
Export policy for dual-use goods*

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Abstract

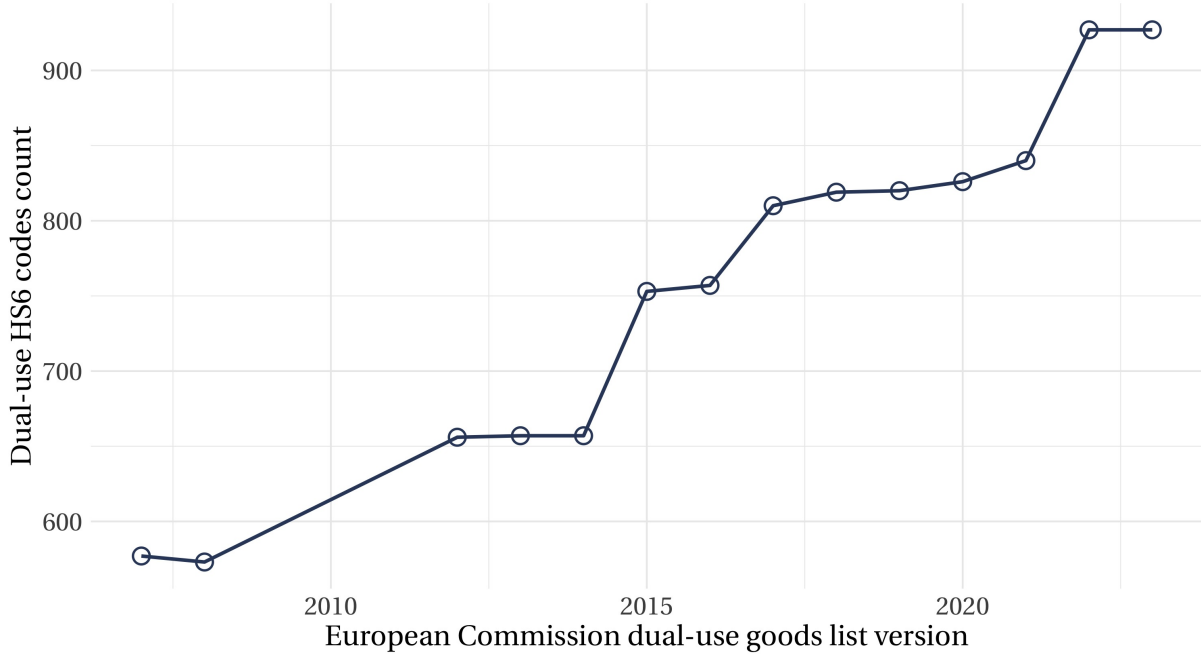
We study optimal export taxes on dual-use goods—items with both military and civilian applications—by adding a military contest into a trade model. The optimal export tax on a given good depends on the trade-off between its network-adjusted sales share to the foreign military and its roundabout sales share to domestic agents, scaled by the good’s demand elasticity. Applying these sufficient statistics to U.S. military procurement data yields a measure of military use that predicts existing export controls. We calibrate our model to the U.S.-China conflict and find that stockpiling, reshipping, and general-equilibrium propagation substantially affect policy outcomes.

Keywords: trade policy, networks, military

JEL Codes: F11, F13, F50

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Recent armed conflicts have renewed the interest of trade economists in export controls. An important variable when it comes to export controls is the scope of targeting trade in dual-use goods—items such as semiconductors or drones with both military and civilian applications. Figure 1 plots how the number of Harmonized System 6-digit product categories flagged for the EU customs dual-use screening has evolved over time. The scope of screening changes over time, especially in response to changes in the security environment.



Notes: Data for dual-use categories comes from the dual-use correlation tables by the EU TARIC electronic system (EC TARIC, 2023). There are ≈ 5500 HS categories in total. The figure reports counts in the HS revision of the release year of the correlation table. The increases are robust to conversions across revisions and to fixing weights for HS categories at their 2015-2019 international trade values (see the Online Appendix).

Figure 1: EU TARIC dual-use goods list

Newer quantitative trade policy studies have paid little attention to the military setting despite its instructive empirical traits—such as a distinct basket of goods and objectives. Given the increased policy relevance of dual-use export controls, closing that gap seems reasonable, especially these days when data on military procurement becomes increasingly available across countries.

Our paper characterizes optimal export policy for dual-use goods by adding a military contest into a neoclassical trade model. We first derive optimal export taxes across goods in a simplified setup with no general equilibrium effects. With U.S. procurement data, we construct a measure of military use across HS6 categories that is grounded in the sufficient statistics derived from our tax formulas. The resulting military use measure strongly predicts dual-use export restrictions in the cross-section of goods, suggesting that our simple

framework can rationalize current policy practices. The paper concludes with a quantitative analysis of the optimal macroeconomic levels of policy targeting for a potential U.S.-China conflict.

We formalize balance-of-militaries considerations within a neoclassical trade model. We begin with a partial equilibrium setup, which we later extend to a general equilibrium network model for our calibration. To that setup, we add the defense department as a second final demand agent alongside households. The defense department procures physical goods and is financed by household taxes. The government calibrates defense spending to offset declines in household consumption with the payoff from a contest with the foreign military. In our baseline specification with a two-country military balance, the contest payoff is a function of a simple ratio of the home military good to the foreign military good; later, we generalize it to a multi-country setting with flexible utility functions of consumption and military aggregates. We solve for the optimal taxes across goods and discuss how our results can be interpreted through various policy instruments—including export licensing, export controls, export bans, firm-level customer filtering, and other measures.

In our model, optimal export taxes depend on a trade-off between foreign military centrality and domestic distortion centrality. Military centrality is a network-adjusted sales share to the foreign military, which is scaled by a utility weight that captures the importance of winning the military contest relative to domestic consumption. Distortion centrality is a network-adjusted domestic sales share via roundabout imports. The trade-off depends on the import demand elasticity, which enters as a denominator that scales the centrality difference. The trade-off is thus more significant for less substitutable goods. A new Marshallian externality term augments standard revenue components in the optimal tax formulas. In our calibration exercise, we extend our model to include production factors in fixed supply and find that the generalized optimal tax formulas feature a similar factor centrality trade-off that is multiplied by the price response of each factor.

As a hypothetical illustration of our model’s mechanism, consider the U.S. microchip exports to China. Taxing microchip exports increases their price for the Chinese military but also increases the price of re-imported electronics containing those microchips for American buyers. For \$1 of U.S. export sales, foreign military centrality is the 30 cents that end up with the Chinese military and domestic distortion centrality is the 20 cents that return to the U.S. via electronics. The U.S. government favors higher export taxes on microchips when military tensions with China are high relative to the domestic consumption weight. If China can easily substitute American microchips with domestically produced ones, the trade-off matters less, and consequently, U.S. microchip exports should be taxed less. If trade instruments are limited to bans, a microchip ban will emerge as a second-best solution if the optimal export tax is high enough.

To benchmark policy targeting across goods against our theory, we bring the sufficient statistics from our tax formulas to the data and validate the resulting military use measure against dual-use export control lists. We construct our military use measure as military centrality for the U.S. closed-economy production network, scaled by the U.S. import demand elasticities. This approach captures production purchase shares in an economy with advanced technologies, open trade in factors, and parsimonious regulation; the goods' substitutability is derived from changes in international flows. The resulting measure is a strong predictor of inclusion in dual-use lists with a robust positive correlation. Its cubic polynomial yields a better fit ($R^2 = 0.85$) compared to a simple military sales share ($R^2 = 0.35$) or a military centrality without the elasticity scaling ($R^2 = 0.59$), as well as other non-model-based measures of centrality. These findings highlight the similarity between our model-based framework and existing export controls, but also demonstrate that both military centrality and import demand elasticities contain decision-relevant variation.

In the final part of the paper, we evaluate the macroeconomic magnitude behind the military-consumption trade-off. For that purpose, we extend our model to a flexible general equilibrium setup, add input-output tables for China, and calibrate the model to a potential U.S.-China conflict. The welfare weight on the military contest is estimated from the military spending levels: a marginal tax dollar allocated to the military should be as valuable as a marginal tax dollar left to households. Our estimate of the weight placed on conflict amounts to 2.5 times the annual U.S. GDP, though the estimate is sensitive to our assumptions regarding existing military stockpiles, as well as general equilibrium factor price adjustments. The returns to scale for military units are recovered from the trajectory of the U.S. military spending in response to the evolution of the Eastern Bloc military spending over time. Following the end of the Cold War, the U.S. spending responded less than one-to-one to the fall in the Eastern Bloc spending, suggesting decreasing returns to scale estimated at $\gamma \approx 0.5$.

Counterfactual exercises portray an intuitive picture. China has a more impactful export policy than the U.S., while the U.S. can respond by reducing China's budget set through import tariffs. The U.S. export policy, however, becomes more impactful than China's when it is coordinated with its allies in the Western coalition. Stockpile depletion doubles the impact of trade policy, while rerouting trade through third countries halves it. Overall, trade policy has a limited impact: roundabout network targeting has a modest pass-through into military production, which relies primarily on domestic resources.

The remainder of the paper proceeds as follows. Section 1 contextualizes our contribution within the broader literature. Section 2 presents a stylized model of trade in dual-use goods. Section 3 develops our empirical measure of military use. Section 4 presents the quantitative calibration. Section 5 concludes.

1 Related literature

Our paper studies the optimal export policy for dual-use goods with a military contest in the utility function. We use methods from the optimal tariff and production networks literature to characterize export taxes that increase the price of the foreign military's procurement basket. Empirically, we quantify the positions of goods in input-output networks and relate them to the existing work on trade restrictions. In contrast with the conflict literature, our calibration treats the military contest in a reduced-form way, using exogenous utility weights and thus abstracting from the more complex game theory behind the contest realization.

We solve for the optimal export taxes with a military contest in the utility function. Optimal tariff formulas have been derived across a variety of market structures (Helpman and Krugman, 1989): most recently, in a Ricardian setup with a continuum of goods (Costinot et al., 2015), under monopolistic competition with firm heterogeneity (Costinot et al., 2020), with economies of scale (Lashkaripour & Lugovskyy, 2022), and with a carbon emissions externality (Farrokhi and Lashkaripour, 2021, Kortum and Weisbach, 2021). Becko (2024) shows that the optimal sanctions problem is a scaled terms-of-trade manipulation problem. Our formulas extend these intuitions to a multi-agent setup with segmented military procurement.

We derive tax formulas for a network economy with arbitrary distortions. In doing so, we build upon the results in the production networks literature (Caliendo and Parro, 2015, Liu, 2019, Baqaee and Farhi, 2024). Our contributions include compact formulas for factor price adjustments and the reformulation of centrality in terms of sales shares for multi-agent economies.

Our military use measure follows the quantifications of industry positions in input-output networks (Leontief, 1936, Jones, 1976, Antràs et al., 2012). Cox et al. (2023) examines the industrial composition of government procurement, including military spending. We also rely on prior work that estimates import demand elasticities (Feenstra, 1994, Broda and Weinstein, 2006, Soderbery, 2015, Fontagné et al., 2022). The consequences of trade restrictions have been quantified for dual-use imports (Amodio et al., 2021), high-skilled immigration (Brinatti & Guo, 2024), and war sanctions (de Souza et al., 2024, Egorov et al., 2024). We compare the goods' network positions with applied international regulations.

The calibration of contest functions has been performed by multiple studies, including Kang (2016) and König et al. (2017). Our paper differs in that it uses reduced-form utility weights and abstracts from more complex game-theoretic protocols (Clayton et al., 2023, Thoenig, 2023, Kooi, 2024, Liu and Yang, 2024). Having established this context, we now turn to formalizing our intuitions in a simple model.

2 Theoretical framework

To put structure on the incentives around military export controls, we begin with a neo-classical model featuring perfectly competitive firms with a constant-returns-to-scale production technology. We adopt a standard Armington setup with a freely tradeable outside good that serves as a numeraire. Additional model components include a tax-financed defense department that buys goods and a military contest in the welfare function. The latter, for analytical convenience, is represented by a simple function of the quantity ratio of the home military good to that of the foreign country. While most of our formulas extend to optimal import tariffs and industrial subsidies, we largely abstract from those in our analysis due to the richer set of policy trade-offs associated with these instruments.

2.1 Model setup

In our baseline environment, we consider a world with two countries, home (H) and foreign (F). Each country has four agents: a representative firm, a representative household, the defense department, and the government. The representative firm uses labor to manufacture a local variety. The remaining labor endowment is transformed into a homogenous freely tradable outside good. There are thus two varieties of a manufactured good in the global economy—one home variety and one foreign variety—as well as the freely tradable outside homogenous good to pin down wage levels.

The representative household consumes varieties of a manufactured good and the freely tradable outside good. Its income is derived from labor earnings and net taxes. Net taxes can be further decomposed into trade revenues from export taxes and defense spending, which is a lump-sum transfer to the military. The defense department utilizes the lump-sum transfer to purchase varieties of a manufactured good, home and foreign, and combines it into the military good, which is country-specific and non-tradable. The government determines trade policy and defense spending to maximize welfare, which consists of the sum of household utility and a military contest term. The formal notation follows below.

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. The firms set their prices as

$$p_k = w_k / z_k^q. \quad (1)$$

Every country-variety on the supply side will later be combined into a local consumption good and a local military good via final demand aggregators, following the standard Arm-

ington model structure.

In addition to two local varieties produced by firms, there is also one homogenous freely tradable outside good that is produced 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. Our later assumptions on household utility and labor endowments will ensure that this would indeed be the case.

Final demand aggregators. In every country $i \in \{H, F\}$, the final demand is given by households and the defense department. The final demand aggregators transform varieties produced by firms into a local final consumption good and a local military good. The latter are non-tradable; they could be thought of as abstract effective units of the consumption and military baskets. To buy from firm k , an aggregator in country i pays the price

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

where $(\tau_{ik}^{\mathcal{X}} - 1)$ is an export tax (or subsidy) by 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 consumption good, the consumption aggregator combines c_{ik} units of firm k 's output, $k \in \{H, F\}$, using a function $\mathcal{F}^C$. Similarly, to deliver m_i units of a local military good, the military aggregator combines m_{ik} units of firm k 's output, $k \in \{H, F\}$, using a function $\mathcal{F}^M$:

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

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

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

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

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

$$C_i \equiv P_i^C c_i, \quad M_i \equiv P_i^M m_i. \quad (6)$$

The resulting expenditure shares are

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

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

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

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

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

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 consumption good (c_i)

$$\max_{B_i, c_i} B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad (10)$$

subject to its budget constraint

$$B_i + C_i \leq \mathcal{I}_i. \quad (11)$$

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 toward the defense department:

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

We assume that the labor endowment L_i is large enough to generate sufficient income for consuming the freely tradable outside good (which could otherwise lead to a corner solution under quasi-linear preferences). We also ensure that the labor endowment in both countries is large enough so that the demand for the freely tradable outside good drives both countries to produce it. This condition fixes $w_H = w_F = p^M = 1$, thereby shutting down the general equilibrium effects. The quasi-linear structure eliminates the income effect of the tax revenue R_i on household consumption spending C_i , which simplifies our analysis in this section.

Defense department. Government lump-sum taxes M_i go toward defense spending. The defense department purchases m_i units of the military good to maximize the military contest payoff

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

subject to the budget constraint

$$P_i^M m_i \leq M_i. \quad (14)$$

The military contest term 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

becomes. One can interpret this specification as a local approximation of more general contest functions that account for various military balance considerations. Its role in this section is to simplify analytical expressions for the utility Jacobians; the intuitions are robust to alternative functional forms, as Proposition 3 in our calibration section will confirm.

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

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

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

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

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

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 $(\mathcal{P}^{(H)}, \mathcal{P}^{(F)})$. Based on $\mathcal{P}$, households, firms, and aggregators make their decisions, and the equilibrium $\mathcal{E}_{\mathcal{P}}$ is realized. The governments subsequently collect their welfare payoffs (W_H, W_F) .

The choice of the optimal trade policy $\mathcal{P}_{\tau}$ is sensitive to assumptions about the game structure. We assume that setting trade policy entails setting linear ad-valorem 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. In a sequential-move game where governments first set trade policy $\mathcal{P}_{\tau}$ and then defense spending $\mathcal{P}_M$, the home government would take into account the foreign reaction to its trade policy. We consider a sequential game variation to gain dynamic insights as an extension. The simultaneous-move game remains our benchmark and is used for our quantitative analysis.

2.2 Optimal trade policy

We characterize the optimal trade policy in the environment specified above. We begin with the 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, which allows us to characterize consumption spending given policies $\mathcal{P}$:

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

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

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

Plugging (44), (45) into (16) allows to recast welfare in the optimum as

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

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*

$$\frac{\tau_{-i,i}^\mathcal{X} - 1}{\tau_{-i,i}^\mathcal{X}} = - \frac{1 + \left(\frac{M_i}{M_{-i}} \right) S_{-i,i}^M}{\mathcal{E}_{-i,i}^{-i,i} - 1}, \quad S_{ik}^M \equiv \frac{s_{ik}^M M_i}{s_{ik}^C C_i + s_{ik}^M M_i}, \quad (20)$$

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

The proof of the proposition is given in the Appendix of the main text and serves as a template for other similar derivations in this paper, which are relegated to the Supplementary Appendix. Given a small policy change, the change in the national welfare function can be expressed as

$$dW_i = \underbrace{dR_i}_{\text{revenue}} + \underbrace{M_i d \log P_{-i}^M}_{\text{foreign military}} - \underbrace{(C_i d \log P_i^C + M_i d \log P_i^M)}_{\text{domestic distortion}}. \quad (21)$$

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

The optimal export tax corrects a Marshallian externality by internalizing the cost that every unit sold to the foreign military imposes on domestic welfare. Here (M_i / M_{-i}) is a

macroeconomic shifter that depends on the final spending, and the sales share $S_{-i,i}^M$ is a price-theoretic term that captures the sectoral contribution to the final demand basket. Setting $S_{-i,i}^M = 0$ isolates the standard terms-of-trade export tax formula $[-1/(\mathcal{E}_{-i,i}^{-i,i} - 1)]$, which extracts the monopoly mark-up.¹ Although the current setup tackles the export of one good, $S_{-i,i}^M$ can also characterize a cross-section of goods, as will be shown in the next section.

Several technical remarks are worth noting. First, the conflict weight β_i does not appear in the formula because military spending is already optimally chosen to equate household and military utilities and thus depends on β_i , as equation (45) indicates. Second, assuming no taxes on the freely tradable good rules out Lerner symmetry considerations and uniquely pins down the export-tax level; any non-zero import tax in this context would be distortionary due to constant-returns-to-scale production and the absence of market failures on the import side. Finally, various policy instruments—including export licensing, export checks, export bans, firm-level customer filtering, and other revenue- and non-revenue-generating measures—can be mapped into the current tax setting (for details, see the Online Appendix).

2.3 Military centrality in production networks

We extend our trade policy analysis to an environment with production networks. We show that the optimal trade taxes balance military centrality and distortion centrality of a trade flow, scaled by the trade flow elasticity. Military centrality is a network- and taxation-adjusted sales share to the foreign military; distortion centrality is a similar statistic for the domestic economy that measures 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 with inputs q_{kl} from firm l 's output, $l \in \mathcal{K}$, according to the production aggregator $\mathcal{F}_k$:

$$q_k = \mathcal{F}_k(L_k, \{q_{kl}\}). \quad (22)$$

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

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

$$p_k = \min_{L_k, \{q_{kl}\}} \left\{ w_k L_k + \sum_{l=1}^K p_{kl} q_{kl} \right\} \quad \text{subject to} \quad q_k = 1. \quad (23)$$

¹Alternatively, one can fix foreign military spending M_{-i} and examine the best response under $\beta_i = 0$ (zero weight on the military contest in national welfare). This would imply $M_i = 0$ and eliminate the Marshallian externality in the optimal export tax.

The resulting procurement shares are denoted by

$$\Omega_{kl} = \frac{p_{kl}q_{kl}}{p_k q_k}. \quad (24)$$

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

$$q_k = \sum_{l \in \mathcal{K}} q_{lk} + \sum_{i \in \{H, F\}} c_{ik} + \sum_{i \in \{H, F\}} m_{ik} \quad (25)$$

For notational simplicity, we assume that all cross-border transactions are firm-to-firm, while the final demand aggregators procure only from local firms. This assumption is made without any loss of generality because, in a situation where a home firm sells directly to a foreign aggregator, we can always create a hypothetical importing node in the other country and assume that the firm sells to that node, which then sells to the foreign aggregator.

Generalizing the economy to production networks given by Leontief matrices

$$\Omega_{kl} \equiv \frac{p_{kl}q_{kl}}{p_k q_k}, \quad \tilde{\Omega}_{kl} \equiv \Omega_{kl}/(\tau_{kl}^{\mathcal{X}} \tau_{kl}^{\mathcal{M}}), \quad \Psi = (\mathbf{I} - \Omega)^{-1}, \quad \tilde{\Psi} = (\mathbf{I} - \tilde{\Omega})^{-1} \quad (26)$$

yields the following proposition:

Proposition 2. *The trade taxes for country $i \in \{H, F\}$ and firm $k \in \mathcal{K}_i$ in the Nash equilibrium satisfy*

$$\frac{\tau_{-i,k}^{\mathcal{X}} - 1}{\tau_{-i,k}^{\mathcal{X}}} = - \frac{\overbrace{\tau_{-i,k}^{\mathcal{X}} + \tau_{-i,k}^{\mathcal{M}}}^{\text{centrality trade-off}} \left[\left(\frac{M_i}{M_{-i}} \right) \mathcal{C}_{-i,k}^M - \mathcal{C}_{i,k}^D \right]}{\mathcal{E}_{-i,k}^{-i,k} - 1}, \quad (27)$$

where $\tau_{-i,k}^{\mathcal{X}}$ is a revenue component that can be expanded as

$$\tau_{-i,k}^{\mathcal{X}} \equiv 1 + \left[\frac{F_{-i,k}}{\tau_{-i,k}^{\mathcal{M}}} \right]^{-1} \left(\sum_{l \in \mathcal{K}_i \setminus \{k\}} \frac{\tau_{-i,l}^{\mathcal{X}} - 1}{\tau_{-i,l}^{\mathcal{X}} \tau_{-i,l}^{\mathcal{M}}} F_{-i,l} \mathcal{E}_{-i,k}^{-i,l} + \sum_{l \in \mathcal{K}} \frac{\tau_{il}^{\mathcal{M}} - 1}{\tau_{il}^{\mathcal{M}}} F_{il} \mathcal{E}_{-i,k}^{il} \right), \quad (28)$$

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

$\mathcal{E}_{-i,k}^{-i,k} \equiv \frac{d \log F_{-i,k}}{d \log \tau_{-i,k}^{\mathcal{X}}}$ is the import demand elasticity,

$\mathcal{C}_{-i,k}^M$ is the military centrality (network-adjusted sales to the foreign military)

$$\mathcal{C}_{jk}^M \equiv \frac{[\Psi' \mathbf{s}^M]_{jk} M_j}{[\tilde{\Psi}' \mathbf{s}^M]_{jk} M_j + [\tilde{\Psi}' \mathbf{s}^C]_{jk} C_j}, \quad (29)$$

$\mathcal{C}_{-i,k}^D$ is the distortion centrality (network-adjusted roundabout sales)

$$\mathcal{C}_{jk}^D \equiv \frac{[\Psi' \mathbf{s}^M]_{jk} M_j + [\Psi' \mathbf{s}^C]_{jk} C_j}{[\tilde{\Psi}' \mathbf{s}^M]_{jk} M_j + [\tilde{\Psi}' \mathbf{s}^C]_{jk} C_j}. \quad (30)$$

One can spot two changes relative to Proposition 1. First, the final sales share S^M is replaced with military centrality C^M . In the horizontal production case of Section 2.1, one can verify that military centrality equals the sales share exactly. Second, there is a new distortion centrality term C^D . This term captures the impact of roundabout imports: what fraction of the exported good ends up in the domestic final demand. In the horizontal case with no roundabout component, distortion centrality equals zero, as exported goods never return as re-imports to the domestic economy.

Centrality emerges as an interpretable sufficient statistic that has many convenient properties. In a distortion-free economy, centrality can be recast as a network-adjusted sales share: for one dollar of export sales, how many cents end up with a given agent. In a distorted economy, the sales share interpretation holds up with a tax correction. For a closed economy, the distortion centrality is equivalent to the measure developed by Liu (2019). A convenient property of the military centrality measure is its rank invariance conditional on factor prices and trade taxes: regardless of how one scales final agents' expenditure, the relative rankings of firms remain the same. This property will be utilized in the empirical analysis in the following section.

3 Empirical measurement

Our theoretical framework suggests that military centrality, distortion centrality, and import demand elasticities are the sufficient statistics that should inform export control targeting across goods. In this section, we apply our sufficient statistics to empirical data. We develop a measure of military use and compare it to existing export administration regulations. We find significant overlap between the two, suggesting that the policy is broadly consistent with our theoretical framework.

Military use measure Our centrality concept is defined in terms of endogenous sales shares. In the data, those sales shares already reflect existing policy regulations. For example, the military centrality of the U.S. fighter jets for China is zero in the data not because fighter jets cannot be used in military applications but because trade policy on both sides has made this transaction infeasible. Our formulas can thus answer the question which exports to China the U.S. should target next given all the regulations in place. This approach, while suitable for policy recommendations in our calibration section, works poorly for generating a policy-independent metric of military use that can be mapped to the cross-section of existing regulations.

To measure military use across goods, we focus on the U.S. closed-economy setup. In this way, we capture production purchase shares in a large economy with access to modern

technologies, free trade in factors, and domestic regulations that are considerably lighter than those for cross-border transactions. Our preferred empirical measure of military use becomes

$$0 \leq \mathcal{C}_{US,k}^M / \sigma_k \leq 1, \quad (31)$$

where $\mathcal{C}_{US,k}^M \equiv \frac{[\Psi' \mathbf{s}^M]_{jk} M_j}{[\Psi' \mathbf{s}^M]_{jk} M_j + [\Psi' \mathbf{s}^C]_{jk} C_j} \in [0, 1]$ represents the U.S. closed-economy military centrality of good k , and $\sigma_k \geq 1$ represents its import demand elasticity.

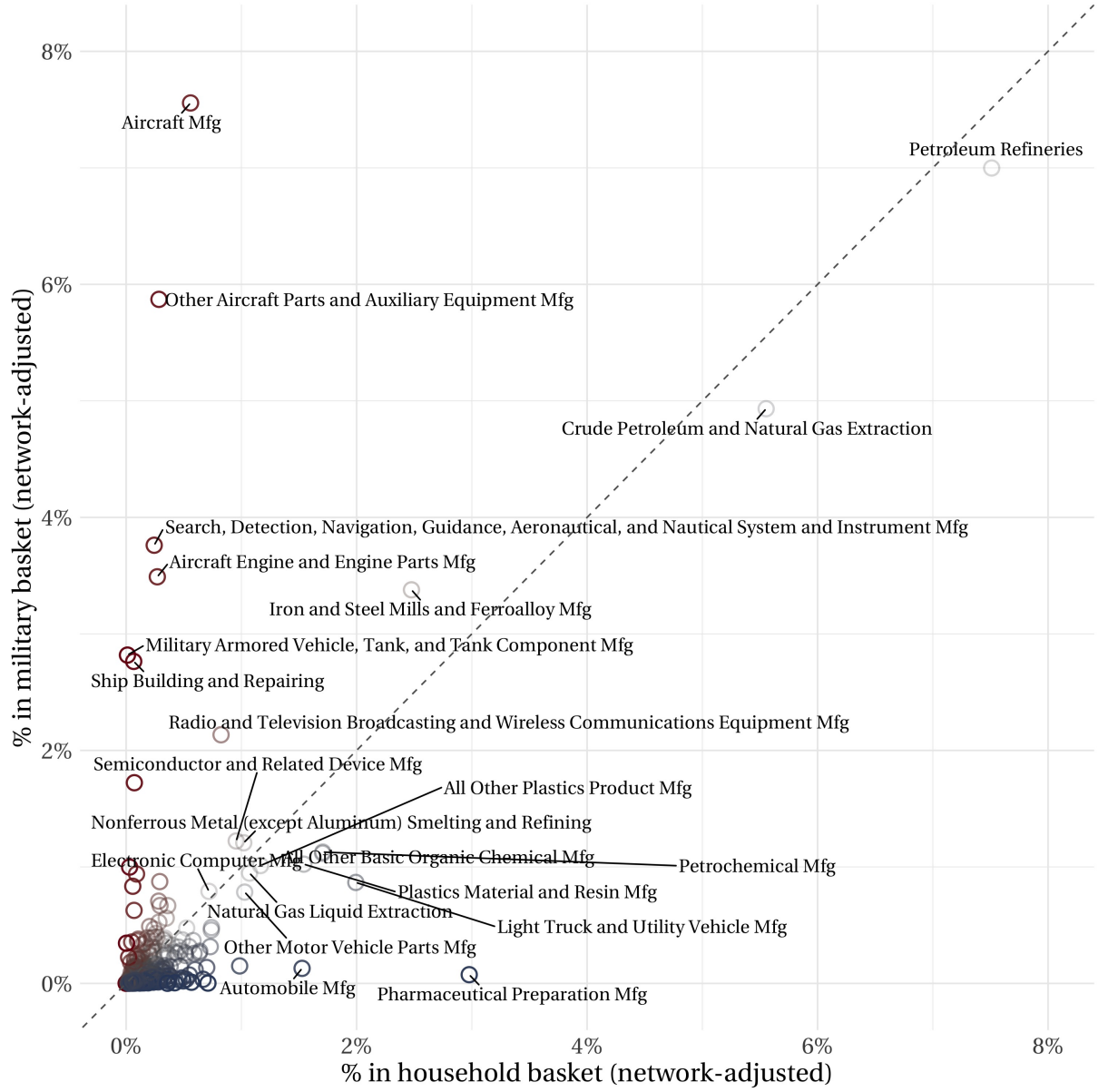
The intuition for this statistic stems from the Marshallian term in our optimal tax formulas. It reflects the differential impact on military prices $\mathcal{C}_{US,k}^M$ and the production base non-substitutability, as captured by import demand elasticities σ_k . We set C and M to the empirical values of the U.S. annual national income and military spending, respectively, with $M \approx 0.03C$, and invoke the rank invariance of $\mathcal{C}_{US,k}^M$ with respect to the choice of M for distributionally robust empirics.

Military centrality $\mathcal{C}_{jk}^M$ reflects the network-adjusted sales share of the U.S. NAICS industries to the Department of Defense. Some industries, such as missile production or tank manufacturing, primarily sell to the military. Others, like automobile manufacturing or pharmaceuticals, mostly sell to households. A range of input industries, such as semiconductors or wireless communications manufacturing, sell to both. Figure 2 displays total sales to the military and households by industry. Industries are mapped to HS 6-digit commodities to obtain measures at the product level.

Import demand elasticities σ_k are the CES elasticities of substitution for a given good between export origins. They serve as empirical proxies for the demand elasticity ($\mathcal{E} - 1$) with networks and general equilibrium dependencies in our optimal tax formulas. We use LIML estimates by [Soderbery \(2015\)](#), which are robust to outliers in trade flows.² These import demand elasticities reflect the substitutability of a good across export origins, implicitly capturing product differentiation, durability, storage capacity, reshipping, and various other characteristics, insofar as those are projected onto a static elasticity estimation strategy.

Table 1 displays the distribution of keywords across goods. The highest-scoring goods are aluminum, warships, tanks, aircraft engines, and various shipbuilding components. At the bottom, one can see various food and luxury items. Manufacturing machinery, chemicals, and minerals constitute the bulk of items in the middle. To provide a sense of tax magnitudes, assuming a starting point of $\tau = 1$ (no tax revenue) and $M_i / M_{-i} = 1$ for the Jacobian, the export tax will be 200% on aluminum powders (highest) and, for instance, 40% on aircraft engines. Appendix B.1 contains additional details on the military use distribution. We then proceed to compare our measure with empirical policy targeting.

²Our results are robust to alternative elasticity measures such as [Broda and Weinstein \(2006\)](#) or [Fontagné et al. \(2022\)](#). The elasticities are estimated at the yearly time horizon.



Notes: The U.S. input-output tables are taken for 2018 ([U.S. Bureau of Economic Analysis, 2018](#)), with additional information from the Survey of U.S. Businesses ([U.S. Census Bureau, 2018](#)). Data for military final demand comes from procurement contracts accessed via USASpending ([U.S. Department of the Treasury, 2024](#)). The military and household network-adjusted sales on the plot are $\Psi's^M M$ and $\Psi's^C C$, with the basket normalization performed by setting $C = 1/(\Psi's_C 1)$ and $M = 1/(\Psi's_M 1)$.

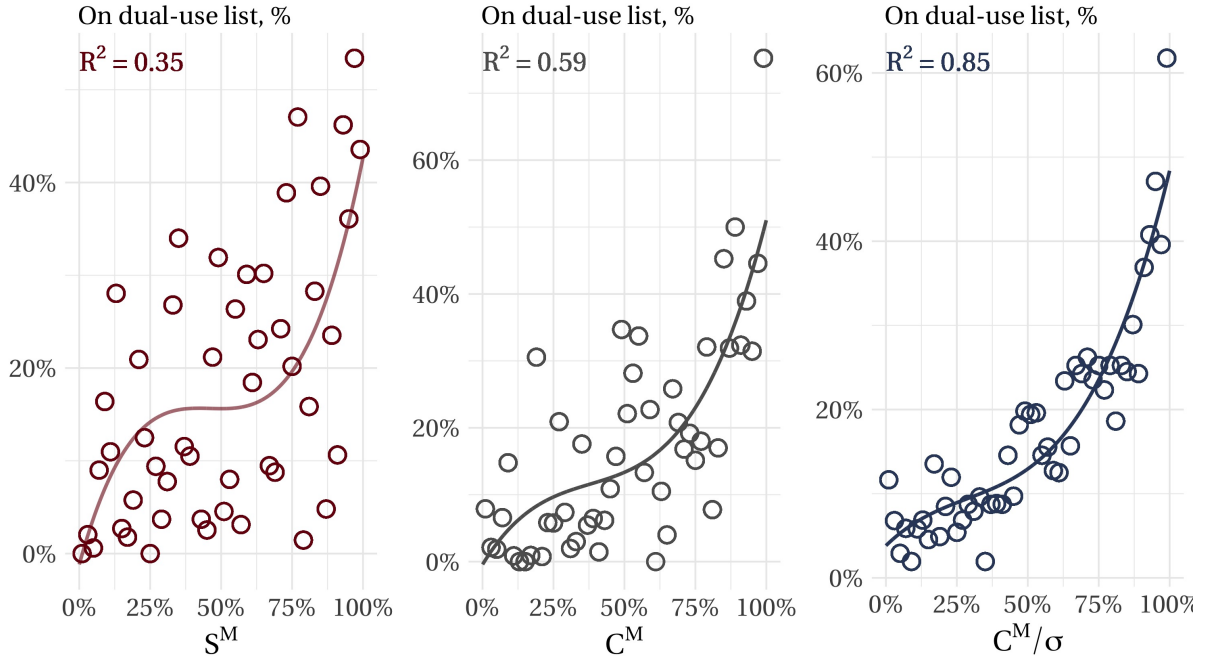
Figure 2: The 2018 U.S. input-output table

Pct C_k^M / σ	C_k^M / σ (%)	N	Key words in HS code descriptions
[99.8, 99.9]	[56.42, 65.17]	2	vehicles, aluminium, powders, flakes, tanks, armoured, fighting, motorised, weapons
[99.7, 99.7]	[39.87, 46.25]	2	boats, vessels, ships, warships, lifeboats, rowing, cruise, excursion, ferry, cargo
[99.5, 99.6]	[32.27, 36.17]	2	floating, vessels, light, fire, floats, dredgers, cranes, navigability, subsidiary, docks
[99.3, 99.4]	[22.13, 27.84]	2	gliders, balloons, dirigibles, hang, powered, aircraft, signalling, safety, traffic, control
[99.2, 99.2]	[16.15, 18.68]	2	aircraft, firearms, spring, air, gas, guns, pistols, truncheons
[98.9, 99.1]	[14.90, 16.05]	3	firearms, devices, pistols, mechanical, sporting, shotguns, rifles, muzzle, loading, firing
[98.6, 98.8]	[10.50, 12.38]	4	apparatus, fuses, detonating, radio, boats, floating, structures, rafts, tanks, coffer
[98.2, 98.5]	[8.16, 10.16]	4	trailers, gear, turbo, semi, vehicles, mechanically, propelled, aircraft, launching, deck
[97.5, 98.2]	[5.80, 7.74]	9	apparatus, vessels, optical, wire, barbed, iron, steel, twisted, instruments, elements
[94.1, 97.4]	[3.30, 5.00]	40	tubes, steel, plates, iron, graphite, carbon, concentrates, metal, electrical, rods
[90.8, 94.1]	[2.78, 3.29]	40	apparatus, steel, machines, iron, wire, recording, electrical, metal, copper, hand
[87.4, 90.7]	[2.48, 2.76]	40	iron, steel, aluminium, waste, machines, dolomite, wire, electrically, scrap, devices
[84.1, 87.4]	[2.14, 2.48]	40	steel, bars, rods, cement, slag, apparatus, alloy, photographic, film, sensitised
[80.9, 84.0]	[1.89, 2.14]	40	natural, ores, concentrates, mechanical, iron, steel, animal, instruments, waste, gas
[77.4, 80.7]	[1.70, 1.88]	40	metal, wax, umbrellas, ores, concentrates, lead, copper, rubber, water, liquid
[74.1, 77.3]	[1.54, 1.70]	40	natural, copper, steel, plates, chemically, sugar, ignition, cut, hair, rods
[70.7, 74.0]	[1.37, 1.53]	40	iron, metal, precious, metals, steel, vegetable, petroleum, oils, matter, glues
[67.4, 70.6]	[1.25, 1.37]	40	watches, tools, tubes, plastics, optical, material, skins, feathers, compounds, fittings
[64.0, 67.2]	[1.08, 1.25]	40	worked, iron, clad, oils, plastics, materials, watches, metal, compounds, alloy
[60.7, 63.9]	[0.98, 1.08]	40	forms, acids, halogenated, sulphonated, nitrated, nitrosated, starches, fabrics, lamps, steel
[57.3, 60.6]	[0.88, 0.97]	40	artificial, stone, forms, retail, sale, machines, synthetic, natural, primary, compounds
[54.0, 57.2]	[0.75, 0.87]	40	textile, polymers, primary, forms, materials, raw, natural, chemical, metal, pens
[50.6, 53.8]	[0.68, 0.75]	40	fabrics, x, ray, apparatus, textile, ether, peroxides, instruments, materials, alpha
[47.3, 50.5]	[0.62, 0.67]	40	wood, ceramic, laminated, forms, plates, vegetable, textile, gas, rubber, sheets
[43.9, 47.2]	[0.55, 0.62]	40	ceramic, wood, preparations, tiles, goods, siliceous, tanning, soap, organic, machines
[40.6, 43.8]	[0.47, 0.54]	40	yarn, waste, wood, hair, textile, fibres, electric, data, vinegar, paper
[37.2, 40.5]	[0.42, 0.47]	40	oils, wood, printed, slate, stone, fractions, paper, forms, machines, apparatus
[33.9, 37.2]	[0.37, 0.42]	40	yarn, paper, paperboard, sewing, machines, machinery, apparatus, wool, fabrics, reagents
[30.3, 33.8]	[0.35, 0.37]	40	glass, worked, paper, sheets, reflecting, cellulose, wood, preparations, fruit, absorbent
[27.2, 30.3]	[0.31, 0.35]	40	paper, fabrics, cork, plates, sheets, papers, rolls, wood, materials, wool
[23.8, 27.1]	[0.24, 0.31]	40	fractions, paper, modified, cotton, mixed, animal, refined, chemically, woven, fibres
[20.5, 23.8]	[0.21, 0.24]	40	fabrics, pulp, silk, woven, leather, yarn, waste, wood, knitted, crocheted
[17.2, 20.4]	[0.17, 0.21]	40	leather, dried, meat, fish, metals, knitted, crocheted, fabrics, genus, printing
[13.8, 17.1]	[0.13, 0.16]	40	fish, coaches, knitted, crocheted, dried, yarn, animal, put, retail, sale
[10.5, 13.7]	[0.09, 0.13]	40	dried, frozen, fresh, leather, nuts, cocoa, prepared, chilled, waters, molluscs
[7.1, 10.4]	[0.06, 0.09]	40	machines, fresh, fish, prepared, chilled, yarn, coffee, vinyl, organs, vegetables
[3.8, 7.0]	[0.04, 0.06]	40	fresh, chilled, knitted, crocheted, machines, oil, machinery, extraction, meat, ground
[0.0, 3.7]	[0.00, 0.04]	45	precious, metal, fresh, prepared, tobacco, preparations, cars, rubber, jackets, chilled

Notes: The first two columns reflect intervals for military use and their percentiles in the distribution. The third column shows the number of HS categories within the defined range. The last column lists the 10 most common words, in decreasing order, found in the associated HS code descriptions.

Table 1: Keywords in HS descriptions across the distribution of our military use measure

Comparison with observed policies Customs authorities implement strategic trade controls to ensure that goods with military applications do not cross international borders. EU customs authorities provide correlation tables that link traditional Harmonized System 6-digit codes with the Export Control Classification Numbers (ECCNs), thereby flagging goods that should be subject to licensing and additional checks at the border under a visa-style screening process. For our analysis, we define dual-use goods as the set of HS 6-digit commodities included in those tables. Appendix B.2 provides additional institutional details about export administration regulations.



Notes: The colored lines display a cubic polynomial fit of the outcome onto the binned sorting variable: military sales share (red), military centrality (gray), and military use (blue). The plots show binscatters with 50 equal-sized bins based on the military use distribution.

Figure 3: Military use and the E.U. dual-use export control lists

We validate our military use measure against a 2018 EU dual-use list. Moving from the 0th percentile to the 100th percentile of our measure increases the probability of being on the dual-use list from 5% to 50%. Figure 3 displays average policy outcomes across the distribution of three sorting variables: military sales (S^M , in red), military centrality (C^M , in gray), and military use (C^M/σ , in blue). While all three variables exhibit monotonic behavior, military use provides the strongest explanatory power of the three. For the dual-use list, the R^2 of the cubic polynomial fit is 0.35 for S^M , 0.59 for C^M , and 0.85 for C^M/σ (Figure 3). Our military use measure outperforms a simple military sales share and remains stable after including flexible sales share polynomials, trade controls, and HS2 fixed effects (Table B.4). Non-model-based measures, such as s^M , $\Psi' s^M$, or $\Psi' s^C$, fare worse than S^M in

terms of their explanatory power. These results are robust across various military contract samples, trade elasticities, and analyses at the 4-digit aggregation level.

We perform similar exercises for two additional measures. Figure B.4 reports a comparison with export restrictions issued by the U.S. Bureau of Industry Security after 2022 (U.S. Bureau of Industry and Security, 2024). We observe similar patterns, with the superior explanatory performance of our military use measure. Figure B.5 plots the global counts of export non-tariff measure announcements over time from the Global Trade Alert (Evenett, 2019). Between 2018 and 2022, we document a monotonic shift in new export restrictions towards goods with potential military use.

Our takeaways from these exercises are twofold. First, current best practices broadly align with predictions issued by a simple theoretical framework that we have constructed. Second, empirically, both military centrality in the numerator and the elasticity of substitution in the denominator contain decision-relevant variance. Having unpacked the cross-sectional targeting patterns across goods, we now proceed to calibrate our model to gauge the macroeconomic magnitudes behind the military-consumption trade-off in general equilibrium.

4 Calibration

Our theoretical framework has imposed a structure to assess the military externality and its macroeconomic implications, allowing us to quantify the military-consumption trade-off. While we have developed a measure of military use across goods, we have not yet taken a quantitative stance on the utility weights in our optimal tax formulas. To address this, we calibrate our model to a U.S.-China conflict and explore various counterfactual scenarios.

We extend our theory from Section 2 to a general equilibrium setup with flexible functional forms and factors in fixed supply. Our global production network incorporates input-output tables for China and its trade with the Rest of the World (Gaulier & Zignago, 2010; NBES, 2018a, 2018b). We derive China’s military basket from the revenues of publicly-traded firms in the defense sector (CSMAR, 2024). We specify functional forms, estimate the parameters of the contest block, and present resulting quantitative policy evaluations.

General equilibrium model We make three amendments to our network model from Section 2. First, we allow for N countries instead of just two. Second, we introduce general utility functions

$$U_i(\{c_j\}_{j=1}^N, \{m_j\}_{j=1}^N). \quad (32)$$

Finally, we rule out the existence of a freely tradable outside good, incorporating factor scarcity with price adjustments into our analysis.

The new household budget constraint is

$$C_i = w_i L_i + D_i + R_i - M_i, \quad (33)$$

and wages w_i cease to be a numeraire.³ Here, D_i represents trade deficits, with $\sum_{i=1}^N D_i = 0$. The following proposition presents optimal tax formulas for the general equilibrium setup.

Proposition 3. *The export taxes in the Nash equilibrium can be expressed as*

$$\frac{\tau_{-i,k}^{\mathcal{X}} - 1}{\tau_{-i,k}^{\mathcal{X}}} = - \frac{\overbrace{\mathcal{T}_{-i,k}^{\mathcal{X}}}^{\text{ToT}} + \overbrace{\mathcal{I}_{-i,k}^{\mathcal{X}}}^{\text{budget}} + \tau_{-i,k}^{\mathcal{M}} \sum_j \overbrace{[w_{ij}^C C_{jk}^C + w_{ij}^M C_{jk}^M]}^{\text{centrality trade-off}} + \tau_{-i,k}^{\mathcal{M}} \sum_{j,j'} \overbrace{[w_{ij}^C C_{jj'}^C + w_{ij}^M C_{jj'}^M]}^{\text{factor centrality trade-off}} \tilde{\mathcal{J}}_{j'k}^{-i}}{\mathcal{E}_{-i,k}^{-i} - 1}, \quad (34)$$

where $\mathcal{T}_{-i,k}^{\mathcal{X}}$ is a revenue component, $\mathcal{I}_{-i,k}^{\mathcal{X}}$ is the income effect term, and $\tilde{\mathcal{J}}_{j'k}^{-i}$ is a wage-tax Jacobian adjusted by the inverse ratio of trade flows to factor payments ($F_{jk}/(w_{j'} L_{j'})$). The centrality weight is determined by the utility Jacobians

$$w_{ij}^C = \left(\frac{U_{ic,j}}{P_j^C} \right) / \left(\frac{U_{ic,i}}{P_i^C} \right), \quad w_{ij}^M = \left(\frac{U_{ic,j}}{P_j^M} \right) / \left(\frac{U_{ic,i}}{P_i^M} \right). \quad (35)$$

The revenue component can be rewritten as

$$\mathcal{T}_{-i,k}^{\mathcal{X}} \equiv 1 + \left[\frac{F_{-i,k}}{\tau_{-i,k}^{\mathcal{M}}} \right]^{-1} \left(\sum_{j \neq i, l \in \mathcal{K}_i} \frac{\tau_{jl}^{\mathcal{X}} - 1}{\tau_{jl}^{\mathcal{X}} \tau_{jl}^{\mathcal{M}}} F_{jl} \mathcal{E}_{-i,k}^{jl} + \sum_l \frac{\tau_{il}^{\mathcal{M}} - 1}{\tau_{il}^{\mathcal{M}}} F_{il} \mathcal{E}_{-i,k}^{il} \right), \quad (36)$$

and an income effect term is

$$\mathcal{I}_{-i,k}^{\mathcal{X}} = \left[\frac{F_{-i,k}}{\tau_{-i,k}^{\mathcal{M}}} \right]^{-1} \left[\sum_{j \neq i} w_{ij}^C \mathcal{J}_{-i,k}^{R_j} + \sum_j w_j L_j \mathcal{J}_{-i,k}^{w_j} \right]. \quad (37)$$

Under factor scarcity, policy affects factor prices and household budgets. The cross-section of factors is characterized by a familiar centrality trade-off that is now modulated by a factor price response. Factors exhibiting large price responses to changes in policy are more important for policy considerations.

One question that arises from Proposition 3 is how to recover the factor price tax Jacobian $\mathcal{J}_{j'k}^w$. To address this, we express the factor market clearing condition using a compact matrix expression

$$\Lambda^L \mathbf{w} \mathbf{L} = \Omega^{L'} \Lambda^X \tilde{\Psi}' (s^C (\mathbf{D} - \mathbf{M}) + s^M \mathbf{M}), \quad (38)$$

³Our analysis extends to the case of multiple factors or when a factor is owned by multiple groups, but we calibrate our model using only fixed country-level labor.

where Λ^R , Λ^X , and Λ^L satisfy

$$\mathbf{R} = \Lambda^R \mathbf{X}, \quad \Lambda^X \equiv (\mathbf{I} - \tilde{\Psi}' \mathbf{s}^C \Lambda^R)^{-1}, \quad \Lambda^L \equiv \mathbf{I} - \Omega^L \Lambda^X \tilde{\Psi}' \mathbf{s}^C. \quad (39)$$

Matrix Λ^R converts firm sales into tax revenues. Matrix Λ^X is the inverse that reflects the amplification of sales via tax revenues that increase household budgets. Matrix Λ^L captures the roundabout propagation of factor prices through the economy, serving as the analog of $(\mathbf{I} - \Omega)$ in the Leontief inverse but for factor prices. Taking a first-order approximation following a small policy change allows us to back out $\mathcal{J}_{j'k}^w$.

When it comes to solving the model numerically, we employ an iterative algorithm, first solving for optimal taxes using (34) and then updating the equilibrium using (38) with standard hat-algebra methods. For model calibration, we need to specify the utility functional forms, a task we address in the following section.

Parameter fit We calibrate our model to a three-country setup with the United States, China, and the Rest of the World. We derive military demand from publicly-traded Chinese firms in the defense sector (whereas for the U.S., publicly available contracts of the Department of Defense are observed). For the Rest of the World, we assume no military production and a horizontal input-output structure that relies only on local labor. Calibration is performed at the NAICS 4-digit level for industries and the HS 4-digit level for trade flows, following a standard network structure as in [Fajgelbaum et al. \(2020\)](#). We impose that the military procures from domestic NAICS industries only, and that imported goods can enter military production only in a roundabout way. Reshipping counterfactuals are constructed with an additional CES nest within product-country pairs for the choice of routes with $\sigma = 8.0$ and trade friction $\tau = 2.0$ for the indirect, policy-free route.

We pick specific functional forms for utility and production. Following [Tullock \(1980\)](#), we adopt a generalized contest function to model balance-of-military considerations, resulting in the following expression for national welfare:

$$U_i(\{c_j\}_{j=1}^N, \{m_j\}_{j=1}^N) = c_i + \sum_{j \neq i} \alpha_{ij} c_j + \beta_i \frac{g(m_i)}{g(m_i) + \sum_{j \neq i} g(m_j)}. \quad (40)$$

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 determines the marginal value of national security. In our quantification, the Rest of the World has no military capabilities and places no weight on the military contest, so that $\nu_{\text{USA}} + \nu_{\text{CHN}} = 1$. We include a derivation for military alliances in the Online Appendix but reserve alliance quantifications for future work, keeping our structure parsimonious.

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. Parameter γ captures returns to scale for a military

good, with values below one dampening military advantage (under $\gamma \rightarrow 0$, everyone gets an equal share regardless of military size) and above one amplifying it (under $\gamma \rightarrow \infty$, a small military advantage yields a certain victory).

Table 2 summarizes our parameter choices. The welfare weights on foreign consumption α_{ij} are set to either $\alpha_{ij} = 0$ or $\alpha_{ij} = P_j^C$ across calibrations to contrast welfare under unilateral and universalist modes of trade policy. This parameter governs the strength of revenue versus Pigouvian incentives across goods; in theory, it could be estimated by fitting predicted taxes to observed policy decisions.

parameter	value
α_{ij}	$\alpha_{ij} = 0$ / $\alpha_{ij} = (P_i^C / P_j^C)^{-1}$
β_i	model inversion to fit 2018 military expenditure levels
γ	$\gamma = 0.5$ (estimated)
σ	from Fajgelbaum et al. (2020), unit otherwise

Notes: Weight $\alpha_{ij} = (P_i^C / P_j^C)^{-1}$ presents a universalist benchmark, under which social marginal utility of consumption is equalized across countries.

Table 2: Calibration parameters

Our trade elasticities across broad nests are derived from the work of Fajgelbaum et al. (2020). We use $\sigma = 2.53$ for import nodes, $\sigma = 1.53$ for nodes that aggregate HS4 codes into imported NAICS categories, and $\sigma = 1.19$ for NAICS aggregators of domestic and foreign varieties. For all other nodes, including consumer and military final demand nodes, we assume unit elasticities. Therefore, the heterogeneity in import demand elasticities across goods emerges only from the underlying network structure.

Country-specific prize size β_i is derived using a revealed preference approach to fit the first-order condition for 2018 observed military spending levels exactly. The marginal value of a dollar allocated to the military should be equal to the marginal value of a dollar going to households, which can be expressed as

$$\gamma \beta_i \kappa_i m_i^{-1} \frac{\nu_i (1 - \nu_i)}{P_i^M} = \frac{1}{P_i^C}, \quad \kappa_i \equiv \frac{m_i}{m_{0i} + m_i}, \quad (41)$$

in partial equilibrium.⁴ We use general equilibrium formulas in our quantification that we omit here for brevity.

The value of γ is estimated with a nonlinear generalized method of moments based on the time series variation in military spending over time. We use military procurement

⁴Note that the unrealistic property that returns to military spending increase when foreign military becomes smaller is now gone in favor of military returns increasing for close ties.

spending of the Western bloc and treat it as the best response to the military spending trajectory of the Eastern bloc:

$$\log m_t = \log[\nu_t(\gamma)(1 - \nu_t(\gamma))] + \log(\gamma\beta_t\kappa_t P_t^C / P_t^M). \quad (42)$$

Our estimating equation is

$$\log m_t = f(m_t/m_t^{\text{east}}; \gamma, \boldsymbol{\xi}) + \epsilon_t, \quad f(\cdot) \equiv \log[\nu_t(\gamma)(1 - \nu_t(\gamma))] + \mathbf{X}_t' \boldsymbol{\xi}. \quad (43)$$

We control for historical periods and shocks tied to U.S. military conflicts, relating these to time variations in β_t and κ_t . Foreign strategic actions, price ratio shocks, and other forces outside our model can jointly impact the military balance ν_t and military purchases m_t beyond the scope of our controls. To address this problem, we use the sudden geopolitical shift caused by the collapse of the Soviet bloc as an instrumental variable for m_t/m_t^{east} .

Returns to scale are estimated at $\gamma \approx 0.5$ (Table 3). We start with a simple year control specification, which 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 an R^2 of 0.96. We then add separate intercepts for geopolitical periods, and include controls for wars and war onsets. We conclude with using the collapse of the Soviet Union as an instrument. The parameter value $\gamma \approx 0.5$ suggests decreasing returns to scale for the military good when it converts into the probability of winning.

Country-specific contest prizes β_i are equal to 2.5 times the U.S. annual GDP and 1.4 times that of China. These values can be interpreted as reduced-form welfare weights on the probability of winning, projected onto our static model. The estimates are sensitive to stockpiles and general equilibrium adjustments, which affect the relative benefits of allocating tax dollars. In our baseline, military spending follows a fiscal rule as a fixed share of household income; we discuss flexible budgets in the final paragraph.

Results Given our calibration fit, we analyze the impact of the optimal trade policies. We consider trade policies applied by the U.S. and China unilaterally—either through export taxes or import tariffs—and report changes in military advantage ($m_{\text{HOME}}/m_{\text{FRGN}}$) and the consumption ratio ($c_{\text{HOME}}/c_{\text{FRGN}}$) following the optimal policy implementation. Figure 4 plots segments with endpoints at $\alpha = 0$ and $\alpha = \omega$, where the weights on the Rest of the World are set to a universalist benchmark.

As evident from the graph, China has a more impactful export policy (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 China's. The magnitude of these effects is reduced by more than half when reshipping through third countries is considered. The drawdown of stockpiles increases incentives for

	trend	+ AR(1)	+ hist. periods	+ wars	+ war start years	inst. var.
$\hat{\gamma}$	0.470	0.487	0.458	0.479	0.482	0.486
R^2	0.859	0.956	0.960	0.969	0.971	0.956

Notes: Controls for historical periods include the Cold War (1950-1989), the End of History (1990-2000), the War on Terror (2001-2013), and the New Cold War (2014-2021). Controls for major U.S. military engagements during this time frame include the Korean War (1950-1953), the Vietnam War (1965-1973), the Gulf War (1990-1991), the Afghanistan War (2001-2014), and the Iraq War (2003-2011).

	yearly budget		+ stock		+ allies' budgets		+ allies' stock	
	CHN	USA	CHN	USA	CHN	USA	CHN	USA
Military value	3.44	3.30	16.97	16.37	17.96	17.98	20.87	22.72
Partial equilibrium	37.10	26.59	182.94	131.80	193.62	144.78	225.07	182.97
General equilibrium	22.84	36.13	112.64	179.08	119.21	196.72	138.58	248.59

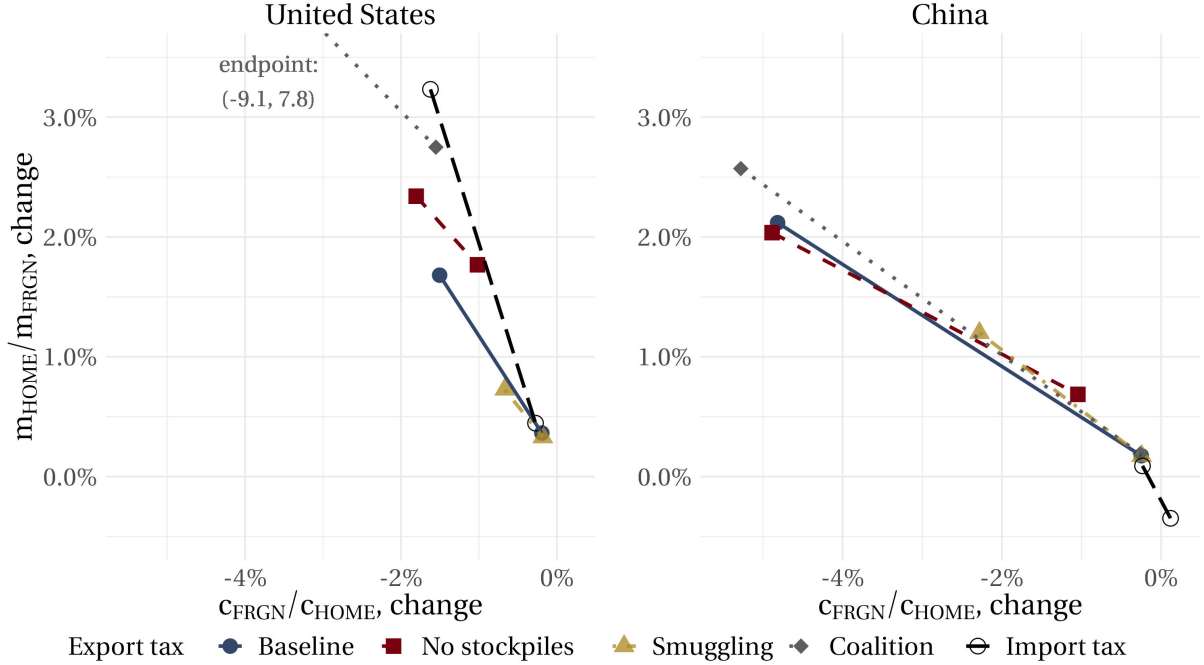
Notes: All values are reported as % of 2018 annual U.S. GDP. The dollar value conversion uses weighted industrial price indices for both consumer and military goods for both countries. Stockpiles refer to the assets of the Department of Defense as reported in its financial statements. The partial equilibrium estimates are obtained using equation (41); the general equilibrium estimates use formulas from the Online Appendix.

Table 3: Returns to military γ and conflict weight β

policy interventions and leads to higher export taxes. Import tariffs are an effective instrument for the U.S. that primarily affects foreign budgets rather than the production price margin.

Figure 4 considers scenarios when the foreign military tax is fixed as a share of the household budget. Once we allow for fiscal flexibility, the policy impact is dampened, working through the foreign economy-wide budget constraint. Due to optimal reallocations toward military spending, foreign households experience a stronger hit characterized by $\Delta_{\alpha}^2(m_{\text{HOME}}/m_{\text{FRGN}}) = 0.3\%$ and $\Delta_{\alpha}^2(c_{\text{FRGN}}/c_{\text{HOME}}) = -1.4\%$. In terms of welfare outcomes, the U.S. unilateral export policy at its baseline improves U.S. national welfare by 0.2%; the analogous Chinese policy improves its domestic welfare by 1.5% (Table C.1). The larger magnitudes for China reflect greater redistribution from foreign to domestic consumers and the country's different starting point in terms of household consumption.

As a final note, industrial policy could serve as a tool for correcting distortions when other policy margins remain inflexible. Under a fixed trade policy, industrial policy can perform an indirect revenue-neutral manipulation, subsidizing domestic industries at the expense of export-oriented ones. Under rigid military spending, industrial policy can help relax budget constraints by redistributing resources from consumer sectors to military ones. In the current model, these tools represent second-best interventions that lie beyond the



Notes: *Baseline* stands for a unilateral application of export taxes, with Rest of the World fixed at the universalist benchmark. *No stockpiles* refers to the scenario when $m_{i0} = 0$. *Smuggling* is modeled as an additional CES nest for a direct route versus the route via the Rest of the World with $\sigma = 8.00$ and the cost of reshipping $\tau = 2.00$. *Coalition* means joint export tax setting with allies. *Import tax* means unilateral import tax enforcement.

Figure 4: Policy impact plot

scope of our topic of optimal export restrictions.

5 Conclusion

To formalize our reasoning around military export controls, we incorporate a military contest into a static neoclassical trade model. A good should be subject to scrutiny if it can be purchased by the foreign military, if it is not heavily utilized in roundabout imports, and if it is difficult to substitute. The intensity of targeting depends on the policy stance on the military-consumption trade-off. A theory-based measure of military use, quantified with the U.S. input-output tables, explains well the cross-section of targeted goods by the U.S. and E.U. export administrations, demonstrating the proximity of positive and normative approaches in our context. Assessing the macroeconomic impact of sanctions requires the parametrization of factor price adjustments, existing stockpiles, and trade diversion.

Our modeling can be enhanced by incorporating production dynamics, state-dependent value of military goods, incomplete information sets, and richer game-theoretic protocols.

One promising extension would be the consideration of non-rival goods such as knowledge stocks. The use of more disaggregated data would improve precision and provide additional insights into the endogenous network adjustment. Our study presents a preliminary quantification of trade policy with a military angle, and we hope it will inspire further research in this domain.

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A Theoretical framework

A.1 Proof of Proposition 1

Proof. We characterize the optimal trade policy in the environment specified above. We begin with the 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, which allows us to characterize consumption spending given the policies $\mathcal{P}$:

$$1 = c_i^{-1/\eta_i} / P_i^C, \quad c_i = (P_i^C)^{-\eta_i}, \quad C_i = (P_i^C)^{1-\eta_i}. \quad (44)$$

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

$$1 = \beta_i \frac{m_i^{-\frac{1}{\zeta_i}} m_{-i}^{\frac{1-\zeta_i}{\zeta_i}}}{P_i^M}, \quad m_i = (P_i^M / \beta_i)^{-\zeta_i} m_{-i}^{1-\zeta_i}, \quad M_i = \beta_i^{\zeta_i} (m_{-i} P_i^M)^{1-\zeta_i}. \quad (45)$$

Equations (44), (45) allow us to recast welfare in the optimum as

$$W_i = wL_i + R_i + \frac{C_i}{\eta_i - 1} + \frac{M_i}{\zeta_i - 1}. \quad (46)$$

We first characterize the best response policies. Then, we describe the Nash equilibrium. The best response for defense spending was established in (45) and is given by

$$M_i = \beta_i^{\zeta_i} \left(M_{-i} \frac{P_i^M}{P_{-i}^M} \right)^{1-\zeta_i}. \quad (47)$$

For trade policy, consider small changes in taxes imposed by government i . The resulting change in welfare is given by

$$dW_i = \underbrace{dR_i}_{\text{revenue}} + \underbrace{M_i d \log P_{-i}^M}_{\text{foreign military}} - \underbrace{(C_i d \log P_i^C + M_i d \log P_i^M)}_{\text{domestic distortion}} \quad (48)$$

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

$$d \log P_i^C = \sum_{k \in \{H, F\}} s_{ik}^C d \log \tau_{ik}^{\mathcal{M}}, \quad d \log P_i^M = \sum_{k \in \{H, F\}} s_{ik}^M d \log \tau_{ik}^{\mathcal{M}}, \quad (49)$$

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

The revenue changes can be expanded as

$$dR_i = \frac{E_{-i,i}}{\tau_{-i,i}^M} \left[\overbrace{\frac{\tau_{-i,i}^X - 1}{\tau_{-i,i}^X} (\mathcal{E}_{-i,i}^{-i,i} - 1)}^{\text{decrease in spending}} + \underbrace{1}_{\text{unit revenue}} \right] d \log \tau_{-i,i}^X \quad (50)$$

$$+ \sum_{k \in \{H,F\}} \left[\overbrace{\frac{\tau_{ik}^M - 1}{\tau_{ik}^M} E_{ik} (\mathcal{E}_{ik}^{ik} - 1)}^{\text{decrease in spending}} + \overbrace{\sum_{l \neq k} \frac{\tau_{il}^M - 1}{\tau_{il}^M} E_{il} \mathcal{E}_{ik}^{il}}^{\text{revenue diversion}} + \underbrace{E_{ik}}_{\text{unit revenue}} \right] d \log \tau_{ik}^M$$

An increase in the export tax increases the revenue earned from one unit exported but also results in lost revenue due to decreased foreign demand. An increase in the import tariff has a similar effect for the home country but additionally generates revenue spillovers due to the shifting of home spending toward other imported goods. Further details about these elasticities are provided in Supplementary Appendix A.1.

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

$$dW_i = \frac{E_{-i,i}}{\tau_{-i,i}^M} \left[\frac{\tau_{-i,i}^X - 1}{\tau_{-i,i}^X} (\mathcal{E}_{-i,i}^{-i,i} - 1) + 1 + \tau_{-i,i}^M \frac{M_i}{M_{-i}} S_{-i,i}^M \right] d \log \tau_{-i,i}^X \quad (51)$$

$$+ \sum_{k \in \{H,F\}} \left[\frac{\tau_{ik}^M - 1}{\tau_{ik}^M} E_{ik} (\mathcal{E}_{ik}^{il} - 1) + \sum_{l \neq k} \frac{\tau_{il}^M - 1}{\tau_{il}^M} E_{il} \mathcal{E}_{ik}^{il} \right] d \log \tau_{ik}^M$$

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:

$$\overbrace{\begin{bmatrix} \frac{\tau_{-i,i}^X - 1}{\tau_{-i,i}^X} \\ \frac{\tau_{-i,i}^M - 1}{\tau_{-i,i}^M} \\ \frac{\tau_{ii}^M - 1}{\tau_{ii}^M} \\ \frac{\tau_{i,-i}^M - 1}{\tau_{i,-i}^M} \end{bmatrix}}^{\text{trade taxes}} = - \overbrace{\begin{bmatrix} \frac{E_{-i,i}}{\tau_{-i,i}^M} (\mathcal{E}_{-i,i}^{-i,i} - 1) & 0 & 0 \\ 0 & E_{ii} (\mathcal{E}_{ii}^{ii} - 1) & E_{i,-i} \mathcal{E}_{ii}^{i,-i} \\ 0 & E_{ii} \mathcal{E}_{i,-i}^{ii} & E_{i,-i} (\mathcal{E}_{i,-i}^{i,-i} - 1) \end{bmatrix}}^{\text{revenue responses}} \overbrace{\begin{bmatrix} \frac{E_{-i,i}}{\tau_{-i,i}^M} \left(1 + \tau_{-i,i}^M \frac{M_i}{M_{-i}} S_{-i,i}^M \right) \\ 0 \\ 0 \end{bmatrix}}^{\text{national security vector}} \quad (52)$$

Thus, we obtain the best response tax policy:

$$\frac{\tau_{-i,i}^X - 1}{\tau_{-i,i}^X} = - \frac{\overbrace{1}^{\text{ToT}} + \overbrace{\tau_{-i,i}^M (M_i/M_{-i}) S_{-i,i}^M}^{\text{military contest externality}}}{\mathcal{E}_{-i,i}^{-i,i} - 1}, \quad \tau_{ik}^M = 1. \quad (53)$$

For a civilian good with $S_{-i,i}^M = 0$, the export tax follows the standard inverse elasticity rule $(\tau_{-i,i}^X - 1)/\tau_{-i,i}^X = -1/(\mathcal{E}_{-i,i}^{-i,i} - 1)$. The presence of an additional term $\tau_{-i,i}^M (M_i/M_{-i}) S_{-i,i}^M$ in the numerator represents a Marshallian correction for a military contest externality by internalizing the cost that every unit sold to a foreign defense sector has on domestic welfare.

This term grows with the sales share of a variety to the foreign defense sector $S_{-i,i}^M$. The best response policy for the import tariff is $\tau_{ik}^M = 1$. Any domestic price manipulation results in a deadweight loss.

Equations (47) and (53) characterize the best response policies. To solve for the Nash equilibrium, we assume that these expressions hold simultaneously for both countries. Taking the logarithm of both sides in (47), we obtain

$$\log M_i = -\zeta_i \log \beta_i + (1 - \zeta_i)(\log M_{-i} + \log P_i^M - \log P_{-i}^M) \quad (54)$$

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

$$M_i = \beta_i^{\zeta_{-i,i}} \beta_{-i}^{(1-\zeta_i)\zeta_{i,-i}} \left(\frac{P_i^M}{P_{-i}^M} \right)^{(1-\zeta_i)\zeta_{i,-i}}, \quad \zeta_{i,-i} \equiv \frac{\zeta_{-i}}{\zeta_i + \zeta_{-i} - \zeta_i \zeta_{-i}} \quad (55)$$

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_i^M / P_{-i}^M). Since the import tariffs are zero for both countries, $\tau_{ik}^M = 1$. We then plug the zero import tariffs into (53) to obtain (20). The derivation is complete. $\square$

More broadly, the best response trade taxes (53) apply to any game in which the home government takes foreign defense spending M_{-i} as given. These are one-shot games in which the foreign government picks its policies $\mathcal{P}^{(-i)}$ before or concurrently with the home trade policy $\mathcal{P}_\tau^i$.

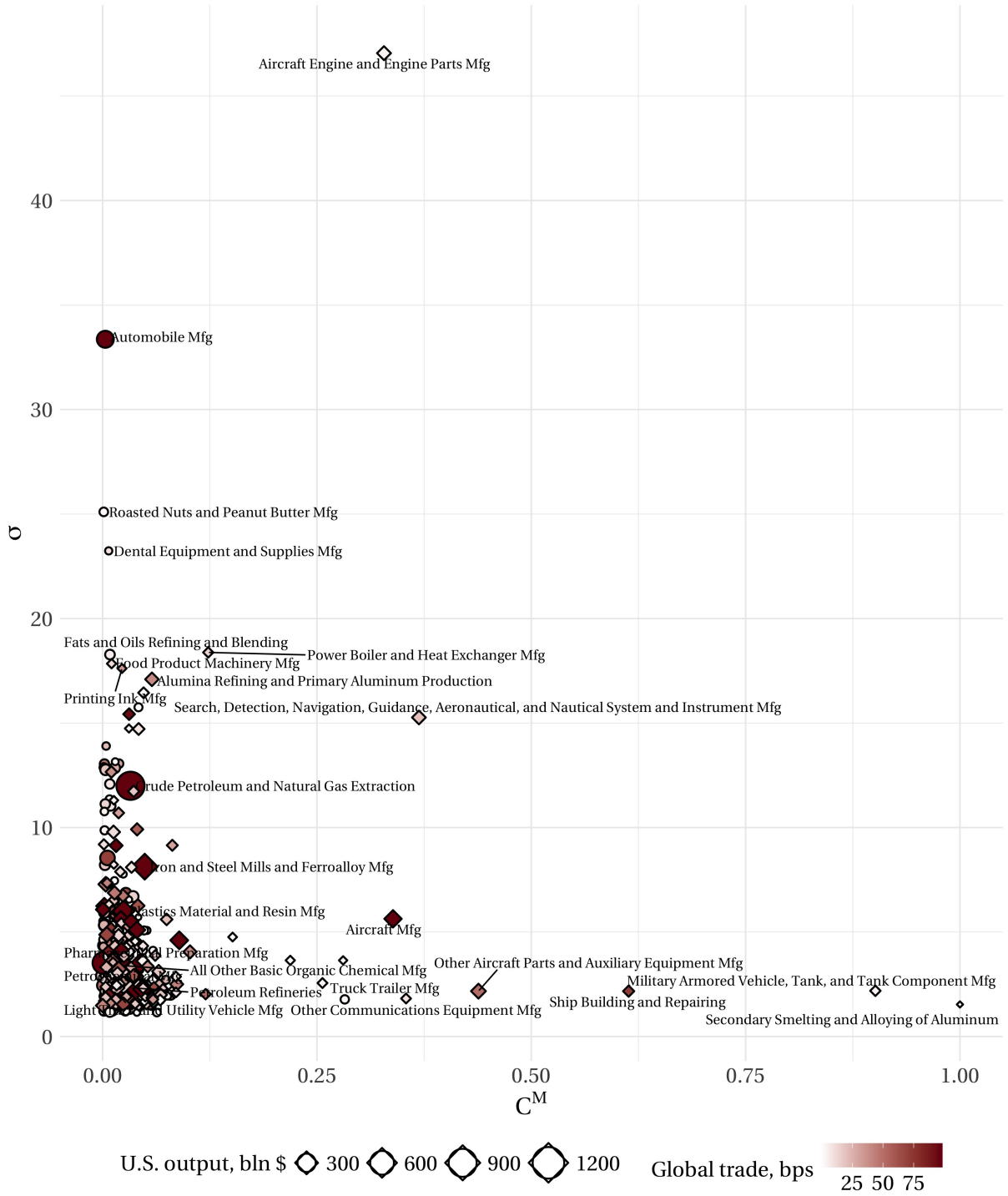
B Empirical measurement

B.1 Military use properties

HS code	Description	$\mathcal{C}_{US,k}^M/\sigma_k$	$\Delta\tau(\%)$	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: The 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 $(\tau_k - 1)/\tau_k = \mathcal{C}_{US,k}/\sigma_k$. The EU dual-use list is from 2018 and is augmented by munitions HS codes 93XXXX (arms and ammunition), 8710XX (tanks), and 890610 (warships).

Table B.1: Top-15 HS codes by military use



Notes: Industries that produce at least one dual-use good are depicted with a diamond; all other industries are depicted with a circle.

Figure B.1: Military centrality and trade elasticities: NAICS 6-digit level

Variable	$\mathcal{C}^M/\sigma$	pct $\mathcal{C}^M/\sigma$	$\mathcal{C}^M$	pct $\mathcal{C}^M$	$\mathcal{S}^M$	pct $\mathcal{S}^M$	s^M	pct s^M	$\Psi' s^M$	pct $\Psi' s^M$	s^C	pct s^C	$\Psi' s^C$	pct $\Psi' s^C$
$\mathcal{C}^M/\sigma$	1.00	0.48	0.90	0.44	0.62	0.35	0.48	0.26	0.30	0.30	-0.07	-0.08	-0.03	-0.08
pct $\mathcal{C}^M/\sigma$		1.00	0.45	0.83	0.32	0.55	0.21	0.36	0.32	0.61	-0.21	-0.21	0.07	0.01
$\mathcal{C}^M$			1.00	0.52	0.68	0.40	0.59	0.31	0.39	0.37	-0.08	-0.08	-0.01	-0.07
pct $\mathcal{C}^M$				1.00	0.36	0.62	0.23	0.41	0.44	0.74	-0.23	-0.23	0.14	0.05
$\mathcal{S}^M$					1.00	0.45	0.45	0.35	0.18	0.22	-0.06	-0.17	-0.10	-0.10
pct $\mathcal{S}^M$						1.00	0.26	0.73	0.11	0.36	-0.12	-0.19	-0.13	-0.17
s^M							1.00	0.30	0.56	0.24	0.28	0.14	0.21	0.07
pct s^M								1.00	0.25	0.53	0.26	0.46	0.22	0.32
$\Psi' s^M$									1.00	0.60	0.20	0.25	0.74	0.48
pct $\Psi' s^M$										1.00	0.07	0.26	0.53	0.65
s^C											1.00	0.50	0.63	0.40
pct s^C												1.00	0.47	0.69
$\Psi' s^C$													1.00	0.70
pct $\Psi' s^C$														1.00

Table B.2: Key variables: Correlation table

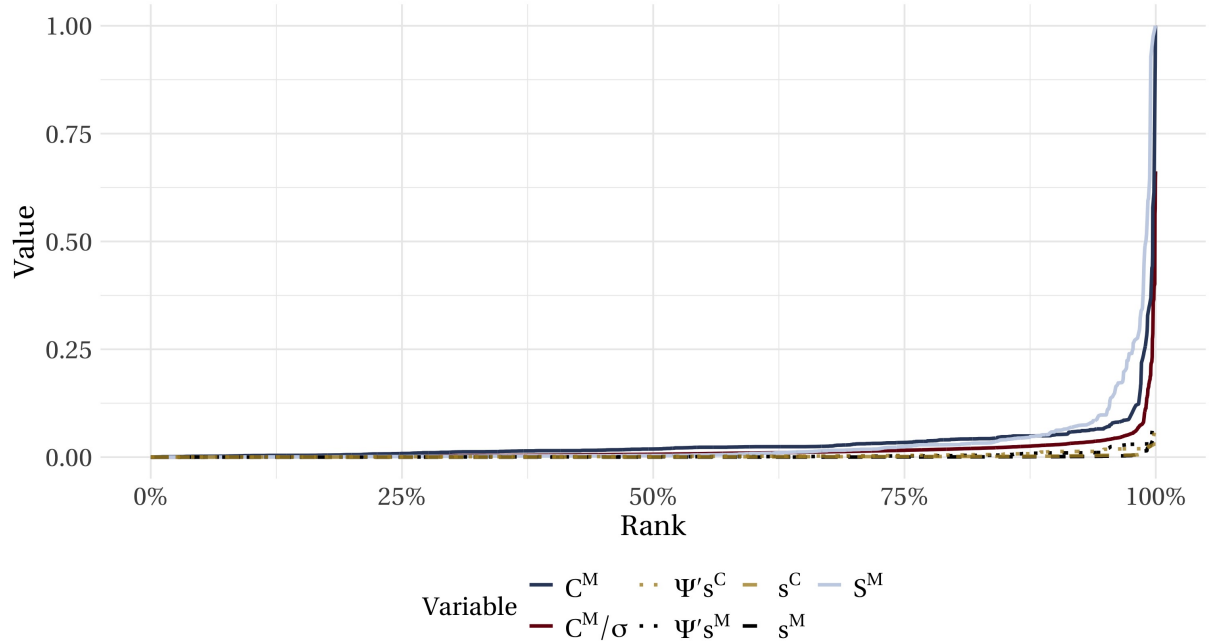


Figure B.2: Cumulative distribution function of key variables

B.2 Institutional details

Table B.3 highlights key institutional elements of the U.S. export control enforcement. The export clearance procedure for dual-use goods follows a visa-like procedure. Exporters must first classify their goods under a relevant ECCN. Then they file documentation for a license, reporting details such as technical specifications, destination, counterparties, and the intended use. Upon obtaining the license, they must keep their export records and provide declarations from the end user that confirm the intended final use. Non-compliance with any of these steps can lead to sanctions such as fines or permanent bans on exporting.

	Dual-use goods	Munitions
List	Commerce Control List (CCL)	U.S. Munitions List (USML)
Categories	Export Control Classification Number (ECCN), 5+ symbols	21 categories; see Federal Code 22.I.M.121
Code	Export Administration Regulations (EAR)	International Traffic in Arms Regulations (ITAR)
Agency	Bureau of Industry Security (BIS)	Directorate of Defense Trade Controls (DDTC)
Ministry	Department of Commerce	Department of State
Consults	Multilateral export control regimes*, DoD	Department of Defense (DoD)

Table B.3: U.S. institutional regulations on arms-related items

In the European Union, EU TARIC is a multilingual database integrating all measures relating to the EU customs tariff, commercial, and agricultural legislation. It provides correlation tables between traditional Harmonized System codes and the Export Control Numbers (ECN), largely mirroring those of the Wassenaar Arrangement or the Bureau of Industry Security (ECCN). As [Chatelus and Heine \(2016\)](#) note, “in the EU, the TARIC correlation table does not determine when exporters must request a permit, but it does determine when exporters must assess whether their exported commodity requires a permit or not. When the customs tariff number indicates a correlation with the dual-use list, EU exporters must fill in code X002 (controlled) or code Y901 (not controlled) in Box 44 of the Single Administrative Document (i.e., the customs declaration).” The EU TARIC system provides the first step in the export administration regulations.

A. End-use	6	95	2	25	15	27	47	5	24	47
B. Production	156	30	91	5	0	3	0	2	0	5
C. Materials	20	258	0	7	0	0	6	0	0	4
D. Software	12	0	1	0	0	0	0	0	0	0
E. Technology	0	0	0	0	0	0	0	0	0	0
	0. Nuclear	1. Chemicals	2. Processing	3. Electronics	4. Computers	5. Telecom & IT	6. Sensors/lasers	7. Navigation	8. Marine	9. Aerospace

(a) Raw HS6 code counts

A. End-use	0.10%	1.62%	0.11%	1.40%	4.05%	2.82%	1.61%	0.65%	1.11%	2.77%
B. Production	6.89%	0.75%	1.89%	0.29%	0.00%	0.05%	0.00%	0.01%	0.00%	0.07%
C. Materials	0.25%	5.10%	0.00%	0.13%	0.00%	0.00%	0.03%	0.00%	0.00%	0.04%
D. Software	0.39%	0.00%	0.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
E. Technology	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	0. Nuclear	1. Chemicals	2. Processing	3. Electronics	4. Computers	5. Telecom & IT	6. Sensors/lasers	7. Navigation	8. Marine	9. Aerospace

(b) Global trade share, 2015-19

Figure B.3: ECCN classification: categories (x-axis) and subcategories (y-axis)

B.3 Comparison with observed policies

Dependent Variable:	On dual-use list: Yes						
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>Variables</i>							
S_{US}^M	0.6027*** (0.0933)		-0.0230 (0.0752)				
C_{US}^M/σ		3.020*** (0.3266)	3.063*** (0.3767)	2.733*** (0.3126)	2.796*** (0.3151)	2.653*** (0.2818)	1.987*** (0.2324)
<i>Fixed-effects</i>							
Polynomial S_{US}^M				Yes			
Piecewise S_{US}^M					Yes	Yes	Yes
Goods controls (trade, sales, ...)						Yes	Yes
HS 2-digit							Yes
<i>Fit statistics</i>							
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	0.12487	0.32321
Within R ²				0.07982	0.04179	0.04849	0.02454

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

Table B.4: 2018 EU dual-use list: Military sales share versus military use

Dependent Variable:	On dual-use list: Yes							
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Variables</i>								
C_{US}^M/σ	1.948*** (0.2803)	2.438*** (0.2796)	2.410*** (0.2844)	2.355*** (0.2575)				
rank C_{US}^M/σ					0.2948*** (0.0190)	0.3206*** (0.0213)	0.2872*** (0.0193)	0.2970*** (0.0232)
<i>Fixed-effects</i>								
Polynomial s_{US}^M	Yes				Yes			
Polynomial $\Psi' s_{US}^M$		Yes				Yes		
Polynomial rank s_{US}^M			Yes				Yes	
Polynomial rank $\Psi' s_{US}^M$				Yes				Yes
<i>Fit statistics</i>								
Observations	5,135	5,135	5,135	5,135	5,135	5,135	5,135	5,135
R ²	0.07464	0.07758	0.08517	0.08686	0.10329	0.08843	0.09592	0.08643
Within R ²	0.07464	0.07758	0.08517	0.08686	0.10329	0.08843	0.09592	0.08643

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

Table B.5: 2018 EU dual-use list: military use and rank of military use

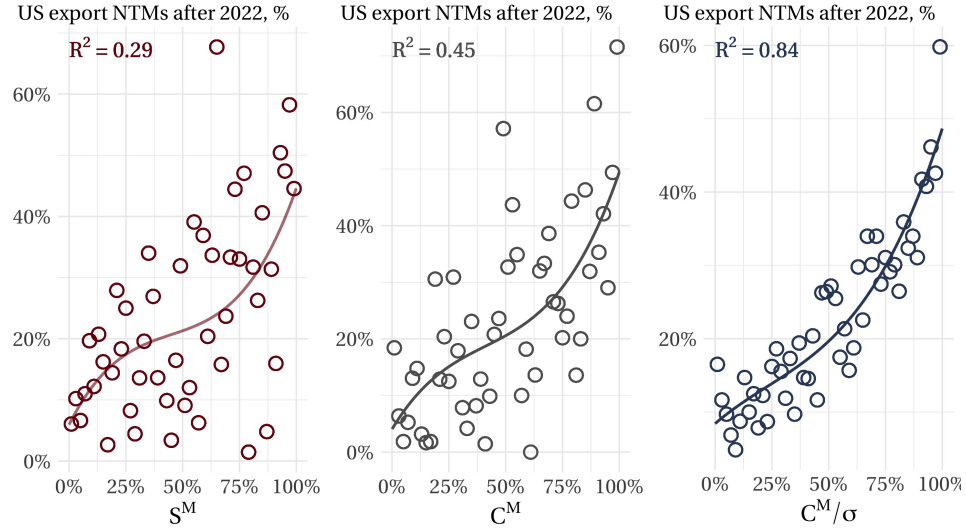
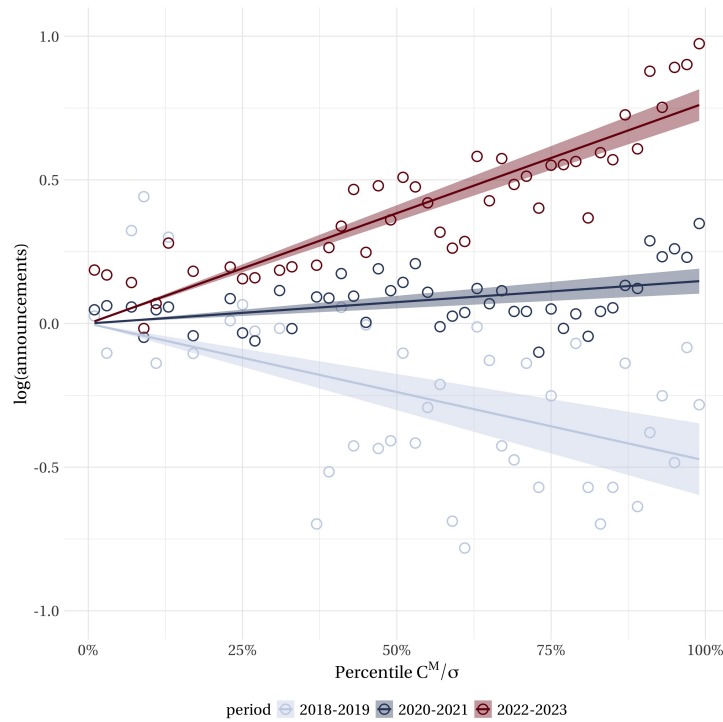


Figure B.4: Military use and the U.S. BIS export restrictions after 2022



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

Figure B.5: Global counts of export NTM announcements

C Calibration

	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.1: Counterfactual: optimal export taxes with a flexible budget