1)$ is an import tariff by country i, and d_{ik} are gravity frictions.

Aggregators combine firm output into final goods. To deliver c_i units of a local consumer good, the consumption aggregator combines c_{ik} units of firm k's output, $k \in \{H, F\}$, with

a function $\mathcal{F}^C$. Similarly, to deliver m_i military units, the military aggregator combines m_{ik} units of firm k's output, $k \in \{H, F\}$, with a function $\mathcal{F}^M$:

$$c_i = \mathcal{F}_i^C(\{c_{ik}\}), \quad m_i = \mathcal{F}_i^M(\{m_{ik}\}). \tag{3}$$

The functions $\mathcal{F}^C$, $\mathcal{F}^M$ are continuously differentiable, increasing, and concave in arguments. They exhibit constant or decreasing returns to scale. Aggregators minimize its unit cost given firm prices p_{ik}:

$$P_i^C = \min_{\{c_{ik}\}} \left\{ \sum_{k=1}^{K} p_{ik} c_{ik} \right\} \quad \text{subject to} \quad c_i = 1, \tag{4}$$

$$P_i^M = \min_{\{m_{ik}\}} \left\{ \sum_{k=1}^{K} p_{ik} m_{ik} \right\} \quad \text{subject to} \quad m_i = 1. \tag{5}$$

We denote the consumption aggregator's expenditure by C_i and the military aggregator's expenditure by M_i.

$$C_i \equiv P_i^C c_i, \quad M_i \equiv P_i^M m_i. \tag{6}$$

The resulting expenditure shares are

$$s_{ik}^C \equiv \frac{p_{ik} c_{ik}}{C_i}, \quad s_{ik}^M \equiv \frac{p_{ik} m_{ik}}{M_i}. \tag{7}$$

The total expenditure on the good k is given by E_{ik}:

$$E_{ik} \equiv s_{ik}^C C_i + s_{ik}^M M_i, \tag{8}$$

while an after-tax expenditure is $\tilde{E}_{ik} \equiv E_{ik}/(\tau_{ik}^{\mathcal{X}} \tau_{ik}^{\mathcal{M}})$. We define the sales shares from firm k that go towards military and consumption aggregators in country i as

$$S_{ik}^C \equiv \frac{s_{ik}^C C_i}{s_{ik}^C C_i + s_{ik}^M M_i}, \quad S_{ik}^M \equiv \frac{s_{ik}^M M_i}{s_{ik}^C C_i + s_{ik}^M M_i}. \tag{9}$$

Households. A representative household in every country maximizes its utility that depends on its consumption of a freely tradable outside good (B_i) and a local consumer good (c_i)

$$\max_{B_i, y_i} \; B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \tag{10}$$

subject to its budget constraint

$$B_i + C_i \leq \mathcal{I}_i. \tag{11}$$

Household income $\mathcal{I}_i$ equals labor income $w_i L_i$ and tax revenues R_i net of government lump-sum taxes M_i that go towards the defense department:

$$\mathcal{I}_i = w_i L_i + R_i - M_i. \tag{12}$$

We assume that the labor endowment L_i is large enough so that there is enough income to consume the freely tradable outside good (which could be not the case when consumers with quasi-linear preferences pick the corner solution). We also make sure that the labor endowment in both countries is large enough so that the demand for a freely tradable outside good makes both countries produce it. That ensures $w_H = w_F = p^M = 1$, shutting down the general equilibrium effects. The quasi-linear structure also avoids the income effect of the tax revenue R_i on household consumption spending C_i, simplifying our analysis in this section.

Defense department. Government lump-sum taxes M_i go towards defense spending. The defense department purchases m_i units of the military to maximize national security

$$\max_{m_i} \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \tag{13}$$

subject to the budget constraint

$$P_i^M m_i \leq M_i. \tag{14}$$

Note that national security depends not only on the military m_i at home but also on the military m_{-i} abroad. The higher the relative buildup (m_i/m_{-i}) is, the more secure the country is. One can treat this functional form as a local approximation of more general contest functions (Tullock, 1980), which we will consider in section 6.

Equilibrium. Given government policies $\mathcal{P} = (\{\tau_{ik}^{\mathcal{X}}\}, \{\tau_{ik}^{\mathcal{M}}\}, \{M_i\})$, $\mathbf{E}_{\mathcal{P}} = (\{q_k\}, \{p_k\}, \{c_i\}, \{P_i^C\}, \{m_i\}, \{P_i^M\})$ is an equilibrium if

(1) firm optimizations (1), aggregator optimizations (4)-(5), household optimizations (10)-(11), and defense department optimizations (13)-(14) hold,

(2) goods markets clear

$$q_k = \sum_{i \in \{H,F\}} c_{ik} + \sum_{i \in \{H,F\}} m_{ik}. \tag{15}$$

Country-specific policies will be denoted as $\mathcal{P}^{(i)} = (\{\tau_{ik}^{\mathcal{M}}\}, \tau_{-i,i}^{\mathcal{X}}, M_i)$. Importantly, here and henceforth, policies marked by $\{\tau_{ik}^{\mathcal{M}}\}$ incorporate ***both trade and industrial policies***.

Welfare. Governments set trade and defense spending policy variables contained in $\mathcal{P}^{(i)} = (\{\tau_{ik}^{\mathcal{M}}\}, \tau_{-i,i}^{\mathcal{X}}, M_i)$. The national welfare payoff equals the sum of household utility and national security:

$$W_i = B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} + \beta_i \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}}, \tag{16}$$

where β_i is a weight that a country places on national security.

Game. The two governments simultaneously set their trade and defense spending policies $(\mathcal{P}^{(H)}, \mathcal{P}^{(F)})$. Conditional on $\mathcal{P}$, households, firms, and aggregators act, and the equilibrium $\mathcal{E}_{\mathcal{P}}$ realizes. The governments then collect welfare payoffs (W_H, W_F).

We note here that the choice of the optimal trade policy $\mathcal{P}_\tau$ is sensitive to assumptions on the game structure. We assume that setting trade policy implies setting linear advalorem taxes τ_{ik} that are not a function of foreign trade policy or foreign defense spending. In the simultaneous-move game described above, the home government takes the foreign defense spending M_{-i} as given. If the game featured sequential moves that first set trade policy $\mathcal{P}_\tau$ and then defense spending $\mathcal{P}_M$, home government would take a foreign reaction to its trade policy into account. We will consider a sequential game variation to gain some dynamic insight as an extension. The simultaneous-move game is our benchmark and will be used for our quantitative analysis.

4.2 Optimal trade policy

We characterize the optimal trade policy in the environment specified above. We begin with household and government spending problems. For households, a marginal dollar spent on a freely tradable outside good should be as beneficial as a marginal dollar spent on consumption. This allows us to characterize consumption spending given policies $\mathcal{P}$:

$$1 = c_i^{-1/\eta_i}/P_i^C, \quad c_i = (P_i^C)^{-\eta_i}, \quad C_i = (P_i^C)^{1-\eta_i}. \tag{17}$$

For governments, a marginal dollar spent on defense should be as beneficial as the marginal dollar left to households. This allows us to characterize defense spending given trade policies $\mathcal{P}_\tau$:

$$1 = \beta_i \frac{m_i^{-\frac{1}{\zeta_i}} m_{-i}^{\frac{1-\zeta_i}{\zeta_i}}}{P_i^M}, \quad m_i = (P_i^M/\beta_i)^{-\zeta_i} m_{-i}^{1-\zeta_i}, \quad M_i = \beta_i^{\zeta_i} \left(m_{-i} P_i^M\right)^{1-\zeta_i} \tag{18}$$

Plugging (17), (18) into (16) allows to recast welfare in the optimum as

$$W_i = wL_i + R_i + \frac{C_i}{\eta_i - 1} + \frac{M_i}{\zeta_i - 1}. \tag{19}$$

With these expressions in hand, we are now ready to characterize the optimal trade policy $\mathcal{P}_\tau$.

Proposition 1. *The trade taxes for country $i \in \{H, F\}$ in the Nash equilibrium satisfy*

$$\tau_{ik}^{\mathcal{M}} = 1, \quad k \in \{H, F\}, \tag{20}$$

$$\frac{\tau^{\mathcal{X}}_{-i,i}-1}{\tau^{\mathcal{X}}_{-i,i}}=-\frac{1+\left(\frac{M_i}{M_{-i}}\right)S^M_{-i,i}}{\mathcal{E}^{-i,i}_{-i,i}-1}, \tag{21}$$

where elasticity $\mathcal{E}^{-i,i}_{-i,i}\equiv d\log E_{-i,i}/d\log\tau^{\mathcal{X}}_{-i,i}$ *is the import demand elasticity.*

The proof of the proposition is given in Appendix D.1. It follows the Ramsey approach and serves as a template for other similar derivations in this paper, which will be relegated to the Supplementary Appendix. Given a small policy change, a change in national welfare function can be expressed as

$$dW_i=\underbrace{dR_i}_{\text{revenue}}+\underbrace{M_i d\log P^M_{-i}}_{\text{foreign military}}-\underbrace{(C_i d\log P^C_i+M_i d\log P^M_i)}_{\text{domestic distortion}} \tag{22}$$

The remainder of our proof expands those elements in terms of tax changes to solve for the optimum.

In the optimum, the export tax corrects a Pigouvian externality by internalizing the cost every unit sold to the foreign military has on domestic welfare. Here (M_i/M_{-i}) is a national security macro shifter that depends on the utility functional forms; $S^M_{-i,i}$, however, is a fundamental price-theoretic term invariant across setups. Setting $S^M_{-i,i}=0$ isolates the standard terms-of-trade export tax formula $[-1/(\mathcal{E}^{-i,i}_{-i,i}-1)]$ that extracts the monopoly mark-up.[14] Any non-zero import tax is distortionary since there are no market failures on the import side.

We now proceed to the case of a sequential game in which trade policy is chosen before defense spending. Such a game presents a reduced-form way of modeling dynamics if one believes that trade policy choices today can affect military build-up tomorrow (e.g. through stockpiling, investment, or a lag in observing foreign military strategies). In Supplementary Appendix A.2, we show that the following proposition holds.

Proposition 2. *Consider the game in which governments set trade policy* $(\mathcal{P}^{(H)}_\tau,\mathcal{P}^{(F)}_\tau)$ *first and defense spending* $(\mathcal{P}^{(H)}_M,\mathcal{P}^{(F)}_M)$ *second. The trade taxes for country* $i\in\{H,F\}$ *in the subgame perfect Nash equilibrium are characterized by*

$$\frac{\tau^{\mathcal{X}}_{-i,i}-1}{\tau^{\mathcal{X}}_{-i,i}}=-\frac{\mathcal{T}^{\mathcal{X}}_{-i,i}+\zeta_{i,-i}\tau^{\mathcal{M}}_{-i,i}(M_i/M_{-i})S^M_{-i,i}}{\mathcal{E}^{-i,i}_{-i,i}-1}, \tag{23}$$

$$\frac{\tau^{\mathcal{M}}_{ik}-1}{\tau^{\mathcal{M}}_{ik}}=-\frac{\mathcal{T}^{\mathcal{M}}_{ik}+(1-\zeta_{i,-i})S^M_{ik}}{\mathcal{E}^{ik}_{ik}-1},\quad k\in\{H,F\}, \tag{24}$$

[14] Alternatively, one can fix foreign military spending M_{-i} and look at the best response under $\beta_i=0$ (zero weight on national security in national welfare). That would result in $M_i=0$ and no Pigouvian externality in the optimal export tax.

where $\mathcal{T}^{\mathcal{X}}$ and $\mathcal{T}^{\mathcal{M}}$ are the usual terms-of-trade terms featuring revenue spillovers following trade diversion and $\zeta_{i,-i} \equiv \zeta_{-i}/(\zeta_i + \zeta_{-i} - \zeta_i\zeta_{-i})$ is conflict elasticity.Terms-of-trade terms can be expanded as

$$\mathcal{T}^{\mathcal{X}}_{-i,i} \equiv 1 + (E_{-i,i}/\tau^{\mathcal{M}}_{-i,i})^{-1} \sum_{k\in\{H,F\}} \frac{\tau^{\mathcal{M}}_{ik} - 1}{\tau^{\mathcal{M}}_{ik}} E_{ik}\mathcal{E}^{ik}_{-i,i}, \tag{25}$$

$$\mathcal{T}^{\mathcal{M}}_{ik} \equiv E^{-1}_{ik}\left[\frac{\tau^{\mathcal{X}}_{-i,i} - 1}{\tau^{\mathcal{X}}_{-i,i}\tau^{\mathcal{M}}_{-i,i}} E_{-i,i}\mathcal{E}^{-i,i}_{ik} + \frac{\tau^{\mathcal{M}}_{ik} - 1}{\tau^{\mathcal{M}}_{ik}} E_{ik}\mathcal{E}^{-i,i}_{ik}\right]. \tag{26}$$

In addition to correcting the Pigouvian externality, trade interventions now have an additional strategic dimension. Export taxes and domestic subsidies act as deterrents, tilting the price ratio to affect the second stage of the game. The welfare choice in the first stage becomes characterized by

$$dW_i = dR_i + M_i\zeta_{i,-i}d\log P^M_{-i} - C_i d\log P^C_i - M_i\zeta_{i,-i}d\log P^M_i. \tag{27}$$

The degree of this strategic force is characterized by the conflict elasticity $\zeta_{i,-i}$, which reflects how sensitive foreign military spending is to the military price ratio. Under $\zeta_{i,-i} = 1$, Propositions 1 and 2 yield the same formulas; under $\zeta_{i,-i} > 1$, strategic incentives amplify export taxes and generate domestic subsidies.[15] Another way to look at it is to see that the strategic force amends the macro shifter (M_i/M_{-i}) from Proposition 1, while keeping sectoral shifters S^M intact.[16] Proposition 2 thus demonstrates how dynamic incentives can make a case for trade policy as a strategic deterrent; for a more in-depth treatment of this topic, see Becko and O'Connor (2024).

We have gained sufficient intuition on how taxation should act under the horizontal production case. In a simultaneous move game, governments correct a Pigouvian externality by imposing higher export taxes on goods with a higher sales share to the foreign military. In a two-stage game, dynamic deterrence incentive makes the case for domestic subsidies. Yet it has not provided us with a sufficient intuition on how to treat inputs with complex downstream propagation, such as CNC machines or semiconductors. The following subsection asks how trade policy should operate in the context when inputs have intermediate uses.

[15] Under $\zeta_{i,-i} < 1$, foreign government decreases its military spending when the military price ratio becomes more favorable. For home government, taxing home military goods becomes the optimal policy, as it both raises domestic revenues and deters foreign military spending.

[16] It also amends terms-of-trade terms. That is because trade policy now affects final demand, which means that taxes make import demand elasticities, that previously used to be zero, non-zero. (E.g., import taxes for a country now affect export flows.)

4.3 Military centrality in production networks

We extend our trade policy analysis to the environment with production networks. We show that the optimal trade taxes balance military centrality and distortion centrality of a trade flow scaled by the flow elasticity. Military centrality is a network- and taxation-adjusted share of sales to the foreign military; distortion centrality is the same for the domestic economy via roundabout imports.

Our setup now features firm-level networks. The set of firms is $\mathcal{K}$ with a set $\mathcal{K}_H$ of home firms and a set $\mathcal{K}_F$ of foreign firms, $\mathcal{K}_H \cup \mathcal{K}_F = \mathcal{K}$. To produce q_k units of output, firm $k \in \mathcal{K}$ combines L_k units of local labor and q_{kl} units of firm l's output, $l \in \mathcal{K}$, into a production aggregator $\mathcal{F}_k$:

$$q_k = \mathcal{F}_k(L_k, \{q_{kl}\}). \tag{28}$$

Aggregators $\mathcal{F}_k$ are continuously differentiable, increasing, and concave in arguments. They exhibit constant or decreasing returns to scale.

Firms minimize their unit costs given procurement prices p_{kl}:

$$p_k = \min_{L_k, \{q_{kl}\}} \left\{ w_k L_k + \sum_{l=1}^{K} p_{kl} q_{kl} \right\} \quad \text{subject to} \quad q_k = 1. \tag{29}$$

The resulting procurement shares are denoted by

$$\Omega_{kl} = \frac{p_{kl} q_{kl}}{p_k q_k}. \tag{30}$$

Aggregators combine the output of all the firms. The market clearing condition now is

$$q_k = \sum_{l \in \mathcal{K}} q_{lk} + \sum_{i \in \{H,F\}} c_{ik} + \sum_{i \in \{H,F\}} m_{ik} \tag{31}$$

For notation simplicity, we assume that all the cross-border transactions are firm-to-firm, while aggregators purchase only from local firms. This is without the loss of generality because, in a situation with a home firm selling directly to a foreign aggregator, we can always create a fake importing node in the other country and assume that the firm sells to that node, which then sells to the foreign aggregator.

Before characterizing the optimal trade policy, we introduce some network definitions. We begin with standard definitions of *Leontief* and *inverse Leontief matrices* and remind the readers of some helpful facts about those. Then we create the concepts of *pull weights* and a *distortion matrix*. We use those concepts to introduce *military centrality*, which is the main focus of our analysis.

Definition 1 (Leontief matrices)**.** *The cost-based Leontief matrix* is $\mathbf{\Omega} = (\Omega_{kl})$. *The revenue-based Leontief matrix* is $\tilde{\mathbf{\Omega}} = (\tilde{\Omega}_{kl})$, $\tilde{\Omega}_{kl} = \Omega_{kl}/(\tau^{\mathcal{X}}_{kl}\tau^{\mathcal{M}}_{kl})$.

Definition 2 (Inverse Leontief matrices)**.** *The inverse cost-based Leontief matrix* $\mathbf{\Psi} = (\Psi_{kl})$ and *the inverse revenue-based Leontief matrix* $\tilde{\mathbf{\Psi}} = (\tilde{\Psi}_{kl})$ are defined as

$$\mathbf{\Psi} \equiv (\mathbf{I} - \mathbf{\Omega})^{-1}, \quad \tilde{\mathbf{\Psi}} \equiv (\mathbf{I} - \tilde{\mathbf{\Omega}})^{-1}. \tag{32}$$

The following two facts about Leontief matrices will be helpful to keep in mind for the definitions to follow. First, all the elements of inverse Leontief matrices Ψ_{kl}, $\tilde{\Psi}_{kl}$ are non-negative. One can see it by recasting inverse matrices as $\mathbf{\Psi} = \sum_{n=0}^{\infty} \mathbf{\Omega}^n$, $\tilde{\mathbf{\Psi}} = \sum_{n=0}^{\infty} \tilde{\mathbf{\Omega}}^n$ and noting that the entries of Leontief matrices $\mathbf{\Omega}$, $\tilde{\mathbf{\Omega}}$ are non-negative. Second, one can rewrite the market clearing condition for goods as

$$\mathbf{X} = \tilde{\mathbf{\Psi}}' \sum_{i \in \{H,F\}} \tilde{\mathbf{E}}_i. \tag{33}$$

To see it, multiply both sides of equation (31) by p_k and recast in matrix form:

$$X_k = \sum_{l=1}^{K} \tilde{\Omega}_{lk} X_l + \sum_{i \in \{H,F\}} \tilde{E}_{ik}, \quad \mathbf{X} = \tilde{\mathbf{\Omega}}' \mathbf{X} + \sum_{i \in \{H,F\}} \tilde{\mathbf{E}}_i. \tag{34}$$

Those facts will be helpful for the next two definitions.

Definition 3 (Final demand weights)**.** *Final demand weights* for firm k from expenditures of country j on firm l's output are

$$\omega_{kl}^{(j)} \equiv \frac{\tilde{E}_{jl} \tilde{\Psi}_{lk}}{X_k} \tag{35}$$

Intuitively, $\omega_{kl}^{(j)}$ is a network-adjusted sales share that goes to country j through final demand for firm l's goods; $\sum_{l \in \mathcal{K}} \omega_{kl}^{(j)}$ is the overall sales share to country j, and $\sum_{j \in \{H,F\}} \sum_{l \in \mathcal{K}} \omega_{kl}^{(j)} = 1$ represents the total sales share, so sums to 1. The way to see the previous statment is to see that

$$X_k = \sum_{j \in \{H,F\}} \sum_{l=1}^{K} \tilde{E}_{jl} \tilde{\Psi}_{lk} \quad \Rightarrow \quad \sum_{j \in \{H,F\}} \sum_{l \in \mathcal{K}} \omega_{kl}^{(j)} = 1. \tag{36}$$

Definition 4 (Distortion matrix)**.** *Distortion matrix* $\boldsymbol{\delta}^{(j)} = (\delta_{kl}^{(j)})$ is defined as

$$\delta_{kl}^{(j)} \equiv \frac{\tau_{jl} \Psi_{lk}}{\tilde{\Psi}_{lk}}, \quad \tau_{jl} \equiv \tau_{jl}^{\mathcal{X}} \tau_{jl}^{\mathcal{M}}. \tag{37}$$

The distortion matrix equals the matrix of ones when there are no taxes. In the economy with nonnegative taxes, distortions are all greater or equal to 1. In the economy with nonnegative subsidies, distortions are all less or equal to 1. The two last statements can be verified by showing that

$$\mathbf{\Psi} - \tilde{\mathbf{\Psi}} = \mathbf{\Psi}(\mathbf{\Omega} - \tilde{\mathbf{\Omega}})\tilde{\mathbf{\Psi}}. \tag{38}$$

With those definitions in hand, we introduce our concepts of firm *centrality*.

Definition 5 (Centrality)**.** We define distortion centrality, consumption centrality, and military centrality of firm k for country j as

$$\mathcal{C}^D_{jk} \equiv \sum_{l \in \mathcal{K}_j} \omega^{(j)}_{kl} \delta^{(j)}_{kl}, \tag{39}$$

$$\mathcal{C}^C_{jk} = \sum_{l \in \mathcal{K}_j} \omega^{(j)}_{kl} \delta^{(j)}_{kl} S^C_{jl}, \qquad S^C_{ik} \equiv \frac{s^C_{ik} C_i}{s^C_{ik} C_i + s^M_{ik} M_i}, \tag{40}$$

$$\mathcal{C}^M_{jk} = \sum_{l \in \mathcal{K}_j} \omega^{(j)}_{kl} \delta^{(j)}_{kl} S^M_{jl}, \qquad S^M_{ik} \equiv \frac{s^M_{ik} M_i}{s^C_{ik} C_i + s^M_{ik} M_i} \tag{41}$$

Intuitively, $\omega^{(j)}_{kl}$ stands for the network adjustment, and $\delta^{(j)}_{kl}$ for the taxation adjustment. Another way to look at those definitions is to say that nodes with some final sales to country j have a military sales share characteristic S^M_{jl} with $S^M_{jl} + S^C_{jl} = 1$. Pull weights $\boldsymbol{\omega}$ and distortion matrix $\boldsymbol{\delta}$ amplify those characteristics:

$$\boldsymbol{\mathcal{C}}^D_j \equiv (\boldsymbol{\omega}^{(j)} \otimes \boldsymbol{\delta}^{(j)})\mathbf{1}, \quad \boldsymbol{\mathcal{C}}^M_j \equiv (\boldsymbol{\omega}^{(j)} \otimes \boldsymbol{\delta}^{(j)})\mathbf{S}^M_j \quad \boldsymbol{\mathcal{C}}^C_j \equiv (\boldsymbol{\omega}^{(j)} \otimes \boldsymbol{\delta}^{(j)})\mathbf{S}^C_j \tag{42}$$

One can see that the sum of consumption and military centralities yield distortion centrality:

$$\mathcal{C}^C_{jk} + \mathcal{C}^M_{jk} = \mathcal{C}^D_{jk}. \tag{43}$$

In an economy with no taxes, distortion centrality equals a network-adjusted sales share to a given country, $\sum_{l \in \mathcal{K}} \omega^{(j)}_{kl} \leq 1$. In a closed economy with no taxes, distortion centrality equals 1.

The following lemma clarifies the relationship between this new definition and our previous definition of a network-adjusted military sales share for the U.S. economy, used in Section 3 to plot the U.S. input-output table for the closed economy:

$$\text{Military sales, \%}_k = \frac{[\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{M}}]_k M_{\text{USA}}}{[\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{M}}]_k M_{\text{USA}} + [\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{C}}]_k C_{\text{USA}}}, \tag{44}$$

$$C_{\text{USA}} = \frac{1}{(\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{C}})' \mathbf{1}}, \qquad M_{\text{USA}} = \frac{1}{(\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{M}})' \mathbf{1}}. \tag{45}$$

Lemma 1 (Centrality equivalence)**.** *Military sales measure equals military centrality under no taxes.*

Proof.

$$\mathcal{C}^M_{jk} = \sum_l \frac{E_{jl} \Psi_{lk}}{X_k} S^M_{jl} = \frac{[\boldsymbol{\Psi}' \mathbf{s}^{\mathbf{M}}]_{jk} M_j}{[\tilde{\boldsymbol{\Psi}}' \mathbf{s}^{\mathbf{M}}]_{jk} M_j + [\tilde{\boldsymbol{\Psi}}' \mathbf{s}^{\mathbf{C}}]_{jk} C_j} \tag{46}$$

□

Another property of this centrality measure is rank invariance in a constant-returns-to-scale economy conditional on factor prices and trade taxes. Regardless of how you scale final agents' income, the relative rankings of industries stay the same. This result is helpful when we measure centrality empirically:

Lemma 2 (Rank invariance)**.** *Consider two economies $\mathcal{A}', \mathcal{A}''$ with identical factor prices and no taxation but different values of final demand M and C (e.g., driven by external endowments). Then for any two industries k and l*

$$\mathcal{C}_{jk}^{M'} \geq \mathcal{C}_{jl}^{M'} \qquad \Leftrightarrow \qquad \mathcal{C}_{jk}^{M''} \geq \mathcal{C}_{jl}^{M''}$$

Proof. The rankings of centrality are the same as the rankings of military specialization:

$$\mathcal{C}_k^M \geq \mathcal{C}_l^M \quad \Leftrightarrow \quad \frac{1}{1+([\mathbf{\Psi}'\mathbf{s}^{\mathbf{C}}]_k/[\mathbf{\Psi}'\mathbf{s}^{\mathbf{M}}]_k)(C/M)} \geq \frac{1}{1+([\mathbf{\Psi}'\mathbf{s}^{\mathbf{C}}]_l/[\mathbf{\Psi}'\mathbf{s}^{\mathbf{M}}]_l)(C/M)} \tag{47}$$

The latter inequality can be recast as

$$\frac{[\mathbf{\Psi}'\mathbf{s}^{\mathbf{C}}]_k}{[\mathbf{\Psi}'\mathbf{s}^{\mathbf{M}}]_k} \leq \frac{[\mathbf{\Psi}'\mathbf{s}^{\mathbf{C}}]_l}{[\mathbf{\Psi}'\mathbf{s}^{\mathbf{M}}]_l}$$

Note that the terms here depend only on the network structure but not on the final demand M and C. Hence, centrality rankings are invariant to the scale of final demand if factor prices are kept constant. □

Having defined and explored a bit our centrality concepts, we can proceed with the proposition for the optimal network taxes. (Details of the proof, as well as the notes detailing optimal domestic subsidies, are relegated to Supplementary Appendix A.3.)

Proposition 3. *The trade taxes for country $i \in \{H, F\}$ and firm $k \in \mathcal{K}_i$ in the Nash equilibrium satisfy*

$$\frac{\tau_{-i,k}^{\mathcal{X}} - 1}{\tau_{-i,k}^{\mathcal{X}}} = -\frac{\overbrace{\mathcal{T}_{-i,k}^{\mathcal{X}}}^{\textit{ToT}} + \overbrace{\tau_{-i,k}^{\mathcal{M}}\left[\left(\frac{M_i}{M_{-i}}\right)\mathcal{C}_{-i,k}^{M} - \mathcal{C}_{i,k}^{D}\right]}^{\textit{centrality trade-off}}}{\mathcal{E}_{-i,k}^{-i,k} - 1}, \tag{48}$$

$$\frac{\tau_{ik}^{\mathcal{M}} - 1}{\tau_{ik}^{\mathcal{M}}} = -\frac{\overbrace{\mathcal{T}_{ik}^{\mathcal{M}}}^{\textit{ToT}} + \overbrace{\left[\left(\frac{M_i}{M_{-i}}\right)\mathcal{C}_{-i,i}^{M} - \mathcal{C}_{ik}^{D}\right]}^{\textit{centrality trade-off}}}{\mathcal{E}_{ik}^{ik} - 1}. \tag{49}$$

where $\mathcal{T}_{-i,k}^{\mathcal{X}}$ and $\mathcal{T}_{ik}^{\mathcal{M}}$ are terms-of-trade terms, $\mathcal{E}_{ik}^{ik}$ and $\mathcal{E}_{-i,k}^{-i,k}$ are import demand elasticities. Terms-of-trade terms can be expanded as

$$\mathcal{T}_{-i,k}^{\mathcal{X}} \equiv 1 + \left[\frac{F_{-i,k}}{\tau_{-i,k}^{\mathcal{M}}}\right]^{-1}\left(\sum_{l\in\mathcal{K}_i\setminus\{k\}}\frac{\tau_{-i,l}^{\mathcal{X}}-1}{\tau_{-i,l}^{\mathcal{X}}\tau_{-i,l}^{\mathcal{M}}}F_{-i,l}\mathcal{E}_{-i,k}^{-i,l} + \sum_{l\in\mathcal{K}}\frac{\tau_{il}^{\mathcal{M}}-1}{\tau_{il}^{\mathcal{M}}}F_{il}\mathcal{E}_{-i,k}^{il}\right), \tag{50}$$

$$\mathcal{T}_{ik}^{\mathcal{M}} \equiv F_{ik}^{-1}\left(\sum_{l\in\mathcal{K}_i}\frac{(\tau_{-i,l}^{\mathcal{X}}-1)F_{-i,l}}{\tau_{-i,l}^{\mathcal{X}}\tau_{-i,l}^{\mathcal{M}}}\mathcal{E}_{ik}^{-i,l}+\sum_{l\in\mathcal{K}\setminus\{k\}}\frac{\tau_{il}^{\mathcal{M}}-1}{\tau_{il}^{\mathcal{M}}}F_{il}\mathcal{E}_{ik}^{il}\right), \tag{51}$$

where F_{jk} is the total cross-border flow from firm k to country j.

Proposition 3 subsumes Proposition 1. There are two changes relative to Proposition 1 in the tax formulas. First, the final sales share S^M is substituted by the military centrality $\mathcal{C}^M$. One can easily verify that, in the horizontal case, military centrality equals the sales share exactly. Second, there is a new distortion centrality term $\mathcal{C}^D$. This term reflects the impact of roundabout imports. In the horizontal case with no roundabout component, distortion centrality is equal to zero, as exported goods never return as re-imports into the domestic economy.

This section has solved for the optimal trade taxes in a simple two-country economy with production networks. We have defined the concept of military centrality. Proposition 3 has shown that the trade policy plays a dual role in balancing foreign military centrality and domestic distortion centrality. With that baseline in mind, we can now proceed with our empirical applications.

5 Empirical measurement

Our simple model suggests that military centrality, distortion centrality, and import demand elasticities are the key sufficient statistics for our optimal taxes that should inform national security aspects of trade policy. Figure 3, coupled with Lemma 1, already produced some suggestive evidence that the U.S. military sales share is correlated with the inclusion on the dual-use list. This section aims to further explore to what extent we can determine what goods are military use from economic data alone without security experts' lists.

We begin by developing a military use measure based on our optimal tax formulas and creating a ranking of dual-use goods. Then we validate our measure using various outcomes, showing that it predicts policy targeting and trade flow responses around conflicts. We conclude this section by using our measure to evaluate the U.S. entity lists, the EU critical goods lists, and sanctions against Russia.

Before introducing data, in Appendix B.2 we briefly review some descriptive evidence that statistics like military sales share are likely to inform policymakers' decisions. We cite a BIS conference discussion on whether one should continue regulating carbon fiber or not given its increased use in sporting and automobile applications. We also look at several technological transitions that decreased military use of certain items, such as the post-WW2 phase-out of internal combustion engines from battlefield vehicles, and see that his-

torically those episodes coincided with an increase in international trade in those items. Our paper aims to provide a quantitative framework for such decisions.

5.1 Military use measure

Our centrality measures are written in terms of endogenous sales shares and, as such, already reflect existing policy interventions. If we were to ask what exports to China the U.S. should tax next given all the regulations already in place, we would construct the Chinese military and the U.S. distortion centrality measures for the U.S. export flows and plug those into our formulas. This approach, however, works poorly for generating a policy-independent metric that predicts existing levels of regulation. The American nuclear warhead centrality for the Chinese military is zero because trade policy on both sides has already made this link infeasible, not because the export of nuclear warheads should not be banned.

To approximate economic production fundamentals in the absence of regulation as sensibly as we can, we instead focus on the U.S. closed-economy setup, just as we did in Section 3. Our preferred empirical measure of military use becomes

$$0 \leq \mathcal{C}^{M}_{\text{US},k}/\sigma_k \leq 1, \tag{52}$$

where σ_k are import demand elasticities from the trade literature. The intuition for this statistic comes from the Pigouvian term in our optimal tax formulas and consists in the trade-off between the potential military externality size $\mathcal{C}^{M}_{\text{US},k}$, measured for a closed-economy benchmark with less regulation, and production (or tax) base non-substitutability, captured by import demand elasticities σ_k. We treat those import demand elasticities as general proxies for the technological substitutability, as well as various dynamic forces such as depreciation and stockpiling, insofar as those intertemporal phenomena are also projected onto a static estimation strategy in trade literature.

Trade elasticities are estimated using the partial equilibrium model for substitution across export origins. We use LIML estimates that are robust to outliers in trade flows computed by Soderbery (2015), based on the Broda and Weinstein (2006) procedure, which extends Feenstra (1994). Supplementary Appendix B.2 discusses various trade elasticities and shows that our results hold under alternative elasticity measures. Numbers for C and M are taken from the U.S. annual consumption and military expenditures; however, figures below will show that our results are qualitatively scale-invariant.

Table 1 lists fifteen goods with the highest military use. The highest-scoring goods are aluminium, warships, tanks, aircraft engines, and various shipbuilding inputs. Out of 15 items, 12 belong to the EU dual-use list or are single-use military items. We report changes

HS code	Description	$\mathcal{C}^{M}_{\text{US},k}/\sigma_k$	$\Delta\tau(\%)$	D-U
760310	Aluminium; powders of non-lamellar structure	0.66	196.38	✓
760320	Aluminium; powders of lamellar structure, flakes	0.64	178.63	✓
890610	Vessels; warships	0.58	136.19	✓
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	0.56	129.46	✓
890110	Cruise ships, excursion boats and similar vessels, principally designed for the transport of persons, ferry boats of all kinds	0.40	67.07	✓
890120	Tankers	0.40	66.32	✓
890130	Vessels, refrigerated; other than tankers	0.40	66.32	✓
890190	Vessels; n.e.c. in heading no. 8901, for the transport of goods and other vessels for the transport of both persons and goods	0.40	65.58	✓
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	0.39	62.89	✓
880310	Aircraft and spacecraft; propellers and rotors and parts thereof	0.37	57.51	✓
890590	Vessels; light, fire-floats, floating cranes and other vessels, the navigability of which is subsidiary to their main function, floating docks	0.36	57.30	✓
890520	Floating or submersible drilling or production platforms	0.36	56.66	✗
890510	Dredgers	0.36	56.04	✗
890400	Tugs and pusher craft	0.32	47.65	✗
840910	Engines; parts of aircraft engines (spark-ignition reciprocating or rotary internal combustion piston engines)	0.29	40.11	✓

Notes: Three last columns report our measure of military use, export tax prescription, and the presence on the EU dual-use list. Military use is an elasticity-adjusted military centrality. The associated export tax prescription is computed based on $(\tau_k - 1)/\tau_k = \mathcal{C}_{\text{US},k}/\sigma_k$. The EU dual-use list is taken for 2018 and augmented by final military HS codes 93XXXX (arms and ammunition), 8710XX (tanks), 890610 (warships).

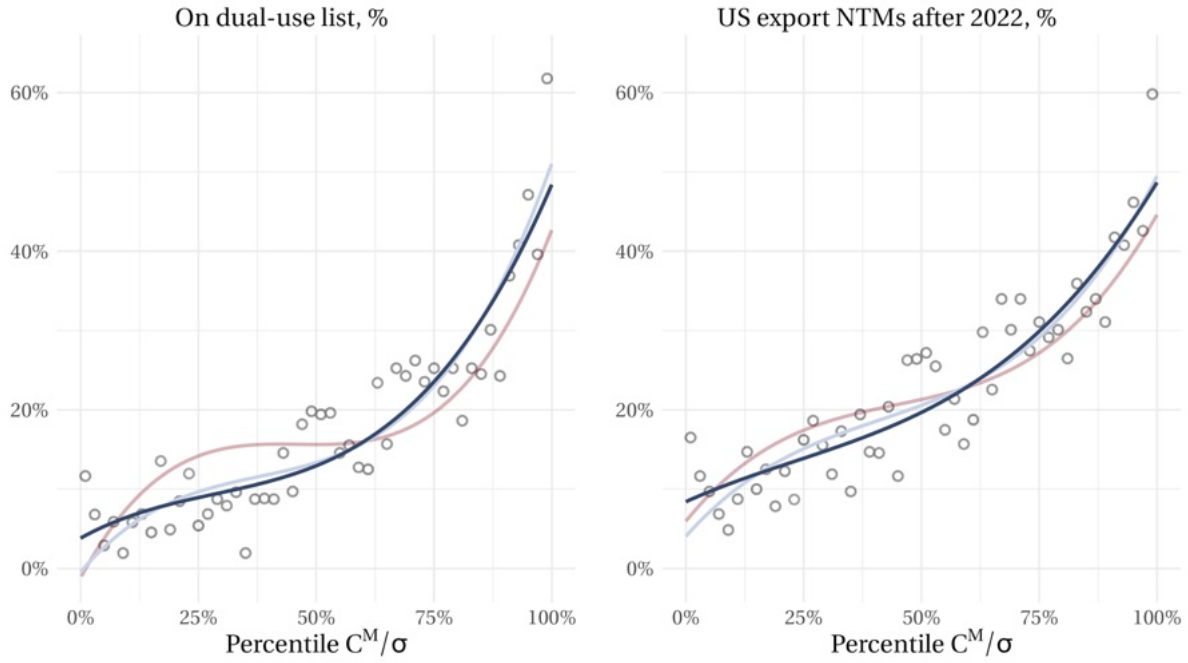
Table 1: Top-15 HS codes by military use

in the optimal export tax rates for those goods assuming starting point $\tau = 1$ (no terms-of-trade) and $M_i/M_{-i} = 1$ for the Jacobian. For this starting point, the taxes turn out to be of reasonable magnitudes, ranging from 200% on aluminum powders (highest) to 40% on aircraft engines (lowest).

5.2 Policy targeting

We compare our military use measure to three policy outcomes: EU dual-use lists, U.S. export restrictions after 2022, and global export policy announcements. Moving from 0th percentile to 100th percentile of our measure increases the probability of being on the dual-use lists from 5% to 50% and the probability of facing a U.S. export restriction after 2022 from 9% to 50%. We observe a striking change in the policy gradient: goods in the top percentile of military use faced 40% less export policy announcements over 2018-2019

compared to goods in the bottom percentile, 7% more over 2020-2021, and 100% more over 2022-2023. As Supplementary Appendix B.2 shows, predictability is stronger when weighted by trade shares or collapsed at the 4-digit level; the results are robust across various military contract samples and trade elasticities. Military use predicts policy targeting as if it were a physics law.

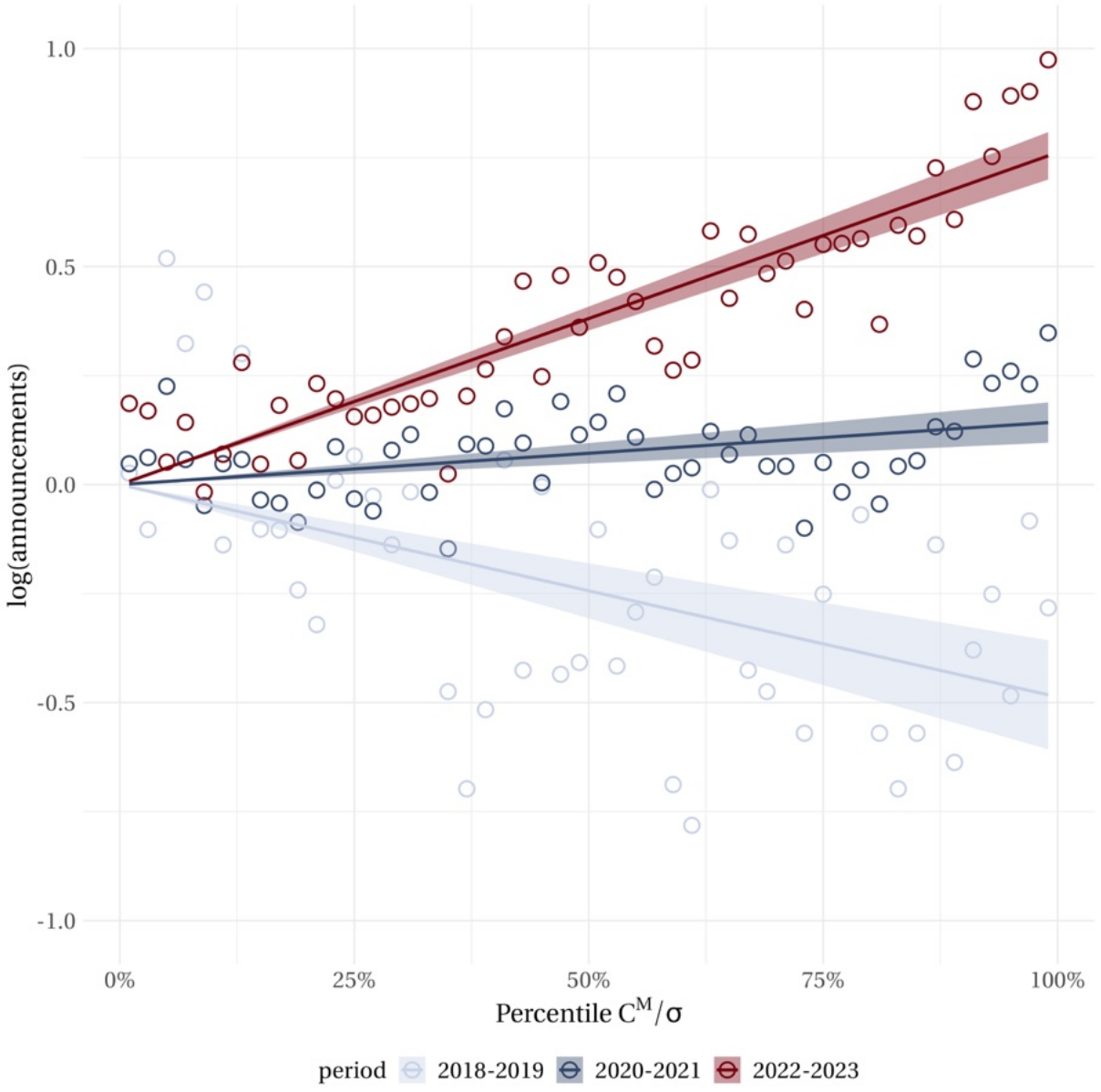


Notes: The colored lines display a cubic polynomial fit of the outcome on the sorting variable percentiles: military use (blue), military centrality (light blue), and military sales share (red). Blue points reflect a binscatter with 50 bins of equal size for military use percentiles. The dual-use list is of 2018 vintage. The U.S. export non-tariff measures (NTMs) are taken from the *Global Trade Alert* data and cover announcements of the U.S. in categories "Foreign customer limit," "Export licensing requirement," "Export ban," "Export-related non-tariff measure, nes."

Figure 6: Military use and policy lists

We first show how military use relates to the probability of being on the critical goods lists. Figure 6 displays how percentiles of different military variables are associated with outcomes: military use ($\mathcal{C}^M/\sigma$, in blue), military centrality ($\mathcal{C}^M$, in light blue), and military sales (S^M, in red). While all the three variables are monotonic, military use delivers the best sorting out of the three. Figure C.6 provides an additional visual illustration that the fit under S^M is much poorer; Tables C.1 and C.2 show that military use dominates a simple sales share in the horserace and remains stable after including flexible sales share polynomials, trade controls, and HS2 fixed effects.

We then analyze global counts of export non-tariff measure announcements over time (Figure 7). In 2018-2019, goods in the top percentile of military use faced 50% less new export policies applied to them compared to the bottom percentile. The situation evened



Notes: The global export non-tariff measures (NTMs) are taken from the *Global Trade Alert* data and cover policy announcements in categories "Foreign customer limit," "Export licensing requirement," "Export ban," "Export-related non-tariff measure, nes." The figure reflects a binscatter with 50 bins of equal size for military use percentiles. Regression lines plot a linear fit of $\log(\text{count}_{kt}) = \alpha_t + \beta_t \text{bin number}_k + \varepsilon_{kt}$ with an intercept normalized to zero.

Figure 7: Global policy counts

out in 2020-2021, with goods covered more or less uniformly. In 2022-2023, most military-centric goods have seen 100% more policies applied to them compared to the least military-centric ones. The switch in policy focus is consistent with an increase in policy attention towards those industries.

5.3 Trade flows

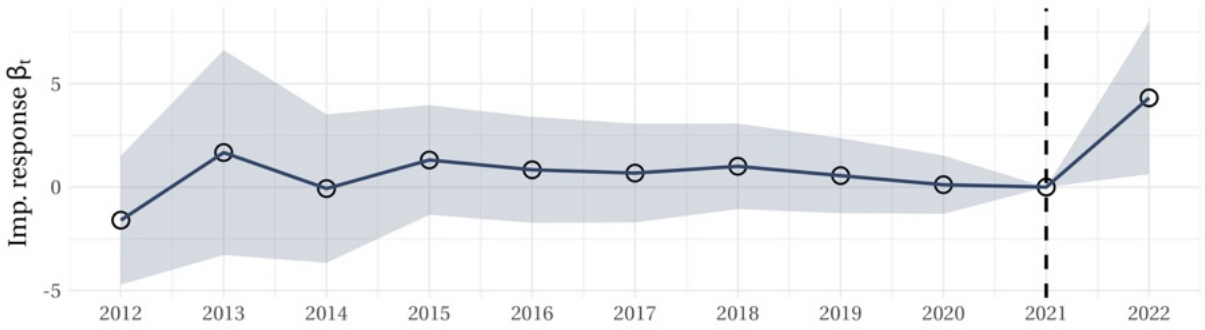
For trade flow outcomes, we look at import changes across goods following changes in the security environment. We do that for three cases: for Ukraine after 2022, for Russia after 2022, and for China after 2016. We also decompose military contributions across source countries and individual goods by measuring the share each source-good contributes to the average military use of country imports and analyzing changes in those shares over time.

In the case of Ukraine, for a 1pp increase in military use, a good sees a 5% increase in imports after 2022 (Figure 8). The leading military contributors are Poland (weapons), Slovakia (ammunition), and Canada (tanks), offset by Russia (fossil fuels), China (electrical apparatus, steel), and Belarus (petroleum). Increases in military use imports are driven by ammunition, tanks, weapons, warships, and electric generating sets (Appendix C.2.3). A decrease in German military use contributions is explained by the fact that Germany supplied helicopters and other military-adjacent items to Ukraine before the war.

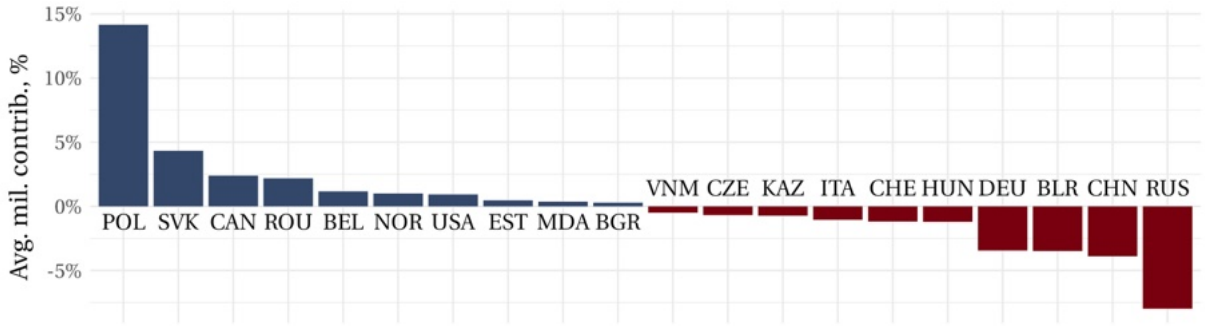
For Russia after 2022, a 1pp increase in centrality leads to a 3.5% decrease in expected imports (Figure C.7). The leading military contributors are China (manufacturing), Kazakhstan (aluminium), and Turkey (vessels), offset by France, Germany, and the United States (all: aerospace, shipbuilding). Belarus used to serve as a reshipping hub for the EU imports, so it contributes less as well. The overall decline is linked to the aerospace and shipbuilding goods, as well as reception and transmission equipment.

A curious finding is that for China since 2016 one observes decoupling in military industries. For a 1pp increase in military use, China has witnessed an 8% decrease in expected imports between 2016 and today. The decrease is driven by the U.S., South Korea, France, Japan, and Taiwan. It is counterbalanced by Vietnam, Indonesia, and Hong Kong; some part of those flows are probably reshipping. The main drivers of the military import decrease belong to aerospace, opticals, and various parts for the transmission and reception of data.[17] Whether this decoupling is a result of demand or supply factors, a natural by-product of Chinese industrial policies or a direct policy intervention, remains a question for future research.

[17]This category includes displays, microchips, electric circuits, and semiconductors, which we learn by looking at the crosswalk with the latest HS Rev. 2022 set of codes.



(a) Ukraine between 2021 and 2022, impact of military use on imports



(b) Ukraine between 2021 and 2022, change in average military use of imports

Notes: Top figure displays β_t from

$$\log y_{kt} = \alpha_k + \gamma_t + \beta_t \left[\mathcal{C}^M_{\text{US},k}/\sigma_k\right] + \varepsilon_{kt},$$

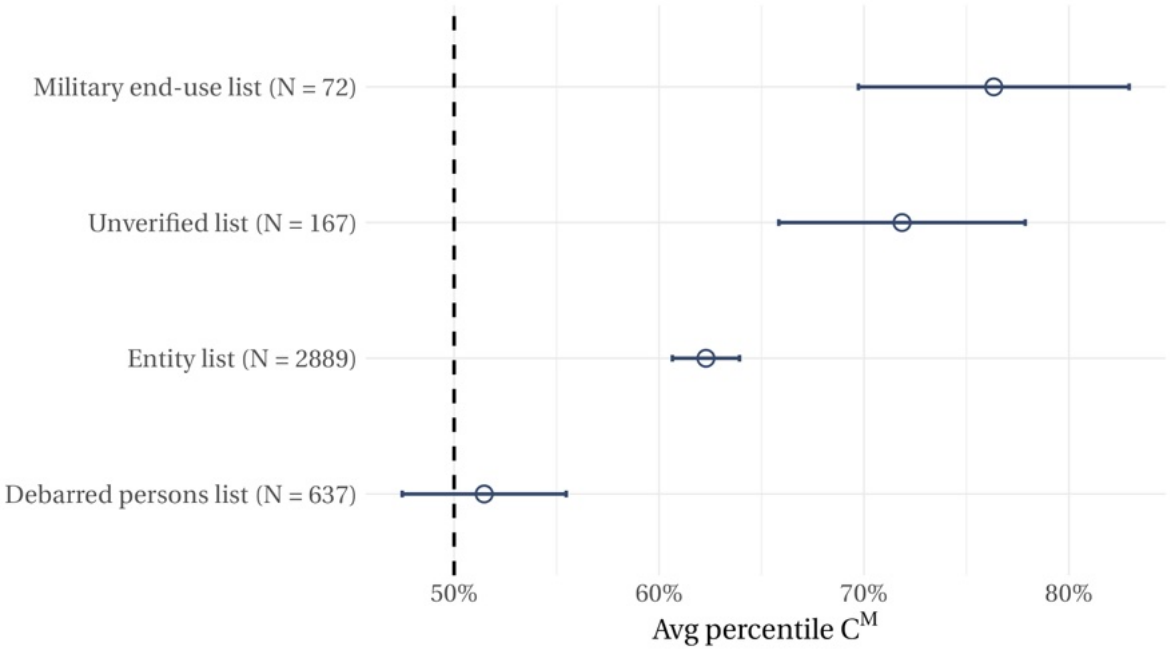
where α_k are good and γ_t are year fixed effects. Year 2021 serves as a baseline. Errors are clustered at the good level.
Bottom figure plots changes in military use contributions between years by country, where the relative contribution is measured as

$$\text{contribution}_{ijkt} = \frac{\sum_k y_{ijk}\left[\mathcal{C}^M_{\text{US},k}/\sigma_k\right]}{\sum_l \sum_k y_{ilk}\left[\mathcal{C}^M_{\text{US},k}/\sigma_k\right]}$$

Figure 8: Trade responses following geopolitical shocks: Ukraine-2022

5.4 Policy evaluation

Given that our military use measure passes some validation checks, we now apply it to evaluate various security measures: the U.S. Bureau of Industry Security lists, EU critical goods lists, and global sanctions against Russia. For the entity lists, we link companies to their NAICS codes (if necessary, via matching with external datasets and using industry classification crosswalks) and report the centrality percentiles of those industries.[18]



Notes: The BIS Military End-Use List includes foreign parties that represent an unacceptable risk of use in or diversion to a "military end use" or "military end user" in countries subject to a U.S. arms embargo. The Unverified List contains names of foreign persons who are or have been parties to transactions involving U.S.-origin items and whose bona fides have not been verified. The BIS Entity List includes names of foreign persons, including businesses, research institutions, government and private organizations, individuals, and other types of legal persons that are subject to specific license requirements for the export, reexport, and/or transfer (in-country) of specified items.
The Debarred Persons List includes individuals and entities that have been denied export privileges; they are matched only if a person that provides services is registered as a company. These restrictions are imposed by the BIS.
The resulting lists of enterprises are matched with the universe of Orbis enterprises by country. The centrality rank is then taken for the industry of the matched enterprise crosswalked into NAICS (Rev. 2012) code.

Figure 9: Centrality by Bureau of Industry Security categories

Figure 9 reports average centrality percentiles across BIS security lists. The Military End-Use List (foreign entities that might divert goods to the military) has the average cen-

[18] Since we have industries and not goods, we report centrality instead of military use, which has the benefit of being available for non-tradable industries as well.

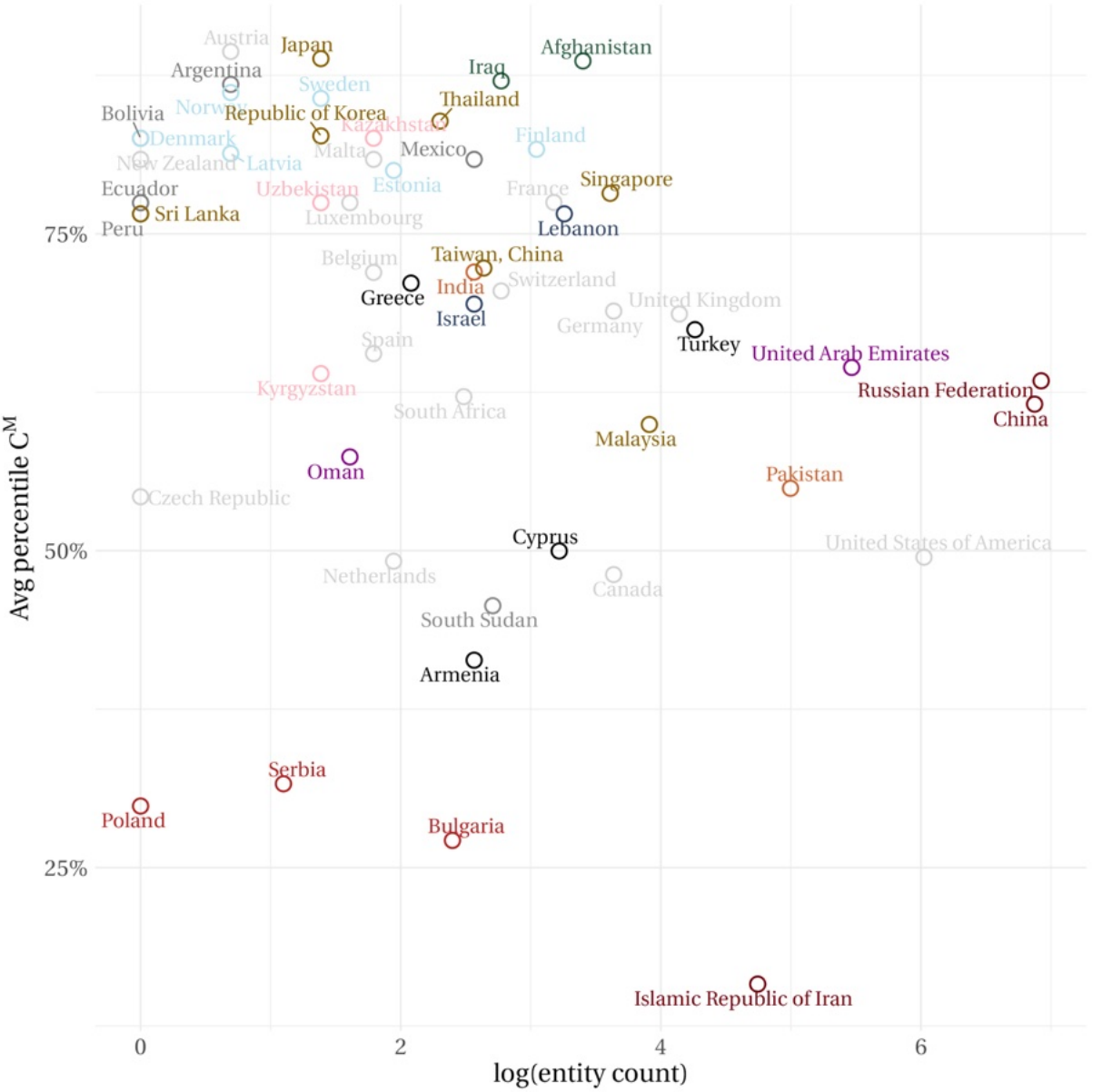
trality percentile around 76%, followed by the Unverified List (no bona fide; 73%), the Entity List (license needed; 62%), and the Debarred Persons List (no export privilege; 51%). Nothing in those entity lists ex-ante says that sorting by centrality would generate an intuitive ranking—and yet it does, which is encouraging for our approach.

Figure 10 decomposes entity lists by country, plotting the average centrality percentile against the number of listed entities. Scandinavian countries, Latin American countries, Iraq and Afghanistan, countries in the South China Sea except China, and most European countries are characterized by the limited number of restricted entities with a high military centrality (>75%), suggesting a targeted sanctions approach. Entrepot countries and countries in conflict-prone regions such as the UAE, Oman, Turkey, and Pakistan, feature more entities on the lists and have average centrality between 50% and 75%. China and Russia, which lead in terms of the number of restrictions applied, also fall into the 50%-75% zone. Outlier countries like Serbia and especially Iran feature a high number of restrictions and low centrality, reflecting a blanket sanctions approach (<50%).

Similarly, we conduct an assessment of the EU critical goods lists. We first go back to the EU dual-use lists (Fact #2, Figure 4) and evaluate how military use composition of the dual-use lists changed over time given the scope expansion. We find that goods targeting improved from 65.9% to 66.9% after the 2014 shock. In 2022, however, average military use decreased from 66.3% to 63.1%, marking a drastic adjustment towards more household-oriented items on the extensive margin (Figure C.9). Using the language of our theory, when a macro shifter on the security externality increases, more goods become screened.

Besides the dual-use lists, since 2022 the EU Commission compiles the list of critical battlefield items. The item groups are radioelectronics (95%; N = 5 HS six-digit codes), semiconductors (74%; N = 4), economically critical goods smuggled via third-party countries (68%; N = 73), navigation & optics (62%; N = 25), and manufacturing equipment (53%; N = 16) (Figure C.10). Interestingly, semiconductors (74%), listed as Tier 1, score less on our measure than radioelectronics (95%), listed as Tier 2. That corresponds to our understanding that semiconductors are more substitutable with household goods and easy to stockpile; while they might constitute an innovation chokepoint (e.g., NVIDIA AI chips), they do not necessarily constitute a physical production chokepoint. Smuggled goods score high on our measure, suggesting that third-country imports might be used in military production, which is in line with existing anecdotal perception.

We conclude by evaluating various lists of sanctions applied against the Russian economy (Figure C.11). Again, there is a group of highly targeted sanctions with centrality higher



Notes: The countries are split and colored according to the following groups: *Afghanistan and Iraq (dark green), Central Asia (Kazakhstan, Uzbekistan, Kyrgystan; pink), Israel and Lebanon (dark blue), Latin America (pale green), Nordic and Baltic countries (Sweden, Norway, Denmark, Finland, Estonia, Latvia; light blue), Asia Minor (Greece, Turkey, Cyprus, Armenia; black), China, Iran, and Russia (dark red), South Asia (India and Pakistan; saffron), South China Sea (Japan, Republic of Korea, Thailand, Sri Lanka, Singapore, Taiwan, Malaysia; gold), South Sudan (gray), UAE and Oman (magenta), Poland, Bulgaria, and Serbia (red), other Western countries (light gray).* Supplementary Appendix Figure SA.B.32 reports confidence intervals on the estimates.

Figure 10: Centrality by country of entity

than 65%: Navalny-35 (72%; N = 1),[19] UK HMT/OFSI Investment Bans (71%; N = 9),[20] or the US Special Legislative Exclusions (65%; N = 7). Then there are sanctions that appear to miss the mark (centrality <50%): Kazakh Terrorist and Terror Financing lists (36%; N = 1), Lithuanian International Sanctions (34%; N = 1), and RISE Moldova People of Interest (30%; N = 1). The bulk of broad-based war-related sanctions scores between 50% and 65%: those, for instance, include Japanese METI end user list (61%; N = 38), Canadian Consolidated Autonomous Santions list (59%; N = 346), and—by far the largest group—Ukraine NSDC State Register of Sanctions (56%; N = 4298).

We have thus constructed an empirical measure of military use that is rooted in theoretical trade-offs and sufficient statistics obtained by our optimal tax formulas. Our measure predicts policy targeting and trade flow changes following conflicts. We have used our measure to evaluate various policy lists. While we have developed an understanding what goods should be targeted, the next section calibrates our model to a potential US-China conflict to evaluate the macroeconomic size of the security-consumption trade-off.

6 Calibration

Our trade model puts structure on the national security externality that allows us to evaluate macroeconomic magnitudes behind the consumption-security trade-off. While we have developed a good-level metric of military use, our current exercise puts numbers on the macro shifters in our optimal tax formulas. In this section, we calibrate our model to a potential U.S.-China conflict and explore various counterfactual scenarios.

We proceed in three steps. We begin with extending the model in section 4 to a general equilibrium setup with flexible functional forms and adjustable factor prices. Then we take a stance on specific functional forms and estimate parameters of the contest block. We conclude with a quantitative policy evaluation.

[19] Navalny 35 List of Individuals for Sanctioning features people and organizations responsible for the Navalny plane poisoning incident. The only organization featured is the *State Laboratory of Organic Chemistry and Technology* with centrality 72%.

[20] Out of nine sanctioned companies, two are in the defense sector (*United Aircraft Corporation, OboronProm*), two are big oil companies (*TransNeft, GazpromNeft*), and five are state banks (*SberBank, VneshEconomBank, Russian Agricultural Bank, GazpromBank*).

6.1 General equilibrium model

We make three amendments to the network model in section 4. First, we allow for N countries instead of two. Second, we now consider general utility functions

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N). \tag{53}$$

Finally, we rule out the existence of a freely tradable outside good, adding potential factor price adjustments into our analysis. In the absence of the outside good, the household budget constraint becomes

$$C_i = w_i L_i + D_i + R_i - M_i, \tag{54}$$

and wages w_i cease to be a numeraire.[21] Here D_i is a number that represents trade deficit with $\sum_{i=1}^N D_i = 0$. The following proposition presents optimal tax formulas for a general equilibrium setup.

Proposition 4.

$$\frac{\tau^{\mathcal{X}}_{-i,k}-1}{\tau^{\mathcal{X}}_{-i,k}} = -\frac{\overbrace{\mathcal{T}^{\mathcal{X}}_{-i,k}}^{\textit{ToT}} + \overbrace{\mathcal{I}^{\mathcal{X}}_{-i,k}}^{\textit{budget}} + \tau^{\mathcal{M}}_{-i,k}\sum_j \overbrace{\left[w^C_{ij}\mathcal{C}^C_{jk} + w^M_{ij}\mathcal{C}^M_{jk}\right]}^{\textit{centrality trade-off}} + \tau^{\mathcal{M}}_{-i,k}\sum_{j,j'} \overbrace{\left[w^C_{ij}\mathcal{C}^C_{jj'} + w^M_{ij}\mathcal{C}^M_{jj'}\right]\tilde{\mathcal{J}}^{-i}_{j'k}}^{\textit{factor centrality trade-off}}}{\mathcal{E}^{-i,k}_{-i,k}-1}, \tag{55}$$

$$\frac{\tau^{\mathcal{M}}_{ik}-1}{\tau^{\mathcal{M}}_{ik}} = -\frac{\overbrace{\mathcal{T}^{\mathcal{M}}_{ik}}^{\textit{ToT}} + \overbrace{\mathcal{I}^{\mathcal{M}}_{ik}}^{\textit{budget}} + \sum_j \overbrace{\left[w^C_{ij}\mathcal{C}^C_{jk} + w^M_{ij}\mathcal{C}^M_{jk}\right]}^{\textit{centrality trade-off}} + \sum_{j,j'} \overbrace{\left[w^C_{ij}\mathcal{C}^C_{jj'} + w^M_{ij}\mathcal{C}^M_{jj'}\right]\tilde{\mathcal{J}}^{i}_{j'k}}^{\textit{factor centrality trade-off}}}{\mathcal{E}^{ik}_{ik}-1}, \tag{56}$$

where $\mathcal{T}^{\mathcal{X}}_{-i,k}, \mathcal{T}^{\mathcal{M}}_{ik}$ are terms-of-trade terms, $\mathcal{I}^{\mathcal{X}}_{-i,k}, \mathcal{I}^{\mathcal{M}}_{ik}$ are income effect terms, and $\tilde{\mathcal{J}}^{j}_{j'k}$ is a wage-tax Jacobian adjusted by inverse trade flow to factor payments ratio $(F_{jk}/(w_{j'}L_{j'}))$. Centrality weights are given by utility Jacobians

$$w^C_{ij} = \left(\frac{U_{ic,j}}{P^C_j}\right) \Big/ \left(\frac{U_{ic,i}}{P^C_i}\right), \quad w^M_{ij} = \left(\frac{U_{ic,j}}{P^M_j}\right) \Big/ \left(\frac{U_{ic,i}}{P^C_i}\right). \tag{57}$$

Terms-of-trade terms can be rewritten as

$$\mathcal{T}^{\mathcal{X}}_{-i,k} \equiv 1 + \left[\frac{F_{-i,k}}{\tau^{\mathcal{M}}_{-i,k}}\right]^{-1} \left(\sum_{j\neq i, l\in\mathcal{K}_i}^{\neg(j=-i\wedge l=k)} \frac{\tau^{\mathcal{X}}_{jl}-1}{\tau^{\mathcal{X}}_{jl}\tau^{\mathcal{M}}_{jl}} F_{jl}\mathcal{E}^{jl}_{-i,k} + \sum_l \frac{\tau^{\mathcal{M}}_{il}-1}{\tau^{\mathcal{M}}_{il}} F_{il}\mathcal{E}^{il}_{-i,k}\right), \tag{58}$$

$$\mathcal{T}^{\mathcal{M}}_{ik} \equiv 1 + F^{-1}_{ik} \left(\sum_{j\neq i, l\in\mathcal{K}_i} \frac{\tau^{\mathcal{X}}_{jl}-1}{\tau^{\mathcal{X}}_{jl}\tau^{\mathcal{M}}_{jl}} F_{jl}\mathcal{E}^{jl}_{ik} + \sum_{l\neq k} \frac{\tau^{\mathcal{M}}_{il}-1}{\tau^{\mathcal{M}}_{il}} F_{il}\mathcal{E}^{il}_{ik}\right), \tag{59}$$

[21] Our analysis extends to the case of multiple factors or ownership of the same factor by multiple groups.

and income effect terms as

$$\mathcal{I}^{\mathcal{X}}_{-i,k} = \left[\frac{F_{-i,k}}{\tau^{\mathcal{M}}_{-i,k}}\right]^{-1}\left[\sum_{j\neq i} w^{C}_{ij}\mathcal{J}^{R_j}_{-i,k} + \sum_{j} w_j L_j \mathcal{J}^{w_j}_{-i,k}\right], \tag{60}$$

$$\mathcal{I}^{\mathcal{M}}_{ik} = F^{-1}_{ik}\left[\sum_{j\neq i} w^{C}_{ij}\mathcal{J}^{R_j}_{ik} + \sum_{j} w_j L_j \mathcal{J}^{w_j}_{ik}\right], \tag{61}$$

with further expansions if necessary.

The proposition proof is given in Supplementary Appendix A.5. In the absence of a freely tradable good, the household budget constraint and factor price adjustments lead to changes in the price system. The new element in the optimal tax formulas becomes a factor centrality trade-off, scaled by a factor price response. As with all the previous formulas, the optimal tax captures both trade and industrial policies.

One question given our expressions is how to recover the factor price tax Jacobian $\mathcal{J}^{w}_{j'k}$. For that purpose, we cast the factor matrix clearing condition into a compact matrix expression

$$\mathbf{\Lambda^{L}wL} = \mathbf{\Omega^{L'}\Lambda^{X}\tilde{\Psi}'(s^{C}(D-M)+s^{M}M)}, \tag{62}$$

where $\mathbf{\Lambda^{R}}$, $\mathbf{\Lambda^{X}}$, and $\mathbf{\Lambda^{L}}$ are defined as

$$\mathbf{R} = \mathbf{\Lambda^{R}X}, \quad \mathbf{\Lambda^{X}} \equiv (\mathbf{I} - \mathbf{\tilde{\Psi}'s^{C}\Lambda^{R}})^{-1}, \quad \mathbf{\Lambda^{L}} \equiv \mathbf{I} - \mathbf{\Omega^{L}\Lambda^{X}\tilde{\Psi}'s^{C}}. \tag{63}$$

Intuitively, $\mathbf{\Lambda^{R}}$ converts firm sales into tax revenues, $\mathbf{\Lambda^{X}}$ is the inverse that reflects the amplification of sales via tax revenues—tax revenues increase household budget and lead to higher demand and more sales—while $\mathbf{\Lambda^{L}}$ captures the roundabout propagation of factor prices through the economy, serving as the analog of $\mathbf{I}-\mathbf{\Omega}$ in the Leontief inverse but for factor prices. Taking a first-order approximation following a small policy change allows us to back out $\tilde{\mathcal{J}}^{w}_{j'k}$ (more details in Appendix D.2).

When it comes to solving the model numerically, we use an iterative algorithm, solving for optimal taxes using (55) and then updating the equilibrium using (62). For numerical calibration, one needs to take a stance on the utility functional forms and parameters, which we do in the following subsection.

6.2 Parameter fit

We calibrate our model to a three-country setup with the United States, China, and the Rest of the World. To do that, we assemble Chinese input-output tables (Figure C.12). Some of the differences with respect to military sectors are driven by the fact that we back out

military demand from publicly traded Chinese firms in the defense sector, whereas for the U.S. the universe of contracts is observed. For the Rest of the World, we assume no military and horizontal production of export varities that uses only local labor, mapping networks only for import nests.

We also take a stance on the functional forms of the utility and production functions. Following Tullock (1980), we pick a generalized contest function to model the military contest, resulting in the following national welfare function:

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N) = c_i + \sum_{j \neq i} \alpha_{ij} c_j + \beta_i \frac{g(m_i)}{g(m_i) + \sum_{j \neq i} g(m_j)}. \tag{64}$$

We will denote the expected prize share of a country in the conflict as $\nu_i = g(m_i)/(g(m_i) + \sum_{j \neq i} g(m_j))$ and interpret β_i as the expected prize size for country i that pins down the marginal value of national security. The Rest of the World has no military and places no weight on national security, so $\nu_{\text{USA}} + \nu_{\text{CHN}} = 1$. A large literature on generalized contest functions starting from Tullock (1980) has extended the contest block to various scenarios, including conflict damages and military alliances (e.g., König et al., 2017). We include a derivation for military alliances in our Supplementary Appendix A.6 but leave alliance quantifications for future work, keeping our contest block minimalist.

We further assume that $g(m_i) = (m_{0i} + m_i)^\gamma$, where m_{0i} is the existing national stockpile of the military good in fixed supply (disciplined by the Department of Defence assets from their accounting statements in the data). The parameter γ measures how noisily military advantage converts into probability of winning, with values below one dampening military advantage (under $\gamma \to 0$, everyone gets an equal share regardless of military size) and above one amplifying it (under $\gamma \to \infty$, a small military advantage yields a sure win).

Table 2 summarizes our parameter choices. Welfare weights on foreign consumption α_{ij} are assumed to be $\alpha_{ij} = 0.01 P_j^C$ or $\alpha_{ij} = P_j^C$ across calibrations to contrast welfare under unilateral and universalist modes of trade policy. Since that parameter governs the strength of terms-of-trade versus Pigouvian incentives across goods, in theory, the parameter could also be recovered by fitting predicted taxes to observed policy decisions.

parameter	value
α_{ij}	$\alpha_{ij} = 0.01 P_j^C$ / $\alpha_{ij} = P_j^C$[22]
β_i	model inversion to fit 2018 military expenditure levels
γ	$\gamma = 0.5$ (estimated)
σ	from Fajgelbaum et al. (2020), unit otherwise

Table 2: Calibration parameters

Our trade elasticities across broad nests come from Fajgelbaum et al. (2020). We use

$\sigma = 2.53$ for import nodes, $\sigma = 1.53$ for nodes that aggregate HS4 codes into imported NAICS, and $\sigma = 1.19$ for NAICS aggregators of domestic and foreign varieties. For all the other nodes, including consumer and military final demand nodes, we use unit elasticities. Heterogeneity in import demand elasticities comes only from the underlying network structure.

Country-specific prize size β_i is backed out using a revealed preference approach from to fit the first-order condition for 2018 observed military spending levels exactly. Only for exposition purposes here, we show that if one omits general equilibrium price effects coming from factor price adjustments, the first-order condition simplifies to a familiar marginal utility trade-off in funds allocation:[23]

$$\beta_i \frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}. \tag{66}$$

Substituting in $g(m_i) = (m_{0i} + m_i)^\gamma$ further yields

$$\gamma \beta_i \kappa_i m_i^{-1} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}, \qquad \kappa_i \equiv \frac{m_i}{m_{0i} + m_i}. \tag{67}$$

Plugging relevant values for 2018 allows us to recover β_i.

The value of γ, which is a prerequisite for recovering β_i, is estimated from the time series variation in military spending over time. We use military spending of the Western bloc and at all points in time treat it as the best response to the exogenous path of Eastern bloc military spending, perhaps with some noise,

$$\log m_t - \log \nu_t(\gamma) - \log(1 - \nu_t(\gamma)) = \varepsilon_t, \qquad \varepsilon_t \equiv \log\left(\gamma \beta_t \kappa_t P_t^C / P_t^M\right), \tag{68}$$

with subscript $i =$ USA omitted for convenience (derivation in Appendix D.3). The residual variation in ε_t can be explained by changes in the security environment (e.g., bloc contest importance, side conflicts, etc), as well as other political and economic factors outside of our model. We select γ for which factors we pick can explain most of the residual variation in terms of R^2: $\varepsilon_t = \mathbf{X}_t' \boldsymbol{\beta}_t + \epsilon_t$.

Table 3 shows that the best fit across specifications is consistently obtained for values of γ around $\gamma = 0.5$. We begin with explaining ε_t just with a year trend, which already gives us an R^2 of 0.86. To reflect stickiness in military spending decisions, we add an autoregressive component $\log m_{t-1}$ with one lag, yielding $R^2 = 0.96$. We then add separate intercepts for geopolitical periods, add dummies for active conflicts, and add shocks for the war start. Figure 11 plots the fit using our preferred specification with $\gamma = 0.463$ and war dummies.

[23] The full formula that takes into account factor price adjustments is

$$\beta_i = \frac{\frac{U_{i,ci}}{P_i^C} + \sum_j \frac{U_{i,cj}}{P_j^C} C_j \mathcal{J}_{M_i}^{P_j^C}}{\frac{U_{i,mi}/\beta_i}{P_i^M} - \sum_j \frac{U_{i,mj}/\beta_i}{P_j^M} M_j \mathcal{J}_{M_i}^{P_j^M}} = \frac{\frac{1}{P_i^C} + \sum_j \frac{\alpha_{ij}}{P_j^C} C_j \mathcal{J}_{M_i}^{P_j^C}}{\frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} + \sum_j \frac{g'(m_j)}{g(m_j)} \frac{\nu_i \nu_j}{P_j^M} M_j \mathcal{J}_{M_i}^{P_j^M}} \tag{65}$$

	trend	trend + AR(1)	+ period dummies	+ war dummies	+ war start shocks
$\hat{\gamma}$	0.517	0.398	0.499	0.463	0.468
R^2	0.860	0.957	0.960	0.968	0.971

Periods are Cold War (1950-1989), End of History (1990-2000), War on Terror (2001-2013), and New Cold War (2014-2021). Wars are Korean War (1950-1953), Vietnam War (1965-1973), Gulf War (1990-1991), Afghanistan War (2001-2014), and Iraq War (2003-2011). For our specification of preference, $\gamma = 0.463$.

Table 3: Various specifications for γ estimation

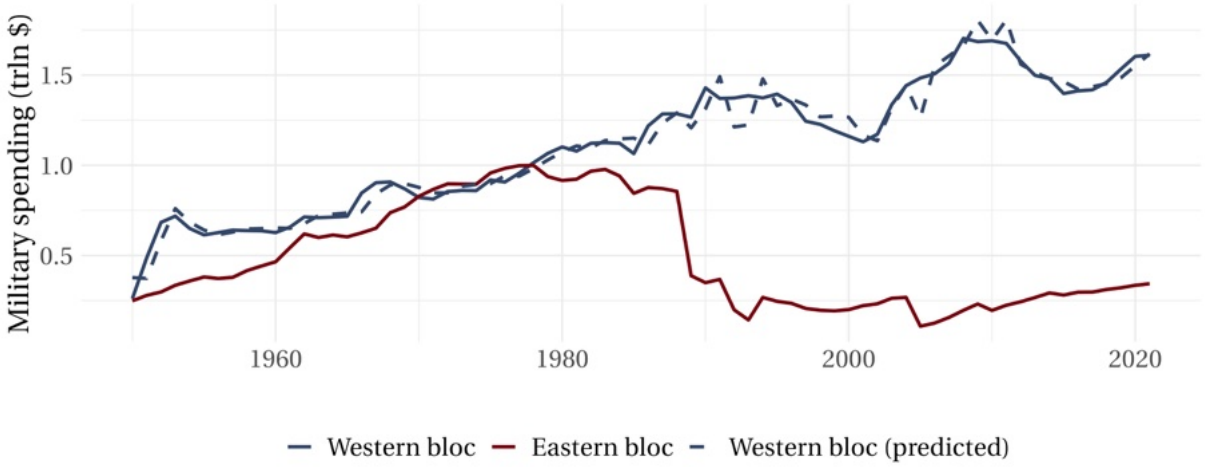


Figure 11: Military expenditures: Fitted values for $\gamma = 0.463$

Country-specific conflict prize β_i is equal to 250% for the U.S. and 140% for China (Table 4). The estimates, however, are sensitive to several assumptions. First, the numbers used for stockpile values m_{0i} affect the estimates: whether one uses no stockpiles (36% annual U.S. GDP), domestic stockpiles (180% annual U.S. GDP), or adds stockpiles together with allies (250% annual U.S. GDP) matters. We feel comfortable picking the upper-bound estimates as our baseline because we think that security environment deteriorated since 2018 and military spending increased. Another nuance is that general equilibrium effects materially move prize estimates: from 180% to 250% for the U.S. and from 225% to 140% for China. That happens because military spending affects factor prices and, as such, relative benefits of shifting tax dollars. An increase in Chinese military demand lowers home wages because military sectors depend more on foreign imports than household ones; the opposite happens in the U.S. (Table C.6). Adding quantitative nuance to those results is an interesting problem on its own and should be a subject of a different research paper.

	yearly budget		+ stock		+ allies' budgets		+ allies' stock	
	CHN	USA	CHN	USA	CHN	USA	CHN	USA
Military value	3.441	3.303	16.968	16.370	17.960	17.985	20.869	22.718
Partial equilibrium	37.097	26.594	182.936	131.798	193.617	144.784	225.071	182.967
General equilibrium	22.842	36.134	112.640	179.077	119.214	196.719	138.576	248.588

Notes: All numbers are reported as % of 2018 annual U.S. GDP. The dollar value conversion involves weighted industrial price indices for consumers and the military for both countries. Stockpiles are the assets of the Department of Defense taken from the accounting statements.

Table 4: Conflict prize, % annual U.S. GDP

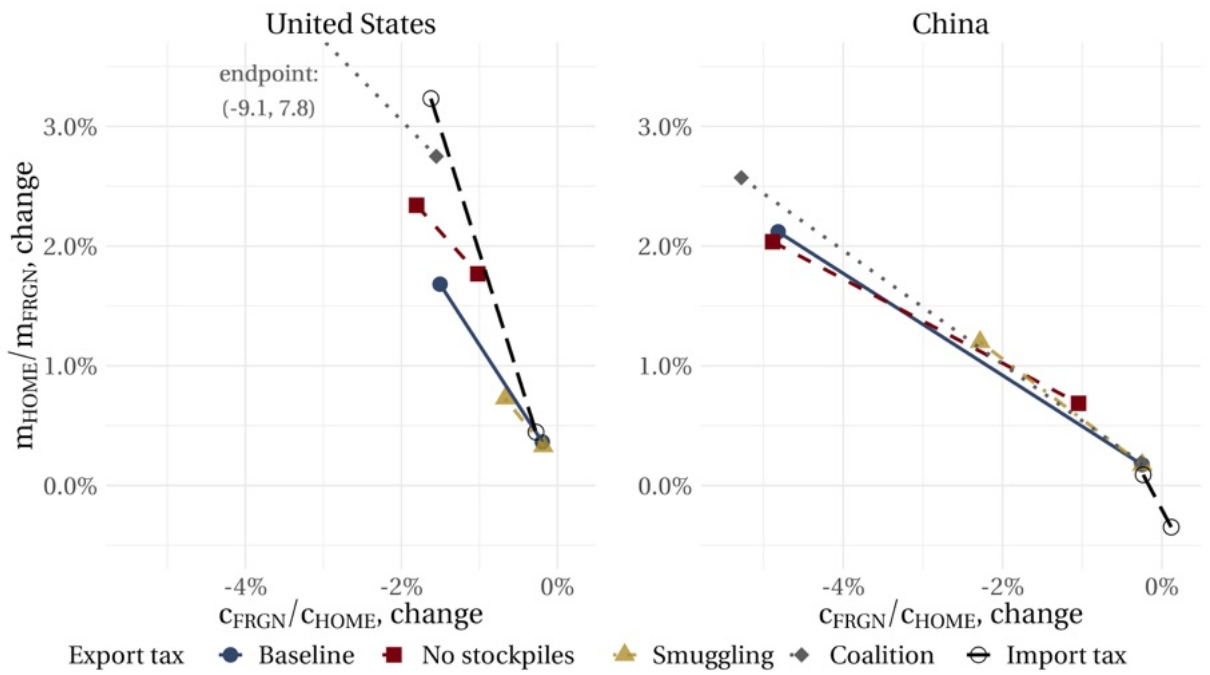
6.3 Results

Given our calibration fit, we quantify the impact of the optimal trade policies. We consider trade policies applied by the U.S. and China unilaterally and report changes in military advantage ($m_{\text{HOME}}/m_{\text{FRGN}}$) and consumption ratio ($c_{\text{FRGN}}/c_{\text{HOME}}$) when trade policy is applied relative to a zero-tax benchmark. Figure 12 plots segments with endpoints at $\alpha_{\text{HOME, FRGN}} = 0.01 P^C_{\text{FRGN}}$ and $\alpha_{\text{FRGN}} = P^C_{\text{FRGN}}$; the weights on the Rest of the World always follow a universalist benchmark ($\alpha_{\text{ROW}} = P^C_{\text{ROW}}$). Both slope and length of the segment are informative about the policy impact.

As one can see from the graph, China has an upper hand compared to the U.S. when it comes to unilateral export policies (2.1% military advantage and -4.9% consumer advantage as opposed to 1.7% and -1.5% for the U.S.). However, under coalition export enforcement, the U.S. trade impact becomes three times larger than that of China. Smuggling more than halves impact magnitudes.[24] Drawdown of stockpiles increases incentives to target exports and makes export taxation more aggressive. Import tariffs are a more powerful instrument for the U.S., while have almost no impact for China, since China does not import from the U.S. much. However, one should keep in mind that import tariff deterrence works mostly through the budget constraint and not on the production price margin.

An important qualification is that Figure 12 considers scenarios when the foreign military tax is fixed as a share of household budget. Once we allow govenrnment flexibility in setting lump sum taxes, the impact of policy on military advantage is dampened due to budget redistribution; foreign households take a stronger hit ($\Delta^2_\alpha(m_{\text{HOME}}/m_{\text{FRGN}}) = 0.3\%$ and $\Delta^2_\alpha(c_{\text{HOME}}/c_{\text{FRGN}}) = -1.4\%$). If the foreign government can tax households limitlessly, the problem becomes that of lowering the foreign economy-wide budget constraint.

[24] If one allows to target exports to the Rest of the World, optimal export taxes across destinations become closer together. Welfare is lower in that scenario compared to a benchmark with no reshipping and possible export taxes on the Rest of the World. That happens due to implicit constraints on taxes across export destinations that reshipping sets.



Notes: Baseline stands for a unilateral application of export taxes, for the U.S. against China and for China against the U.S. (but not the Rest of the World). *No stockpiles* refers to the scenario when $m_{i0} = 0$. *Smuggling* is modeled as an additional CES nest for different routes with $\sigma = 8.0$ and the cost of reshipping $\tau = 2.0$. *Coalition* means joint export tax setting with allies. *Import tax* means unilateral import tax enforcement.

Figure 12: Policy impact plot

In terms of welfare outcomes, the U.S. unilateral export policy at its baseline improves the U.S. national welfare by 0.2%; the analogous Chinese policy improves domestic welfare by 1.5% (Table C.7). Larger magnitudes for China reflect more redistribution from foreign consumers to home ones and a different starting point in terms of consumption.

Finally, and perhaps most importantly, industrial policy is a much more potent tool compared to trade policy. Under a universalist benchmark $\alpha_{ij} = P_j^C$ and a balanced-budget constraint on taxation, optimal industrial policy moves military advantage by 11% while keeping consumption sharing at just 0.7% (Table C.8). The optimal policy redistributes from export-oriented sectors towards the defense sector, which is mostly domestic, thus performing an indirect terms-of-trade manipulation similar to Ottonello et al. (2024).[25] During conflict, our model prescribes ramping up military spending and subsidizing military sectors at the expense of export-oriented ones. Redistributive domestic taxation is an indirect way to impact conflicts when the first-best is unattainable due to some reason.

[25] In a closed economy with a flexible defense budget, there is no need for industrial policy since defense spending is a first-best lever of addressing variations in national security environment. The only rationale for industrial policy in our setting comes from the fact that the economy is open.

7 Conclusion

National security shapes trade flows and regulation of military inputs. In our model, an input should be subject to scrutiny if it is what foreign military buys, it is not what goes into roundabout imports much, and it is hard to substitute. Increasing prices for foreign military should begin with sectors that satisfy those conditions in input-output networks. The extent to which inputs should be restricted depends on the choice on the consumption-security trade-off that policymakers prefer. Our preliminary macroeconomic framework quantifies that trade-off.

Our paper can serve as a starting point for further research. First, an important issue is that of conflict dynamics: the speed of goods' production versus destruction; build-up, scaling, and replacement of the durable manufacturing base. Second, the value of the military is inherently state-contingent: it is high during conflict but low during peacetime. That state contingency adversely affects incentives for peacetime military build-up, meant to deter wars. Third, our framework should be extended to innovation and knowledge flows similar to E. Liu and Ma (2021). Stopping diffusion of critical technologies with military applications is a highly policy-relevant problem, and such technologies can be identified in a network setup similar to ours. Fourth, a better estimation of behavioral policy responses is needed: empirical policy functions for military spending, stockpiles, and diplomacy. Fifth, game-theoretic questions around optimal responses to conflicts promise interesting problems: whether a country should let aggression slide, respond in kind, or respond harshly, within military or in another domain. Sixth, our work would benefit from firm- and plant-level data, richer spatial setup, as well as properly-measured "engineering" elasticities of production on the supply and demand side. Finally, studying industrial organization of dual-use sectors such as space, drones, cyber, AI, and nuclear is an exciting direction full of granular settings for the questions above.

More broadly, the nuances of dynamic games and the subtleties of diplomatic communications make international political economy an exciting area of study. Direct and indirect measures tracking attitudes, political support, and information flows are becoming increasingly available, opening up areas for new creative work combining structural models with data. In the meantime, our paper offers a vast space for applied national security research by economists, the endpoint of which hopefully becomes a new security framework that does not allow military conflicts to ever happen again.

References

Acemoglu, D., Aghion, P., Barrage, L., & Hémous, D. (2023). Climate Change, Directed Innovation, and Energy Transition: The Long-run Consequences of the Shale Gas Revolution.

Acemoglu, D., Golosov, M., Tsyvinski, A., & Yared, P. (2012). A Dynamic Theory of Resource Wars *. *The Quarterly Journal of Economics*, *127*(1), 283–331.

Acemoglu, D., & Yared, P. (2010). Political Limits to Globalization. *American Economic Review*, *100*(2), 83–88.

Adão, R., Becko, J. S., Costinot, A., & Donaldson, D. (2023). Why is Trade Not Free? A Revealed Preference Approach.

Adão, R., Becko, J. S., Costinot, A., & Donaldson, D. (2024). A World Trading System For Whom? Evidence from Global Tariffs.

Alfaro, L., Antràs, P., Chor, D., & Conconi, P. (2019). Internalizing Global Value Chains: A Firm-Level Analysis. *Journal of Political Economy*, *127*(2), 508–559.

Andrade, T. (2016). *The Gunpowder Age: China, Military Innovation, and the Rise of the West in World History*. Princeton University Press.

Antràs, P. (2016). *Global Production: Firms, Contracts, and Trade Structure*. Princeton University Press.

Antràs, P., & Chor, D. (2013). Organizing the Global Value Chain. *Econometrica*, *81*(6), 2127–2204.

Antràs, P., & Chor, D. (2018). On the Measurement of Upstreamness and Downstreamness in Global Value Chains. *NBER Working Papers*.

Antràs, P., Chor, D., Fally, T., & Hillberry, R. (2012). Measuring the Upstreamness of Production and Trade Flows. *American Economic Review*, *102*(3), 412–416.

Antràs, P., Fort, T. C., Gutiérrez, A., & Tintelnot, F. (2024). Trade Policy and Global Sourcing: An Efficiency Rationale for Tariff Escalation. *Journal of Political Economy Macroeconomics*, *2*(1), 1–44.

Antràs, P., & Padró i Miquel, G. (2011). Foreign influence and welfare. *Journal of International Economics*, *84*(2), 135–148.

Antràs, P., & Padró i Miquel, G. (2023). Exporting Ideology: The Right and Left of Foreign Influence.

Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production (Une théorie de la demande de produits différenciés d'après leur origine) (Una teoría de la demanda de productos distinguiéndolos según el lugar de producción). *Staff Papers (International Monetary Fund)*, *16*(1), 159–178.

Auerbach, A. J., & Gorodnichenko, Y. (2012). Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*, *4*(2), 1–27.

Austal Launches Largest Vessel to Date - Lake Express High-Speed Vehicle-Passenger Ferry. (2004).

Bai, J., Bernstein, S., Dev, A., & Lerner, J. (2022). The Dance Between Government and Private Investors: Public Entrepreneurial Finance around the Globe.

Baqaee, D. R., & Farhi, E. (2024). Networks, Barriers, and Trade. *Econometrica*, *92*(2), 505–541.

Becko, J. S. (2023). How Should Sanctions Account for Bystander Countries? *AEA Papers and Proceedings*, *113*, 39–42.

Becko, J. S. (2024). A theory of economic sanctions as terms-of-trade manipulation. *Journal of International Economics*, *150*, 103898.

Becko, J. S., & O'Connor, D. G. (2024). Strategic (Dis) Integration.

Belenzon, S., & Cioaca, L. C. (2021). Guaranteed Markets and Corporate Scientific Research.

Bianchi, J., & Sosa-Padilla, C. (2023). International Sanctions and Dollar Dominance.

Bigio, S., & La'O, J. (2020). Distortions in Production Networks*. *The Quarterly Journal of Economics*, *135*(4), 2187–2253.

Bilal, A., & Rossi-Hansberg, E. (2023). Anticipating Climate Change Across the United States.

BIS Annual Conference. (2018).

Bloom, N., Hassan, T. A., Kalyani, A., Lerner, J., Tahoun, A., & Carvalho, M. (2023). The Diffusion of New Technologies.

Bowett, A. (1994). The Commercial Introduction of Mahogany and the Naval Stores Act of 1721. *Furniture History*, *30*, 43–56.

Broda, C., & Weinstein, D. E. (2006). Globalization and the Gains From Variety*. *The Quarterly Journal of Economics*, *121*(2), 541–585.

Chatagnier, J. T., & Kavakl, K. C. (2017). From Economic Competition to Military Combat: Export Similarity and International Conflict. *Journal of Conflict Resolution*, *61*(7), 1510–1536.

Chatelus, R., & Heine, P. (2016). Rating Correlations Between Customs Codes and Export Control Lists: Assessing the Needs and Challenges. *Strategic Trade Review*, *2*(3).

Chen, J., & Roth, J. (2024). Logs with Zeros? Some Problems and Solutions*. *The Quarterly Journal of Economics*, *139*(2), 891–936.

Chupilkin, M., Javorcik, B., Peeva, A., & Plekhanov, A. (2024). Decision to Leave: Economic Sanctions and Intermediated Trade.

Chupilkin, M., & Koczan, Z. (2022). The economic consequences of war: Estimates using synthetic controls.

Clark, D., & Swanson, A. (2022). U.S. Restricts Sales of Sophisticated Chips to China and Russia. *The New York Times*.

Clayton, C., Maggiori, M., & Schreger, J. (2023). A Framework for Geopolitics and Economics.

Clayton, C., Maggiori, M., & Schreger, J. (2024). A Theory of Economic Coercion and Fragmentation. *SocArXiv*.

Conte, B., Desmet, K., & Rossi-Hansberg, E. (2022). On the Geographic Implications of Carbon Taxes.

Copeland, B. R., Shapiro, J. S., & Scott Taylor, M. (2022). Globalization and the environment. In *Handbook of International Economics* (pp. 61–146). Elsevier.

Costinot, A., Donaldson, D., Vogel, J., & Werning, I. (2015). Comparative Advantage and Optimal Trade Policy *. *The Quarterly Journal of Economics*, *130*(2), 659–702.

Costinot, A., Rodríguez-Clare, A., & Werning, I. (2020). Micro to Macro: Optimal Trade Policy With Firm Heterogeneity. *Econometrica*, *88*(6), 2739–2776.

Couttenier, M., Marcoux, J., Mayer, T., & Thoenig, M. (2023). The Gravity of Violence.

Cox, L., Müller, G. J., Pasten, E., Schoenle, R., & Weber, M. (2023). Big G.

Cruz, J.-L., & Rossi-Hansberg, E. (2022). Local Carbon Policy.

Cruz, J.-L., & Rossi-Hansberg, E. (2023). The Economic Geography of Global Warming. *The Review of Economic Studies*, rdad042.

Davis, A., Lopez-Pena, P., Mobarak, M., & Wen, J. (2023). Causes and Consequences of State Violence against Civilians: The Rohingya of Myanmar.

de Souza, G., Hu, N., Li, H., & Mei, Y. (2024). (Trade) War and peace: How to impose international trade sanctions. *Journal of Monetary Economics*, *146*, 103572.

Egorov, K., Korovkin, V., Makarin, A., & Nigmatulina, D. (2024). Trade Sanctions.

Eichengreen, B., Ferrari Minesso, M., Mehl, A., Vansteenkiste, I., & Vicquéry, R. (2024). Sanctions and the exchange rate in time. *Economic Policy*, *39*(118), 323–354.

Evenett, S. J. (2019). Protectionism, state discrimination, and international business since the onset of the Global Financial Crisis. *Journal of International Business Policy*, *2*(1), 9–36.

Fajgelbaum, P. D., Goldberg, P. K., Kennedy, P. J., & Khandelwal, A. K. (2020). The Return to Protectionism*. *The Quarterly Journal of Economics*, *135*(1), 1–55.

Farrokhi, F., & Lashkaripour, A. (2021). Can Trade Policy Mitigate Climate Change? *Working paper*.

Federle, J., Meier, A., Muller, G., Mutschler, W., & Schularick, M. (2024). The Price of War. *CEPR*.

Feenstra, R. C. (1994). New Product Varieties and the Measurement of International Prices. *The American Economic Review*, *84*(1), 157–177.

Galeotti, A., Golub, B., & Goyal, S. (2020). Targeting Interventions in Networks. *Econometrica*, *88*(6), 2445–2471.

Gaulier, G., & Zignago, S. (2010). *BACI: International Trade Database at the Product-Level. The 1994-2007 Version* (Working Paper). CEPII research center.

Ghironi, F., Kim, D., & Ozhan, G. K. (2023). International Economic Sanctions and Third-Country Effects.

Goldberg, P. K., Juhász, R., Lane, N. J., Lo Forte, G., & Thurk, J. (2024). Industrial Policy in the Global Semiconductor Sector.

Golosov, M., Hassler, J., Krusell, P., & Tsyvinski, A. (2014). Optimal Taxes on Fossil Fuel in General Equilibrium. *Econometrica*, *82*(1), 41–88.

Gopinath, G., Gourinchas, P.-O., Presbitero, A., & Topalova, P. B. (2024). Changing Global Linkages: A New Cold War?

Grassi, B. (2018). IO in I-O: Size, Industrial Organization, and the Input-Output NetworkMake a Firm Structurally Important. *Working Papers*.

Grassi, B., & Sauvagnat, J. (2019). Production networks and economic policy. *Oxford Review of Economic Policy*, *35*(4), 638–677.

Grossman, G. M., & Helpman, E. (1994). Protection for Sale. *The American Economic Review*, *84*(4), 833–850.

Grubel, H. G., & Lloyd, P. J. (1975). *Intra-industry Trade: The Theory and Measurement of International Trade in Differentiated Products*. Macmillan.

Gustafson, T. (1981). *Selling the Russians the Rope? : Soviet Technology Policy and U.S. Export Controls* (tech. rep.). RAND Corporation.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. MIT Press.

Helpman, E., & Krugman, P. (1989). Trade Policy and Market Structure.

Horn, S., Reinhart, C., & Trebesch, C. (2024). International Lending in War and Peace.

Hsiao, A. (2022). Coordination and Commitment in International Climate Action: Evidence from Palm Oil.

Hsiao, A., Moscona, J., & Sastry, K. (2024). Food Policy in a Warming World.

Itskhoki, O., & Mukhin, D. (2022). Sanctions and the Exchange Rate.

Itskhoki, O., & Mukhin, D. (2023). International Sanctions and Limits of Lerner Symmetry. *AEA Papers and Proceedings*, *113*, 33–38.

Itskhoki, O., & Ribakova, E. (2024). The economics of sanctions: From theory into practice.

Iyoha, E., Malesky, E. J., Wen, J., Wu, S.-J., & Feng, B. (2024). Exports in Disguise: Trade Re-Routing During the U.S.-China Trade War.

Jones, L. P. (1976). The Measurement of Hirschmanian Linkages*. *The Quarterly Journal of Economics*, *90*(2), 323–333.

Juhász, R., Lane, N., Oehlsen, E., & Pérez, V. C. (2022). The Who, What, When, and How of Industrial Policy: A Text-Based Approach.

Kaempfer, W. H., & Lowenberg, A. D. (2007). Chapter 27. The Political Economy of Economic Sanctions. In T. Sandler & K. Hartley (Eds.), *Handbook of Defense Economics* (pp. 867–911). Elsevier.

Kang, K. (2016). Policy Influence and Private Returns from Lobbying in the Energy Sector. *The Review of Economic Studies*, *83*(1), 269–305.

Kessler, S. (2022). What Is Friendshoring? *The New York Times*.

Kleinman, B., Liu, E., & Redding, S. J. (2023). International Friends and Enemies. *American Economic Journal: Macroeconomics*.

König, M. D., Rohner, D., Thoenig, M., & Zilibotti, F. (2017). Networks in Conflict: Theory and Evidence From the Great War of Africa. *Econometrica*, *85*(4), 1093–1132.

Kortum, S. S., & Weisbach, D. A. (2021). Optimal Unilateral Carbon Policy.

Lashkaripour, A., & Beshkar, M. (2020). *The Cost of Dissolving the WTO: The Role of Global Value Chains* (CAEPR Working Paper 2020-005 Classification-). Center for Applied Economics and Policy Research, Department of Economics, Indiana University Bloomington.

Lashkaripour, A., & Lugovskyy, V. (2022). Profits, Scale Economies, and the Gains from Trade and Industrial Policy.

Leontief, W. W. (1936). Quantitative Input and Output Relations in the Economic Systems of the United States. *The Review of Economics and Statistics*, *18*(3), 105–125.

Li, H., Li, Z., Park, Z., Wang, Y., & Wu, J. (2024). To Comply or Not to Comply: Understanding Neutral Country Supply Chain Responses to Russian Sanctions.

Liu, E. (2019). Industrial Policies in Production Networks*. *The Quarterly Journal of Economics*, *134*(4), 1883–1948.

Liu, E., & Ma, S. (2021). Innovation Networks and R&D Allocation.

Liu, E., & Tsyvinski, A. (2024). A Dynamic Model of Input-Output Networks.

Liu, E., & Yang, D. (2024). International Power.

Liu, X., Liu, Y., & Wen, J. Y. (2024). The Consequences of Export Controls in Target Countries.

Long, J. B., & Plosser, C. I. (1983). Real Business Cycles. *Journal of Political Economy*, *91*(1), 39–69.

Martin, P., Mayer, T., & Thoenig, M. (2008). Make Trade Not War? *The Review of Economic Studies*, *75*(3), 865–900.

Martin, P., Mayer, T., & Thoenig, M. (2012). The Geography of Conflicts and Regional Trade Agreements. *American Economic Journal: Macroeconomics*, *4*(4), 1–35.

Martin, P., Thoenig, M., & Mayer, T. (2008). Civil Wars and International Trade. *Journal of the European Economic Association*, *6*(2/3), 541–550.

Méndez, E., & Van Patten, D. (2022). Voting on a Trade Agreement: Firm Networks and Attitudes Toward Openness.

Miller, C., Tsunashima, T., Seddon, M., Joiner, S., Campbell, C., & Cook, C. (2024). Type of Russian missile that struck Kyiv childrens hospital uses western components. *Financial Times*.

Mozur, P., & Hopkins, V. (2023). Ukraines War of Drones Runs Into an Obstacle: China. *The New York Times*.

Neri-Laine, M. (2024). Sovereign Gravity: The Military Alliances' Effect on Trade.

Ossa, R. (2014). Trade Wars and Trade Talks with Data. *American Economic Review*, *104*(12), 4104–4146.

Ottonello, P., Perez, D. J., & Witheridge, W. (2024). The Exchange Rate as an Industrial Policy.

Pitron, G. (2020). *The Rare Metals War: The dark side of clean energy and digital technologies*. Scribe Publications Pty Limited.

Rivkin, A. (2021). German technology found in China's warships: Report. *Deutsche Welle*.

Rohner, D., Thoenig, M., & Zilibotti, F. (2013). War Signals: A Theory of Trade, Trust, and Conflict. *The Review of Economic Studies*, *80*(3), 1114–1147.

Sarkees, M., & Wayman, F. (2010). *Resort to War, 1816-2007*.

Shiffman, J., & Shalal-Esa, A. (2014). Exclusive: U.S. waived laws to keep F-35 on track with China-made parts. *Reuters*.

Skaperdas, S., & Syropoulos, C. (2001). Guns, Butter, and Openness: On the Relationship between Security and Trade. *American Economic Review*, *91*(2), 353–357.

Soderbery, A. (2015). Estimating import supply and demand elasticities: Analysis and implications. *Journal of International Economics*, *96*(1), 1–17.

Teti, F., Scheckenhofer, L., & Wanner, J. (2024). Trade Sanctions against Russia: Light Strokes or Massive Blows?

Thoenig, M. (2023). Trade policy in the shadow of war: A quantitative toolkit for geoeconomics.

Tullock, G. (1980). Efficient Rent Seeking. In J. Buchanan, G. Tullock, & R. Tollison (Eds.), *Toward a Theory of the Rent-Seeking Society* (pp. 97–112). Texas A&M University Press.

Wen, J. (2012). Industry-Level Supply-Side Market Concentration and the Price of Military Conflict. *Conflict Management and Peace Science*, *29*(1), 79–92.

Wu, L. (2022). Network Lerner Index: Demand and Distortions across Industries.

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All errors are our own.

B Examples

B.1 Dual-use goods examples

B.1.1 Rare-earths magnets in F-35 and Tesla

The fiscal budget of the U.S. Air Force is $215 bln USD. Every year it is used to procure ≈70 F-35 fighter jets from Lockheed Martin, which cost more than $100 mln USD per jet. Around $10 mln USD of those $100 mln is the cost of a high-precision radar AN/APG-81 that Lockheed Martin subcontracts to Northrop Grumman. The high-precision radar technology makes use of neodymium permanent magnets, which Northrop Grumman, as the 2012 Pentagon investigation showed, procures from Chengdu Magnetic Material Science and Technology, located in an industrial hub near rare earths deposits in Sichuan, China. (Shiffman & Shalal-Esa, 2014).

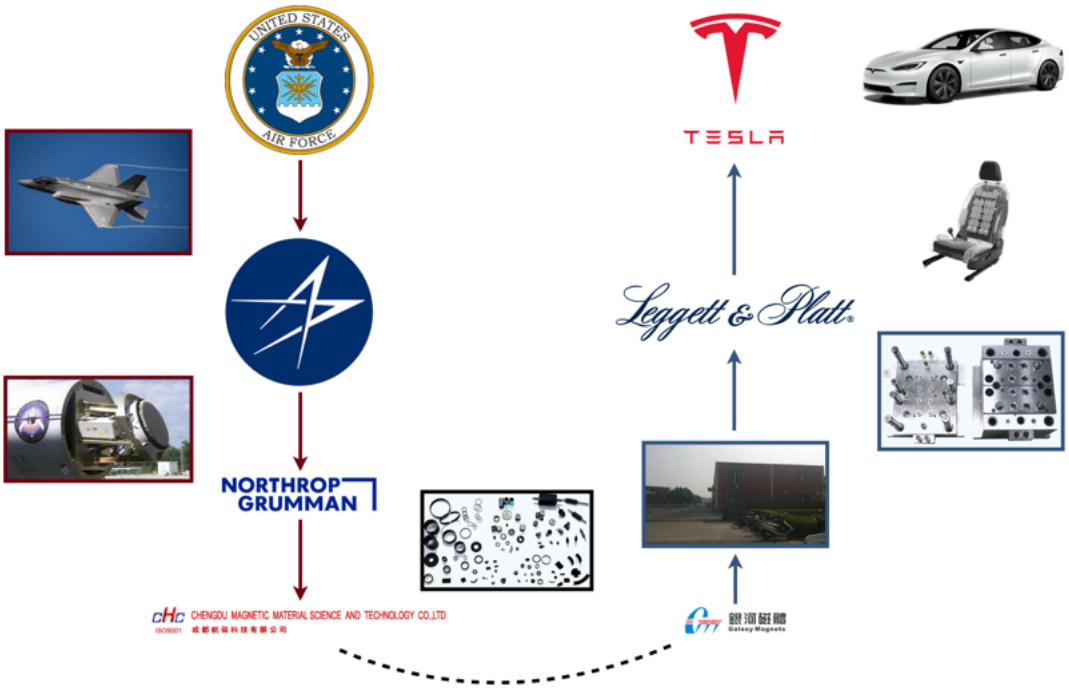


Figure B.1: Neodymium magnets as components of F-35 fighter jet and Tesla cars

Located some 30 minutes away is Chengdu Galaxy Magnets, which also sells permanent magnets made of neodymium. One of its customers is Guangdong Zhaoqing LV, which is a subsidiary of the furniture company Leggett & Platt (Factset). The automotive branch of the company sells car seats to Tesla (Factset), and in those car seats, permanent magnets underpin the engineering mechanism behind the seat adjustment and recline. The same

$2 neodymium magnets thus are used both in 100 mln USD fighter jets in the U.S. military and Tesla cars purchased by American consumers.

Why would the U.S. military subject itself to a potential supply chain and security vulnerability? “Kendall [Frank Kendall, chief U.S. Arms buyer] said the waivers were needed to keep production, testing and training of the Pentagon’s newest warplane on track; avert millions of dollars in retrofit costs; and prevent delays in the Marine Corps’ plan to start using the jets in combat from mid-2015, according to the documents. [...] In one case [of an F-35 jet], it would cost $10.8 million and take about 25,000 man-hours to remove the Chinese-made magnets and replace them with American ones.” (Shiffman & Shalal-Esa, 2014). According to Anthony Marchese, the CEO of Texas Mineral Resources, who is leading the efforts to re-shore the rare earth supply chain, “The manufacturers of the F-35 still buy rare earths in China. Period.” (Pitron, 2020).

B.1.2 Engines in PRC navy ships and Lake Express

PRC missile destroyer Luyang II is powered by 2 MTU 20V-956-TB92 diesel engines produced by MTU Friedrichshafen, a German company that is a part of Rolls-Royce Holdings (Rivkin, 2021). A similar, slightly less powerful engine, MTU 16V-4000-M70 is installed in *Lake Express* that carries passengers across Lake Michigan (“Austal Launches Largest Vessel to Date - Lake Express High-Speed Vehicle-Passenger Ferry”, 2004).



Figure B.2: MTU engines in PRC navy ships and Lake Express

B.1.3 CNC machines producing Iskander missiles and Top Flite golf clubs

HAAS VF2SS milling machine is used both to produce custom golf clubs (Custom Golf Club Putter Made With CNC Machining — Star Rapid, 2017) and Iskander missiles on the Titan-Barikadnyy plant (Galeev et al., 2024)



Figure B.3: CNC machines producing Iskander missiles and Top Flite golf clubs

B.1.4 Drones in amateur photography and trench warfare

500$ DJI drones, purposed for amateur photography, have been used by the Ukrainian armed forces in trench warfare (Mozur & Hopkins, 2023).



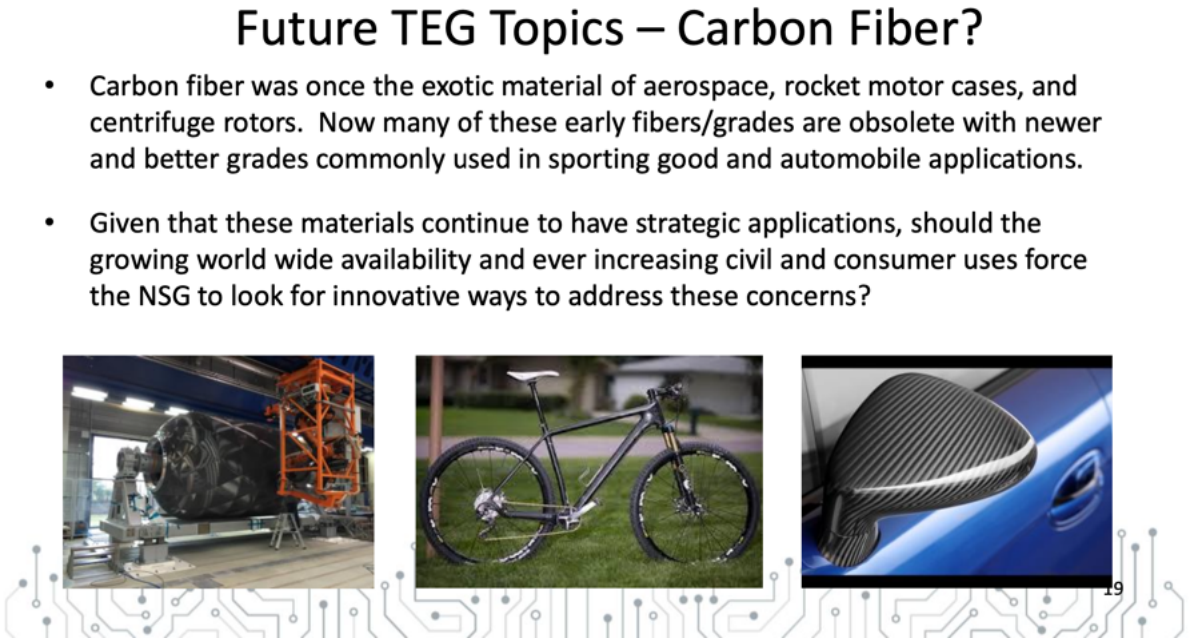
Figure B.4: DJI drones in trench warfare and amateur photography

B.2 Descriptive evidence for sufficient statistics

Figure B.5 displays a slide on the uses of carbon fiber from the Bureau of Industry Security conference that suggests that regulators indeed consider where the relative sales of a good go. Authorities are uncertain whether they should regulate carbon fiber given its increased prevalence in non-military applications. This is exactly the type of question our paper aims to resolve quantitatively.

We also look at several anecdotal episodes when certain goods were replaced in military production and look at how international trade in those goods evolved. The three technological transitions we consider are the phase-out of combustion piston engines in military vehicles, the replacement of analog manufacturing by high-precision CNC machines, and the microelectronics revolution. With the advent of gas turbines and alternative propulsion systems, internal combustion piston engines gradually stopped being used in battlefield vehicles, particularly in aerospace and navy.[26] The high-precision manufacturing started

[26] Some first models that replaced internal combustion engines are M1 Abrams (1980; gas turbine; replaced

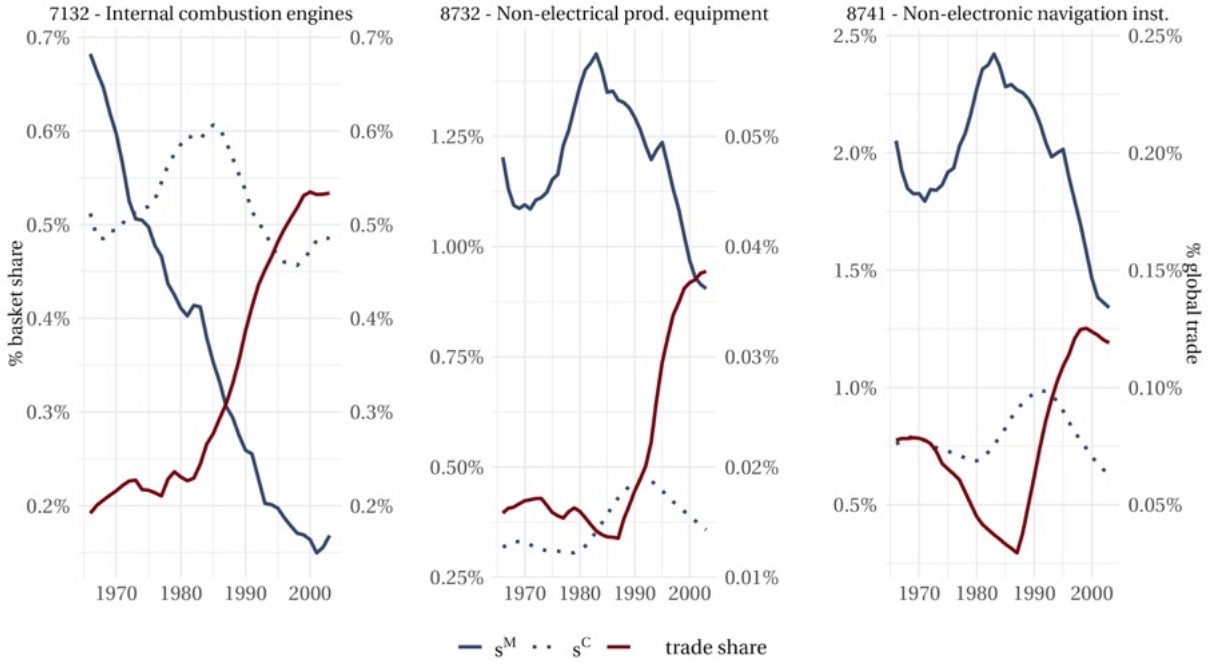


Notes: Slide from the 2018 discussion from the Bureau of Industry Security ("BIS Annual Conference", 2018).

Figure B.5: Policymakers discuss relative uses: The case of carbon fiber

replacing analog instruments with CNCs around 1970-1980s, leading to the phase-out of the latter from military procurement. The microelectronics revolution, happening around the same time, decreased military reliance on non-electronic navigation instruments. Despite military phaseout and stable US consumer shares, international trade in those goods increased, not decreased, producing suggestive (but not in any case conclusive) evidence in favor of more lax trade regulation (Figure B.6).

diesel-powered M60 Patton), Bell UH-1 Iroquois (1959; gas turbine; replaced Bell H-13 with piston engines), jet-powered Boeing B-47 Stratojet (1951; replaced B-29 Superfortress with piston engines), nuclear-powered USS Enterprise CVN-65 (1961; replaced the USS Essex CV-9 driven by piston-engines), and nuclear-powered USS Nautilus SSN-571 (1954; replaced the diesel-electric USS Gato-class submarines).



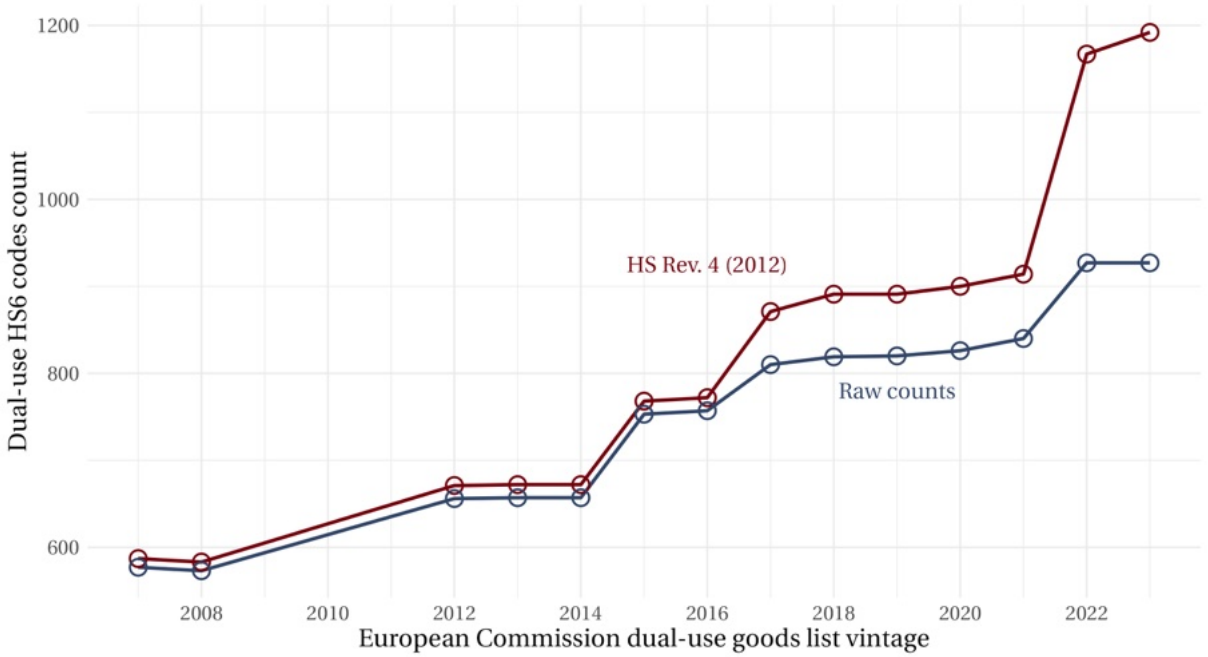
Notes: The trade data for the Cold War (1962-2021) comes from the Atlas of Economic Complexity and is at the SITC Rev. 2 (1975) level. The military procurement share is reconstructed from the National Archives (1966-2006) and crosswalked from FSC (Federal Supply Codes) to SITC Rev. 2. The consumer share is reconstructed using value-added numbers from NBER manufacturing database and crosswalked from NAICS to SITC Rev. 2. Supplementary Appendix Figure SA.B.7 provides additional figures for components of internal combustion engines, SITC 7139 "Parts of internal combustion engines" and SITC 7783 "Electrical equipment for internal combustion engines," showing analogous patterns there.

Figure B.6: Cases of technological transitions

C Empirics

C.1 Motivating facts

C.1.1 Fact #2. Trade in dual-use goods is increasingly regulated: Policy scope



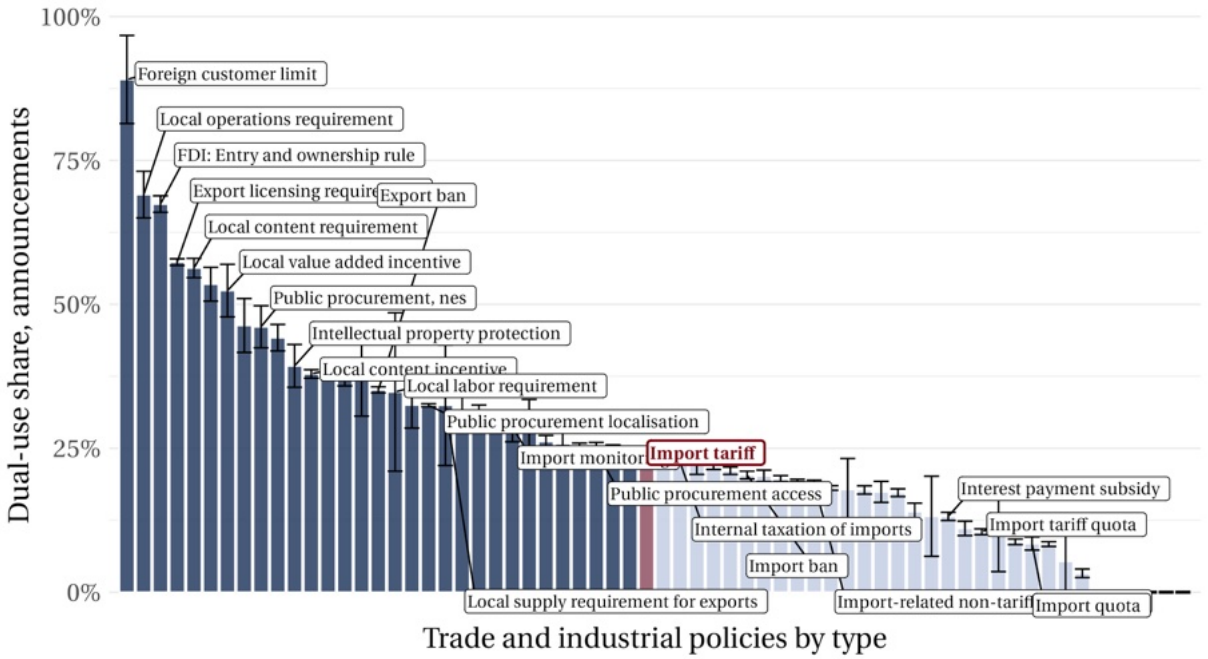
Notes: Data for dual-use categories is taken from the EU TARIC dual-use correlation tables. CN8 codes are converted to HS6 codes and then converted to Rev. 4 (2012). The blue line counts raw 6-digit stems without conversion. It is lower due to many-to-many mapping between Rev. 4 (2012) codes and Rev. 5/Rev. 6 (2017/2022) codes, with some Rev. 5/Rev. 6 categories taking pieces from many Rev. 4 categories.

Figure C.1: Dual-use goods count

C.1.2 Fact #2. Trade in dual-use goods is increasingly regulated: Policy intensity

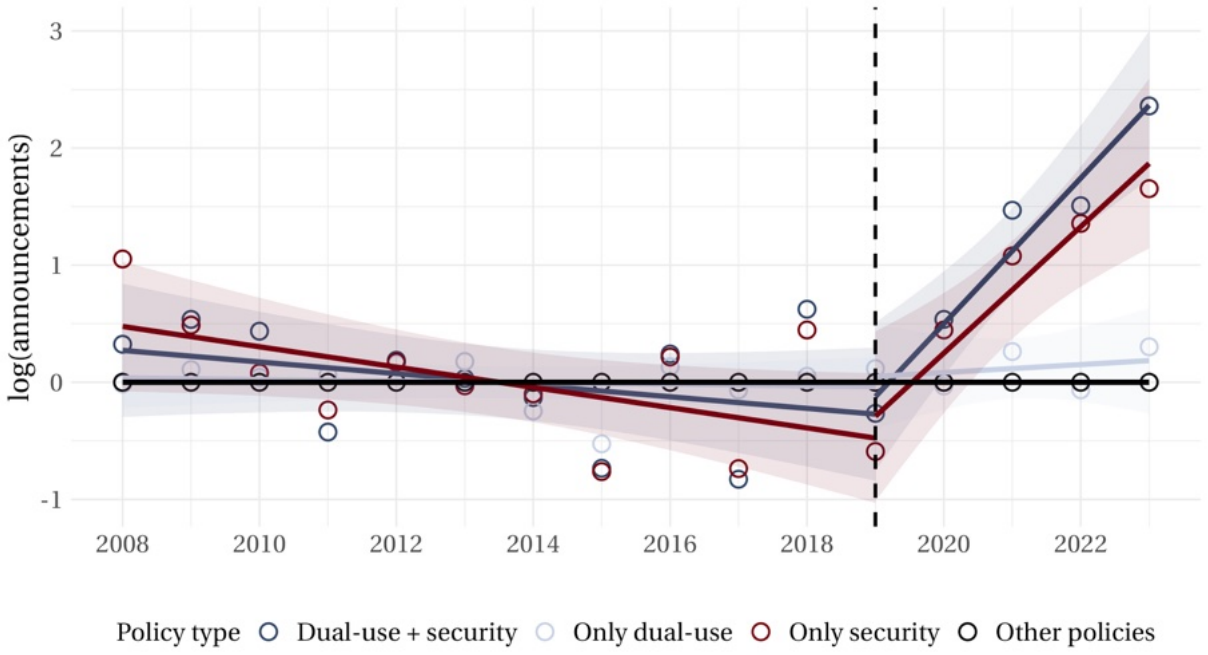
Trade policies that restrict foreign access disproportionately target goods defined as dual-use (Figure C.2). Consider import tariff policy acts as a benchmark. Approximately 25% of these policy acts target goods from the dual-use list, close to the 21.8% number predicted by uniformly drawing HS codes. Policies that target dual-use goods at a rate higher than import tariffs tend to involve actions restricting foreign access. Top-5 such "security" policies are foreign customer limit (89% dual-use), local operations requirement (69%), rules regulating entry and ownership of FDI (67%), export licensing (57%), and local content requirements (56%). On the other hand, dual-use goods are less targeted by standard protectionist measures such as import bans (20%) or import quotas (8.5%).

Recent years have seen an increase in security policies, especially for dual-use goods (Figure C.3). The beginning of a new trend can be attributed to an increase in geopolitical tensions in 2020 following the pandemic, with unprecedented levels observed since 2022. The 2023 count in new security policies represents a tenfold increase over the pre-pandemic period trend.



Notes: The data is taken from the *Global Trade Alert* project (Evenett, 2019), which is the basis under industrial policy analysis by Juhász et al. (2022). Here a unit of observation is policy act-HS code; if the same policy act covers multiple HS codes, it will be counted as multiple observations. Every policy act is classified into a text category by the *Global Trade Alert*, which is displayed in text labels above the bars. For every text category, the bar reflects the share of policy acts in that category directed towards dual-use goods. The dual-use goods definition is taken from the 2018 vintage of the EU customs list.

Figure C.2: Dual-use goods as targets of trade and industrial policies



Notes: The data is taken from the *Global Trade Alert* project (Evenett, 2019), which is the basis under industrial policy analysis by Juhász et al. (2022). The individual points correspond to a double difference in new policy acts relative to the pre-trend period 2008-2019:

$$\left[\log(\#\,\text{acts}_{it}) - \frac{1}{13}\sum_{t=2008}^{2019}\log(\#\,\text{acts}_{i,\text{2008-19}})\right] - \left[\log(\#\,\text{acts}_{\text{Other},t}) - \frac{1}{13}\sum_{t=2008}^{2019}\log(\#\,\text{acts}_{\text{Other,2008-19}})\right]$$

Security policies are classified based on Figure C.2 with and are enumerated in Table SA.B.5.

Figure C.3: Security trade policies over time

C.1.3 Fact #3. Dual-use trade responds to changes in security environment over time

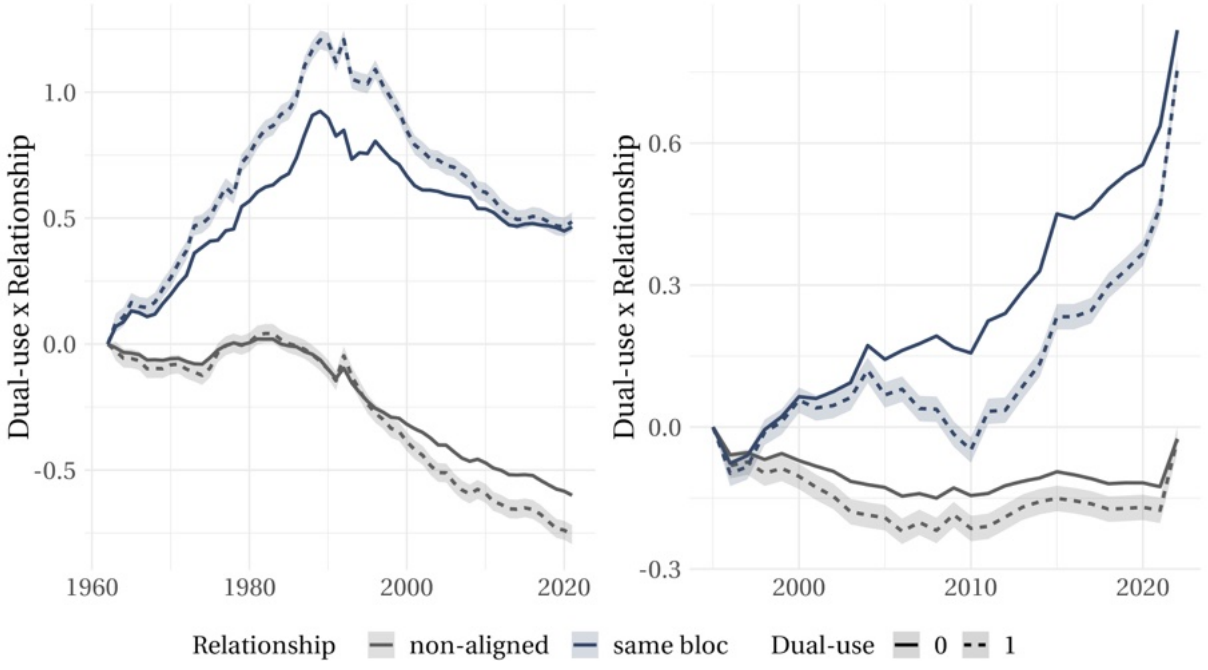
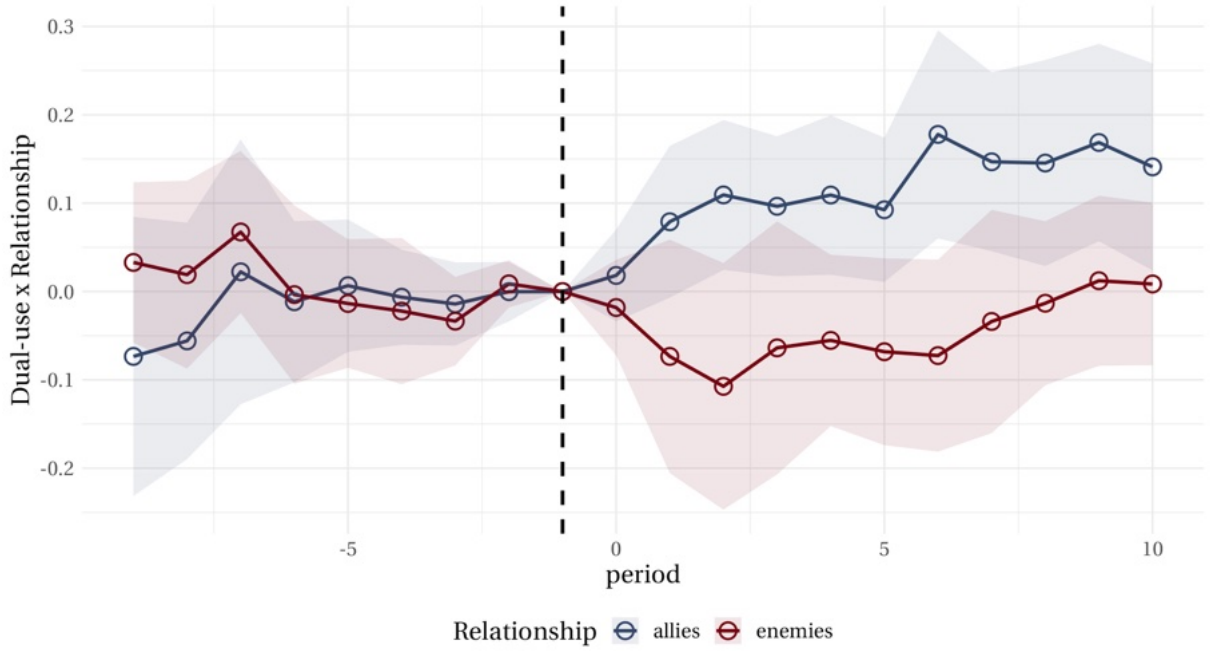


Figure C.4: Coefficient $\gamma_{R,t}$ over time



Notes: The trade data for the Cold War (1962-2021) comes from the Atlas of Economic Complexity and is at the SITC Rev. 2 (1975) level. We take all the inter-state and extra-state wars from the Correlates of War project from 1962 onwards (Sarkees & Wayman, 2010).

We list conflict participants who were geographically proximate to the main war theater. Then we designate diplomatic alliances by manually classifying mentions of various state actors in Wikipedia articles related to the wars listed. While the text analysis with Wikipedia articles has been used in some studies (e.g., Bloom et al., 2023), our approach has obvious limitations and as such presents a preliminary inquiry open for refinement in future studies. Independent from alliance classifications, Figure SA.B.6 shows that dual-use goods post-conflict experience stronger absolute changes in imports within all country pairs with a war-participant receiver. Table SA.B.3 lists the conflicts and alliances that we use.

Our regression equation is

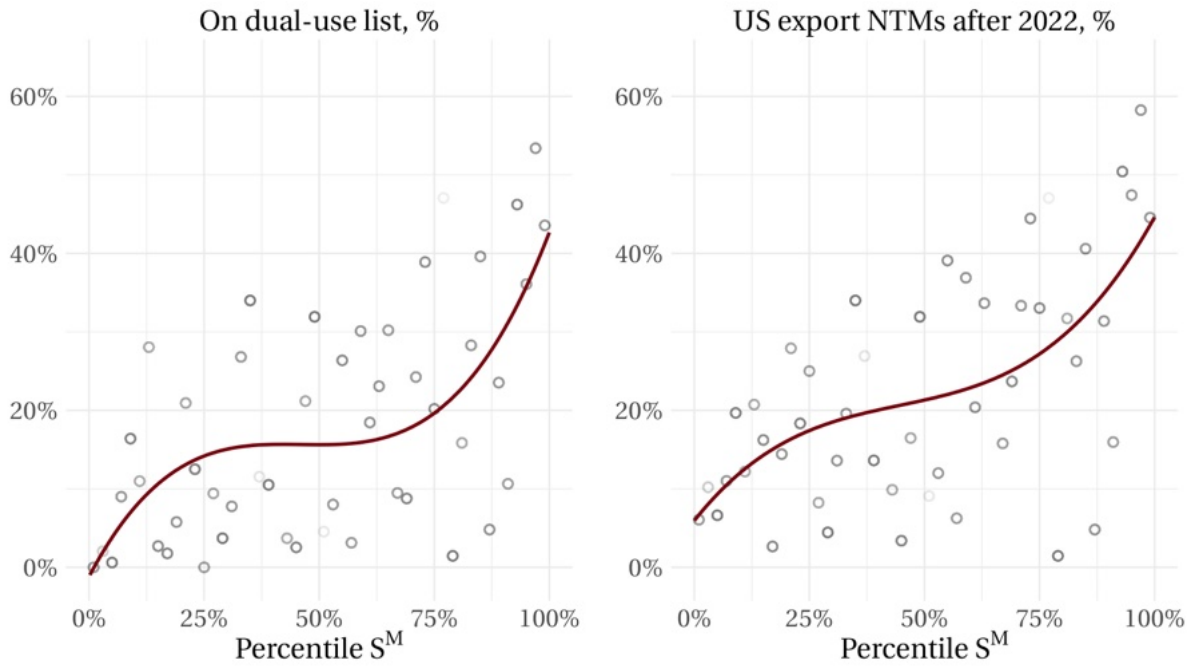
$$\log y_{wijkt} = \alpha^{\mathcal{T}}_{wijk} + \alpha^{\mathcal{X}}_{wikt} + \alpha^{\mathcal{M}}_{wjkt} + \gamma_{t,R} \times \text{Relationship}_{wij} + \beta_{t,R} \times \text{Relationship}_{wij} \times \text{Dual-use}_{k} + \varepsilon_{wijkt},$$

where $\alpha^{\mathcal{T}}_{wijk}$, $\alpha^{\mathcal{X}}_{wikt}$, and $\alpha^{\mathcal{M}}_{wjkt}$ are a set of war-exporter-importer-product, war-exporter-product-period, and war-importer-product-period fixed effects. $\text{Relationship}_{wij}$ is an indicator for allies, enemies, or neither, with the first two values attainable only when i is a war participant. Period $t = 0$ marks the start of the war. Period $t = -1$ is used as a baseline. Standard errors are heteroskedasticity-robust; confidence intervals are 95%. Figure SA.B.5 plots $\gamma_{t,R}$.

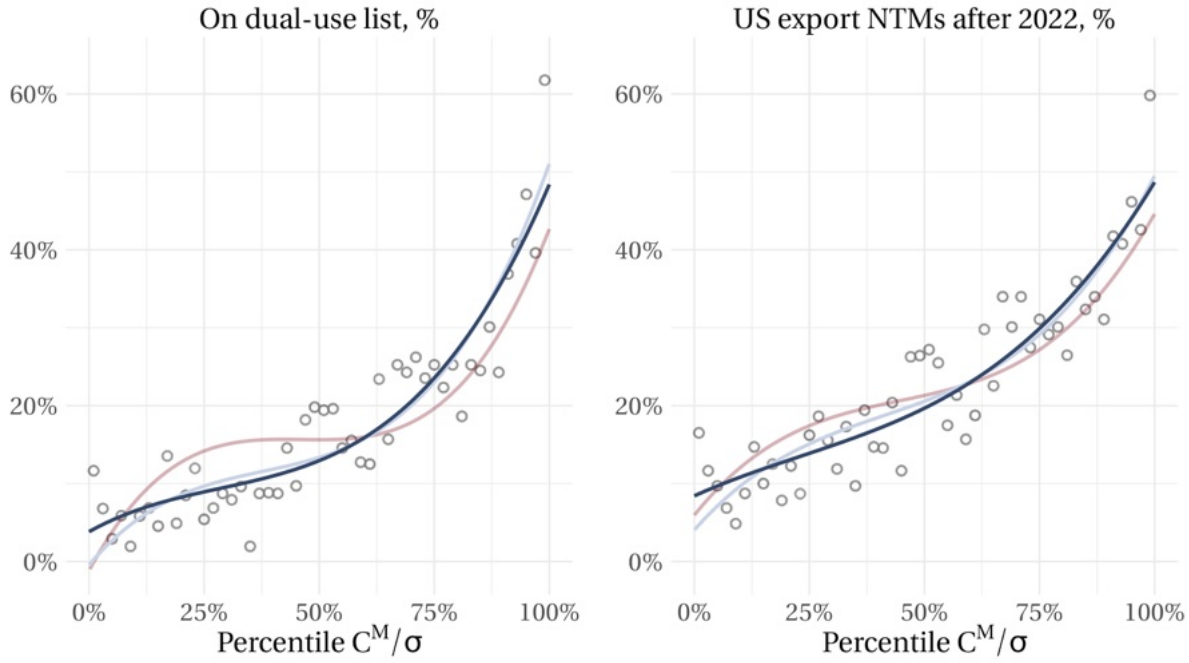
Figure C.5: Trade in dual-use goods by diplomatic relationship: War studies

C.2 Empirical measurement

C.2.1 Policy targeting



(a) Share



(b) Centrality

Figure C.6: Military sales share and policy lists

Dependent Variable:	On dual-use list: Yes						
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
S^M_{US}	0.6027***		-0.0230				
	(0.0933)		(0.0752)				
$\mathcal{C}^M_{\text{US}}/\sigma$		3.020***	3.063***	2.733***	2.796***	2.647***	1.989***
		(0.3266)	(0.3767)	(0.3126)	(0.3151)	(0.2830)	(0.2326)
Fixed-effects							
Polynomial S^M_{US}				Yes			
Piecewise S^M_{US}					Yes	Yes	Yes
Goods controls (trade, sales, ...)						Yes	Yes
HS 2-digit							Yes
Fit statistics							
Observations	5,135	5,135	5,135	5,135	5,135	5,134	5,134
R^2	0.02127	0.05871	0.05872	0.07982	0.08109	0.12472	0.32306
Within R^2				0.07982	0.04179	0.04813	0.02436

Heteroskedasticity-robust standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

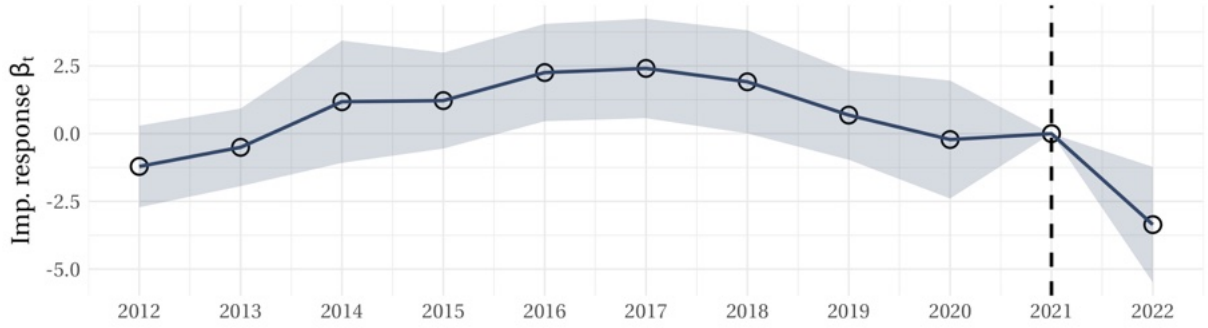
Table C.1: Dual-use goods: A regression analysis

Dependent Variable:	Had a US export NTM after 2022						
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
S^M_{US}	0.5773***		0.0783				
	(0.0926)		(0.0915)				
$\mathcal{C}^M_{\text{US}}/\sigma$		2.589***	2.443***	2.179***	2.166***	1.936***	0.7753*
		(0.3339)	(0.3825)	(0.3200)	(0.3249)	(0.2989)	(0.3023)
Fixed-effects							
Polynomial S^M_{US}				Yes			
Piecewise S^M_{US}					Yes	Yes	Yes
Goods controls (trade, sales, ...)						Yes	Yes
HS 2-digit							Yes
Fit statistics							
Observations	5,135	5,135	5,135	5,135	5,135	5,134	5,134
R^2	0.01597	0.03529	0.03547	0.05602	0.06666	0.16260	0.38638
Within R^2				0.05602	0.02950	0.03695	0.01805

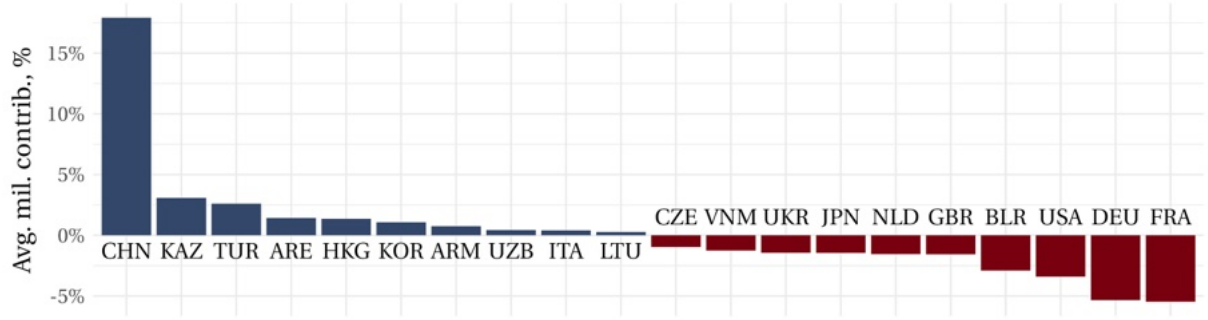
Heteroskedasticity-robust standard-errors in parentheses
*Signif. Codes: ***: 0.001, **: 0.01, *: 0.05*

Table C.2: Robustness: Baseline

C.2.2 Trade flows: Events

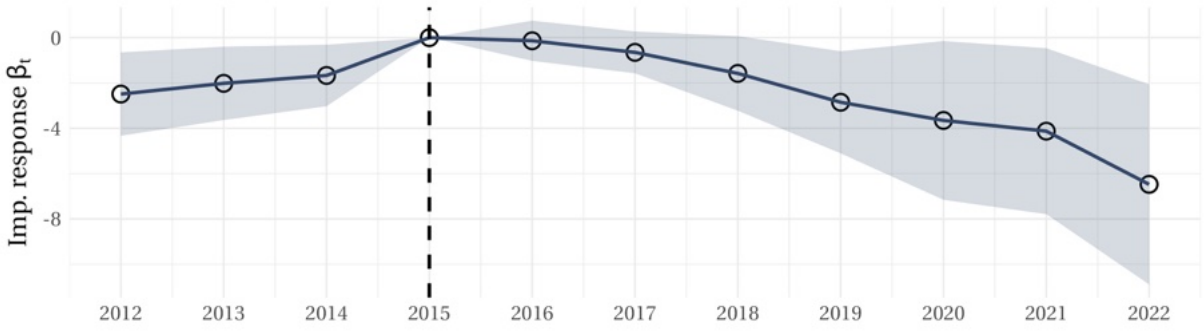


(a) Russia, change between 2021 and 2022

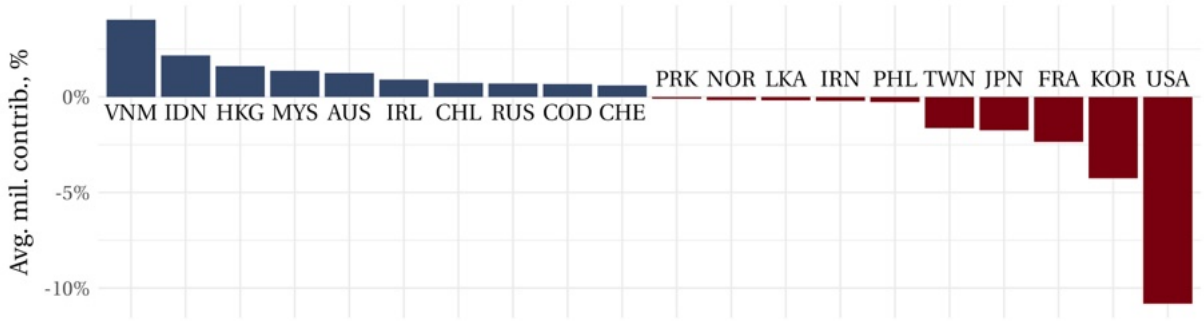


(b) Russia, 2022 War

Figure C.7: Trade responses following geopolitical shocks: Russia-2022



(a) China, change between 2015 and 2022



(b) China, 2015-2022

Figure C.8: Trade responses following geopolitical shocks: China-2016

C.2.3 Trade flows: Decomposition by good

HS code	Description	ISO	chg (%)
930690	Ammunition; n.e.c. in chapter 93	POL	8.22
930110	Military weapons; artillery weapons (e.g. guns, howitzers, and mortars)	POL	5.05
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	CAN	2.68
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	POL	2.04
930690	Ammunition; n.e.c. in chapter 93	SVK	1.83
890610	Vessels; warships	USA	1.41
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	BEL	1.38
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	ROU	1.18
930110	Military weapons; artillery weapons (e.g. guns, howitzers, and mortars)	SVK	1.12
271000	Petroleum oils and oils from bituminous minerals, not containing biodiesel, not crude, not waste oils; preparations n.e.c, containing by weight 70% or more of petroleum oils or oils from bituminous minerals; light oils and preparations	POL	0.94
930690	Ammunition; n.e.c. in chapter 93	NOR	0.89
930630	Ammunition; cartridges and parts thereof n.e.c. in heading no. 9306	USA	0.78
880212	Helicopters; of an unladen weight exceeding 2000kg	ROU	0.57
850220	Electric generating sets; with spark-ignition internal combustion piston engines	CHN	0.49
880212	Helicopters; of an unladen weight exceeding 2000kg	SVK	0.47
871639	Trailers and semi-trailers; (other than tanker type)	POL	0.42
271000	Petroleum oils and oils from bituminous minerals, not containing biodiesel, not crude, not waste oils; preparations n.e.c, containing by weight 70% or more of petroleum oils or oils from bituminous minerals; light oils and preparations	BGR	0.40
930630	Ammunition; cartridges and parts thereof n.e.c. in heading no. 9306	SVK	0.38
271000	Petroleum oils and oils from bituminous minerals, not containing biodiesel, not crude, not waste oils; preparations n.e.c, containing by weight 70% or more of petroleum oils or oils from bituminous minerals; light oils and preparations	IND	0.38
871631	Tanker trailers and tanker semi-trailers	TUR	0.36

Table C.3: Ukraine: country-goods

HS code	Description	ISO	chg (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	FRA	-4.16
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	DEU	-2.12
841112	Turbo-jets; of a thrust exceeding 25kN	USA	-1.92
890510	Dredgers	CHN	-1.78
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	CHN	-0.94
841112	Turbo-jets; of a thrust exceeding 25kN	GBR	-0.64
851712	Telephones for cellular networks or for other wireless networks	VNM	-0.59
890190	Vessels; n.e.c. in heading no. 8901, for the transport of goods and other vessels for the transport of both persons and goods	NLD	-0.58
871639	Trailers and semi-trailers; (other than tanker type)	DEU	-0.50
890120	Tankers	CHN	-0.49
890399	Yachts and other vessels; for pleasure or sports, rowing boats and canoes, n.e.c. in heading no. 8903, other than inflatable	NLD	-0.47
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	VNM	-0.40
841112	Turbo-jets; of a thrust exceeding 25kN	POL	-0.39
890190	Vessels; n.e.c. in heading no. 8901, for the transport of goods and other vessels for the transport of both persons and goods	DEU	-0.34
281820	Aluminium oxide; other than artificial corundum	UKR	-0.31
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	CHN	-0.30
281820	Aluminium oxide; other than artificial corundum	AUS	-0.29
890590	Vessels; light, fire-floats, floating cranes and other vessels, the navigability of which is subsidiary to their main function, floating docks	TUR	-0.27
890130	Vessels, refrigerated; other than tankers	JPN	-0.25
841112	Turbo-jets; of a thrust exceeding 25kN	FRA	-0.24

Table C.4: Russia: country-goods

HS code	Description	ISO	chg (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	USA	-9.89
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	KOR	-4.28
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	TWN	-2.77
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	FRA	-2.10
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	KOR	-1.33
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	JPN	-1.14
890190	Vessels; n.e.c. in heading no. 8901, for the transport of goods and other vessels for the transport of both persons and goods	TWN	-0.69
890120	Tankers	KOR	-0.68
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	DEU	-0.64
841112	Turbo-jets; of a thrust exceeding 25kN	RUS	-0.63
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	JPN	-0.50
841191	Turbines; parts of turbo-jets and turbo-propellers	USA	-0.49
890590	Vessels; light, fire-floats, floating cranes and other vessels, the navigability of which is subsidiary to their main function, floating docks	JPN	-0.32
901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013	THA	-0.31
841112	Turbo-jets; of a thrust exceeding 25kN	USA	-0.29
270112	Coal; bituminous, whether or not pulverised, but not agglomerated	AUS	-0.28
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	JPN	-0.24
901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013	JPN	-0.22
901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013	TWN	-0.19
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	SGP	-0.19

Table C.5: China: country-goods

C.3 Policy evaluation

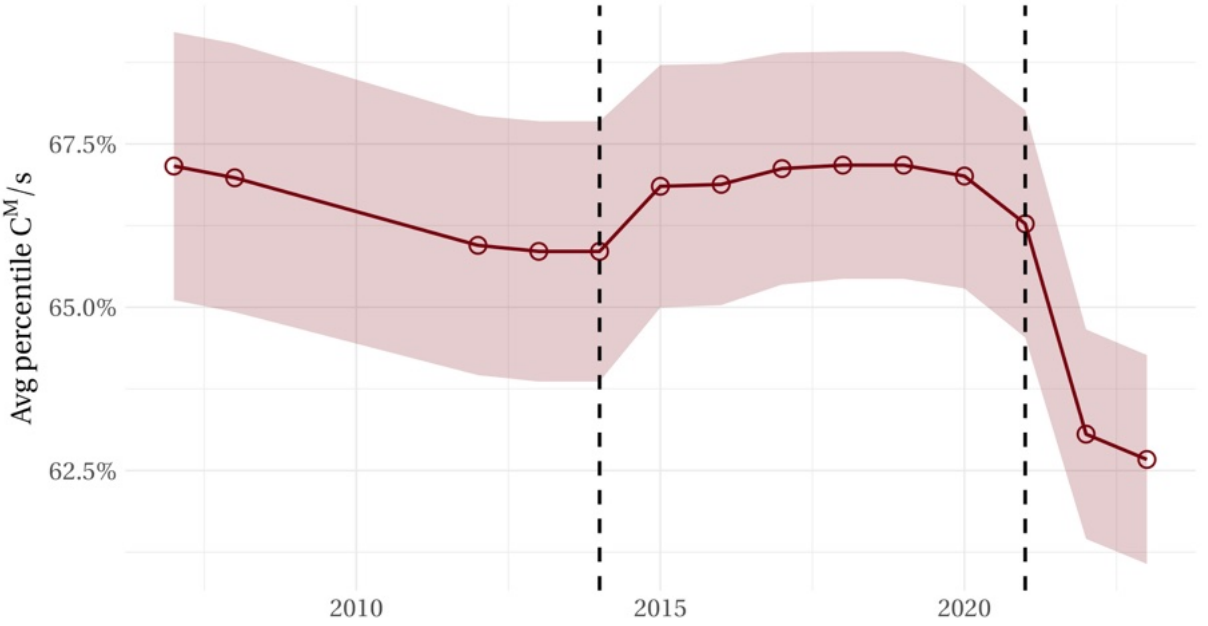


Figure C.9: EU dual-use lists: Military use over time

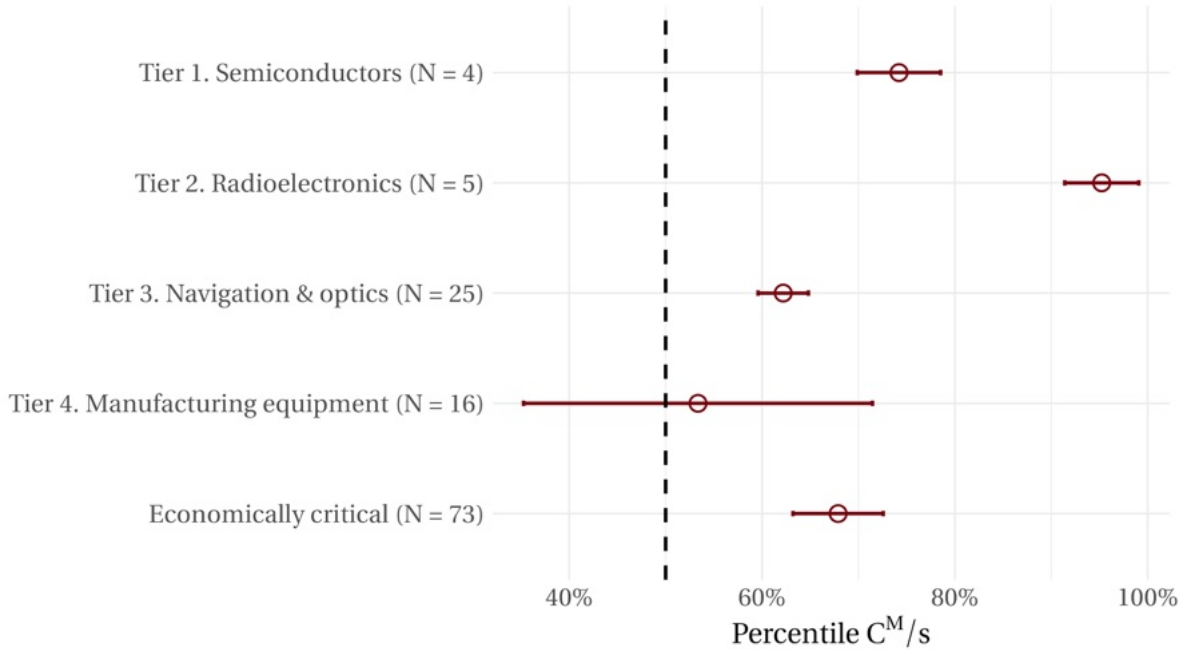
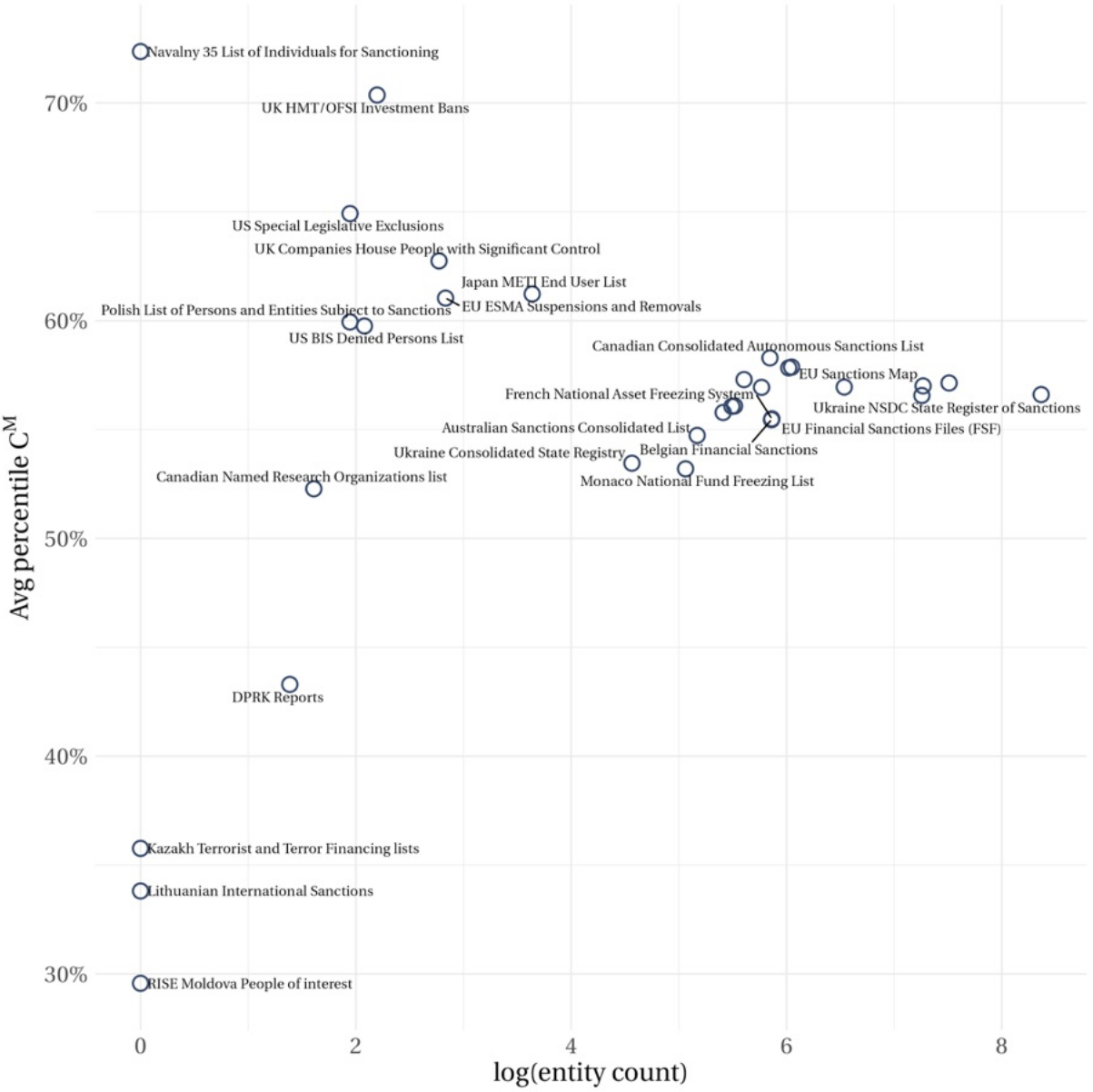


Figure C.10: EU Commission critical goods



Notes: The database of sanctions is taken from the OpenSanctions project. The Russian enterprises are matched to the Russian tax registry EGRUL, and the provided OKVED industries are then crosswalked into NAICS (Rev. 2012) codes. The centrality rank is then taken for the resulting industries. When an entity is linked to multiple industries, we treat those probabilistically, so one entity can have several weighted observations. Supplementary Appendix Figure SA.B.33 reports confidence intervals on the estimates.

Figure C.11: Sanctions against Russia

C.4 Calibration

The effect for the U.S. increases from 180% to 250%, while the effect for China drops from 225% to 140%. That happens because military spending affects demand for factors across countries, which affects final goods' prices. An increase in Chinese military demand lowers home wages ($d \log w_{\text{CHN}}/dM_{\text{CHN}} = -0.025$) because military sectors depend more on the Rest of the World than consumer sectors (38% and 25.8% of the basket respectively; Table C.6). The opposite happens in the U.S. ($d \log w_{\text{CHN}}/dM_{\text{CHN}} = 0.017$, 31% and 19% of the basket). That results in the value of the prize being lower compared to the partial equilibrium in China and higher in the U.S..

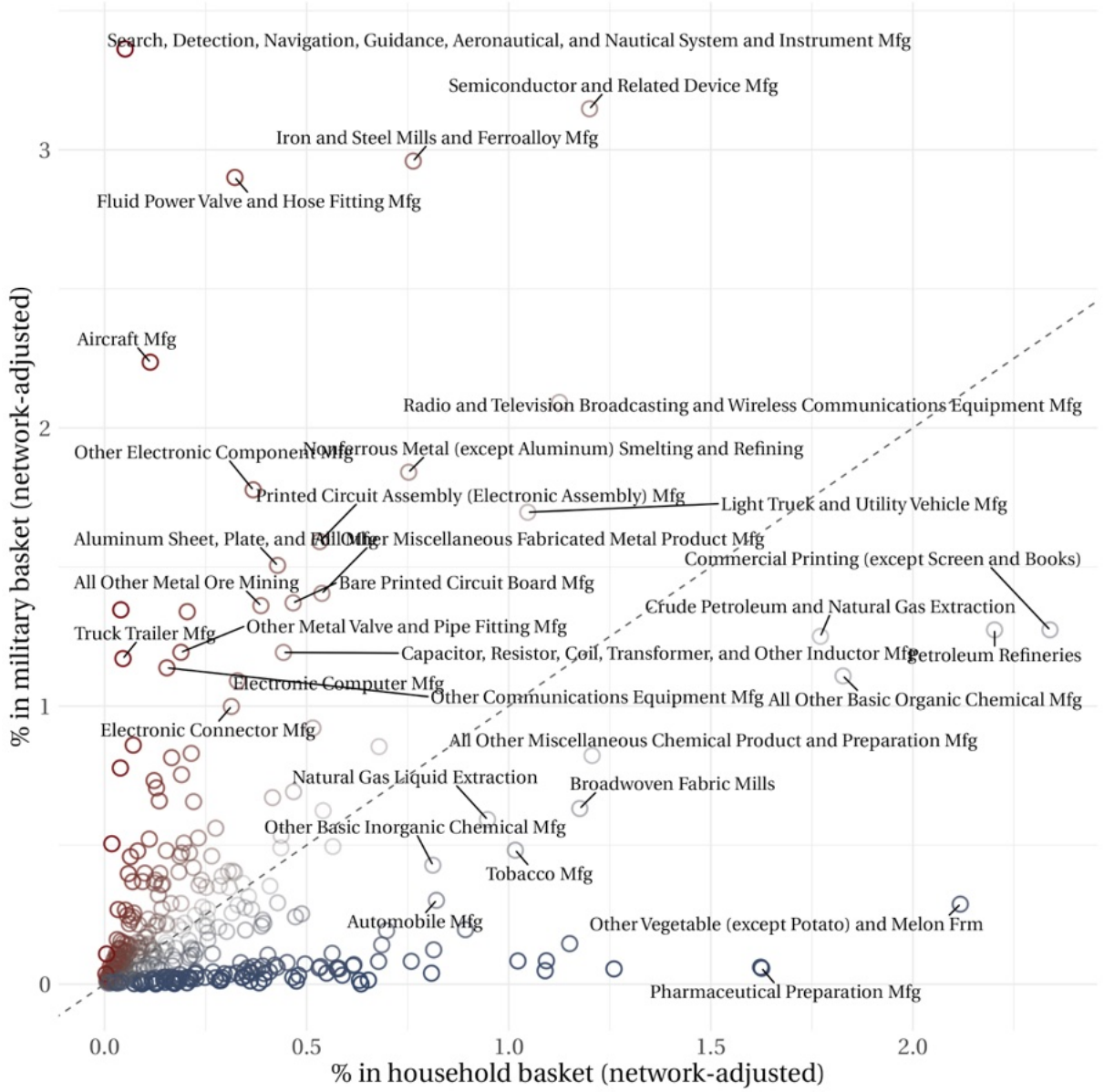
	CHN			USA			ROW		
	w	P^C	P^M	w	P^C	P^M	w	P^C	P^M
CHN	-2.4847	-1.8049	-1.4985	0.0615	0.0740	0.0635	-0.8000	-0.5867	-0.4875
USA	-0.2051	-0.2245	-0.2136	1.6932	1.1047	1.3337	-0.3901	-0.2833	-0.3238
ROW	0.0000	-0.0951		0.0000	0.0473		0.0000	-0.0392	

Notes: The rows indicate the country that increases its military spending. The columns report reactions for various prices in respective countries. The rest of the world wage is normalized.

	CHN		USA		ROW	
	C	M	C	M	C	M
CHN	72.498	60.181	3.659	2.101	3.608	0.000
USA	1.739	1.565	65.115	78.693	2.662	0.000
ROW	25.763	38.254	31.226	19.206	93.730	100.000

Notes: The rows report the network-adjusted purchase share of the labor factor across various countries by consumers and military.

Table C.6: Decomposition of general equilibrium effects behind military spending



Notes: Data for the Chinese input-output table is taken for 2018 from the National Bureau of Economic Statistics. Data for the final military demand is coming from the revenue of military firms accessed via CSMAR. We convert NBES industry classifications to NAICS (Rev. 2012). The consumer and military network-adjusted sales are calculated using Leontief inverses as $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{C}}]'\mathbf{1}}\right]$ and $\left[\frac{(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}}{[(\mathbf{I}-\mathbf{\Omega})^{-1\prime}\mathbf{s}^{\mathbf{M}}]'\mathbf{1}}\right]$, where $\mathbf{\Omega}$ is an input-output expenditure matrix and $\mathbf{s}^{\mathbf{C}}$, $\mathbf{s}^{\mathbf{M}}$ are expenditure shares of final agents.

Figure C.12: 2018 input-output table for China

	USA (% change)			CHN (% change)			baseline		
	CHN	USA	ROW	CHN	USA	ROW	CHN	USA	ROW
U^I	-1.000	0.166	0.019	1.506	-1.583	0.270	19.436	53.941	41.553
U^C	-1.182	0.245	0.016	1.748	-2.846	0.254	16.144	29.162	41.993
U^M	-0.068	0.065		0.082	-0.079		3.994	25.348	
c	-1.241	0.256	0.019	1.874	-2.917	0.270	63.222	28.592	41.553
C	-0.582	-1.105	0.000	-4.655	-0.654	0.000	15.442	28.592	41.553
P^C	0.668	-1.358	-0.019	-6.408	2.330	-0.269	0.244	1.000	1.000
ν	-0.033	0.033		0.040	-0.040		0.489	0.511	
m	-1.104	0.572		0.743	-1.369		0.707	0.678	
M	-0.582	-1.105		-4.655	-0.654		0.233	0.682	
P^M	0.528	-1.668		-5.358	0.725		0.329	1.006	
wL	-0.656	-2.141	0.000	-8.793	-0.933	0.000	13.895	20.533	52.074
R/wL	0.000	0.578		3.883	0.000		0.000	0.000	
$mp_{\text{CHN},\cdot}$	-0.730	-2.450	-0.748	-9.955	-41.796	2.596	63.561	1.883	2.477
$mp_{\text{USA},\cdot}$	-50.105	-2.078	1.105	-11.102	-0.942	-3.833	0.549	70.238	1.678
$mp_{\text{ROW},\cdot}$	3.764	-2.317	0.000	-11.837	7.285	0.000	5.591	9.085	4.155

Table C.7: Baseline welfare

	USA (% change)			CHN (% change)			baseline		
	CHN	USA	ROW	CHN	USA	ROW	CHN	USA	ROW
U^I	-0.090	-0.158	-0.015	-0.218	-0.097	0.037	18.879	54.522	41.553
U^C	-0.235	-0.235	-0.235	-0.034	-0.034	-0.034	85.587	85.587	85.587
U^M	-0.427	0.410		0.230	-0.220		3.437	25.929	
c	-0.015	-0.673	-0.015	-0.318	0.015	0.037	63.222	28.592	41.553
C	0.147	-0.232	0.000	0.107	-0.050	0.000	15.442	28.592	41.553
P^C	0.161	0.444	0.015	0.426	-0.065	-0.037	0.244	1.000	1.000
ν	-0.209	0.209		0.113	-0.113		0.489	0.511	
m	-0.004	11.604		5.518	0.036		0.707	0.678	
M	0.147	-0.232		0.107	-0.050		0.233	0.682	
P^M	0.151	-10.605		-5.128	-0.086		0.329	1.006	
wL	0.166	-0.148	0.000	0.142	-0.071	0.000	13.895	20.533	52.074
R/wL	0.000	-0.183		-0.021	0.000		0.000	0.000	
$mp_{\text{CHN},\cdot}$	0.111	-0.388	0.431	0.156	0.341	0.314	63.561	1.883	2.477
$mp_{\text{USA},\cdot}$	-3.090	-0.246	-0.636	0.255	-0.060	-0.464	0.549	70.238	1.678
$mp_{\text{ROW},\cdot}$	0.364	-0.224	0.000	0.228	-0.141	0.000	5.591	9.085	4.155

Table C.8: Industrial policy results

D Theory

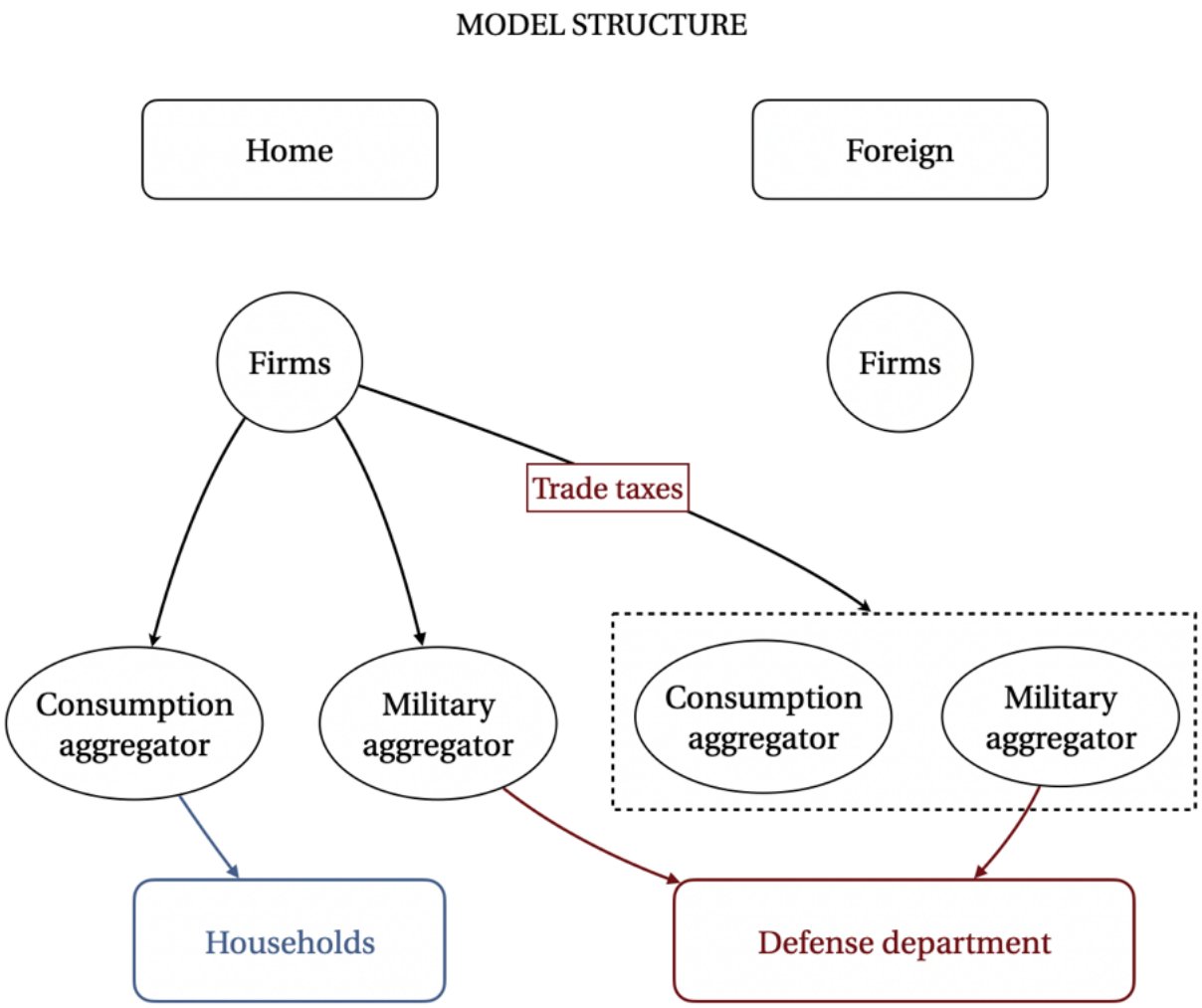


Figure D.1: Horizontal model structure

D.1 Proof of Proposition 1

Proof. We first characterize the best response policies. After that, we describe the Nash equilibrium. The best response for defense spending was established in (18) and is given by

$$M_i = \beta_i^{\zeta_i} \left(M_{-i} \frac{P_i^M}{P_{-i}^M} \right)^{1-\zeta_i}. \tag{69}$$

For trade policy, consider small changes in taxes imposed by government i. The result-

ing change in welfare is given by

$$dW_i = \underbrace{dR_i}_{\text{revenue}} + \underbrace{M_i d\log P_{-i}^M}_{\text{foreign military}} - \underbrace{(C_i d\log P_i^C + M_i d\log P_i^M)}_{\text{domestic distortion}} \tag{70}$$

It is a sum of revenue and price effects. By Shephard's lemma, the changes in prices are

$$d\log P_i^C = \sum_{k\in\{H,F\}} s_{ik}^C d\log \tau_{ik}^{\mathcal{M}}, \qquad d\log P_i^M = \sum_{k\in\{H,F\}} s_{ik}^M d\log \tau_{ik}^{\mathcal{M}}, \tag{71}$$

$$d\log P_{-i}^M = s_{-i,i}^M d\log \tau_{-i,i}^{\mathcal{X}}.$$

The revenue changes can be expanded as

$$\begin{aligned} dR_i = \frac{E_{-i,i}}{\tau_{-i,i}^{\mathcal{M}}} \Bigg[\overbrace{\frac{\tau_{-i,i}^{\mathcal{X}}-1}{\tau_{-i,i}^{\mathcal{X}}}(\mathcal{E}_{-i,i}^{-i,i}-1)}^{\text{decrease in spending}} + \underbrace{1}_{\text{unit revenue}} \Bigg] d\log \tau_{-i,i}^{\mathcal{X}} \\ + \sum_{k\in\{H,F\}} \Bigg[\overbrace{\frac{\tau_{ik}^{\mathcal{M}}-1}{\tau_{ik}^{\mathcal{M}}} E_{ik}(\mathcal{E}_{ik}^{ik}-1)}^{\text{decrease in spending}} + \overbrace{\sum_{l\neq k} \frac{\tau_{il}^{\mathcal{M}}-1}{\tau_{il}^{\mathcal{M}}} E_{il}\mathcal{E}_{ik}^{il}}^{\text{revenue diversion}} + \underbrace{E_{ik}}_{\text{unit revenue}} \Bigg] d\log \tau_{ik}^{\mathcal{M}} \end{aligned} \tag{72}$$

An increase in the export tax increases the revenue earned from one unit exported but loses revenue due to decreased foreign demand. An increase in the import tariff does the same for home but additionally generates revenue spillovers due to shifts of home spending to other imported goods. Elasticities are further expanded in the Supplementary Appendix A.1.

Combining changes in revenue and changes in trade taxes, we obtain

$$\begin{aligned} dW_i = \frac{E_{-i,i}}{\tau_{-i,i}^{\mathcal{M}}} \left[\frac{\tau_{-i,i}^{\mathcal{X}}-1}{\tau_{-i,i}^{\mathcal{X}}}(\mathcal{E}_{-i,i}^{-i,i}-1) + 1 + \tau_{-i,i}^{\mathcal{M}} \frac{M_i}{M_{-i}} S_{-i,i}^M \right] d\log \tau_{-i,i}^{\mathcal{X}} \\ + \sum_{k\in\{H,F\}} \left[\frac{\tau_{ik}^{\mathcal{M}}-1}{\tau_{ik}^{\mathcal{M}}} E_{ik}(\mathcal{E}_{ik}^{il}-1) + \sum_{l\neq k} \frac{\tau_{il}^{\mathcal{M}}-1}{\tau_{il}^{\mathcal{M}}} E_{il}\mathcal{E}_{ik}^{il} \right] d\log \tau_{ik}^{\mathcal{M}} \end{aligned} \tag{73}$$

Under the best response policies, small changes in trade taxes should not lead to changes in welfare. Rearranging the terms in brackets generates the following matrix expression:

$$\overbrace{\begin{bmatrix} \frac{\tau_{-i,i}^{\mathcal{X}}-1}{\tau_{-i,i}^{\mathcal{X}}} \\ \frac{\tau_{ii}^{\mathcal{M}}-1}{\tau_{ii}^{\mathcal{M}}} \\ \frac{\tau_{i,-i}^{\mathcal{M}}-1}{\tau_{i,-i}^{\mathcal{M}}} \end{bmatrix}}^{\text{trade taxes}} = -\overbrace{\begin{bmatrix} \frac{E_{-i,i}}{\tau_{-i,i}^{\mathcal{M}}}(\mathcal{E}_{-i,i}^{-i,i}-1) & 0 & 0 \\ 0 & E_{ii}(\mathcal{E}_{ii}^{ii}-1) & E_{i,-i}\mathcal{E}_{ii}^{i,-i} \\ 0 & E_{ii}\mathcal{E}_{i,-i}^{ii} & E_{i,-i}(\mathcal{E}_{i,-i}^{i,-i}-1) \end{bmatrix}}^{\text{revenue responses}}{}^{-1} \overbrace{\begin{bmatrix} \frac{E_{-i,i}}{\tau_{-i,i}^{\mathcal{M}}}\left(1+\tau_{-i,i}^{\mathcal{M}}\frac{M_i}{M_{-i}}S_{-i,i}^M\right) \\ 0 \\ 0 \end{bmatrix}}^{\text{national security vector}} \tag{74}$$

Thus, we obtain the best response tax policy:

$$\frac{\tau^{\mathcal{X}}_{-i,i}-1}{\tau^{\mathcal{X}}_{-i,i}} = -\frac{\overbrace{1}^{\text{ToT}} + \overbrace{\tau^{\mathcal{M}}_{-i,i}(M_i/M_{-i})S^{M}_{-i,i}}^{\text{national security externality}}}{\mathcal{E}^{-i,i}_{-i,i}-1}, \qquad \tau^{\mathcal{M}}_{ik}=1. \tag{75}$$

For a civilian good with $S^{M}_{-i,i}=0$, the export tax follows the standard inverse elasticity rule $(\tau^{X}_{-i,i}-1)/\tau^{X}_{-i,i} = -1/(\mathcal{E}^{-i,i}_{ii}-1)$. An additional term $\tau^{\mathcal{M}}_{-i,i}(M_i/M_{-i})S^{M}_{-i,i}$ in the numerator presents a Pigouvian way to correct for a national security externality by internalizing the cost every unit sold to a foreign defense sector has on domestic welfare. It grows with the sales share of a variety to the foreign defense sector $S^{M}_{-i,i}$. The best response policy for the import tariff is $\tau^{\mathcal{M}}_{ik}=1$. Any domestic price manipulation results in a deadweight loss.

Equations (69) and (75) characterize the best response policies. To solve for the Nash equilibrium, we posit that those expressions hold simultaneously for both countries. Taking the logs of both sides in (69), we obtain

$$\log M_i = -\zeta_i \log \beta_i + (1-\zeta_i)(\log M_{-i} + \log P^{M}_{i} - \log P^{M}_{-i}) \tag{76}$$

Solving the system of equations for $i \in \{H,F\}$ yields

$$M_i = \beta_i^{\zeta_{-i,i}} \beta_{-i}^{(1-\zeta_i)\zeta_{i,-i}} \left(\frac{P^{M}_{i}}{P^{M}_{-i}}\right)^{(1-\zeta_i)\zeta_{i,-i}}, \quad \zeta_{i,-i} \equiv \frac{\zeta_{-i}}{\zeta_i + \zeta_{-i} - \zeta_i\zeta_{-i}} \tag{77}$$

Here $\zeta_{i,-i}$, which we will call *conflict elasticity*, is a measure of how responsive home welfare is to changes in the relative military price ratio (P^{M}_{i}/P^{M}_{-i}). The import tariffs are zero for both countries, $\tau^{\mathcal{M}}_{ik}=1$. Following that, we plug zero import tariffs into (75) to obtain (21). The derivation is complete. □

More broadly, the best response trade taxes (75) apply to any game in which home government takes foreign defense spending M_{-i} as given. These are one-shot games in which foreign government picks its policies $\mathcal{P}^{(-i)}$ before or simultaneously with home trade policy $\mathcal{P}^{i}_{\tau}$.

D.2 Calibration: Jacobian calculation

The goods market clearing can be written as

$$\mathbf{X} = \tilde{\mathbf{\Psi}}'(\mathbf{s}^{\mathbf{C}}(\mathbf{wL}+\mathbf{R}+\mathbf{D}-\mathbf{M}) + \mathbf{s}^{\mathbf{M}}\mathbf{M}) \tag{78}$$

Note that

$$R_i = \sum_{k\in\mathcal{K}_{-i}} \frac{\tau^{\mathcal{X}}_{ki}-1}{\tau^{\mathcal{X}}_{ki}} \frac{\Omega^{M}_{ki}}{\tau^{\mathcal{M}}_{ki}} X_k + \sum_{k\in\mathcal{K}} \frac{\tau^{\mathcal{M}}_{k,-j}-1}{\tau^{\mathcal{M}}_{k,-j}} \Omega^{M}_{k,-j} X_k, \tag{79}$$

which can be recast in matrix form as $\mathbf{R} = \mathbf{\Lambda^R X}$. Accounting for revenue amplification, the goods market clearing can be recast as

$$\mathbf{X} = \mathbf{\Lambda^X}\tilde{\mathbf{\Psi}}'(\mathbf{s^C}(\mathbf{wL} + \mathbf{D} - \mathbf{M}) + \mathbf{s^M M}), \quad \mathbf{\Lambda^X} \equiv (\mathbf{I} - \tilde{\mathbf{\Psi}}'\mathbf{s^C}\mathbf{\Lambda^R})^{-1}. \tag{80}$$

The factor market clearing is

$$\mathbf{wL} = \mathbf{\Omega^{L'}X}. \tag{81}$$

Plugging in an expression for $\mathbf{X}$ yields

$$\mathbf{\Lambda^L wL} = \mathbf{\Omega^{L'}\Lambda^X}\tilde{\mathbf{\Psi}}'(\mathbf{s^C}(\mathbf{D} - \mathbf{M}) + \mathbf{s^M M}), \quad \mathbf{\Lambda^L} \equiv \mathbf{I} - \mathbf{\Omega^{L'}\Lambda^X}\tilde{\mathbf{\Psi}}'\mathbf{s^C}. \tag{82}$$

Solving for that equation allows us to solve for factor prices.

To find a wage jacobian, we now consider an equation that results from small policy changes:

$$\begin{aligned}(d\mathbf{\Lambda^L})\mathbf{wL} + \mathbf{\Lambda^L wL}d\log\mathbf{w} = {} & d\mathbf{\Omega^{L'}\Lambda^X}\tilde{\mathbf{\Psi}}'(\mathbf{s^C}(-\mathbf{D} - \mathbf{M}) + \mathbf{s^M M}) \\ & + \mathbf{\Omega^{L'}}(d\mathbf{\Lambda^X})\tilde{\mathbf{\Psi}}'(\mathbf{s^C}(-\mathbf{D} - \mathbf{M}) + \mathbf{s^M M}) \\ & + \mathbf{\Omega^{L'}\Lambda^X}(d\tilde{\mathbf{\Psi}}')(\mathbf{s^C}(-\mathbf{D} - \mathbf{M}) + \mathbf{s^M M}) \\ & + \mathbf{\Omega^{L'}\Lambda^X}\tilde{\mathbf{\Psi}}'d(\mathbf{s^C}(-\mathbf{D} - \mathbf{M}) + \mathbf{s^M M})\end{aligned} \tag{83}$$

One can further expand changes in each matrix:

$$d\tilde{\mathbf{\Psi}}' = -\tilde{\mathbf{\Psi}}'(d\tilde{\mathbf{\Omega}}')\tilde{\mathbf{\Psi}}', \qquad d\mathbf{\Lambda^X} = \mathbf{\Lambda^X}d(\tilde{\mathbf{\Psi}}'\mathbf{s^C}\mathbf{\Lambda^R})\mathbf{\Lambda^X}. \tag{84}$$

Expressing the primitive $d\mathbf{\Omega}$ as a function of $d\log\mathbf{w}$ and $d\log\mathbf{P}$ for taxes and military changes allows to recast the expression as

$$\mathbf{A}d\log\mathbf{w} = d\log\mathbf{P}, \tag{85}$$

which allows us to recover a relevant jacobian.

D.3 Calibration: Stockpiling

The utility contest function is

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N) = c_i + \sum_{j\neq i}\alpha_{ij}c_j + \beta_i\frac{g(m_i)}{g(m_i) + \sum_{j\neq i}g(m_j)}. \tag{86}$$

Taking the first-order condition with two players yields

$$\frac{\beta_i}{P_i^M}\frac{g'(m_i)(g(m_i) + \sum_{j\neq i}g(m_j)) - g(m_i)g'(m_i)}{(g(m_i) + \sum_{j\neq i}g(m_j))^2} = \frac{1}{P_i^C} \tag{87}$$

or

$$\beta_i \frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}. \tag{88}$$

The derivative with respect to m_j is

$$\beta_i \frac{g'(m_j)}{g(m_j)} \frac{\nu_i \nu_j}{P_j^M}. \tag{89}$$

If $g(m_i) = m_i^\gamma$, then $g'/g = \gamma m_i^{-1}$. If there is a stockpile of goods m_{0i} and $g(m_i) = (m_{0i} + m_i)^\gamma$, then $g'/g = \gamma(m_{0i} + m_i)^{-1}$. We introduce $g'/g = \gamma \kappa_i m_i^{-1}$, where $\kappa_i = m_i/(m_{0i} + m_i)$ is the ratio of military good to the total good including the stockpile. Note that in that case

$$\nu_i = \frac{(m_{0i} + m_i)^\gamma}{(m_{0i} + m_i)^\gamma + (m_{0,-i} + m_{-i})^\gamma} = \frac{\kappa_i^{-\gamma} m_i^\gamma}{\kappa_i^{-\gamma} m_i^\gamma + \kappa_{-i}^{-\gamma} m_{-i}^\gamma}. \tag{90}$$

For the purpose of γ estimation we assume that $\kappa_i = \kappa_{-i}$, simplifying the expression to

$$\nu_i = \frac{m_i^\gamma}{m_i^\gamma + m_{-i}^\gamma}. \tag{91}$$

From that,

$$\gamma \beta_i \kappa_i m_i^{-1} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}, \qquad \kappa_i \equiv \frac{m_i}{m_{0i} + m_i}, \tag{92}$$

naturally follows.