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

Maxim Alekseev Xinyue Lin

January 2, 2025


UNITED STATES
AIR FORCE

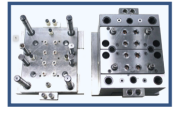

UNITED STATES
AIR FORCE

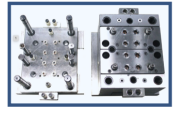
cHc CHENGDU MAGNETIC MATERIAL SCIENCE AND TECHNOLOGY CO.,LTD
ISO9001 成都航磁科技有限公司

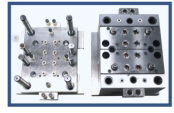
NORTHROP GRUMMAN

CHENGDU MAGNETIC MATERIAL SCIENCE AND TECHNOLOGY CO.,LTD
ISO9001 成都航磁科技有限公司

銀河磁體 Galaxy Magnets







ship engines | CNC | drones | history

This paper

National security considerations increasingly shape trade and industrial policy

- We document some empirical facts about dual-use goods

How should governments treat dual-use goods, and what does dual-use even mean?

- We formalize a military externality and derive optimal trade taxes across goods

Can we determine what goods are dual-use in the data?

- We develop an empirical measure of military use based on our tax formulas

How big is the national security externality?

- We calibrate our model to a potential U.S.-China conflict

This paper

National security considerations increasingly shape trade and industrial policy

- We document some empirical facts about dual-use goods

How should governments treat dual-use goods, and what does dual-use even mean?

- We formalize a military externality and derive optimal trade taxes across goods

Can we determine what goods are dual-use in the data?

- We develop an empirical measure of military use based on our tax formulas

How big is the national security externality?

- We calibrate our model to a potential U.S.-China conflict

This paper

National security considerations increasingly shape trade and industrial policy

- We document some empirical facts about dual-use goods

How should governments treat dual-use goods, and what does dual-use even mean?

- We formalize a military externality and derive optimal trade taxes across goods

Can we determine what goods are dual-use in the data?

- We develop an empirical measure of military use based on our tax formulas

How big is the national security externality?

- We calibrate our model to a potential U.S.-China conflict

This paper

National security considerations increasingly shape trade and industrial policy

- We document some empirical facts about dual-use goods

How should governments treat dual-use goods, and what does dual-use even mean?

- We formalize a military externality and derive optimal trade taxes across goods

Can we determine what goods are dual-use in the data?

- We develop an empirical measure of military use based on our tax formulas

How big is the national security externality?

- We calibrate our model to a potential U.S.-China conflict

Literature

Thematically: **Trade and international political economy** more

Grossman-Helpman (1994), Antràs-Padró i Miquel (2011, 2023), Kleinman-Liu-Redding (2023), Adão-Costinot-Donaldson-Sturm (2023, 2024)

Contribution: military contest in a trade model

Theoretically: **Optimal tariffs on networks with an externality** more

Helpman-Krugman (1989), Costinot-Donaldson-Vogel-Werning (2015), Liu (2019), Farrokhi-Lashkaripour (2022), Baqaee-Farhi (2024), Becko (2024)

Contribution: optimal taxes with multiple agents, externality, and wedges in GE

Empirically: **Industry network quantifications** more

Leontief (1937), Antràs-Chor-Fally-Hillberry (2012), Hausmann-Hidalgo-Bustos-Coscia-Simoes-Yildirim (2013), Evenett (2019), Cox-Müller-Pasten-Schoenle-Weber (2023)

Contribution: military use measure

Literature

Thematically: **Trade and international political economy** more

Grossman-Helpman (1994), Antràs-Padró i Miquel (2011, 2023), Kleinman-Liu-Redding (2023), Adão-Costinot-Donaldson-Sturm (2023, 2024)

Contribution: military contest in a trade model

Theoretically: **Optimal tariffs on networks with an externality** more

Helpman-Krugman (1989), Costinot-Donaldson-Vogel-Werning (2015), Liu (2019), Farrokhi-Lashkaripour (2022), Baqaee-Farhi (2024), Becko (2024)

Contribution: optimal taxes with multiple agents, externality, and wedges in GE

Empirically: **Industry network quantifications** more

Leontief (1937), Antràs-Chor-Fally-Hillberry (2012), Hausmann-Hidalgo-Bustos-Coscia-Simoes-Yildirim (2013), Evenett (2019), Cox-Müller-Pasten-Schoenle-Weber (2023)

Contribution: military use measure

Literature

Thematically: **Trade and international political economy** more

Grossman-Helpman (1994), Antràs-Padró i Miquel (2011, 2023), Kleinman-Liu-Redding (2023), Adão-Costinot-Donaldson-Sturm (2023, 2024)

Contribution: military contest in a trade model

Theoretically: **Optimal tariffs on networks with an externality** more

Helpman-Krugman (1989), Costinot-Donaldson-Vogel-Werning (2015), Liu (2019), Farrokhi-Lashkaripour (2022), Baqaee-Farhi (2024), Becko (2024)

Contribution: optimal taxes with multiple agents, externality, and wedges in GE

Empirically: **Industry network quantifications** more

Leontief (1937), Antràs-Chor-Fally-Hillberry (2012), Hausmann-Hidalgo-Bustos-Coscia-Simoes-Yildirim (2013), Evenett (2019), Cox-Müller-Pasten-Schoenle-Weber (2023)

Contribution: military use measure

Roadmap

(1) Motivating facts

(2) Simple model

(3) Empirical measurement

(4) Calibration

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Roadmap

(1) Motivating facts

(2) Simple model

(3) Empirical measurement

(4) Calibration

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Roadmap

(1) Motivating facts

(2) Simple model

(3) Empirical measurement

(4) Calibration

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Roadmap

(1) Motivating facts

(2) Simple model

(3) Empirical measurement

(4) Calibration

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Data sources

Input-output tables
BEA + Survey of U.S. Businesses, China NBES

Trade flows
BACI CEPII, Atlas of Economic Complexity

Military final demand
USASpending (government procurement), CSMAR (publicly traded Chinese firms), SIPRI (military spending), NARA Archives (historical)

Policy
EU Commission, U.S. Bureau of Industry Security, Global Trade Alert, OpenSanctions

Entities
Orbis, EGRUL

Data sources

Input-output tables
BEA + Survey of U.S. Businesses, China NBES

Trade flows
BACI CEPII, Atlas of Economic Complexity

Military final demand
USASpending (government procurement), CSMAR (publicly traded Chinese firms), SIPRI (military spending), NARA Archives (historical)

Policy
EU Commission, U.S. Bureau of Industry Security, Global Trade Alert, OpenSanctions

Entities
Orbis, EGRUL

Data sources

Input-output tables
BEA + Survey of U.S. Businesses, China NBES

Trade flows
BACI CEPII, Atlas of Economic Complexity

Military final demand
USASpending (government procurement), CSMAR (publicly traded Chinese firms), SIPRI (military spending), NARA Archives (historical)

Policy
EU Commission, U.S. Bureau of Industry Security, Global Trade Alert, OpenSanctions

Entities
Orbis, EGRUL

Data sources

Input-output tables
BEA + Survey of U.S. Businesses, China NBES

Trade flows
BACI CEPII, Atlas of Economic Complexity

Military final demand
USASpending (government procurement), CSMAR (publicly traded Chinese firms), SIPRI (military spending), NARA Archives (historical)

Policy
EU Commission, U.S. Bureau of Industry Security, Global Trade Alert, OpenSanctions

Entities
Orbis, EGRUL

Data sources

Input-output tables
BEA + Survey of U.S. Businesses, China NBES

Trade flows
BACI CEPII, Atlas of Economic Complexity

Military final demand
USASpending (government procurement), CSMAR (publicly traded Chinese firms), SIPRI (military spending), NARA Archives (historical)

Policy
EU Commission, U.S. Bureau of Industry Security, Global Trade Alert, OpenSanctions

Entities
Orbis, EGRUL

Motivating facts

Definition

For the purpose of this section,

dual-use goods $\equiv$ HS6 categories marked as “dual-use” by the EU customs with the purpose of licensing and monitoring trade flows

▸ institutions

Notes:

- Dual-use for now is a “legal” definition; no “economics” involved so far
- We will be linking this definition to economic properties

Definition

For the purpose of this section,

dual-use goods $\equiv$ HS6 categories marked as "dual-use" by the EU customs with the purpose of licensing and monitoring trade flows ▸ institutions

Notes:

- Dual-use for now is a "legal" definition; no "economics" involved so far
- We will be linking this definition to economic properties

Roadmap

Motivating facts:

(1) Dual-use goods are overwhelmingly intermediate inputs

(2) Dual-use goods are increasingly targeted by policy

(3) Dual-use trade responds to the security environment

Roadmap

Motivating facts:

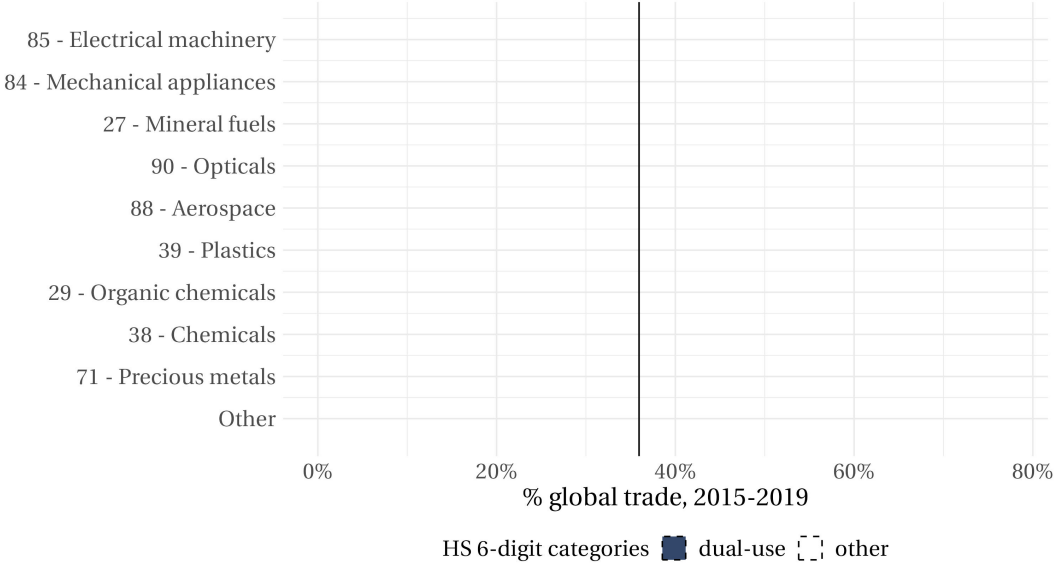
(1) Dual-use goods are overwhelmingly intermediate inputs
   - categories such as machine tools, aerospace, chemicals
   - in midstream industries selling more to the military

Sources: EU TARIC, BACII, BEA, Survey of U.S. Businesses, USASpending.gov

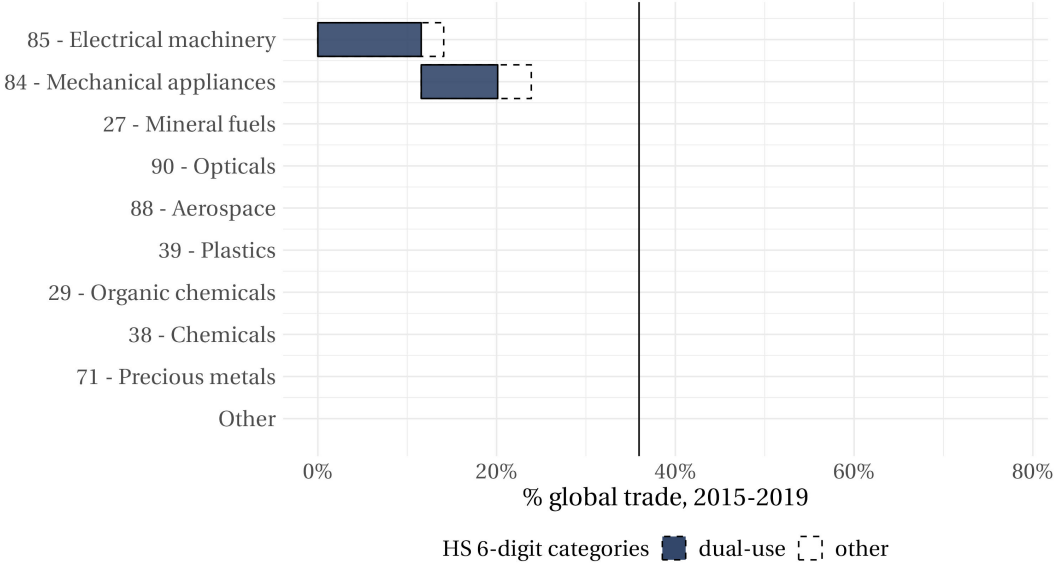
(2) Dual-use goods are increasingly targeted by policy

(3) Dual-use trade responds to the security environment

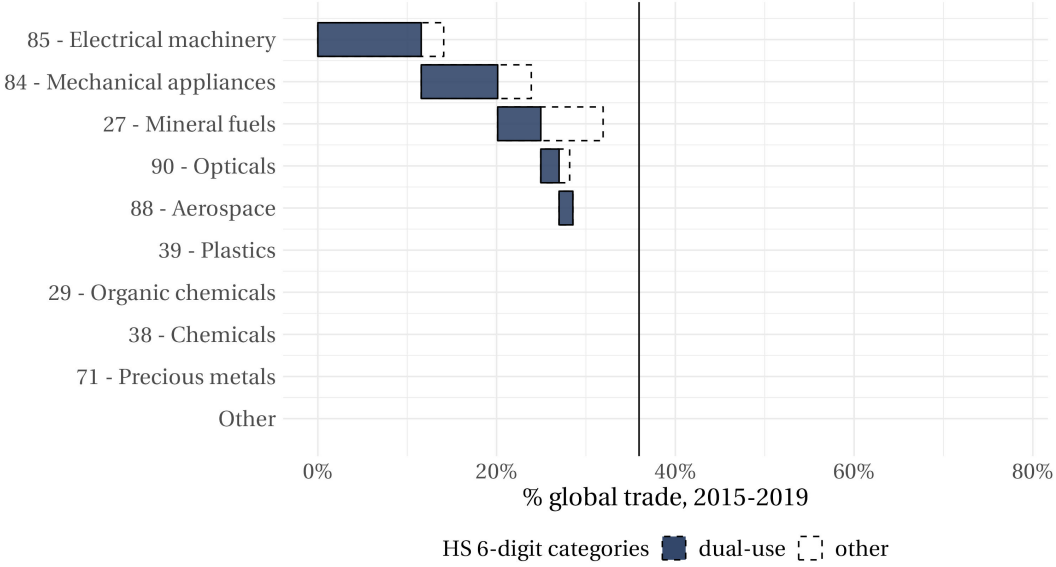
Fact #1. Dual-use goods are intermediate inputs



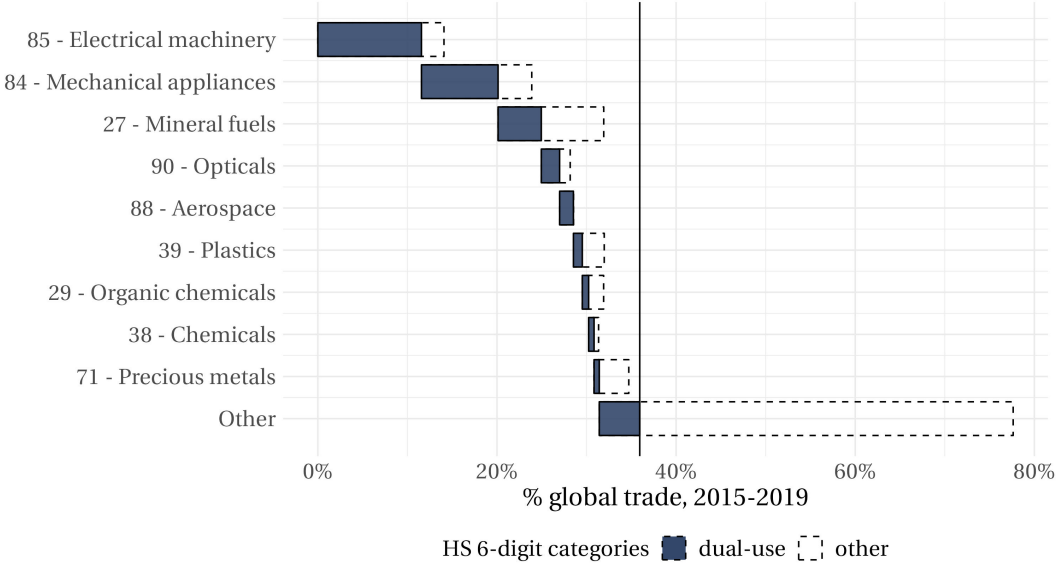
Fact #1. Dual-use goods are intermediate inputs



Fact #1. Dual-use goods are intermediate inputs

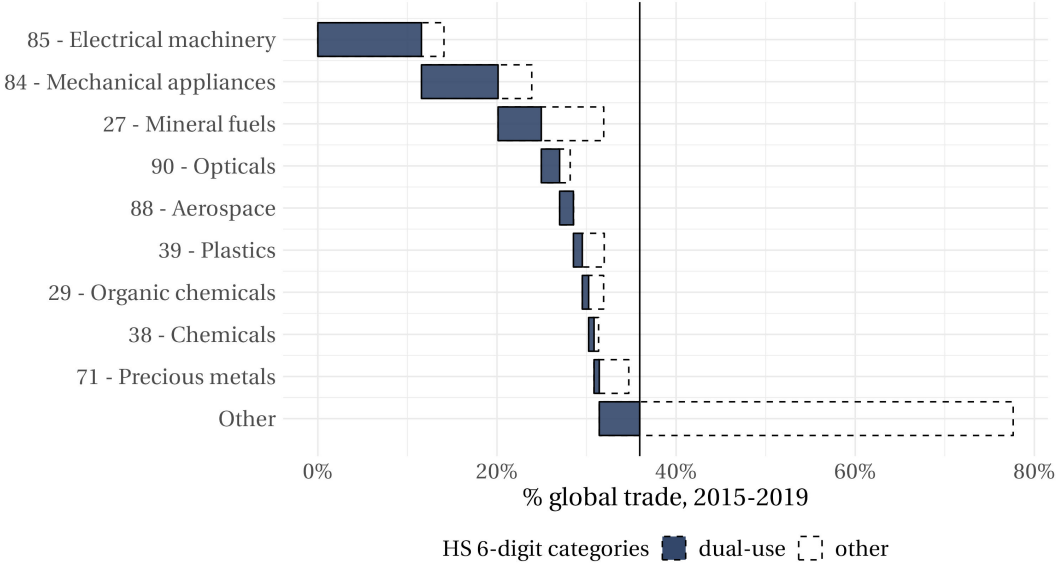


Fact #1. Dual-use goods are intermediate inputs



▸ ECCN share ▸ ECCN count

Fact #1. Dual-use goods are intermediate inputs



Dual-use HS6 are produced by midstream industries in the U.S. I-O tables

details

Roadmap

Motivating facts:

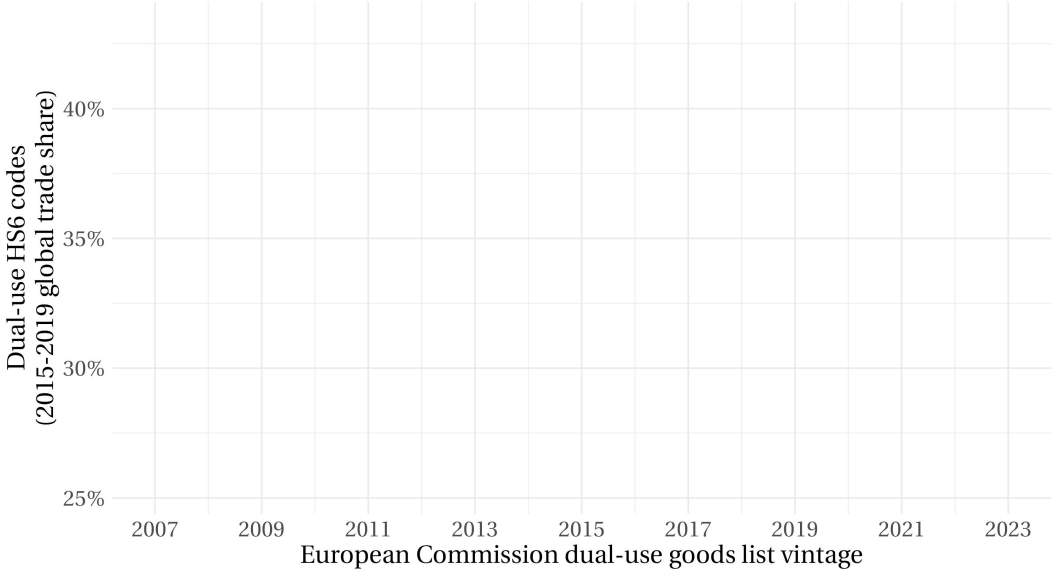
(1) Dual-use goods are overwhelmingly intermediate inputs

(2) Dual-use goods are increasingly targeted by policy
- EU doubled goods marked as D-U since 2007 with increases after 2014 and 2022
- "ringfencing" non-tariff measures that limit foreign access target dual-use goods
- rollout of new such measures increased tenfold relative to pre-2019 levels

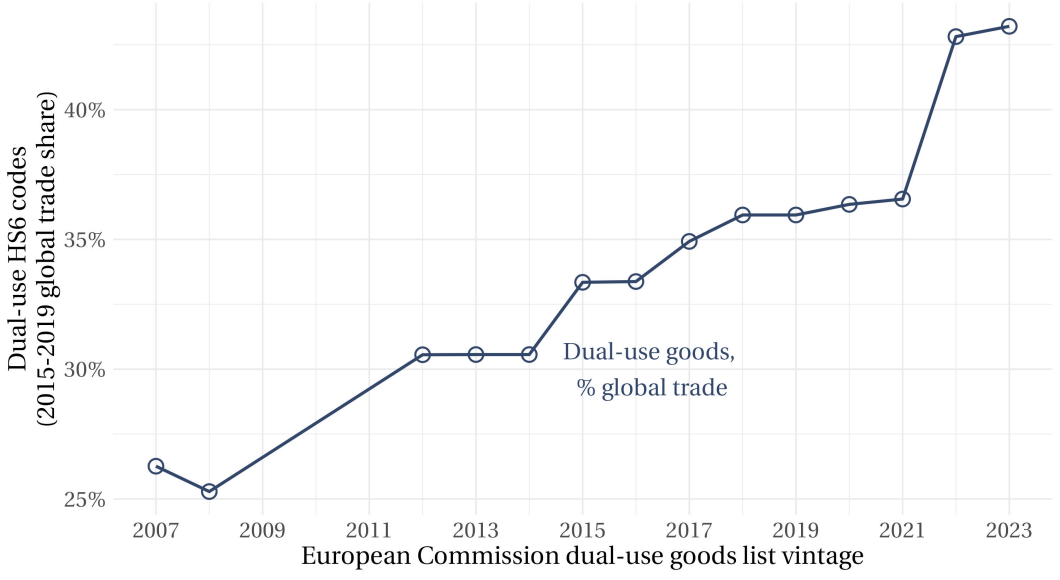
Sources: EU TARIC, Global Trade Alert

(3) Dual-use trade responds to changes in the security environment

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

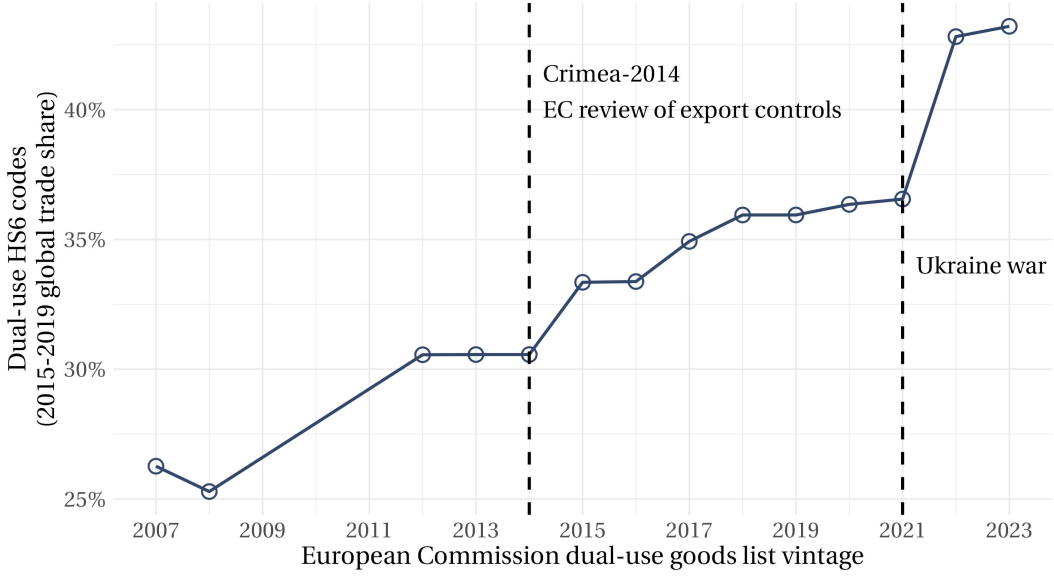


Fact #2. Trade in dual-use goods is increasingly regulated



▸ HS6 count

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



HS6 count | 2015 | 2022 | policies

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

HS6 count | 2015 | 2022 | policies

Roadmap

Motivating facts:

(1) Dual-use goods are overwhelmingly intermediate inputs

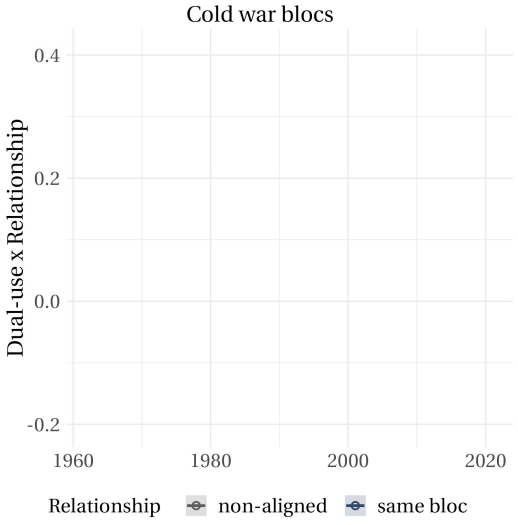
(2) Dual-use goods are increasingly targeted by policy

(3) Dual-use trade responds to changes in the security environment

- subsidy equivalent for D-U trade within Cold War blocs peaked in 1990 with 40%
- Ukraine war reversed half of post-Cold War decrease in bloc importance for D-U
- post-1960s wars give D-U goods 10% subsidy eq. for allies, 10% tariff eq. for enemies

Sources: BACI CEPII, Atlas of Economic Complexity, Correlates of War project, Wikipedia

Fact #3. Dual-use trade responds to the security environment

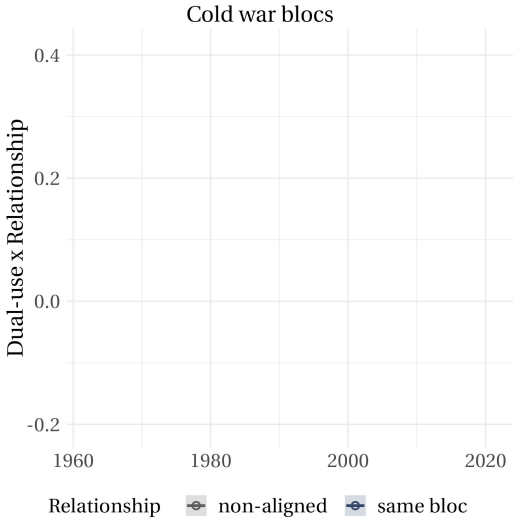


- Gravity equation

$$\log y_{ijkt} = \overbrace{\alpha^{\mathcal{T}}_{ijk}}^{\text{exp-imp-good}} + \overbrace{\alpha^{\mathcal{X}}_{ikt}}^{\text{exp-good-yr}} + \overbrace{\alpha^{\mathcal{M}}_{jkt}}^{\text{imp-good-yr}} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{D-U}_k \times \text{Relationship}_{ij} + \varepsilon_{ijkt}$$

- Western bloc, Eastern bloc, ROW
  non-aligned $\equiv$ E./W. bloc $\leftrightarrow$ ROW
- No weight on extensive margin
  $y_{ijkt} = \$0 \rightarrow \$1$ (Chen & Roth, 2024)
- 1960 serves as a base year

Fact #3. Dual-use trade responds to the security environment

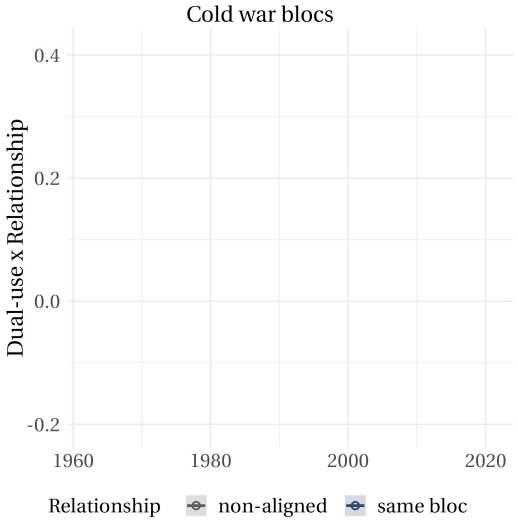


- Gravity equation

$$\log y_{ijkt} = \overbrace{\alpha^{\mathcal{T}}_{ijk}}^{\text{exp-imp-good}} + \overbrace{\alpha^{\mathcal{X}}_{ikt}}^{\text{exp-good-yr}} + \overbrace{\alpha^{\mathcal{M}}_{jkt}}^{\text{imp-good-yr}} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{D-U}_k \times \text{Relationship}_{ij} + \varepsilon_{ijkt}$$

- Western bloc, Eastern bloc, ROW
  non-aligned $\equiv$ E./W. bloc $\leftrightarrow$ ROW
- No weight on extensive margin
  $y_{ijkt} = \$0 \rightarrow \$1$ (Chen & Roth, 2024)
- 1960 serves as a base year

Fact #3. Dual-use trade responds to the security environment

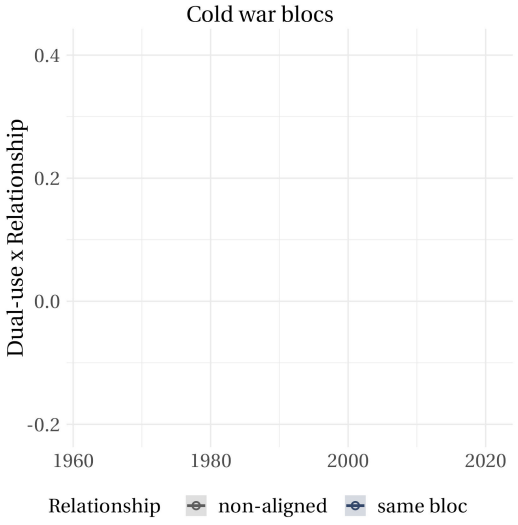


- Gravity equation

$$\log y_{ijkt} = \overbrace{\alpha^{\mathcal{T}}_{ijk}}^{\text{exp-imp-good}} + \overbrace{\alpha^{\mathcal{X}}_{ikt}}^{\text{exp-good-yr}} + \overbrace{\alpha^{\mathcal{M}}_{jkt}}^{\text{imp-good-yr}} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{D-U}_k \times \text{Relationship}_{ij} + \varepsilon_{ijkt}$$

- Western bloc, Eastern bloc, ROW
  non-aligned $\equiv$ E./W. bloc $\leftrightarrow$ ROW
- No weight on extensive margin
  $y_{ijkt} = \$0 \rightarrow \$1$ (Chen & Roth, 2024)
- 1960 serves as a base year

Fact #3. Dual-use trade responds to the security environment

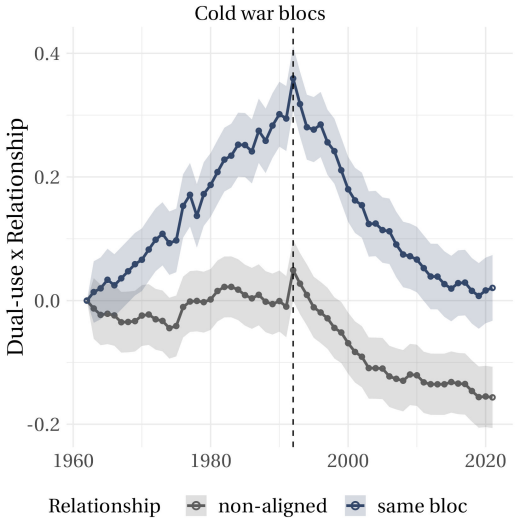


- Gravity equation

$$\log y_{ijkt} = \overbrace{\alpha^{\mathcal{T}}_{ijk}}^{\text{exp-imp-good}} + \overbrace{\alpha^{\mathcal{X}}_{ikt}}^{\text{exp-good-yr}} + \overbrace{\alpha^{\mathcal{M}}_{jkt}}^{\text{imp-good-yr}} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{D-U}_k \times \text{Relationship}_{ij} + \varepsilon_{ijkt}$$

- Western bloc, Eastern bloc, ROW
  non-aligned $\equiv$ E./W. bloc $\leftrightarrow$ ROW
- No weight on extensive margin
  $y_{ijkt} = \$0 \rightarrow \$1$ (Chen & Roth, 2024)
- 1960 serves as a base year

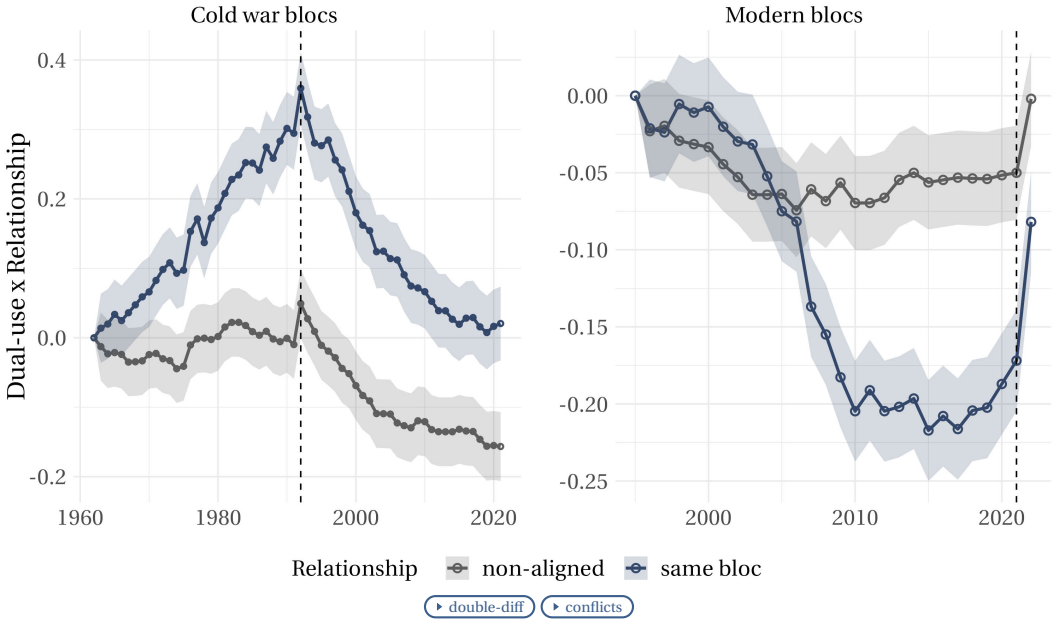
Fact #3. Dual-use trade responds to the security environment



$$\log y_{ijkt} = \overbrace{\alpha^{\mathcal{T}}_{ijk}}^{\text{exp-imp-good}} + \overbrace{\alpha^{\mathcal{X}}_{ikt}}^{\text{exp-good-yr}} + \overbrace{\alpha^{\mathcal{M}}_{jkt}}^{\text{imp-good-yr}} + \gamma_{t,R} \times \text{Relationship}_{ij} + \beta_{t,R} \times \text{D-U}_k \times \text{Relationship}_{ij} + \varepsilon_{ijkt}$$

– 40% subsidy equivalent in 1990

Fact #3. Dual-use trade responds to the security environment



Simple model

Roadmap

We introduce a military contest externality into a standard static trade model ...

(1) Start with the simplest case with convenient functional form picks
  - two-country Armington with an outside freely tradable good to pin down wages

(2) Add defense department as an agent that consumes goods besides households
  - home and foreign variety combined into a military aggregator

(3) National welfare = consumption + weight $\times$ home military vs foreign military
  - government chooses trade taxes and a military lump-sum tax on households

... and solve for optimal taxes across various scenarios

(i) no military contest (weight = 0)

(ii) trade taxes and military set simultaneously

(iii) first trade taxes, then military

(iv) add production networks

(v) networks + factors of production in fixed supply *(left for calibration)*

Roadmap

We introduce a military contest externality into a standard static trade model ...

(1) Start with the simplest case with convenient functional form picks
   - two-country Armington with an outside freely tradable good to pin down wages

(2) Add defense department as an agent that consumes goods besides households
   - home and foreign variety combined into a military aggregator

(3) National welfare = consumption + weight $\times$ home military vs foreign military
   - government chooses trade taxes and a military lump-sum tax on households

... and solve for optimal taxes across various scenarios

(i) no military contest (weight = 0)

(ii) trade taxes and military set simultaneously

(iii) first trade taxes, then military

(iv) add production networks

(v) networks + factors of production in fixed supply *(left for calibration)*

Roadmap

We introduce a military contest externality into a standard static trade model ...

(1) Start with the simplest case with convenient functional form picks
  - two-country Armington with an outside freely tradable good to pin down wages

(2) Add defense department as an agent that consumes goods besides households
  - home and foreign variety combined into a military aggregator

(3) National welfare = consumption + weight $\times$ home military vs foreign military
  - government chooses trade taxes and a military lump-sum tax on households

... and solve for optimal taxes across various scenarios

(i) no military contest (weight = 0)

(ii) trade taxes and military set simultaneously

(iii) first trade taxes, then military

(iv) add production networks

(v) networks + factors of production in fixed supply *(left for calibration)*

Roadmap

We introduce a military contest externality into a standard static trade model ...

(1) Start with the simplest case with convenient functional form picks
  - two-country Armington with an outside freely tradable good to pin down wages

(2) Add defense department as an agent that consumes goods besides households
  - home and foreign variety combined into a military aggregator

(3) National welfare = consumption + weight $\times$ home military vs foreign military
  - government chooses trade taxes and a military lump-sum tax on households

... and solve for optimal taxes across various scenarios

(i) no military contest (weight = 0)

(ii) trade taxes and military set simultaneously

(iii) first trade taxes, then military

(iv) add production networks

(v) networks + factors of production in fixed supply *(left for calibration)*

Roadmap

We introduce a military contest externality into a standard static trade model ...

(1) Start with the simplest case with convenient functional form picks
   - two-country Armington with an outside freely tradable good to pin down wages

(2) Add defense department as an agent that consumes goods besides households
   - home and foreign variety combined into a military aggregator

(3) National welfare = consumption + weight $\times$ home military vs foreign military
   - government chooses trade taxes and a military lump-sum tax on households

... and solve for optimal taxes across various scenarios

(i) no military contest (weight = 0)

(ii) trade taxes and military set simultaneously

(iii) first trade taxes, then military

(iv) add production networks

(v) networks + factors of production in fixed supply *(left for calibration)*

Setup

diagram

Firms: produce local variety with labor, $q_k = \mathcal{F}_k(L_k)$

Aggregators: flexibly combine varieties from firms $k \in \{H, F\}$ to yield goods

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

Households: maximize quasi-linear utility U^C with an outside freely tradable good

$$\max_{B_i, y_i} B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad \text{subject to} \quad B_i + C_i \leq wL_i + R_i - M_i$$

Defense department: maximizes national security U^M

$$\max_{m_i} \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \quad \text{subject to} \quad P_i^M m_i \leq M_i$$

Government: set trade taxes and military spending to maximize national welfare

$$\max_{\{\tau_i\}, M_i} U_i^C + \beta_i \times U_i^M$$

Setup

diagram

Firms: produce local variety with labor, $q_k = \mathcal{F}_k(L_k)$

Aggregators: flexibly combine varieties from firms $k \in \{H, F\}$ to yield goods

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

Households: maximize quasi-linear utility U^C with an outside freely tradable good

$$\max_{B_i, y_i} B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad \text{subject to} \quad B_i + C_i \leq wL_i + R_i - M_i$$

Defense department: maximizes national security U^M

$$\max_{m_i} \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \quad \text{subject to} \quad P_i^M m_i \leq M_i$$

Government: set trade taxes and military spending to maximize national welfare

$$\max_{\{\tau_i\}, M_i} U_i^C + \beta_i \times U_i^M$$

Setup

diagram

Firms: produce local variety with labor, $q_k = \mathcal{F}_k(L_k)$

Aggregators: flexibly combine varieties from firms $k \in \{H, F\}$ to yield goods

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

Households: maximize quasi-linear utility U^C with an outside freely tradable good

$$\max_{B_i, y_i} \; B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad \text{subject to} \quad B_i + C_i \leq wL_i + R_i - M_i$$

Defense department: maximizes national security U^M

$$\max_{m_i} \; \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \quad \text{subject to} \quad P_i^M m_i \leq M_i$$

Government: set trade taxes and military spending to maximize national welfare

$$\max_{\{\tau_i\}, M_i} \; U_i^C + \beta_i \times U_i^M$$

Setup

diagram

Firms: produce local variety with labor, $q_k = \mathcal{F}_k(L_k)$

Aggregators: flexibly combine varieties from firms $k \in \{H, F\}$ to yield goods

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

Households: maximize quasi-linear utility U^C with an outside freely tradable good

$$\max_{B_i, y_i} \; B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad \text{subject to} \quad B_i + C_i \leq wL_i + R_i - M_i$$

Defense department: maximizes national security U^M

$$\max_{m_i} \; \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \quad \text{subject to} \quad P_i^M m_i \leq M_i$$

Government: set trade taxes and military spending to maximize national welfare

$$\max_{\{\tau_i\}, M_i} \; U_i^C + \beta_i \times U_i^M$$

Setup

diagram

Firms: produce local variety with labor, $q_k = \mathcal{F}_k(L_k)$

Aggregators: flexibly combine varieties from firms $k \in \{H, F\}$ to yield goods

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

Households: maximize quasi-linear utility U^C with an outside freely tradable good

$$\max_{B_i, y_i} \; B_i + \frac{\eta_i}{\eta_i - 1} c_i^{\frac{\eta_i - 1}{\eta_i}} \quad \text{subject to} \quad B_i + C_i \leq wL_i + R_i - M_i$$

Defense department: maximizes national security U^M

$$\max_{m_i} \; \frac{\zeta_i}{\zeta_i - 1} \left(\frac{m_i}{m_{-i}} \right)^{\frac{\zeta_i - 1}{\zeta_i}} \quad \text{subject to} \quad P_i^M m_i \leq M_i$$

Government: set trade taxes and military spending to maximize national welfare

$$\max_{\{\tau_i\}, M_i} \; U_i^C + \beta_i \times U_i^M$$

Optimal taxes: No military

Setup: (1) $\beta_i = 0$, (2) M_{-i} fixed

$$dW_i = \underbrace{dR_i}_{\text{revenue}} - \underbrace{C_i d \log P_i^C}_{\text{domestic distortion}}$$

$$\tau_{ik}^{\mathcal{M}} = 1, \qquad \frac{\tau_{-i,i}^{\mathcal{X}} - 1}{\tau_{-i,i}^{\mathcal{X}}} = -\frac{\overbrace{1}^{\text{ToT}}}{\mathcal{E}_{-i,i}^{-i,i} - 1},$$

$\mathcal{E}_{-i,i}^{-i,i}$ elasticity of country $-i$'s imports wrt firm i's goods

Intuition:

- Export taxes extract monopoly markup (terms of trade)
- Any domestic taxes are distortive

Optimal taxes: No military

Setup: (1) $\beta_i = 0$, (2) M_{-i} fixed

$$dW_i = \underbrace{dR_i}_{\text{revenue}} - \underbrace{C_i d \log P_i^C}_{\text{domestic distortion}}$$

$$\tau_{ik}^{\mathcal{M}} = 1, \qquad \frac{\tau_{-i,i}^{\mathcal{X}} - 1}{\tau_{-i,i}^{\mathcal{X}}} = -\frac{\overbrace{1}^{\text{ToT}}}{\mathcal{E}_{-i,i}^{-i,i} - 1},$$

$\mathcal{E}_{-i,i}^{-i,i}$ elasticity of country $-i$'s imports wrt firm i's goods

Intuition:

- Export taxes extract monopoly markup (terms of trade)
- Any domestic taxes are distortive

Optimal taxes: No military

Setup: (1) $\beta_i = 0$, (2) M_{-i} fixed

$$dW_i = \underbrace{dR_i}_{\text{revenue}} - \underbrace{C_i d \log P_i^C}_{\text{domestic distortion}}$$

$$\tau_{ik}^{\mathcal{M}} = 1, \qquad \frac{\tau_{-i,i}^{\mathcal{X}} - 1}{\tau_{-i,i}^{\mathcal{X}}} = -\frac{\overbrace{1}^{\text{ToT}}}{\mathcal{E}_{-i,i}^{-i,i} - 1},$$

$\mathcal{E}_{-i,i}^{-i,i}$ elasticity of country $-i$'s imports wrt firm i's goods

Intuition:

- Export taxes extract monopoly markup (terms of trade)
- Any domestic taxes are distortive

Optimal taxes: No military

Setup: (1) $\beta_i = 0$, (2) M_{-i} fixed

$$dW_i = \underbrace{dR_i}_{\text{revenue}} - \underbrace{C_i d \log P_i^C}_{\text{domestic distortion}}$$

$$\tau_{ik}^{\mathcal{M}} = 1, \qquad \frac{\tau_{-i,i}^{\mathcal{X}} - 1}{\tau_{-i,i}^{\mathcal{X}}} = -\frac{\overbrace{1}^{\text{ToT}}}{\mathcal{E}_{-i,i}^{-i,i} - 1},$$

$\mathcal{E}_{-i,i}^{-i,i}$ elasticity of country $-i$'s imports wrt firm i's goods

Intuition:

- Export taxes extract monopoly markup (terms of trade)
- Any domestic taxes are distortive

Optimal taxes: Simultaneous game

Setup: (1) $\beta_i \neq 0$, (2) trade taxes and a military tax imposed simultaneously

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

$$\tau_{ik}^{\mathcal{M}} = 1, \qquad \frac{\tau_{-i,i}^{\mathcal{X}} - 1}{\tau_{-i,i}^{\mathcal{X}}} = -\frac{\overbrace{1}^{\text{ToT}} + \overbrace{(M_i/M_{-i})}^{\text{macro}} \times \overbrace{S_{-i,i}^M}^{\text{sectoral}}}{\mathcal{E}_{-i,i}^{-i,i} - 1}$$

$S_{-i,i}^M$ share of firm i's foreign sales going to foreign military

Intuition:

- ToT + Pigouvian externality

Optimal taxes: Sequential game

Setup: (1) $\beta_i \neq 0$, (2) sequential move game (trade policy first, military second)

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

$$\frac{\tau^{\mathcal{M}}_{ik} - 1}{\tau^{\mathcal{M}}_{ik}} = -\frac{\text{ToT} + \overbrace{(1-\zeta_{i,-i})}^{\text{policy}} S^M_{ik}}{\mathcal{E}^{ik}_{ik} - 1}, \qquad \frac{\tau^{\mathcal{X}}_{-i,i} - 1}{\tau^{\mathcal{X}}_{-i,i}} = -\frac{\text{ToT} + \overbrace{\zeta_{i,-i}}^{\text{policy}} \times \tau^{\mathcal{M}}_{i,-i}(M_i/M_{-i}) S^M_{-i,i}}{\mathcal{E}^{-i,i}_{-i,i} - 1}.$$

$\zeta_{i,-i}$ conflict elasticity (captures foreign behavioral response for military build-up)

Intuition:

- ToT (▶) + Pigouvian externality + dynamic deterrent (a-la Becko & O'Connor, 2024)
- Domestic and import subsidies start playing a deterrence role

Optimal taxes: Networks

Setup: (1) simultaneous game, (2) add production networks

$$\frac{\tau^{\mathcal{X}}_{ki} - 1}{\tau^{\mathcal{X}}_{ki}} = -\frac{\text{ToT} + \tau^{\mathcal{M}}_{ki}\left[\left(\frac{M_i}{M_{-i}}\right)\mathcal{C}^{M}_{-i,k} - \mathcal{C}^{D}_{i,k}\right]}{\mathcal{E}^{ki} - 1}$$

$\mathcal{C}^{M}_{jk} \equiv \frac{[\Psi' s^{M}]_{jk} M_j}{[\tilde{\Psi}' s^{M}]_{jk} M_j + [\tilde{\Psi}' s^{C}]_{jk} C_j}$ military centrality of firm k for country j

$\mathcal{C}^{D}_{jk} \equiv \frac{[\Psi' s^{M}]_{jk} M_j + [\Psi' s^{C}]_{jk} C_j}{[\tilde{\Psi}' s^{M}]_{jk} M_j + [\tilde{\Psi}' s^{C}]_{jk} C_j}$ distortion centrality of firm k for country j

Intuition:

- ToT ▸ + trade-off b/w military (export) and distortion (roundabout) centrality
- Centrality is a network-adjusted sales share
  - For $1 of sales, how many cents go to foreign military/domestic economy? (with some taxation adjustments along the way)
  - Has some intuitive properties/ways to write it ▸ details

Empirical measurement

Future TEG Topics – Carbon Fiber?

- Carbon fiber was once the exotic material of aerospace, rocket motor cases, and centrifuge rotors. Now many of these early fibers/grades are obsolete with newer and better grades commonly used in sporting good and automobile applications.
- Given that these materials continue to have strategic applications, should the growing world wide availability and ever increasing civil and consumer uses force the NSG to look for innovative ways to address these concerns?

19

Roadmap

Which goods should be targeted in practice?

(1) We measure product-level military use in the data ...

(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

(4) ... and describe trade flows

Roadmap

Which goods should be targeted in practice?

(1) We measure product-level military use in the data ...

(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

(4) ... and describe trade flows

Measurement

Issue: optimal trade taxes and ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) are endogeneous equilibrium objects

- if bans on exchange of nuclear warheads exist, those are not military-centric
- ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) indicate where trade policy should move next but not where it is

Our military use measure captures production structure in a closed economy:

$$0 \leq \mathcal{C}^M_{\text{US},k}/\sigma_k \leq 1$$

- $\mathcal{C}^M_{jk} \equiv \frac{[\Psi' \boldsymbol{s}^M]_{jk} M_j}{[\Psi' \boldsymbol{s}^M]_{jk} M_j + [\Psi' \boldsymbol{s}^C]_{jk} C_j} \in [0,1]$ is the U.S. closed-economy military centrality
  - Sufficient statistic for a domestic setup with no trade regulations
- $\sigma_k \geq 1$ are import demand elasticities
  - CES elasticity of substitution within variety between export origins
  - partial equilibrium proxy for demand elasticity ($\mathcal{E}_k - 1$) with networks and GE
  - also proxies for stockpiling projected on a static estimation strategy
  - Soderbery (2015) estimates with robustness to other methods

Measurement

Issue: optimal trade taxes and ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) are endogeneous equilibrium objects

- if bans on exchange of nuclear warheads exist, those are not military-centric
- ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) indicate where trade policy should move next but not where it is

Our military use measure captures production structure in a closed economy:

$$0 \leq \mathcal{C}^M_{\text{US},k}/\sigma_k \leq 1$$

- $\mathcal{C}^M_{jk} \equiv \frac{[\Psi' s^M]_{jk} M_j}{[\Psi' s^M]_{jk} M_j + [\Psi' s^C]_{jk} C_j} \in [0,1]$ is the U.S. closed-economy military centrality
  - Sufficient statistic for a domestic setup with no trade regulations
- $\sigma_k \geq 1$ are import demand elasticities
  - CES elasticity of substitution within variety between export origins
  - partial equilibrium proxy for demand elasticity ($\mathcal{E}_k - 1$) with networks and GE
  - also proxies for stockpiling projected on a static estimation strategy
  - Soderbery (2015) estimates with robustness to other methods

Measurement

Issue: optimal trade taxes and ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) are endogeneous equilibrium objects

- if bans on exchange of nuclear warheads exist, those are not military-centric
- ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) indicate where trade policy should move next but not where it is

Our military use measure captures production structure in a closed economy:

$$0 \leq \mathcal{C}^M_{\text{US},k}/\sigma_k \leq 1$$

- $\mathcal{C}^M_{jk} \equiv \frac{[\mathbf{\Psi}' \boldsymbol{s}^{\boldsymbol{M}}]_{jk} M_j}{[\mathbf{\Psi}' \boldsymbol{s}^{\boldsymbol{M}}]_{jk} M_j + [\mathbf{\Psi}' \boldsymbol{s}^{\boldsymbol{C}}]_{jk} C_j} \in [0,1]$ is the U.S. closed-economy military centrality
  - Sufficient statistic for a domestic setup with no trade regulations
- $\sigma_k \geq 1$ are import demand elasticities
  - CES elasticity of substitution within variety between export origins
  - partial equilibrium proxy for demand elasticity ($\mathcal{E}_k - 1$) with networks and GE
  - also proxies for stockpiling projected on a static estimation strategy
  - Soderbery (2015) estimates with robustness to other methods

Measurement

Issue: optimal trade taxes and ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) are endogeneous equilibrium objects

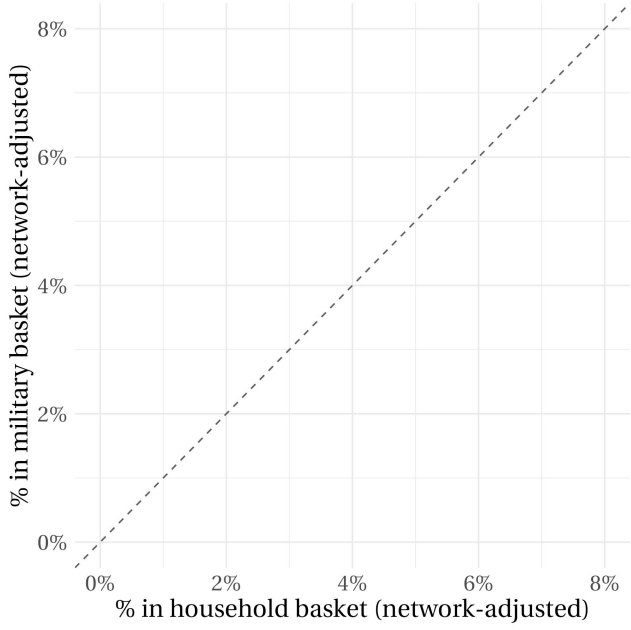
- if bans on exchange of nuclear warheads exist, those are not military-centric
- ($\mathcal{C}^M$, $\mathcal{C}^D$, $\mathcal{E}$) indicate where trade policy should move next but not where it is

Our military use measure captures production structure in a closed economy:

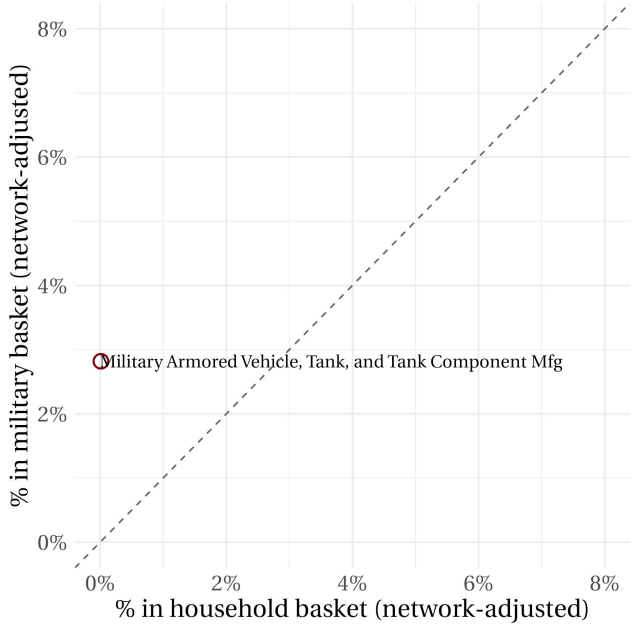
$$0 \leq \mathcal{C}^M_{\text{US},k}/\sigma_k \leq 1$$

- $\mathcal{C}^M_{jk} \equiv \frac{[\boldsymbol{\Psi}' \boldsymbol{s}^{\boldsymbol{M}}]_{jk} M_j}{[\boldsymbol{\Psi}' \boldsymbol{s}^{\boldsymbol{M}}]_{jk} M_j + [\boldsymbol{\Psi}' \boldsymbol{s}^{\boldsymbol{C}}]_{jk} C_j} \in [0,1]$ is the U.S. closed-economy military centrality
  - Sufficient statistic for a domestic setup with no trade regulations
- $\sigma_k \geq 1$ are import demand elasticities
  - CES elasticity of substitution within variety between export origins
  - partial equilibrium proxy for demand elasticity ($\mathcal{E}_k - 1$) with networks and GE
  - also proxies for stockpiling projected on a static estimation strategy
  - Soderbery (2015) estimates with robustness to other methods

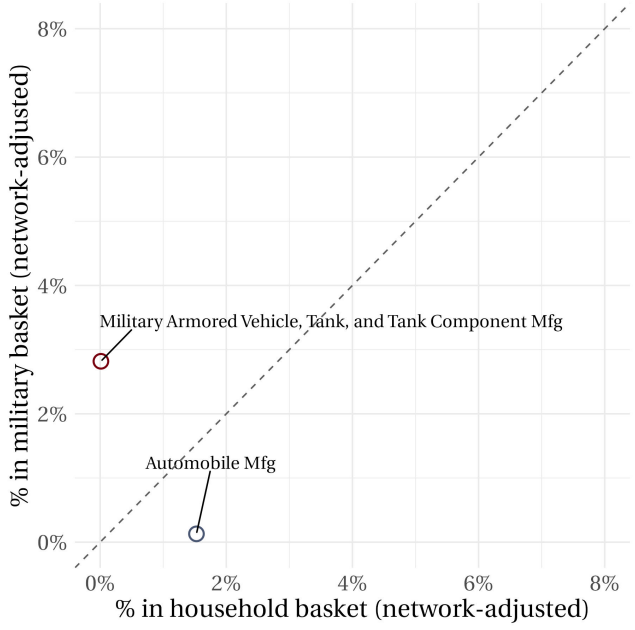
U.S. input-output tables



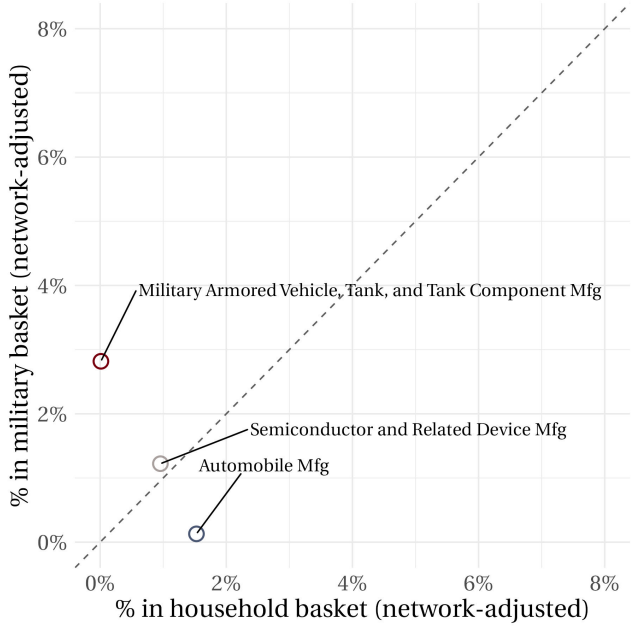
U.S. input-output tables



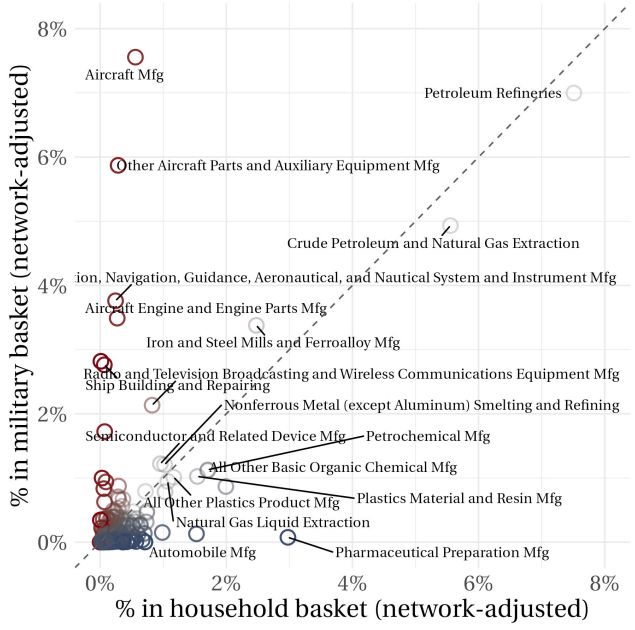
U.S. input-output tables



U.S. input-output tables



U.S. input-output tables



Top-15 goods

HS code	Description	$\mathcal{C}^{M}_{\mathrm{US},k}/\sigma_k$	$\Delta\tau(\%)$	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	✓

keywords | industries | correlations | distribution

Roadmap

Which goods should be targeted in practice?

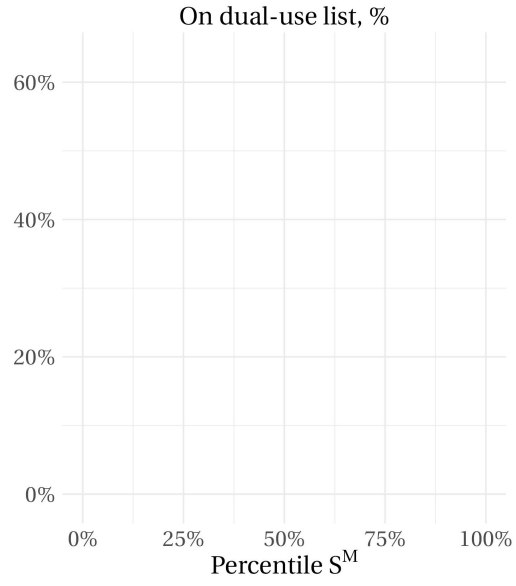
(1) We measure product-level military use in the data ...

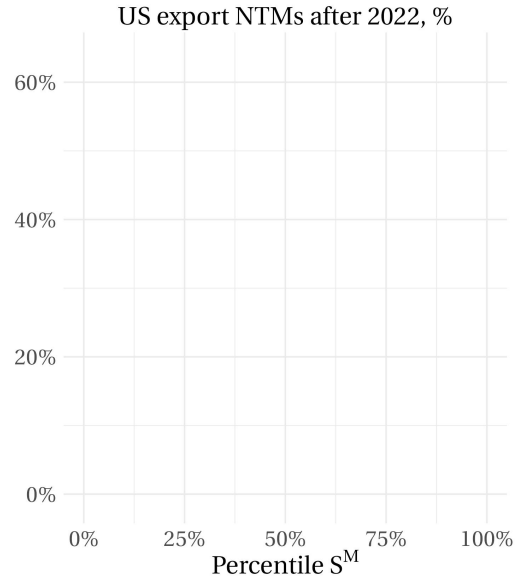
(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

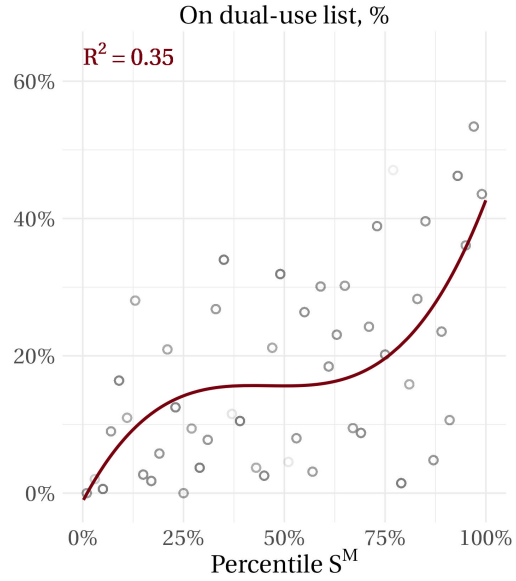
(4) ... and describe trade flows

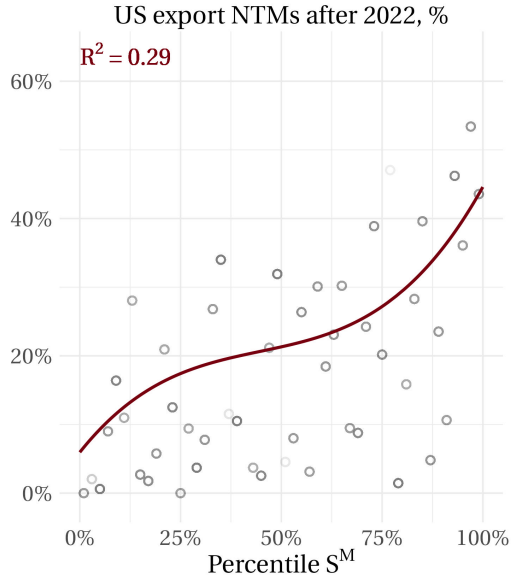
Sales fit


On dual-use list, %
60%
40%
20%
0%
0%
25%
50%
75%
100%
Percentile S^M

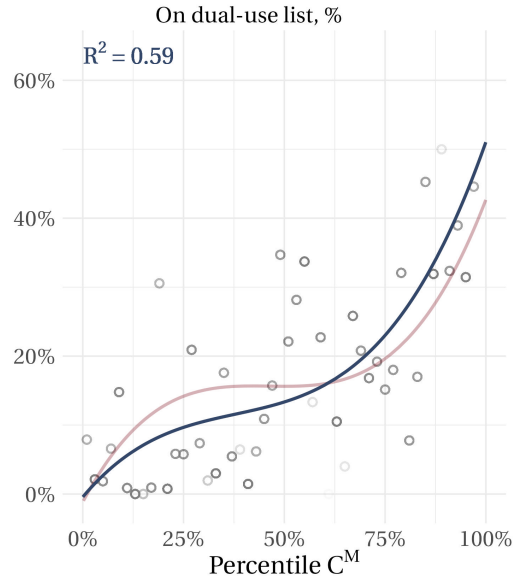

US export NTMs after 2022, %
60%
40%
20%
0%
0%
25%
50%
75%
100%
Percentile S^M

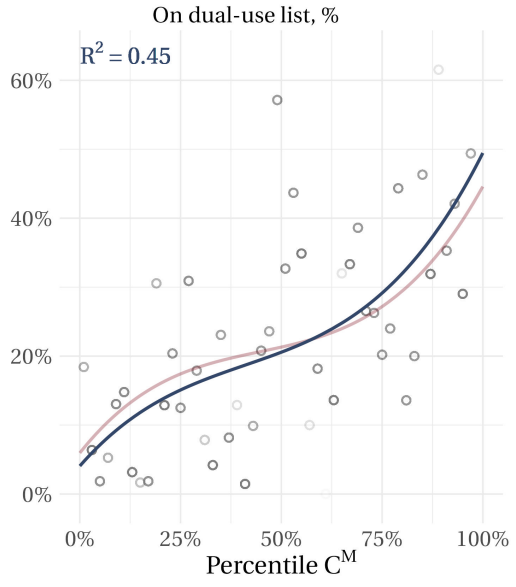
Sales fit


On dual-use list, %
$R^2 = 0.35$
60%
40%
20%
0%
0%
25%
50%
75%
100%
Percentile S^M


US export NTMs after 2022, %
$R^2 = 0.29$
60%
40%
20%
0%
0%
25%
50%
75%
100%
Percentile S^M

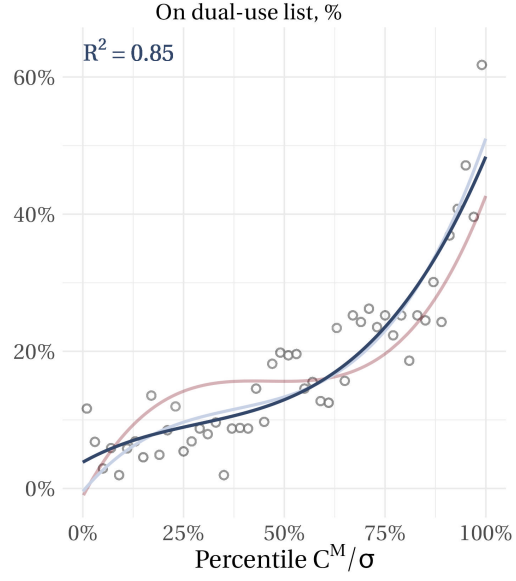
Centrality fit

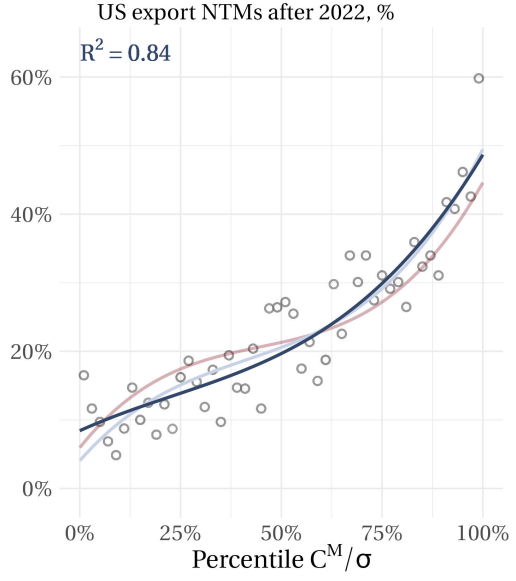




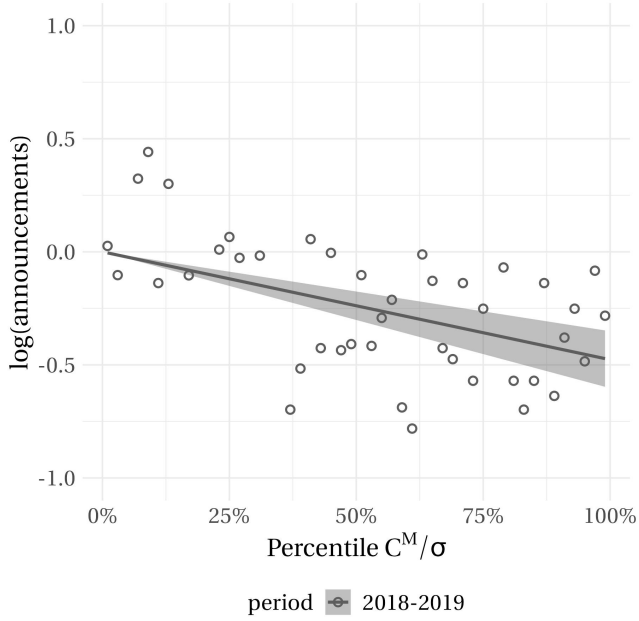
Military use fit

dual-use table | export table

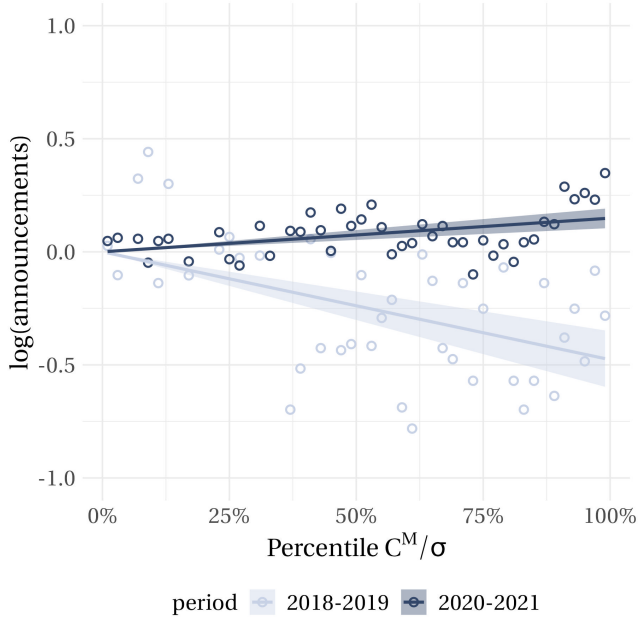




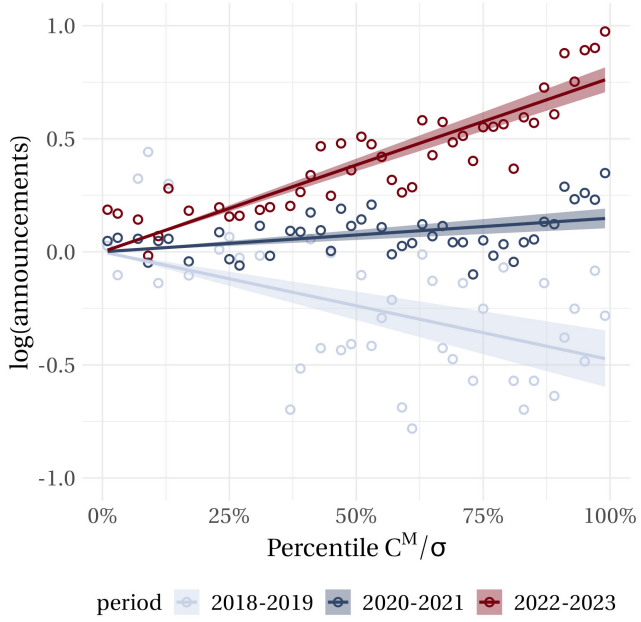
Global export non-tariff measures



Global export non-tariff measures



Global export non-tariff measures



Trade responses

Trade responses following conflict events

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

- Ukraine-2022 details
- Similar exercises for Russia-2022 ... details
- ... and China 2016-2022 details

Trade responses

Trade responses following conflict events

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

- Ukraine-2022 ▸ details
- Similar exercises for Russia-2022 ... ▸ details
- ... and China 2016-2022 ▸ details

Trade responses

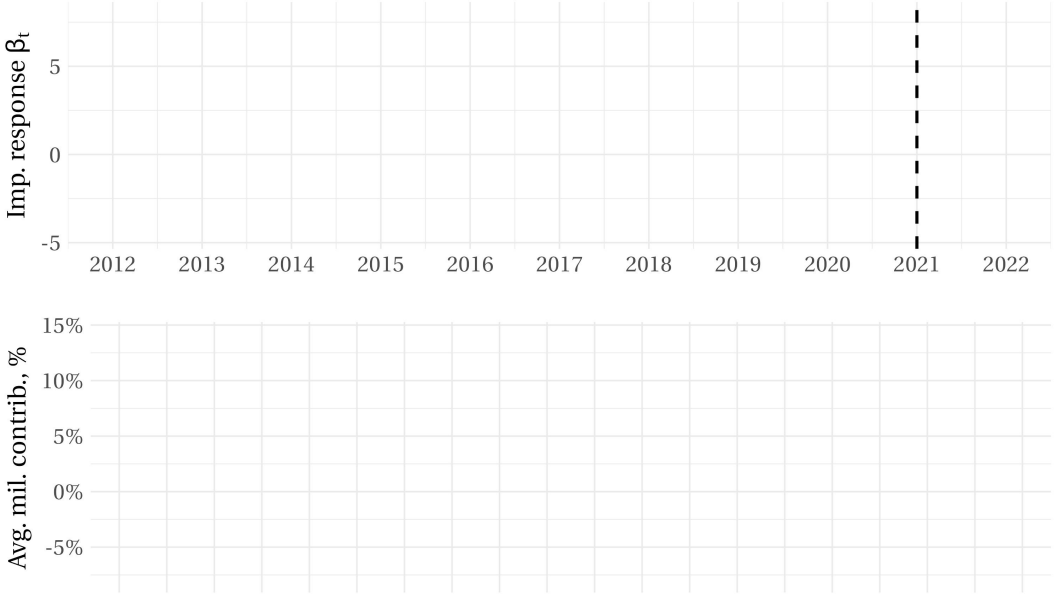
Trade responses following conflict events

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

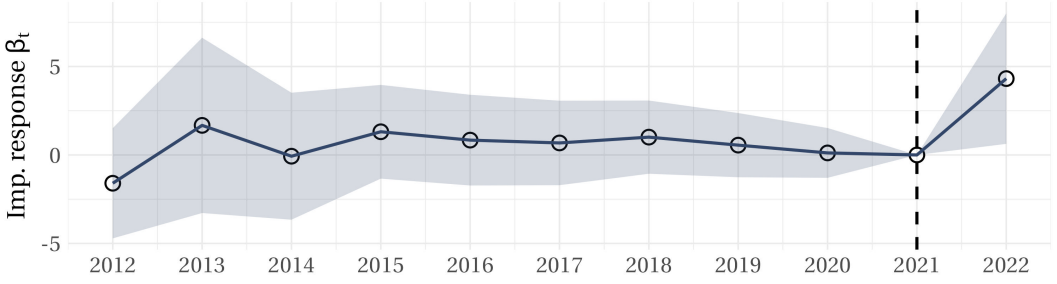
- Ukraine-2022 ▸ details
- Similar exercises for Russia-2022 ... ▸ details
- ... and China 2016-2022 ▸ details

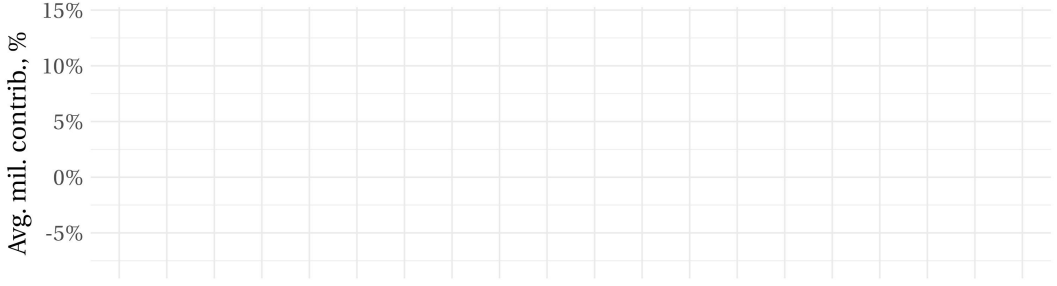
Ukraine-2022

▸ UKR goods ▸ UKR country-goods ▸ back



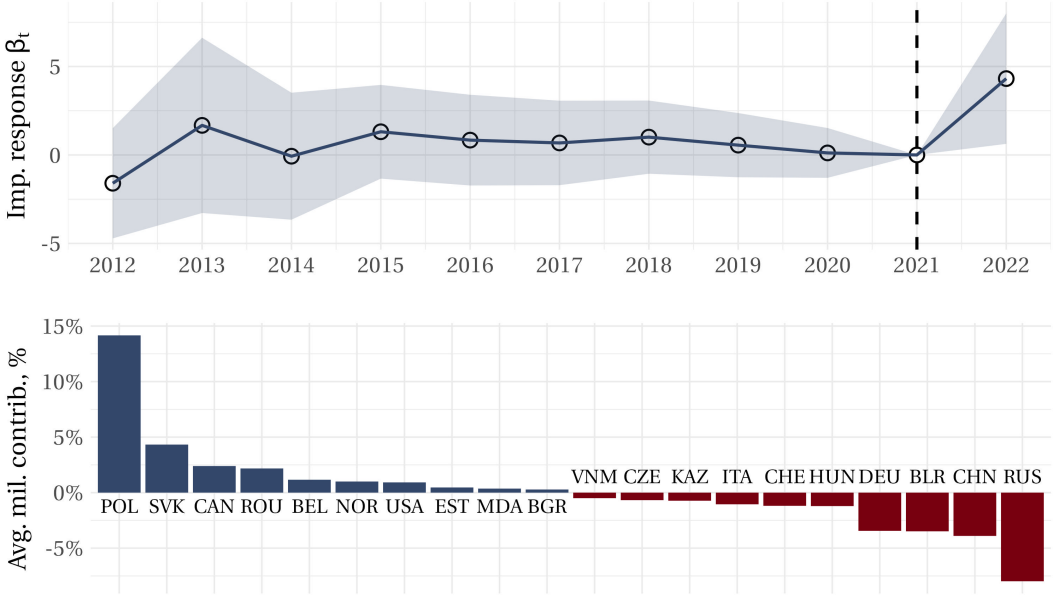
Ukraine-2022





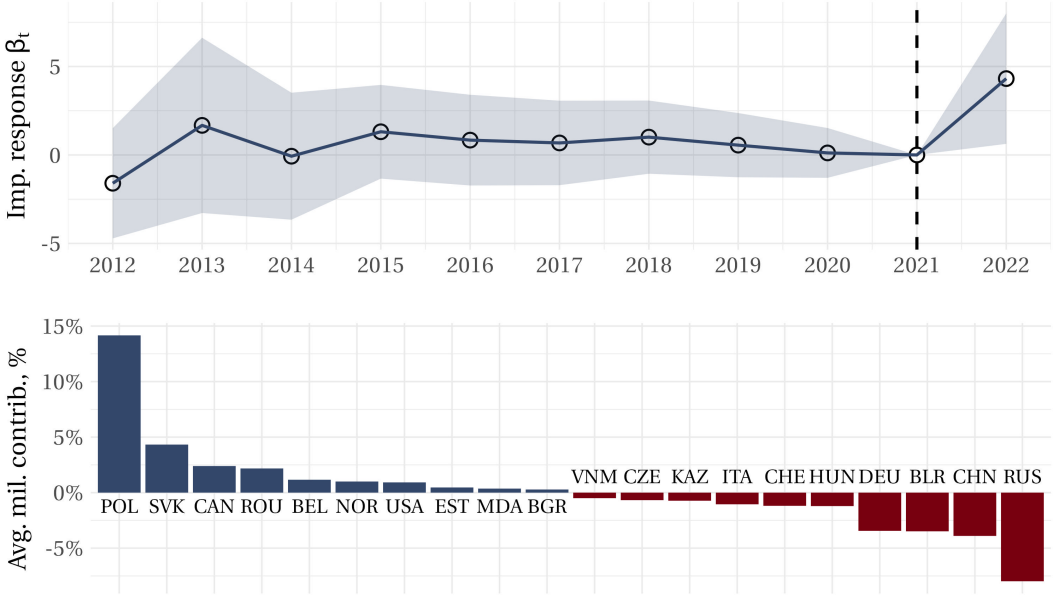
Ukraine-2022

UKR goods | UKR country-goods | back



Ukraine-2022

UKR goods | UKR country-goods | back



driven by: ammunition, tanks, weapons, warships, electric generating sets

Roadmap

Which goods should be targeted in practice?

(1) We measure product-level military use in the data ...

(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

(4) ... and describe trade flows

Evaluation

U.S. entity lists details

Sources: Bureau of Industry Security, Orbis

- by type
- by country

Similar exercises for EU critical goods lists ... details

Sources: EU Commission

... and sanctions against Russia details

Sources: OpenSanctions, EGRUL

Evaluation

U.S. entity lists ▸ details

Sources: Bureau of Industry Security, Orbis

- by type
- by country

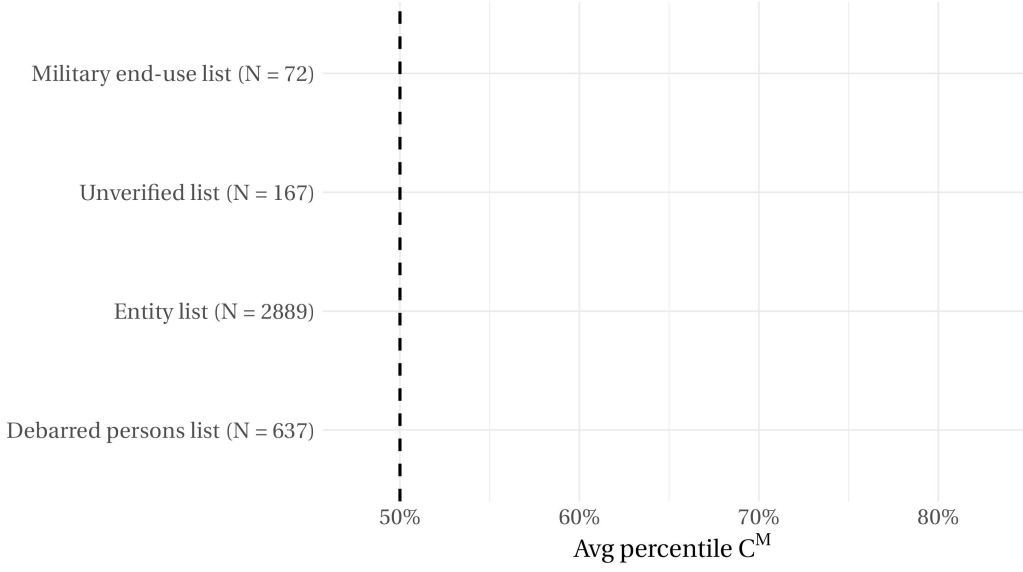
Similar exercises for EU critical goods lists ... ▸ details

Sources: EU Commission

... and sanctions against Russia ▸ details

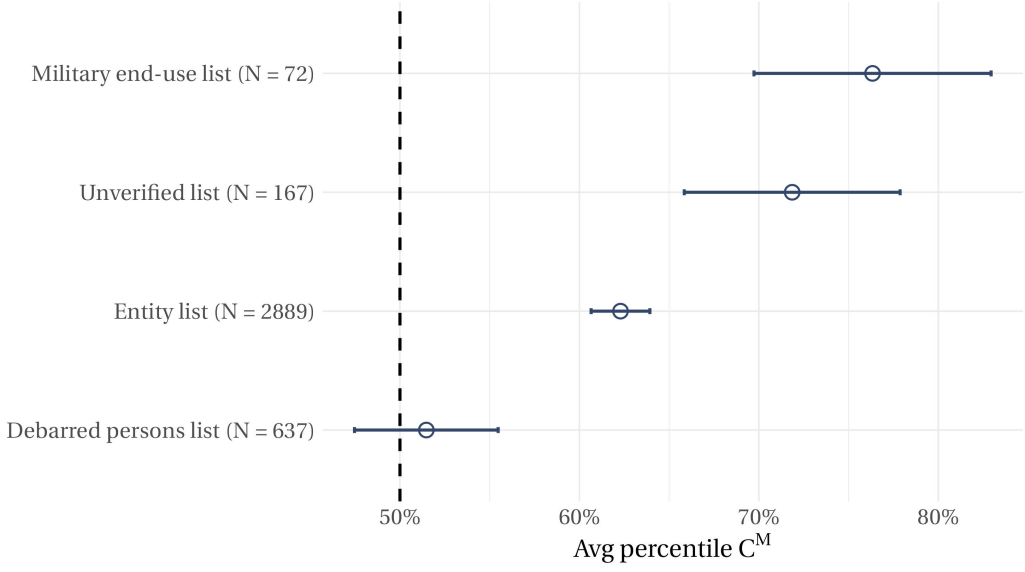
Sources: OpenSanctions, EGRUL

BIS lists



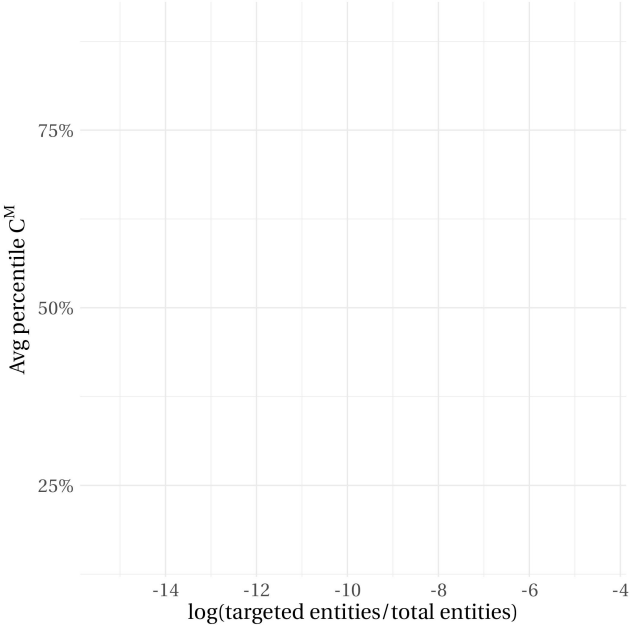
MEU, UV, DPL = trade ban, EL = verification

BIS lists



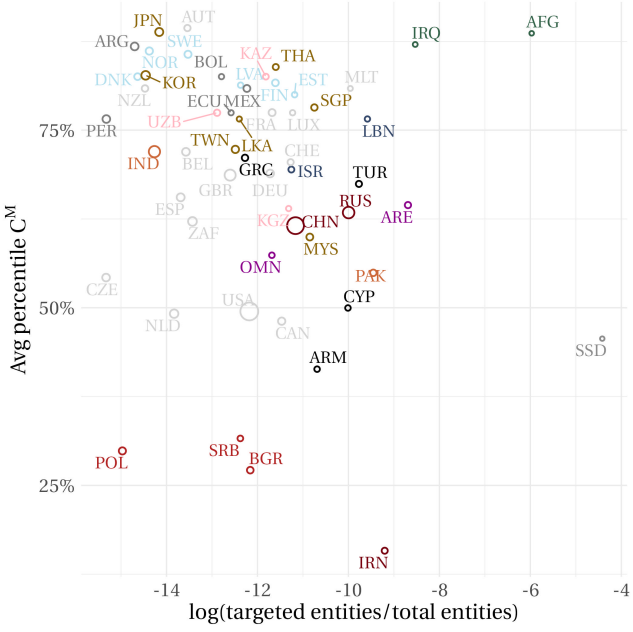
MEU, UV, DPL = trade ban, EL = verification

BIS lists: Targeting across countries



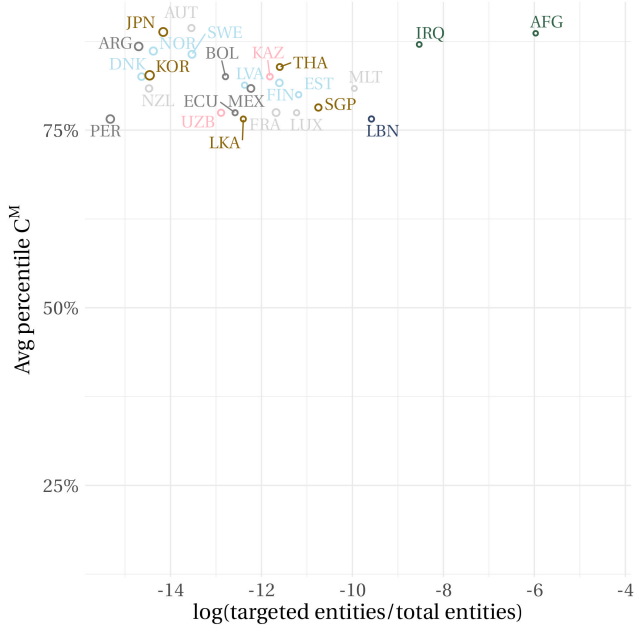
total per capita

BIS lists: Targeting across countries



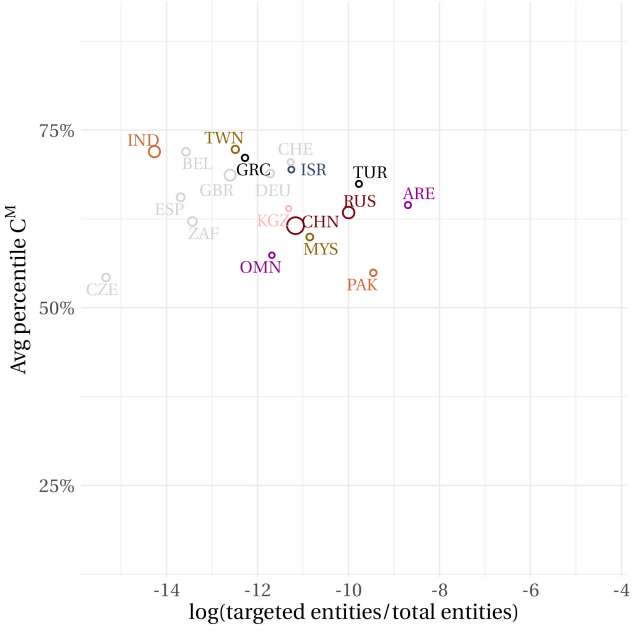
▸ total ▸ per capita

BIS lists: Targeting across countries



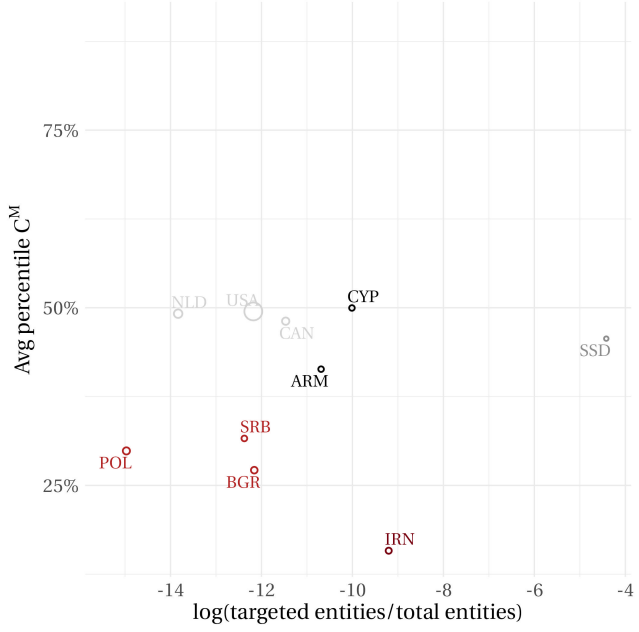
total per capita

BIS lists: Targeting across countries



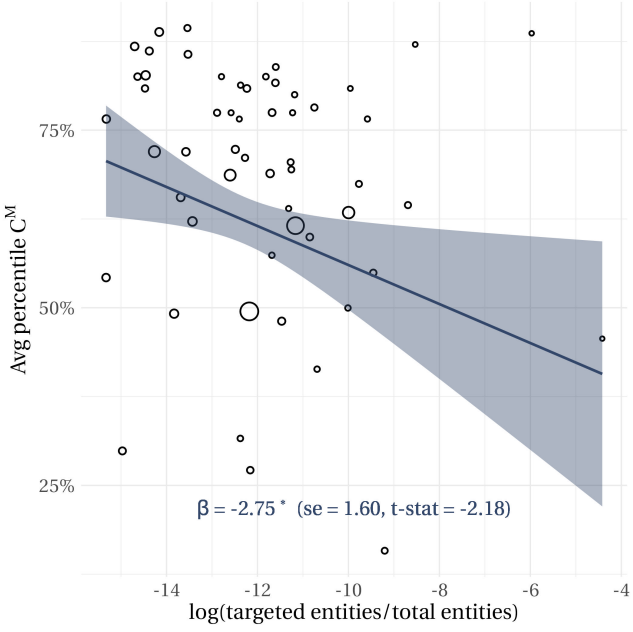
▸ total ▸ per capita

BIS lists: Targeting across countries



▸ total ▸ per capita

BIS lists: Targeting across countries



▸ total ▸ per capita

Roadmap

Which goods should be targeted in practice?

(1) We measure product-level military use in the data ...

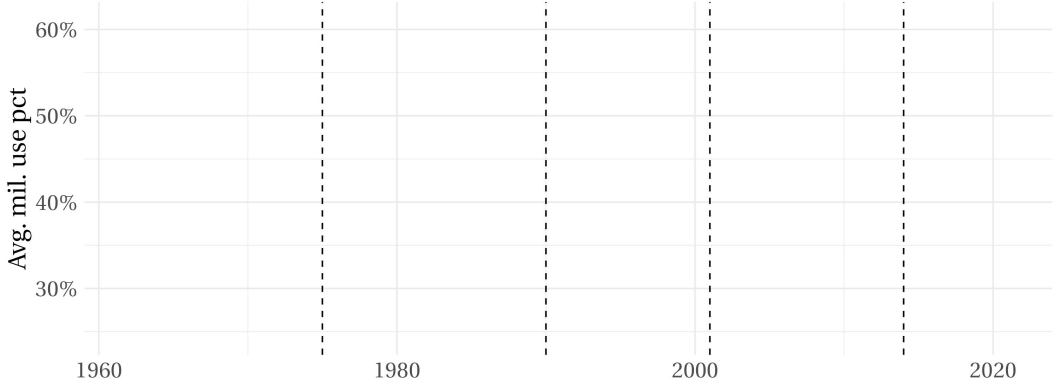
(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

(4) ... and describe trade flows

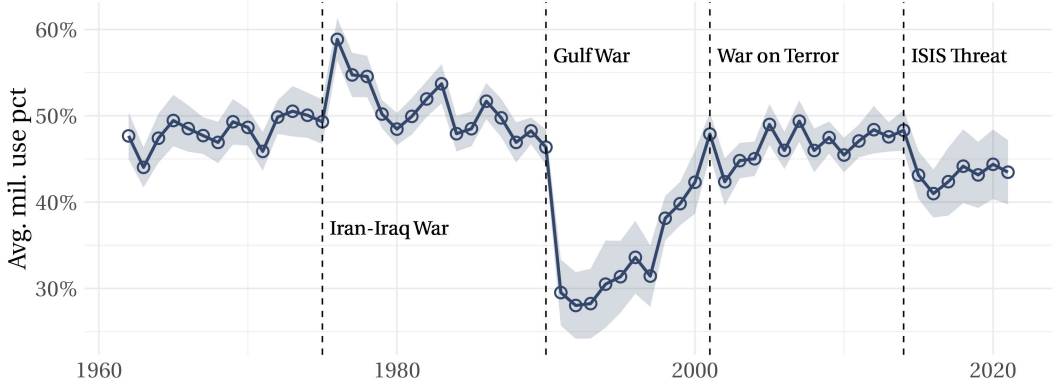
Trade flows

Iraq imports:



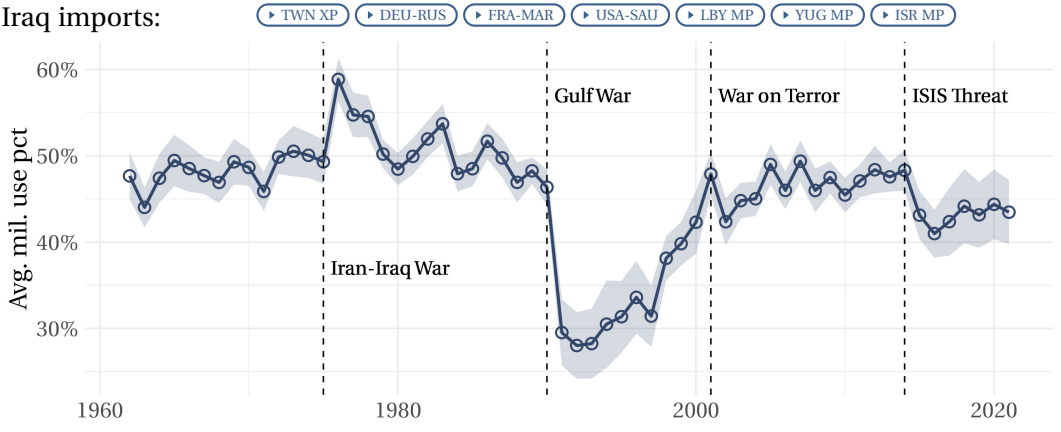
Trade flows

Iraq imports:



Trade flows

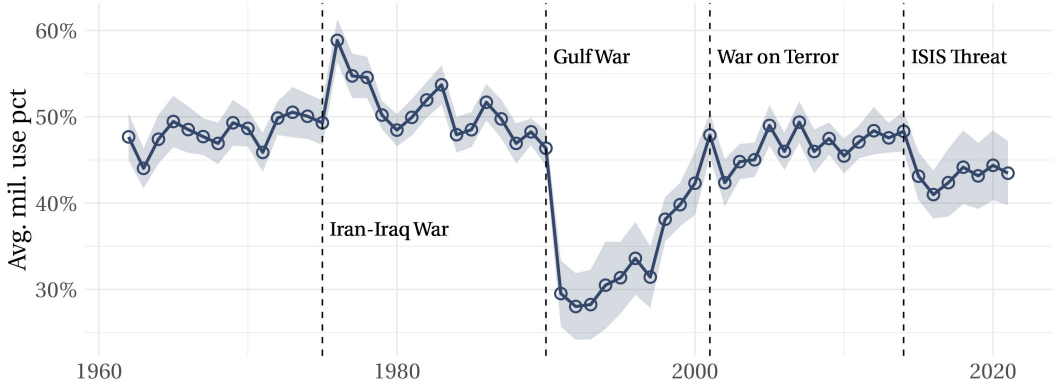
Iraq imports:



Trade flows

Iraq imports:

TWN XP | DEU-RUS | FRA-MAR | USA-SAU | LBY MP | YUG MP | ISR MP



Cumulative military export content:

cross-section | exports | imports | pairs

- China (17%), USA (9%), Germany (8%)
- 1995-2015: China ↑ (+13pp), Western Europe, North America, Japan ↓
- 1965-1995: East Asia, Mexico, Spain ↑, Western Europe, North America ↓

Calibration

Roadmap

What is the macroeconomic size of the national security externality?

(1) We extend our model to factors and pick functional forms, ...

(2) ... then calibrate the extended model to a potential U.S.-China conflict ...

(3) ... and look at the welfare implications of different policies

Roadmap

What is the macroeconomic size of the national security externality?

(1) We extend our theory to factors and pick functional forms, ... details

- ToT + centrality trade-off + factor centrality trade-off $\times$ factor price responses
- factor price responses calculated off compact propagation matrix formulas

$$\text{firm sales} \leftrightarrow \text{tax revenues} \leftrightarrow \text{factor income}$$

- domestic consumption + $\alpha\times$ foreign consumption + $\beta\times$ generalized contest

(2) ... then calibrate the model to a potential U.S.-China conflict ...

(3) ... and look at the welfare implications of different policies

Roadmap

What is the macroeconomic size of the national security externality?

(1) We extend our theory to factors and pick functional forms, ... ▸ details

(2) ... then calibrate the model to a potential U.S.-China conflict ...

- construct input-output tables for China ▸ China IO
  - military basket from the revenue of publicly traded Chinese military firms
- estimate model parameters

(3) ... and look at the welfare implications of different policies

Estimation

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N) = c_i + \sum_{j \neq i} \alpha_{ij} c_j + \beta_i \overbrace{\frac{g(m_i)}{g(m_i) + \sum_{j \neq i} g(m_j)}}^{\text{winning probability } \nu_t}, \quad g(m_i) = \underbrace{(m_{0i}}_{\text{stockpiles}} + m_i)^\gamma$$

Parameters:

- returns to scale $\gamma \approx 0.5$ off the U.S. response to the Eastern bloc build-up

  best fit for FOC: $\log m_t - \log[\nu_t(\gamma)(1 - \nu_t(\gamma))] = \boldsymbol{X}_t'\boldsymbol{\beta} + \epsilon_t$ ▸ plot

- security weight $\beta \approx 250\%$ annual U.S. GDP off marginal dollar spent

  PE intuition for GE: $\beta_i \frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}$ ▸ details

  - m_{0i} plays a role: when stockpiles are low, expenditures M_i are high, and vice versa
  - if m_{0i} were zero, the estimated value of β is $\approx 30\%$ annual U.S. GDP

Estimation

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N) = c_i + \sum_{j \neq i} \alpha_{ij} c_j + \beta_i \overbrace{\frac{g(m_i)}{g(m_i) + \sum_{j \neq i} g(m_j)}}^{\text{winning probability } \nu_t}, \quad g(m_i) = \underbrace{(m_{0i}}_{\text{stockpiles}} + m_i)^\gamma$$

Parameters:

- returns to scale $\gamma \approx 0.5$ off the U.S. response to the Eastern bloc build-up

  best fit for FOC: $\log m_t - \log[\nu_t(\gamma)(1 - \nu_t(\gamma))] = \boldsymbol{X}_t'\boldsymbol{\beta} + \epsilon_t$ ▸ plot

- security weight $\beta \approx 250\%$ annual U.S. GDP off marginal dollar spent

  PE intuition for GE: $\beta_i \frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}$ ▸ details

  - m_{0i} plays a role: when stockpiles are low, expenditures M_i are high, and vice versa
  - if m_{0i} were zero, the estimated value of β is $\approx 30\%$ annual U.S. GDP

Estimation

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N) = c_i + \sum_{j \neq i} \alpha_{ij} c_j + \beta_i \overbrace{\frac{g(m_i)}{g(m_i) + \sum_{j \neq i} g(m_j)}}^{\text{winning probability } \nu_t}, \quad g(m_i) = \underbrace{(m_{0i}}_{\text{stockpiles}} + m_i)^\gamma$$

Parameters:

- returns to scale $\gamma \approx 0.5$ off the U.S. response to the Eastern bloc build-up

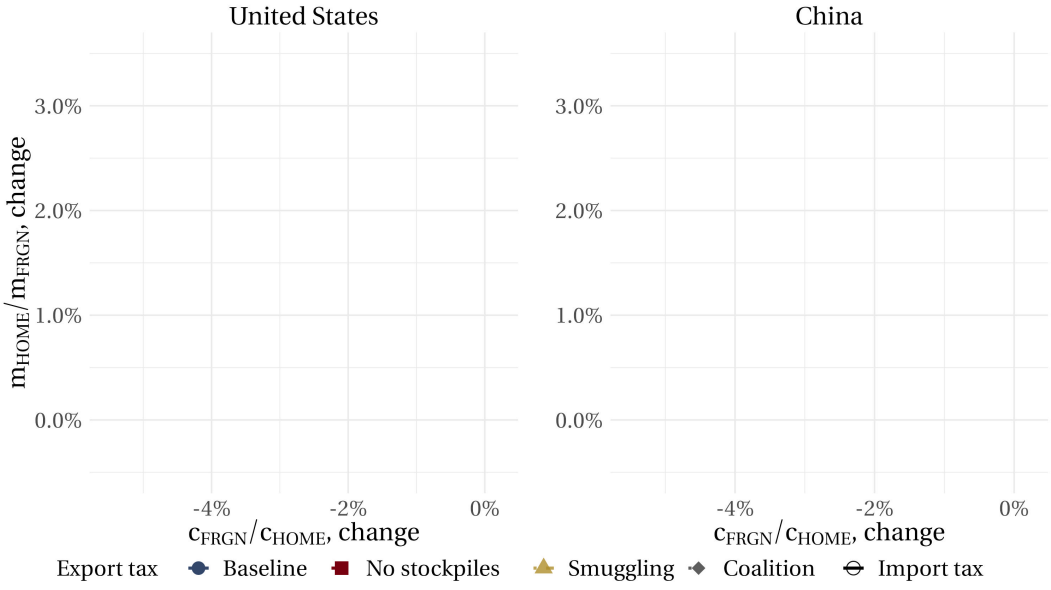
  best fit for FOC: $\log m_t - \log[\nu_t(\gamma)(1 - \nu_t(\gamma))] = \boldsymbol{X}_t'\boldsymbol{\beta} + \epsilon_t$ ▸ plot

- security weight $\beta \approx 250\%$ annual U.S. GDP off marginal dollar spent

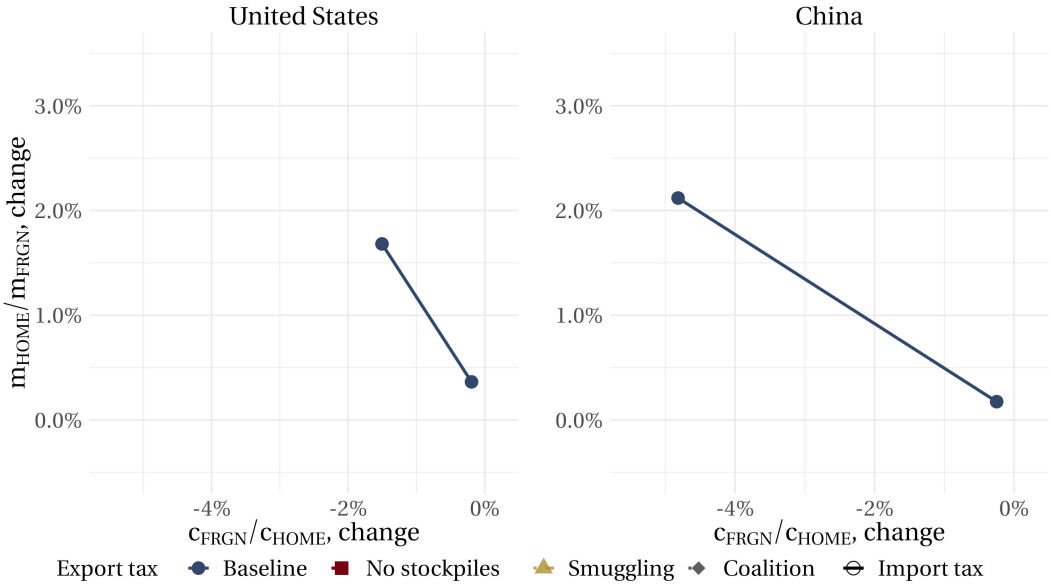
  PE intuition for GE: $\beta_i \frac{g'(m_i)}{g(m_i)} \frac{\nu_i(1-\nu_i)}{P_i^M} = \frac{1}{P_i^C}$ ▸ details

  - m_{0i} plays a role: when stockpiles are low, expenditures M_i are high, and vice versa
  - if m_{0i} were zero, the estimated value of β is $\approx 30\%$ annual U.S. GDP

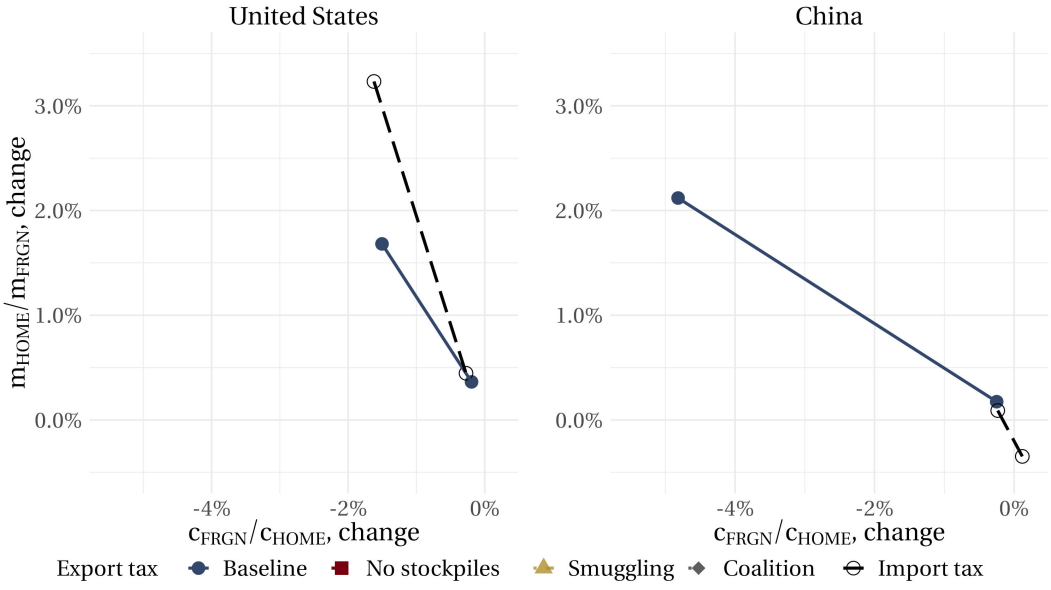
Results


United States
China
3.0%
2.0%
1.0%
0.0%
m_{HOME}/m_{FRGN}, change
-4%
-2%
0%
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

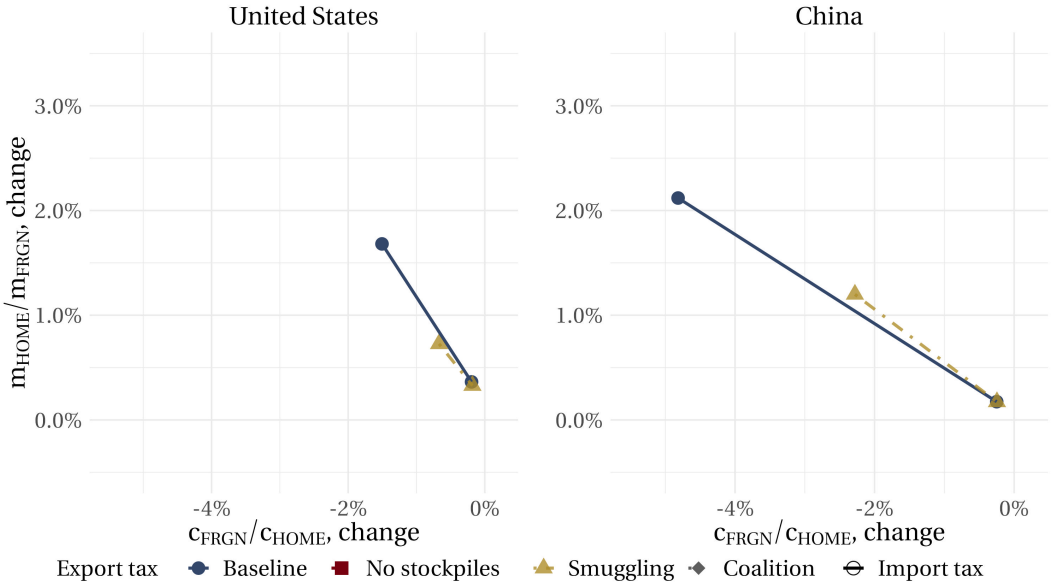
Results


United States
China
3.0%
2.0%
1.0%
0.0%
m_{HOME}/m_{FRGN}, change
-4%
-2%
0%
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

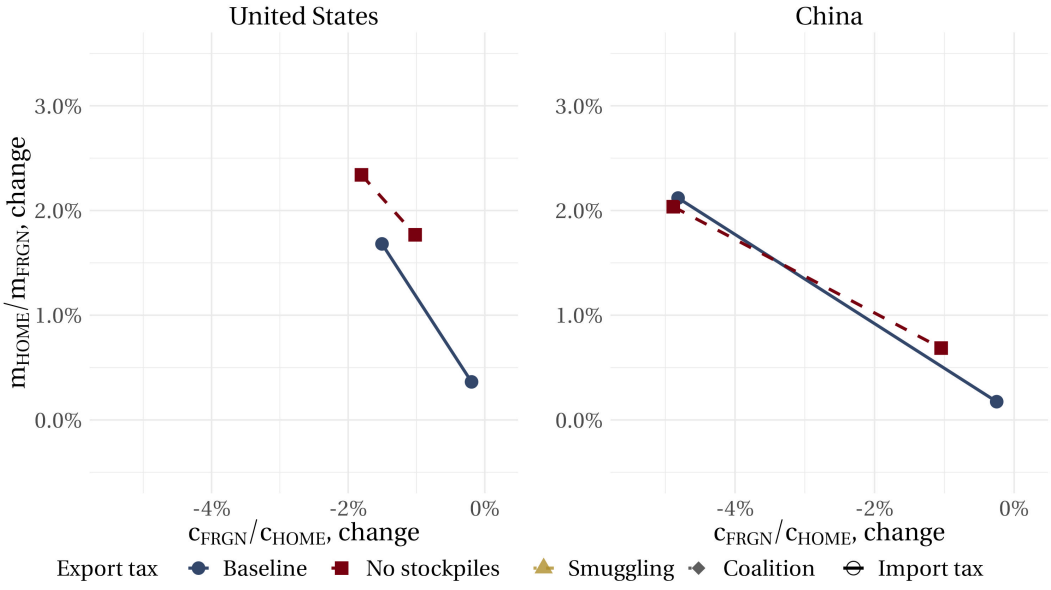
Results


United States
China
3.0%
2.0%
1.0%
0.0%
m_{HOME}/m_{FRGN}, change
-4%
-2%
0%
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

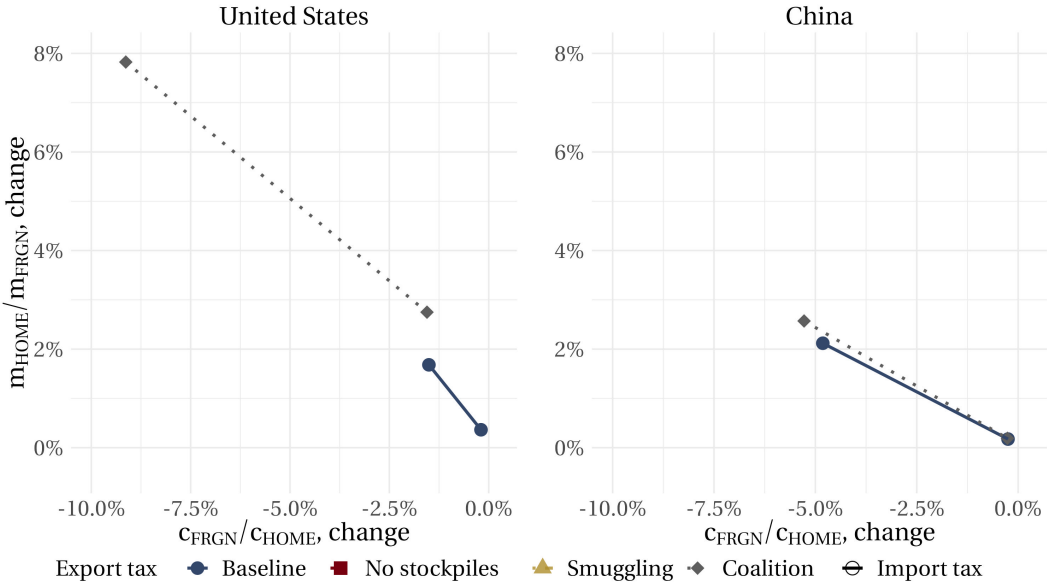
Results


United States
China
3.0%
2.0%
1.0%
0.0%
m_{HOME}/m_{FRGN}, change
-4%
-2%
0%
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

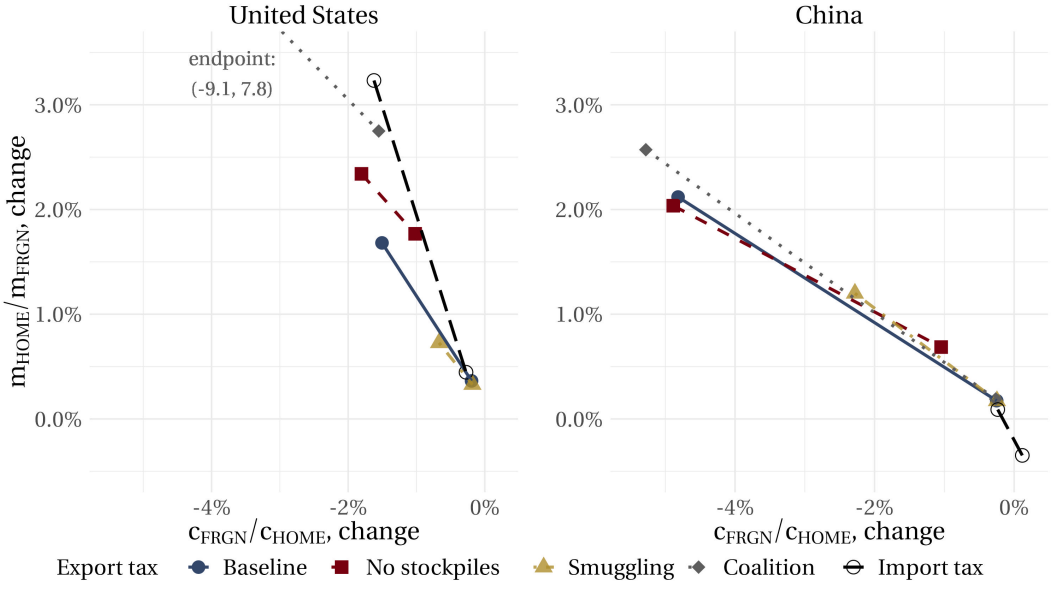
Results


United States
China
3.0%
2.0%
1.0%
0.0%
m_{HOME}/m_{FRGN}, change
-4%
-2%
0%
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

Results


United States
China
8%
6%
4%
2%
0%
-10.0%
-7.5%
-5.0%
-2.5%
0.0%
m_{HOME}/m_{FRGN}, change
c_{FRGN}/c_{HOME}, change
Export tax
Baseline
No stockpiles
Smuggling
Coalition
Import tax

Results



– Industrial policy yields (0.7%, 11%) via indirect ToT manipulation takeaway

Conclusion

Conclusion

This paper:

- Military as an interest group ...
- ... that shapes policy and trade outcomes ...
- ... relevant on a macro scale

Contributions:

- Military contest in a trade model
- Optimal taxes with multiple agents, externality, and wedges in GE
- Military use measure

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Conclusion

This paper:

- Military as an interest group ...
- ... that shapes policy and trade outcomes ...
- ... relevant on a macro scale

Contributions:

- Military contest in a trade model
- Optimal taxes with multiple agents, externality, and wedges in GE
- Military use measure

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Conclusion

This paper:

- Military as an interest group ...
- ... that shapes policy and trade outcomes ...
- ... relevant on a macro scale

Contributions:

- Military contest in a trade model
- Optimal taxes with multiple agents, externality, and wedges in GE
- Military use measure

Takeaways:

- Optimal tariff approach explains security trade policies
- Policy targets less military-centric dual-use items in less secure settings
- Factor price adjustments affect statistics of interest in the model

Future research

Follow-ups:

- Conflict dynamics; stockpiles; build-up, scaling, & replacement of durable capital
- State-contigent value of military capabilities
- Innovation and knowledge diffusion of critical technologies

Broad topics:

- Estimation of empirical policy functions
- Conflict game theory: choice of domain (military, trade, finance) for response
- Data tracking attitudes, political support, and information flows

Quantitative advances:

- Firm- and plant-level data, richer spatial setup, engineering elasticities
- Industrial organization of space, drones, cyber, AI, and nuclear
- Applied national security research for conflict resolution frameworks

Future research

Follow-ups:

- Conflict dynamics; stockpiles; build-up, scaling, & replacement of durable capital
- State-contigent value of military capabilities
- Innovation and knowledge diffusion of critical technologies

Broad topics:

- Estimation of empirical policy functions
- Conflict game theory: choice of domain (military, trade, finance) for response
- Data tracking attitudes, political support, and information flows

Quantitative advances:

- Firm- and plant-level data, richer spatial setup, engineering elasticities
- Industrial organization of space, drones, cyber, AI, and nuclear
- Applied national security research for conflict resolution frameworks

Future research

Follow-ups:

- Conflict dynamics; stockpiles; build-up, scaling, & replacement of durable capital
- State-contigent value of military capabilities
- Innovation and knowledge diffusion of critical technologies

Broad topics:

- Estimation of empirical policy functions
- Conflict game theory: choice of domain (military, trade, finance) for response
- Data tracking attitudes, political support, and information flows

Quantitative advances:

- Firm- and plant-level data, richer spatial setup, engineering elasticities
- Industrial organization of space, drones, cyber, AI, and nuclear
- Applied national security research for conflict resolution frameworks

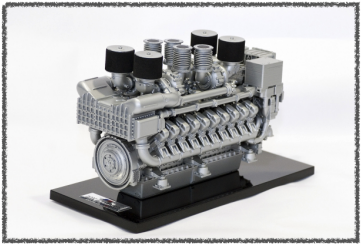
Thank you!

maxim.e.alekseev@gmail.com xinyue_lin@g.harvard.edu

Extra slides

Ship engine

- 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)



back

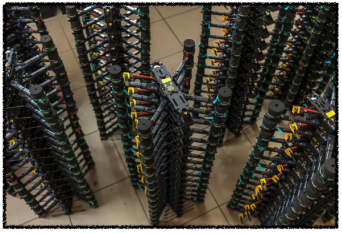
CNC

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)

back

Drones

- 500$ DJI drones, purposed for amateur photography, have been used by the Ukrainian armed forces in trench warfare (Mozur & Hopkins, 2023).
- On September 1st 2023, China introduced export controls on drones and drone components


back

History

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 colonies. 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 (Bowett, 1994)
- 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)

back

Literature

Thematically: Trade and international political economy

interest groups:
Grossman-Helpman (1994), Acemoglu-Yared (2010), Ossa (2014),
Méndez-Van Patten (2022), Adão-Costinot-Donaldson-Sturm (2023),
Kleinman-Liu-Redding (2023)

international coercion:
Antràs-Padró i Miquel (2011, 2023), Bianchi-Sosa-Padilla (2023), Becko (2023, 2024),
Becko-O'Connor (2024), Clayton-Maggiori-Schreger (2023, 2024), Liu-Yang (2024)

price determinants of conflict:
Skaperdas-Syropoulos (2001), Kaempfer-Lowenberg (2007),
Acemoglu-Golosov-Tsyvinsky (2012)

trade determinants of conflict:
Martin-Mayer-Thoenig (2008, 2012), Wen (2012), Rohner-Thoenig-Zilibotti (2013),
Chatagnier-Kavakl (2017)

back

Literature

Theoretically: **Optimal taxation on networks**

optimal tariffs:
Ramsey (1927), Helpman-Krugman (1989), Costinot-Donaldson-Vogel-Werning (2015), Costinot-Rodriguez-Clare-Werning (2020), Lashkaripour-Lugovskyy (2022)

wedges on networks:
Liu (2019), Bigio-La'O (2020), Lashkaripour-Beshkar (2020), Wu (2022), Baqaee-Farhi (2024)

taxation under externality:
Pigou (1924), Golosov-Hassler-Krusell-Tsyvinsky (2014), Farrokhi-Lashkaripour (2022), Kortum-Weisbach (2022)

back

Literature

Empirically: Facts about industries, policies, and military

industry positioning:
Leontief (1937), Jones (1976), Antràs-Chor-Fally-Hillberry (2012), Fally (2012), Antràs-Chor (2013), Hausmann-Hidalgo-Bustos-Coscia-Simoes-Yildirim (2013), Antràs (2016), Antràs-Chor (2018), Grassi (2019), Alfaro-Antràs-Chor-Conconi (2019), Antràs-Chor (2022)

policy quantification:
Evenett (2019), Bai-Bernstein-Dev-Lerner (2022), Copeland-Shapiro-Scott Taylor (2022), Juhász-Lane-Oehlsen-Pérez (2022), Goldberg-Juhász-Lane-Lo Forte-Thurk (2024)

U.S. defense contracts:
Auerbach-Gorodnichenko (2012), Belenzon-Cioaca (2021), Cox-Müller-Pasten-Schoenle-Weber (2023)

economic consequences of war:
Chupilkin-Koczan (2022), Davis-Lopez-Pena-Mobarak-Wen (2023), Federle-Meier-Muller-Mutschler-Schularick (2024), Neri-Laine (2024), de Souza-Hu-Li-Mei (2024), Gopinath-Gourinchas-Presbitero-Topalova (2024)

calibration and elasticity estimation:
Ghironi-Kim-Ozhan (2023), de Souza-Hu-Li-Mei (2024), Chupilkin-Javorcik-Peeva-Plekhanov (2024), Egorov-Korovkin-Makarin-Nigmatulina (2024), Li-Li-Park-Wang-Wu (2024), Teti-Scheckenhofer-Wanner (2024)

back

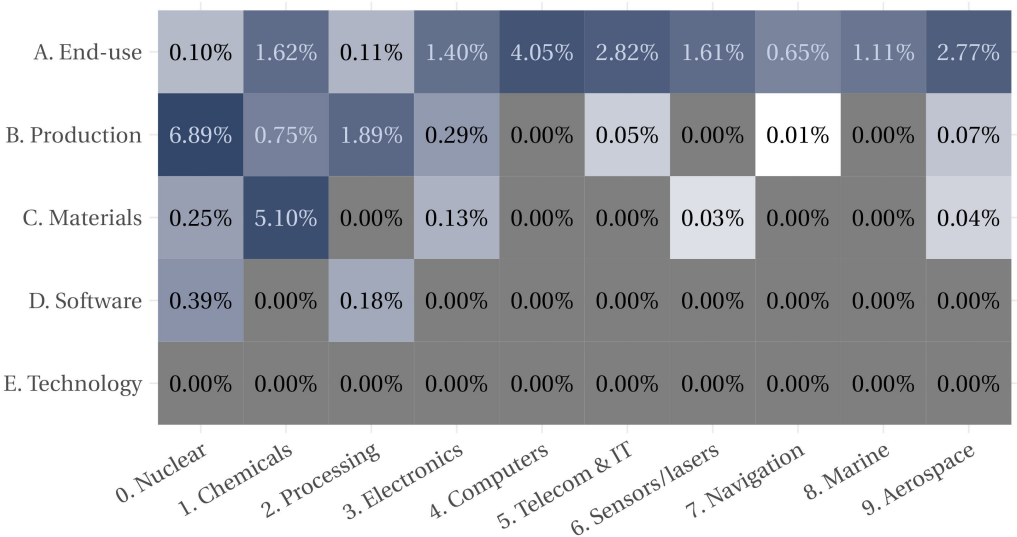
Institutions

	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)

back

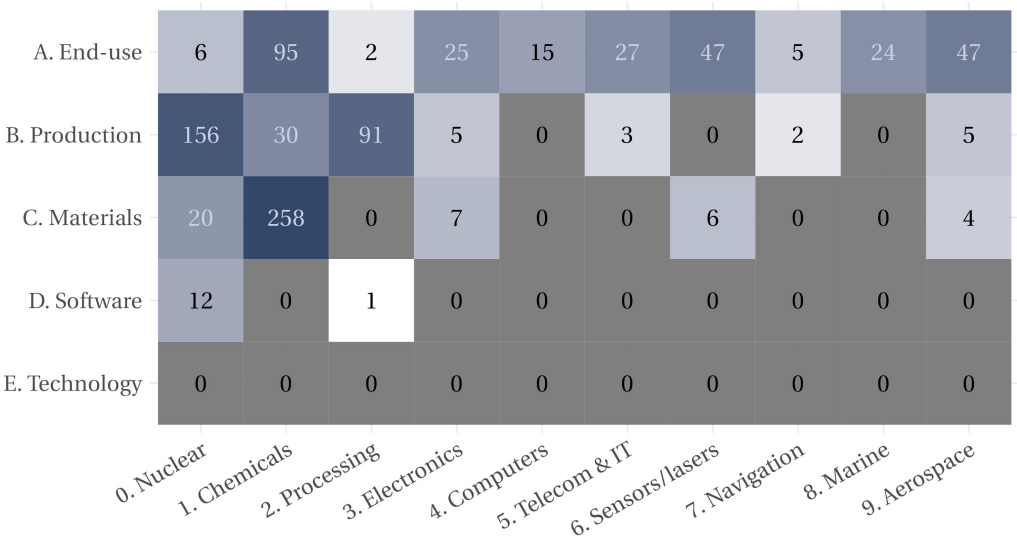
ECCN share

back

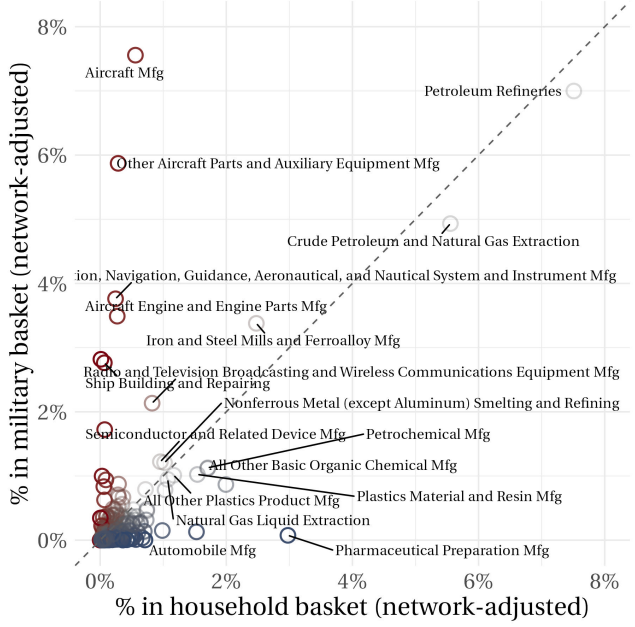


ECCN count

back

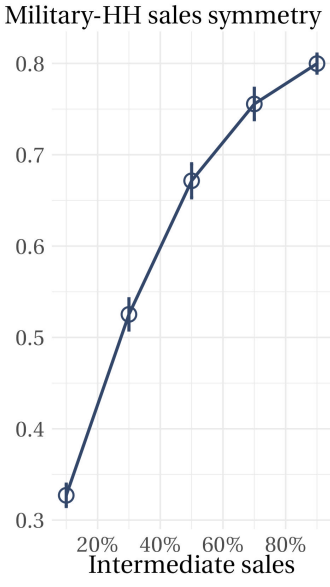


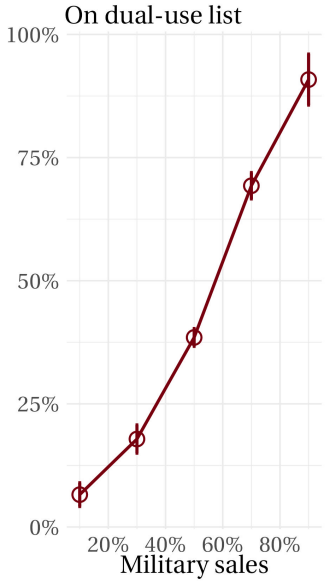
Fact #1. Dual-use goods are intermediate inputs: U.S. input-output

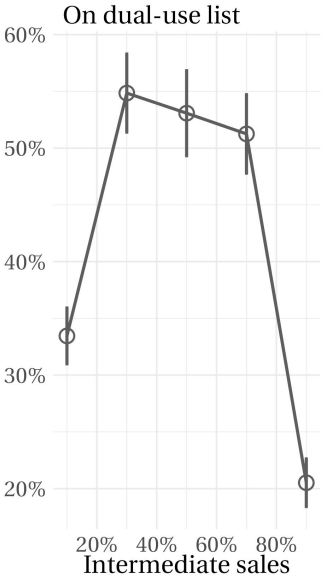


back

Fact #1. Dual-use goods are intermediate inputs







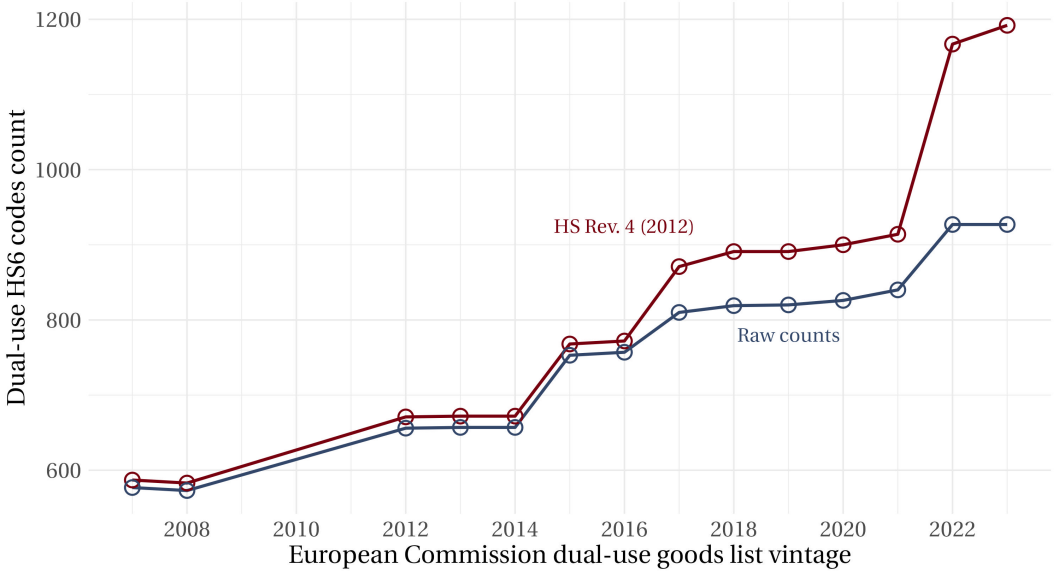
▸ definitions ▸ back

$$\text{Customer breadth}_i \equiv 1 - \frac{|\text{Military sales}_i - \text{Consumer sales}_i|}{\text{Military sales}_i + \text{Consumer sales}_i} \in [0,1]$$

$$\text{Input use}_i \equiv \frac{\text{Intermediate sales}_i}{\text{Intermediate sales}_i + \text{Final sales}_i}$$

$$\text{Military specialization}_i \equiv \frac{\text{Military sales}_i}{\text{Military sales}_i + \text{Consumer sales}_i}$$

back


1200
1000
800
600
Dual-use HS6 codes count
HS Rev. 4 (2012)
Raw counts
2008
2010
2012
2014
2016
2018
2020
2022
European Commission dual-use goods list vintage

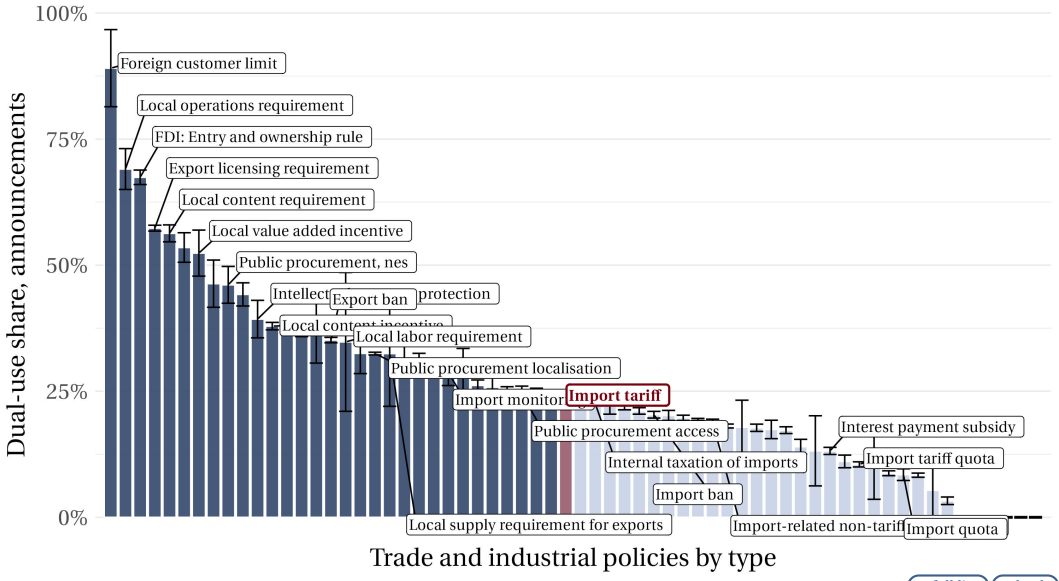
back

HS4	Description	HS2 #	Trade (%)
8481	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves	12	0.117
8477	Machinery; for working rubber or plastics or for the manufacture of products from these materials, n.e.c. in this chapter	12	0.035
8474	Machinery for sorting, screening, separating, washing, crushing, grinding, mixing or kneading earth, stone, ores in solid form, shaping, moulding machinery for solid mineral fuels	12	0.019
8424	Mechanical appliances for projecting, dispersing or spraying liquids or powders; fire extinguishers, spray guns, steam, sand blasting machines	12	0.018
8419	Machinery, plant (not domestic), or laboratory equipment; electrically heated or not, (excluding items in 85.14) for the treatment of materials by a process involving change of temperature; including instantaneous or non electric storage water heaters	12	0.012
8447	Knitting machines, stitch-bonding machines and machines for making gimped yarn, tulle, lace, embroidery, trimmings, braid or net and machines for tufting	12	0.005
8448	Machinery, auxiliary; for use with machines of heading no. 8444 to 8447 (e.g. dobbies, jacquards, automatic stop motions, shuttle changing mechanisms) parts, accessories for machines of heading no. 8444, 8447	12	0.004
8460	Machine-tools; for deburring, sharpening, grinding, honing, lapping, polishing or otherwise finishing metal, sintered metal carbides or cermets by means of grinding stones, abrasives or polishing products	12	0.002
8468	Machinery and apparatus for soldering, brazing, welding, whether or not capable of cutting, other than those of heading no. 8515; gas-operated surface tempering machines and appliances	12	0.002
8459	Machine-tools; (including way-type unit head machines) for drilling, boring, milling, threading or tapping by removing metal, other than lathes of heading no. 8458	12	0.001

HS4	Description	HS2 #	Trade (%)
8415	Air conditioning machines; comprising a motor driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated	20	0.268
8418	Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines of heading no. 8415	20	0.158
8477	Machinery; for working rubber or plastics or for the manufacture of products from these materials, n.e.c. in this chapter	20	0.118
8413	Pumps; for liquids, whether or not fitted with measuring device, liquid elevators	20	0.098
8438	Machinery n.e.c. in this chapter, for the industrial preparation or manufacture of food or drink; other than machinery for extraction or preparation of animal or fixed vegetable fats or oils	20	0.077
8421	Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus for liquids or gases	20	0.064
8419	Machinery, plant (not domestic), or laboratory equipment; electrically heated or not, (excluding items in 85.14) for the treatment of materials by a process involving change of temperature; including instantaneous or non electric storage water heaters	20	0.052
8462	Machine-tools; (including presses) for working metal by forging, hammering or die-stamping, for bending, folding, straightening, flattening, shearing or punching metal	20	0.049
8451	Machinery (not of heading no. 8450) for washing, cleaning, wringing, drying, ironing, pressing, bleaching, dyeing, dressing, finishing, coating or impregnating textile yarn, fabrics or made up articles	20	0.049
8436	Agricultural, horticultural, forestry, poultry-keeping, bee-keeping machinery; including germination plant fitted with mechanical or thermal equipment; poultry incubators and brooders	20	0.042

back

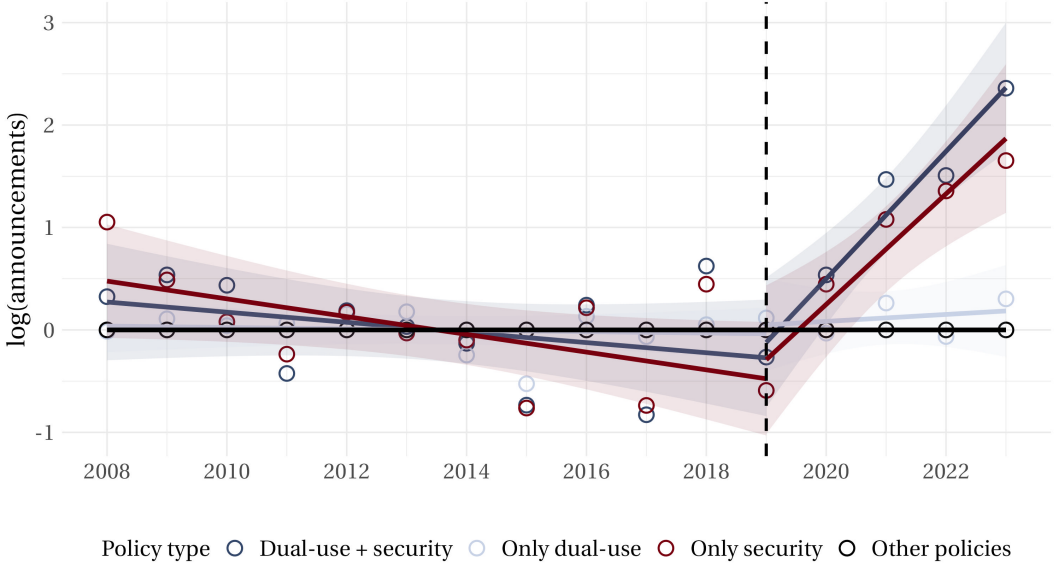
Fact #2. Trade in dual-use goods is increasingly regulated: Policies



Notes: observation unit is policy act announcement-HS6 code

full list back

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



specification back

Security policies	Other policies
Foreign customer limit	Import tariff
Local operations requirement	Tax or social insurance relief
FDI: Entry and ownership rule	Internal taxation of imports
Export licensing requirement	Public procurement preference margin
Local content requirement	Tax-based export incentive
Import incentive	Other export incentive
Local value added incentive	Import ban
Repatriation & surrender requirements	Export subsidy
Public procurement, nes	Export-related non-tariff measure, nes
In-kind grant	Financial grant
Intellectual property protection	Import-related non-tariff measure, nes
Local content incentive	State loan
Trade finance	Controls on credit operations
Capital injection and equity stakes (including bailouts)	Export tax
FDI: Financial incentive	Export quota
Export ban	Trade payment measure
Local labor requirement	Safeguard
Controls on commercial transactions and investment instruments	Trade balancing measure
Public procurement localisation	Interest payment subsidy
Local supply requirement for exports	State aid, nes
Anti-subsidy	Import tariff quota
Financial assistance in foreign market	Localisation, nes
Loan guarantee	Production subsidy
Import monitoring	Import quota
FDI: Treatment and operations, nes	State aid, unspecified
Anti-dumping	Technical barrier to trade
Anti-circumvention	Price stabilisation
Competitive devaluation	Labor market access
Public procurement access	Export tariff quota
Instrument unclear	Local operations incentive
Import licensing requirement	Control on personal transactions
	Local labor incentive
	Special safeguard

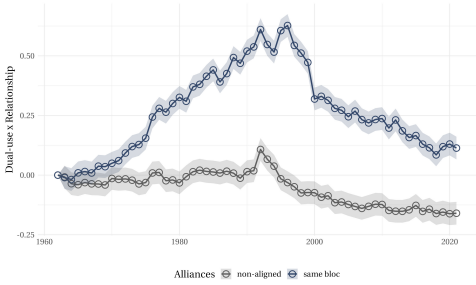
back

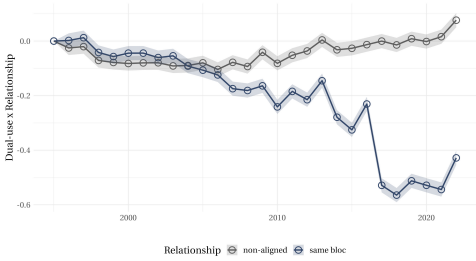
Specification

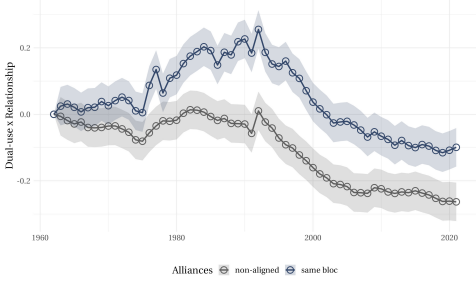
$$\left[\log(\#\ \text{acts}_{it}) - \frac{1}{12}\sum_{t=2008}^{2019}\log(\#\ \text{acts}_{i,\text{2008-19}})\right] - \left[\log(\#\ \text{acts}_{\text{Other},t}) - \frac{1}{12}\sum_{t=2008}^{2019}\log(\#\ \text{acts}_{\text{Other,2008-19}})\right]$$

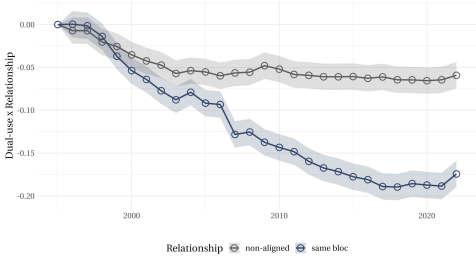
back

Weights



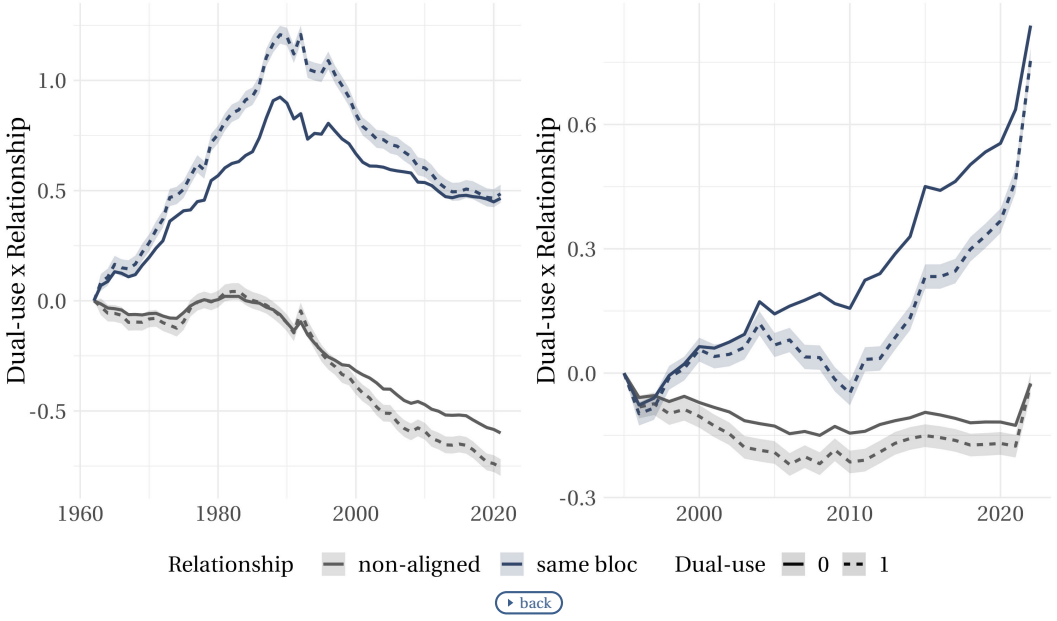






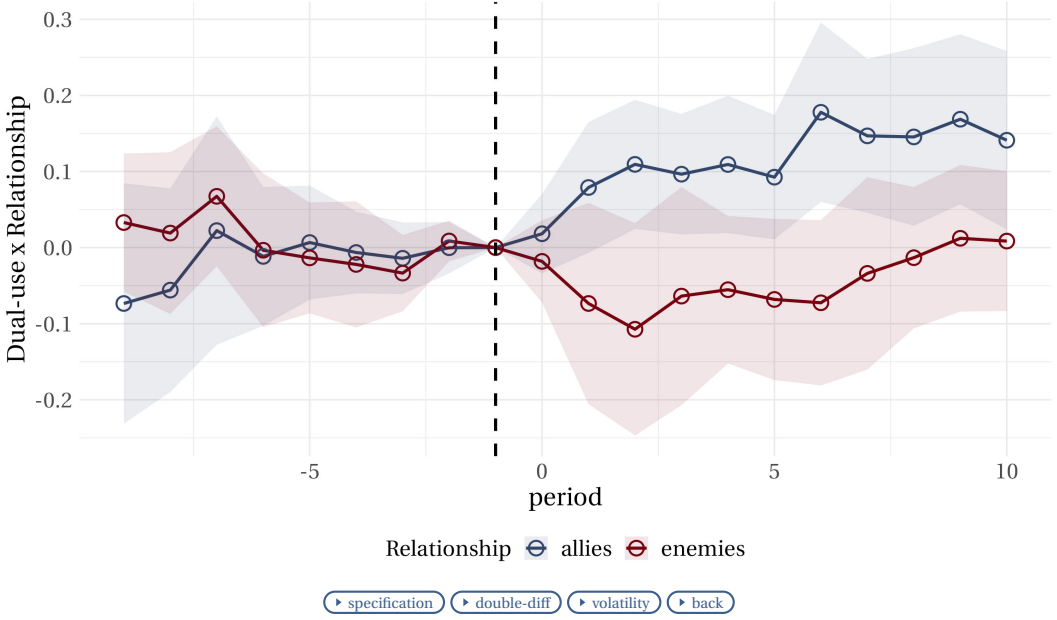
back

Double difference



back

Fact #3. Dual-use trade responds to the security environment: Wars



specification double-diff volatility back

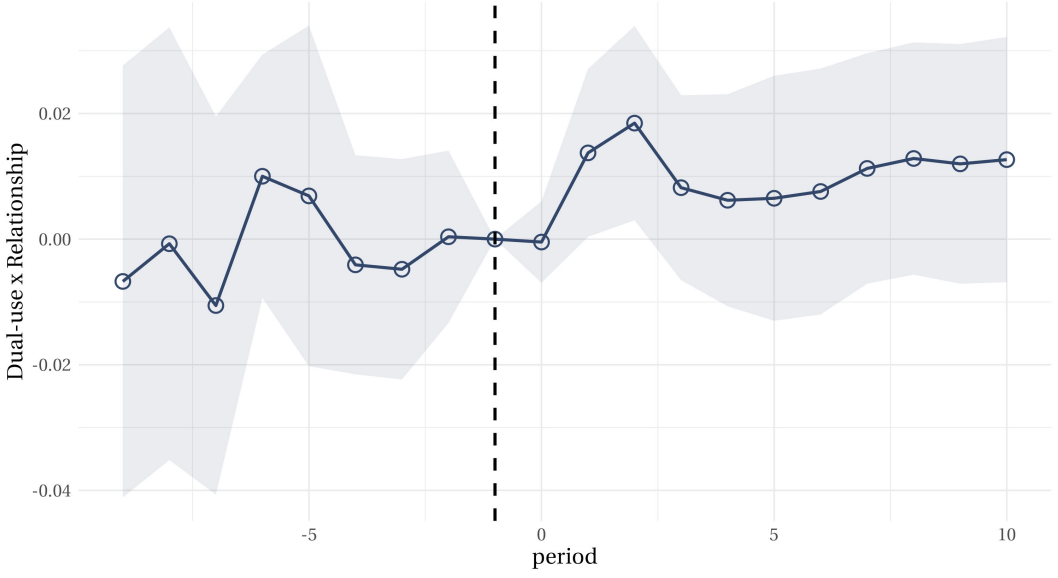
Specification

- Data on wars from COW
- For every conflict, locate a Wikipedia page and pull mentions of other countries
- Manually classify mentions as allies, enemies, or neutral
- Classification available in the Appendix

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

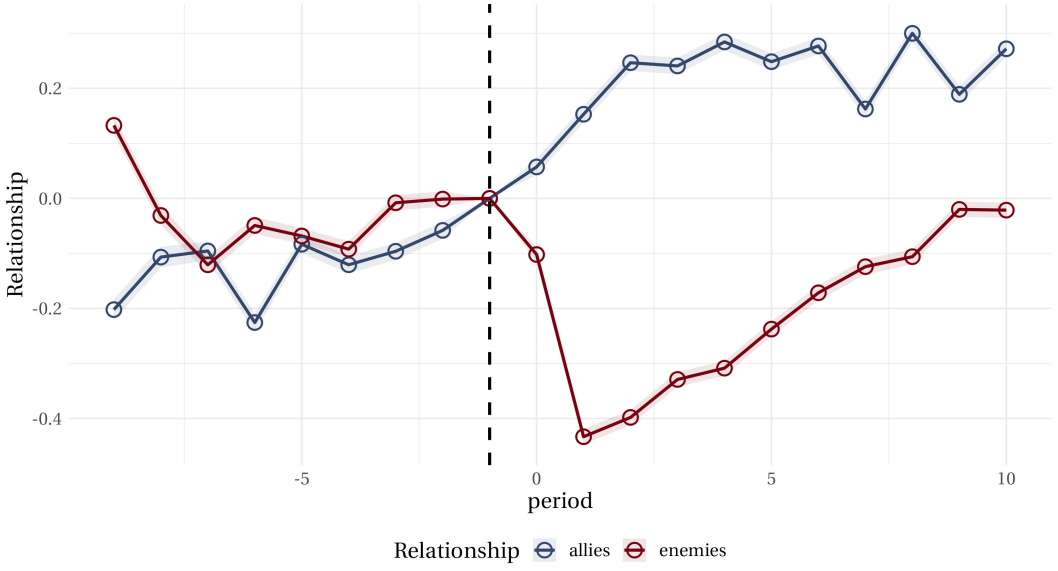
back

Robustness



back

Double-diff



back

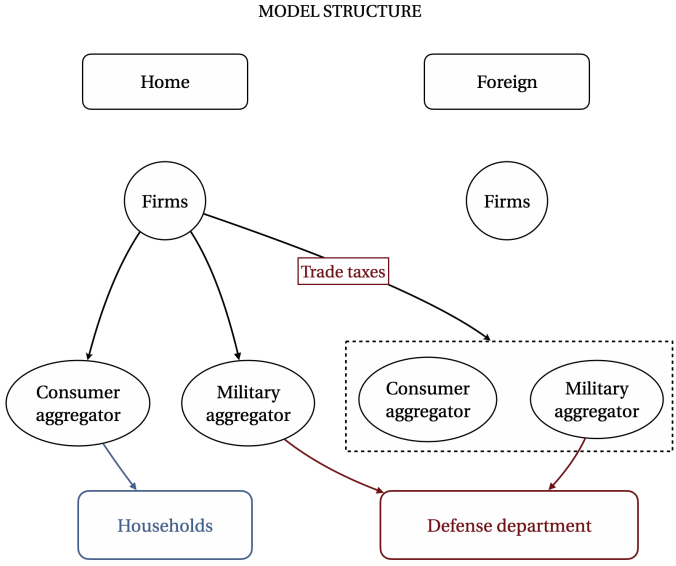
Diagram

Two countries:
home (H) and foreign (F)

Five blocks:

- Firms
- Aggregators
- Households
- Defense department
- Government

back



Terms of trade

Sequential game: back

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

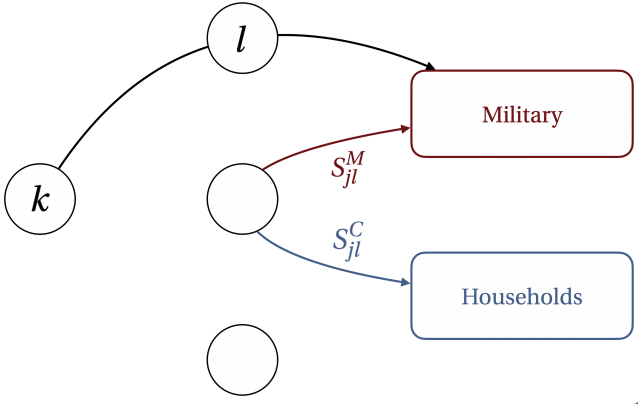
$$\mathcal{T}^{\mathcal{M}}_{ik} \equiv E^{-1}_{ik}\left[\frac{\tau^{\mathcal{X}}_{-i,i} - 1}{\tau^{\mathcal{X}}_{-i,i}\tau^{\mathcal{M}}_{-i,i}} E_{-i,i}\mathcal{E}^{-i,i}_{ik} + \frac{\tau^{\mathcal{M}}_{ik} - 1}{\tau^{\mathcal{M}}_{ik}} E_{ik}\mathcal{E}^{-i,i}_{ik}\right]$$

Networks: back

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

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

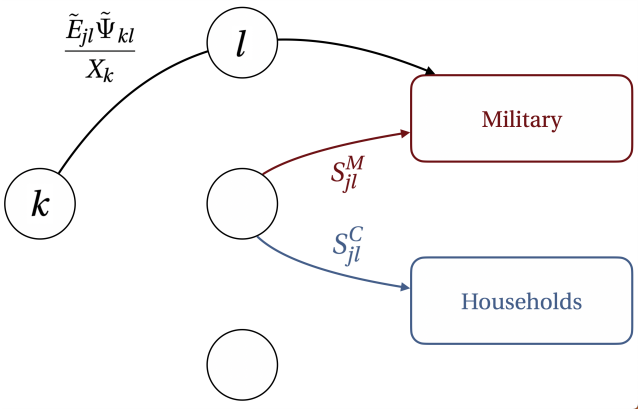
Centrality



$$C_{jk}^{M} = \sum_{l} S_{jl}^{M} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \begin{matrix}\text{distortions along} \\ j-l-k \text{ path}\end{matrix}$$

back

Centrality

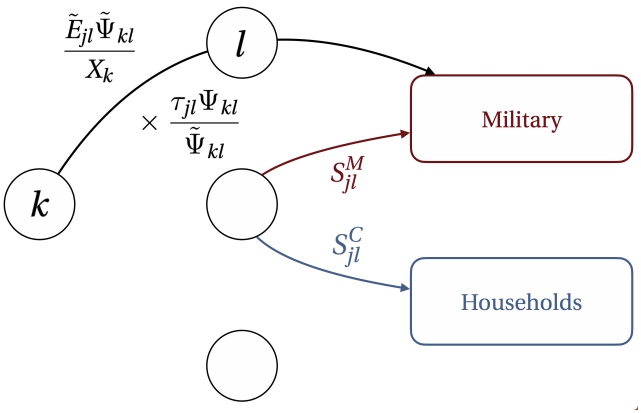


$$C^M_{jk} = \sum_l S^M_{jl} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \text{distortions along } j-l-k \text{ path}$$

$$\sum_{j,l} \frac{\tilde{E}_{jl}\tilde{\Psi}_{kl}}{X_k} = 1$$

back

Centrality



$$C^M_{jk} = \sum_l S^M_{jl} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \frac{\text{distortions along}}{j-l-k \text{ path}} \qquad \tau \geq 1 \Rightarrow \frac{\tau_{jl}\Psi_{kl}}{\tilde{\Psi}_{kl}} \geq 1$$

back

Properties

$$C_{jk}^{M} = \sum_{l} S_{jl}^{M} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \begin{matrix}\text{distortions along} \\ j-l-k \text{ path}\end{matrix}$$

$$C_{jk}^{M} \equiv \frac{[\Psi' \boldsymbol{s^M}]_{jk} M_j}{[\tilde{\Psi}' \boldsymbol{s^M}]_{jk} M_j + [\tilde{\Psi}' \boldsymbol{s^C}]_{jk} C_j} \equiv \text{“network-adjusted sales share”}$$

Antras & Chor (2011), Fally (2011) $\rightarrow$ Antras, Chor, Fally & Hillberry (2012)

Keeping factor prices and taxes fixed, military centrality is rank-invariant to changes in final demand M and C

back

Properties

$$\mathcal{C}^M_{jk} = \sum_l S^M_{jl} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \begin{matrix}\text{distortions along} \\ j-l-k \text{ path}\end{matrix}$$

$$\mathcal{C}^M_{jk} \equiv \frac{[\boldsymbol{\Psi}' \boldsymbol{s^M}]_{jk} M_j}{[\tilde{\boldsymbol{\Psi}}' \boldsymbol{s^M}]_{jk} M_j + [\tilde{\boldsymbol{\Psi}}' \boldsymbol{s^C}]_{jk} C_j} \equiv \text{“network-adjusted sales share”}$$

Antras & Chor (2011), Fally (2011) $\rightarrow$ Antras, Chor, Fally & Hillberry (2012)

Keeping factor prices and taxes fixed, military centrality is rank-invariant to changes in final demand M and C

back

Properties

$$\mathcal{C}^M_{jk} = \sum_l S^M_{jl} \times \frac{k\text{'s sales to } j \text{ through } l}{\text{firm } k\text{'s total sales}} \times \begin{matrix}\text{distortions along} \\ j-l-k \text{ path}\end{matrix}$$

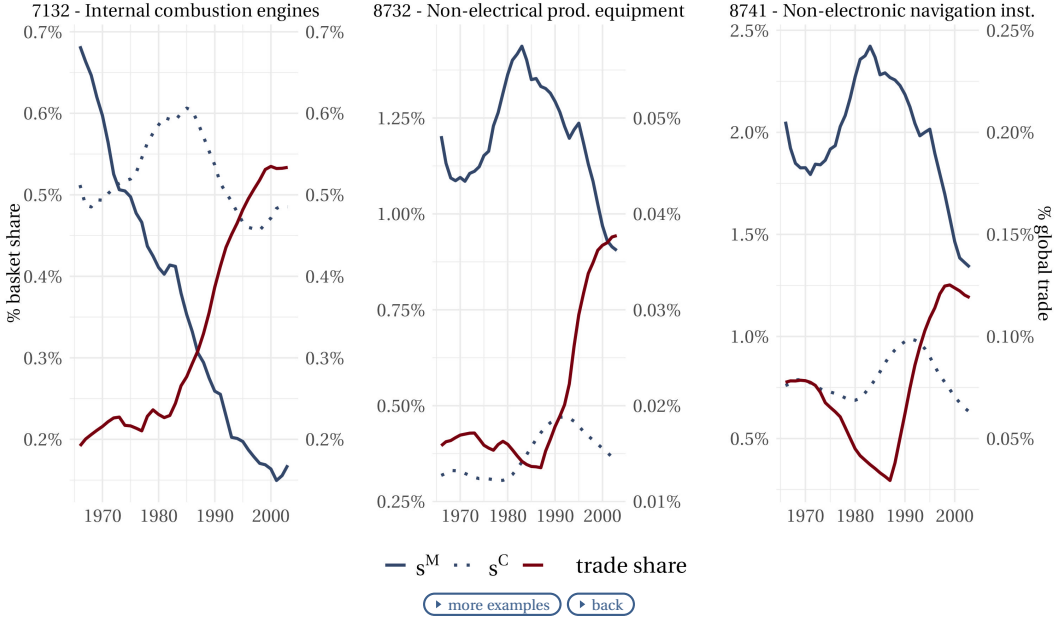
$$\mathcal{C}^M_{jk} \equiv \frac{[\boldsymbol{\Psi}' \boldsymbol{s^M}]_{jk} M_j}{[\tilde{\boldsymbol{\Psi}}' \boldsymbol{s^M}]_{jk} M_j + [\tilde{\boldsymbol{\Psi}}' \boldsymbol{s^C}]_{jk} C_j} \equiv \text{“network-adjusted sales share”}$$

Antras & Chor (2011), Fally (2011) $\rightarrow$ Antras, Chor, Fally & Hillberry (2012)

Keeping factor prices and taxes fixed, military centrality is rank-invariant to changes in final demand M and C

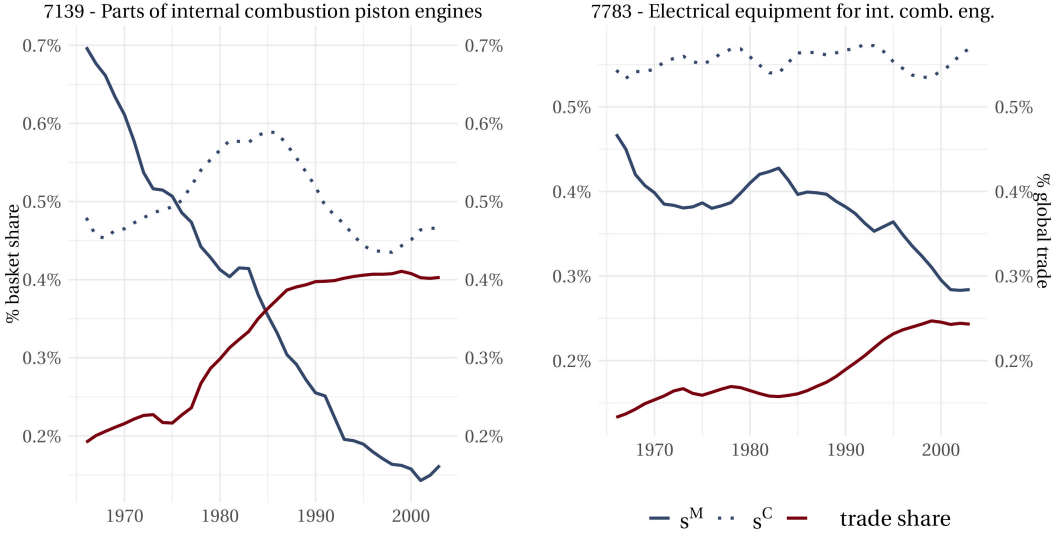
back

Technological transitions



▸ more examples ▸ back

Technological transitions: More examples



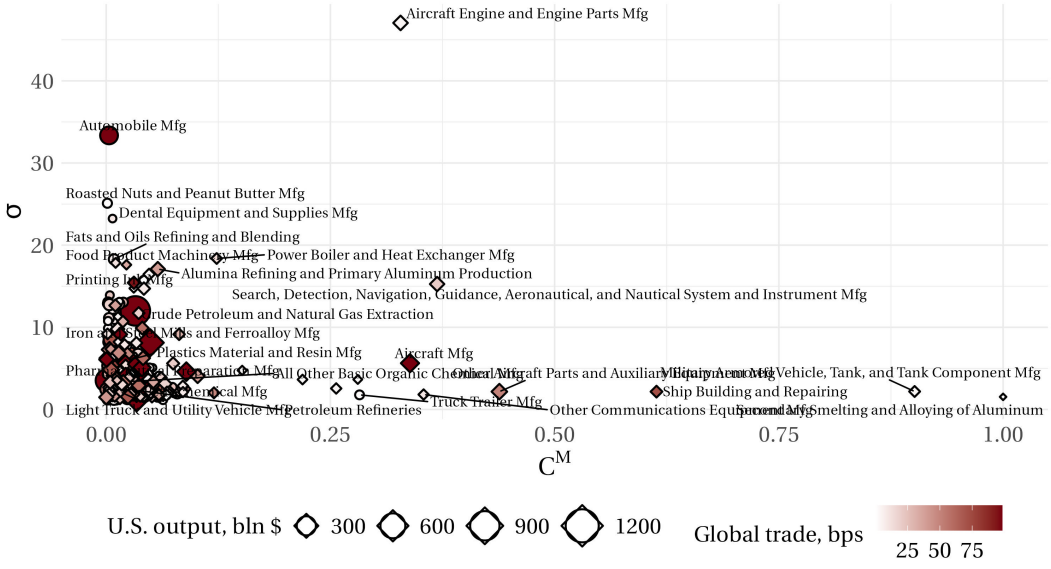
back

Keywords

Pct $\mathcal{C}_k^M/\sigma$	$\mathcal{C}_k^M/\sigma$ (%)	N	Key words in HS code descriptions
[99.6, 99.9]	[36.17, 65.17]	5	vessels, boats, floating, vehicles, ships, aluminium, powders, flakes, tanks, armoured
[99.2, 99.5]	[16.15, 32.27]	5	gliders, aircraft, tugs, pusher, craft, balloons, dirigibles, hang, powered, signalling
[98.7, 99.1]	[11.32, 16.05]	5	firearms, devices, pistols, mechanical, safety, fuses, detonating, sporting, shotguns, rifles
[98.3, 98.7]	[8.17, 11.01]	5	apparatus, radio, trailers, gear, radar, navigational, aid, remote, control, firearms
[97.7, 98.2]	[6.68, 8.16]	8	vessels, wire, turbo, apparatus, barbed, iron, steel, twisted, jets, propellers
[96.8, 97.6]	[4.16, 6.15]	10	graphite, carbon, metal, optical, instruments, elements, iron, steel, electrically, colloidal
[90.5, 96.7]	[2.74, 4.06]	75	apparatus, steel, iron, machines, electrical, copper, wire, tubes, waste, scrap
[84.3, 90.5]	[2.16, 2.73]	75	steel, iron, aluminium, slag, waste, bars, rods, plates, alloy, cement
[78.0, 84.2]	[1.73, 2.15]	75	ores, concentrates, natural, metal, mechanical, steel, iron, animal, electrical, wax
[71.7, 77.9]	[1.42, 1.73]	75	copper, natural, iron, chemically, steel, defined, umbrellas, halogenated, sulphonated, nitrated
[65.4, 71.6]	[1.17, 1.42]	75	metal, oils, watches, iron, worked, plastics, clad, rods, tubes, plates
[59.2, 65.4]	[0.94, 1.17]	75	forms, acids, artificial, compounds, halogenated, sulphonated, nitrated, nitrosated, iron, fabrics
[52.9, 59.1]	[0.72, 0.94]	75	textile, forms, natural, primary, machines, synthetic, polymers, materials, metal, retail
[46.6, 52.8]	[0.61, 0.72]	75	wood, ceramic, textile, fabrics, impregnated, vegetable, organic, materials, laminated, goods
[40.3, 46.6]	[0.47, 0.61]	75	wood, fibres, waste, machines, yarn, preparations, textile, tanning, electric, woven
[34.1, 40.3]	[0.38, 0.47]	75	yarn, paper, paperboard, machines, apparatus, printed, stone, slate, rolls, sheets
[27.8, 34.0]	[0.31, 0.38]	75	glass, paper, sheets, wood, worked, fabrics, cellulose, preparations, cork, plates
[21.5, 27.7]	[0.21, 0.31]	75	fabrics, paper, woven, yarn, pulp, fractions, machines, cotton, animal, put
[15.2, 21.4]	[0.15, 0.21]	75	fabrics, leather, knitted, crocheted, fish, meat, woven, yarn, without, railway
[9.0, 15.1]	[0.08, 0.14]	75	dried, fresh, leather, machines, frozen, prepared, chilled, preserved, fish, nuts
[0.0, 8.9]	[0.00, 0.08]	107	fresh, chilled, knitted, crocheted, prepared, precious, machines, meat, oil, frozen

back

Industries



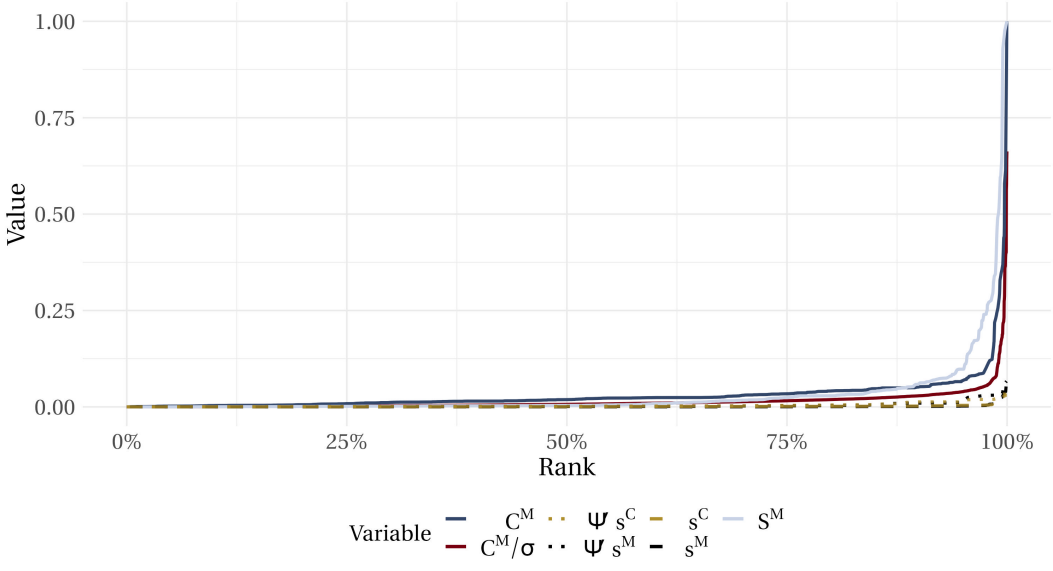
back

Correlations

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

back

Distribution



back

Centrality table

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)				
$\mathcal{C}^M_{US}/\sigma$		3.020***	3.063***	2.733***	2.796***	2.653***	1.987***
		(0.3266)	(0.3767)	(0.3126)	(0.3151)	(0.2818)	(0.2324)
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	0.12487	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*

back

Centrality table

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)				
$\mathcal{C}^M_{US}/\sigma$		2.589***	2.443***	2.179***	2.166***	1.947***	0.7805*
		(0.3339)	(0.3825)	(0.3200)	(0.3249)	(0.2984)	(0.3037)
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	0.16382	0.38737
Within R^2				0.05602	0.02950	0.03845	0.01941

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

back

Roadmap

Which goods should be targeted in practice?

(1) We measure product-level military use in the data ...

(2) ... and validate our measure against empirical outcomes

(3) We then use it to evaluate policies ...

Validation: Trade responses

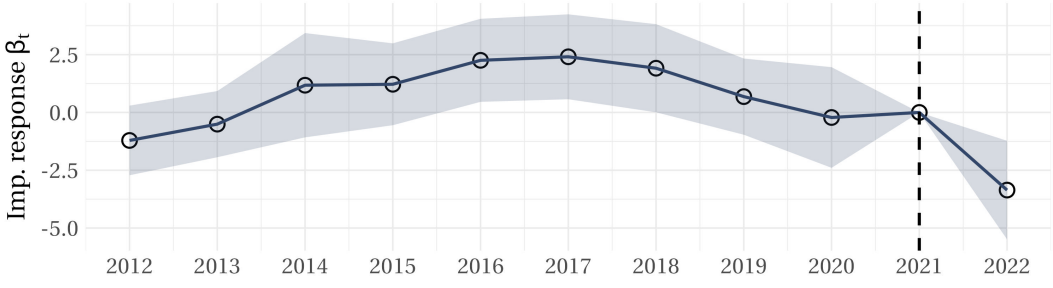
Trade responses following conflicts

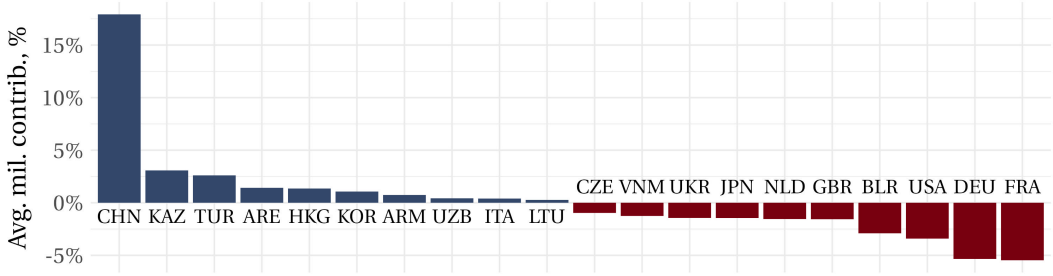
Specification: $$\log y_{ikt} = \overbrace{\alpha_{ik}}^{\text{exp-good}} + \overbrace{\gamma_{it}}^{\text{exp-year}} + \beta_t \left[\mathcal{C}^M_{\text{US},k}/\sigma_k\right] + \varepsilon_{ikt}$$

- Ukraine-2022 back
  - 1pp ↑ in centrality → 5% ↑ in expected imports
  - driven by: ammunition, tanks, weapons, warships, electric generating sets
  - leading contributors: Poland (weapons), Slovakia (ammunition), Canada (tanks)
  - offset by: Russia (fossil fuels), China (electrical apparatus, steel), Belarus (petroleum)
- Similar exercises for Russia-2022 ... details
  - 1pp ↑ in centrality → 3.5% ↓ in expected imports
  - driven by: aerospace, shipbuilding, reception & transmission equipment
  - leading contributors: China (manufacturing), Kaz. (aluminium), Turkey (vessels)
  - offset by: France, Germany, United States (all: aerospace, shipbuilding)
- ... and China 2016-2022 details
  - 1pp ↑ in centrality → 8% ↓ in expected imports
  - driven by: aerospace, optical devices, chips
  - leading contributors: Vietnam (phone parts), Indonesia (alloys), HK (turbo-jets)
  - offset by: United States (aerospace), Korea (chips, opticals), France (aerospace)

Russia-2022

RUS goods | RUS country-goods | back





Validation: Trade responses

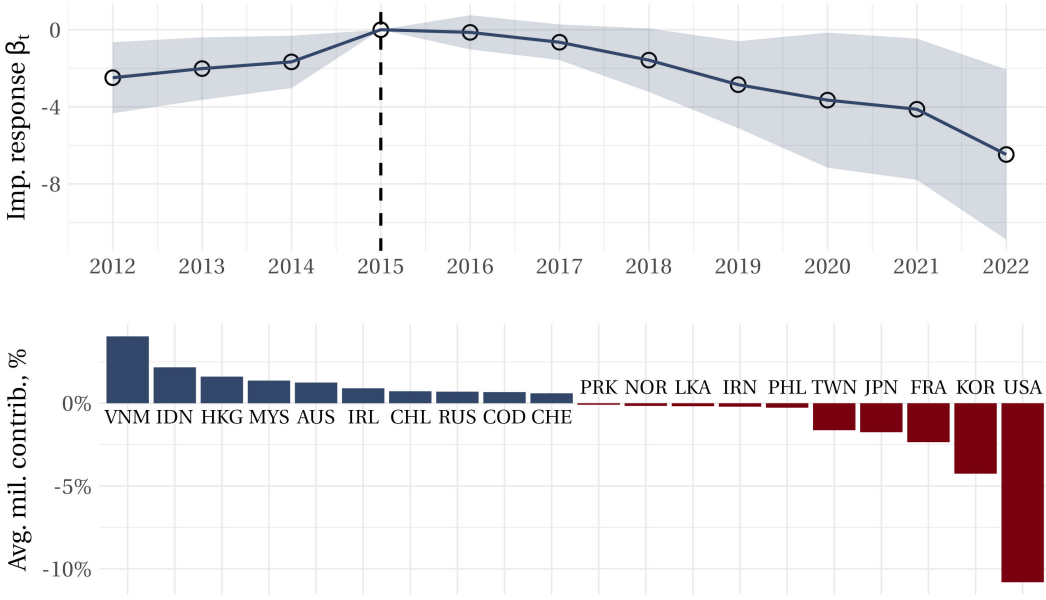
Trade responses following conflicts

$$\text{Specification:} \qquad \log y_{ikt} = \overbrace{\alpha_{ik}}^{\text{exp-good}} + \overbrace{\gamma_{it}}^{\text{exp-year}} + \beta_t \left[\mathcal{C}^M_{\text{US},k}/\sigma_k\right] + \varepsilon_{ikt}$$

- Ukraine-2022 (back)
  - 1pp ↑ in centrality → 5% ↑ in expected imports
  - driven by: ammunition, tanks, weapons, warships, electric generating sets
  - leading contributors: Poland (weapons), Slovakia (ammunition), Canada (tanks)
  - offset by: Russia (fossil fuels), China (electrical apparatus, steel), Belarus (petroleum)
- Similar exercises for Russia-2022 ... (details)
  - 1pp ↑ in centrality → 3.5% ↓ in expected imports
  - driven by: aerospace, shipbuilding, reception & transmission equipment
  - leading contributors: China (manufacturing), Kaz. (aluminum), Turkey (vessels)
  - offset by: France, Germany, United States (all: aerospace, shipbuilding)
- ... and China 2016-2022 (details)
  - 1pp ↑ in centrality → 8% ↓ in expected imports
  - driven by: aerospace, optical devices, chips
  - leading contributors: Vietnam (phone parts), Indonesia (alloys), HK (turbo-jets)
  - offset by: United States (aerospace), Korea (chips, opticals), France (aerospace)

China-2016

CHN goods | CHN country-goods | back



Ukraine: goods

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
930690	Ammunition; n.e.c. in chapter 93	0.13	1.43	46.58
871000	Tanks and other armoured fighting vehicles; motorised, whether or not fitted with weapons, and parts of such vehicles	0.56	0.22	31.83
930110	Military weapons; artillery weapons (e.g. guns, howitzers, and mortars)	0.21	0.48	25.17
271000	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	0.01	8.38	10.67
871639	Trailers and semi-trailers; (other than tanker type)	0.12	0.19	5.76
930630	Ammunition; cartridges and parts thereof n.e.c. in heading no. 9306	0.05	0.42	5.55
890610	Vessels; warships	0.58	0.04	5.52
871631	Tanker trailers and tanker semi-trailers	0.14	0.13	4.69
850220	Electric generating sets; with spark-ignition internal combustion piston engines	0.03	0.49	3.46
850211	Electric generating sets; with compression-ignition internal combustion piston engines (diesel or semi-diesel engines), of an output not exceeding 75kVA	0.03	0.28	1.95

back

Ukraine: goods reverse

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	0.19	-0.14	-6.46
270112	Coal; bituminous, whether or not pulverised, but not agglomerated	0.01	-0.86	-3.15
271320	Petroleum bitumen; obtained from bituminous minerals	0.03	-0.41	-2.93
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	0.39	-0.03	-2.53
840130	Fuel elements (cartridges); non-irradiated	0.01	-0.40	-1.52
880212	Helicopters; of an unladen weight exceeding 2000kg	0.22	-0.03	-1.49
721070	Iron or non-alloy steel; flat-rolled, width 600mm or more, painted, varnished or coated with plastics	0.03	-0.18	-1.49
841112	Turbo-jets; of a thrust exceeding 25kN	0.17	-0.03	-1.27
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	0.09	-0.05	-1.20
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes	0.02	-0.19	-1.12

back

Ukraine: country-goods

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	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	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	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	BGR	0.40
930630	Ammunition; cartridges and parts thereof n.e.c. in heading no. 9306	SVK	0.38
271000	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	IND	0.38
871631	Tanker trailers and tanker semi-trailers	TUR	0.36

Ukraine: country-goods reverse

HS code	Description	ISO	chg (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	POL	-2.31
880212	Helicopters; of an unladen weight exceeding 2000kg	DEU	-2.05
270112	Coal; bituminous, whether or not pulverised, but not agglomerated	RUS	-1.21
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	USA	-1.20
271000	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	BLR	-0.88
271121	Petroleum gases and other gaseous hydrocarbons; in gaseous state, natural gas	CHE	-0.84
271320	Petroleum bitumen; obtained from bituminous minerals	BLR	-0.60
271112	Petroleum gases and other gaseous hydrocarbons; liquefied, propane	RUS	-0.46
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes	CHN	-0.43
851712	Telephones for cellular networks or for other wireless networks	VNM	-0.42
721070	Iron or non-alloy steel; flat-rolled, width 600mm or more, painted, varnished or coated with plastics	CHN	-0.42
271000	Waste Oils; of petroleum or obtained from bituminous minerals, not crude; and preparations n.e.c., weight 70% or preparations of the same, containing polychlorinated biphenyls (PCBs), polychorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)	RUS	-0.41
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	CHN	-0.39
270112	Coal; bituminous, whether or not pulverised, but not agglomerated	USA	-0.38
841112	Turbo-jets; of a thrust exceeding 25kN	POL	-0.37
840130	Fuel elements (cartridges); non-irradiated	SWE	-0.36
270111	Coal; anthracite, whether or not pulverised, but not agglomerated	RUS	-0.35
271121	Petroleum gases and other gaseous hydrocarbons; in gaseous state, natural gas	HUN	-0.34
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	CAN	-0.24
930400	Firearms; (e.g. spring, air or gas guns and pistols, truncheons), excluding those of heading no. 9307	CZE	-0.24

Russia: goods

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	0.19	-0.59	31.83
841112	Turbo-jets; of a thrust exceeding 25kN	0.17	-0.38	18.62
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	-0.09	9.76
890510	Dredgers	0.36	-0.09	9.59
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	0.09	-0.32	8.71
890400	Tugs and pusher craft	0.32	-0.03	3.19
870829	Vehicles; parts and accessories, of bodies, other than safety seat belts	0.02	-0.53	3.19
890120	Tankers	0.40	-0.03	3.00
890399	Yachts and other vessels; for pleasure or sports, rowing boats and canoes, n.e.c. in heading no. 8903, other than inflatable	0.17	-0.06	2.88
871639	Trailers and semi-trailers; (other than tanker type)	0.12	-0.08	2.83

back

Russia: goods reverse

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
890590	Vessels; light, fire-floats, floating cranes and other vessels, the navigability of which is subsidiary to their main function, floating docks	0.36	0.06	-6.30
890520	Floating or submersible drilling or production platforms	0.36	0.03	-2.74
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	0.39	0.02	-2.44
281820	Aluminium oxide; other than artificial corundum	0.04	0.14	-1.58
851712	Telephones for cellular networks or for other wireless networks	0.03	0.19	-1.55
890110	Cruise ships, excursion boats and similar vessels, principally designed for the transport of persons, ferry boats of all kinds	0.40	0.01	-1.47
284410	Uranium; natural uranium and its compounds, alloys, dispersions (including cermets), ceramic products and mixtures containing natural uranium or natural uranium compounds	0.02	0.30	-1.33
854519	Carbon electrodes; with or without metal, of a kind used for other than furnaces	0.04	0.10	-1.22
870423	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 20 tonnes), n.e.c. in item no 8704.1	0.01	0.30	-1.10
730890	Iron or steel; structures and parts thereof, n.e.c. in heading 7308	0.02	0.18	-1.01

back

Russia: country-goods

HS code	Description	ISO	chg (%)
890590	Vessels; light, fire-floats, floating cranes and other vessels, the navigability of which is subsidiary to their main function, floating docks	CHN	2.28
851712	Telephones for cellular networks or for other wireless networks	ARE	1.05
890520	Floating or submersible drilling or production platforms	CHN	0.98
890690	Vessels; other, including lifeboats other than rowing boats, other than warships	KOR	0.97
851712	Telephones for cellular networks or for other wireless networks	HKG	0.72
281820	Aluminium oxide; other than artificial corundum	CHN	0.66
890110	Cruise ships, excursion boats and similar vessels, principally designed for the transport of persons, ferry boats of all kinds	TUR	0.59
870423	Vehicles; compression-ignition internal combustion piston engine (diesel or semi-diesel), for transport of goods, (of a g.v.w. exceeding 20 tonnes), n.e.c. in item no 8704.1	CHN	0.55
848180	Taps, cocks, valves and similar appliances; for pipes, boiler shells, tanks, vats or the like, including thermostatically controlled valves	CHN	0.55
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	DNK	0.47
284410	Uranium; natural uranium and its compounds, alloys, dispersions (including cermets), ceramic products and mixtures containing natural uranium or natural uranium compounds	KAZ	0.42
852691	Radio navigational aid apparatus	CHN	0.40
281820	Aluminium oxide; other than artificial corundum	KAZ	0.38
854519	Carbon electrodes; with or without metal, of a kind used for other than furnaces	CHN	0.37
730890	Iron or steel; structures and parts thereof, n.e.c. in heading 7308	KOR	0.34
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	CAN	0.33
382490	Chemical products, preparations and residual products of the chemical or allied industries, n.e.c. or included in heading no. 3824	CHN	0.31
860900	Containers; (including containers for transport of fluids) specially designed and equipped for carriage by one or more modes of transport	CHN	0.28
740100	Copper mattes; cement copper (precipitated copper)	FIN	0.26
281820	Aluminium oxide; other than artificial corundum	IRL	0.24

back

Russia: country-goods reverse

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

back

China: goods

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	0.19	-1.44	52.81
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	0.07	-2.34	31.08
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	0.06	-0.47	5.16
901390	Optical appliances and instruments; parts and accessories for articles of heading no. 9013	0.08	-0.23	3.31
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	-0.04	2.89
890120	Tankers	0.40	-0.03	2.48
841191	Turbines; parts of turbo-jets and turbo-propellers	0.19	-0.06	2.22
270750	Aromatic hydrocarbon mixtures; n.e.c. in heading no. 2707, of which 65% or more by volume (including losses) distils at 250 degrees Celsius by the ASTM D 86 method	0.02	-0.29	1.35
710812	Metals; gold, non-monetary, unwrought (but not powder)	0.01	-0.80	1.32
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes	0.02	-0.27	1.21

back

China: goods reverse

HS code	Description	$\mathcal{C}^{M}_{US,k}/\sigma_k$	trade chg (%)	contribution (%)
851712	Telephones for cellular networks or for other wireless networks	0.03	0.92	-5.07
271111	Petroleum gases and other gaseous hydrocarbons; liquefied, natural gas	0.02	1.36	-4.33
260300	Copper ores and concentrates	0.02	1.00	-3.55
760120	Aluminium; unwrought, alloys	0.14	0.12	-3.45
854239	Electronic integrated circuits; n.e.c. in heading no. 8542	0.02	0.84	-2.97
720260	Ferro-alloys; ferro-nickel	0.02	0.60	-2.83
260111	Iron ores and concentrates; non-agglomerated	0.01	1.69	-2.48
890520	Floating or submersible drilling or production platforms	0.36	0.02	-1.75
903141	Optical instruments and appliances; for inspecting semiconductor wafers or devices or for inspecting photomasks or reticles used in manufacturing semiconductor devices, n.e.c. in chapter 90	0.08	0.10	-1.52
760320	Aluminium; powders of lamellar structure, flakes	0.64	0.01	-1.43

back

China: country-goods

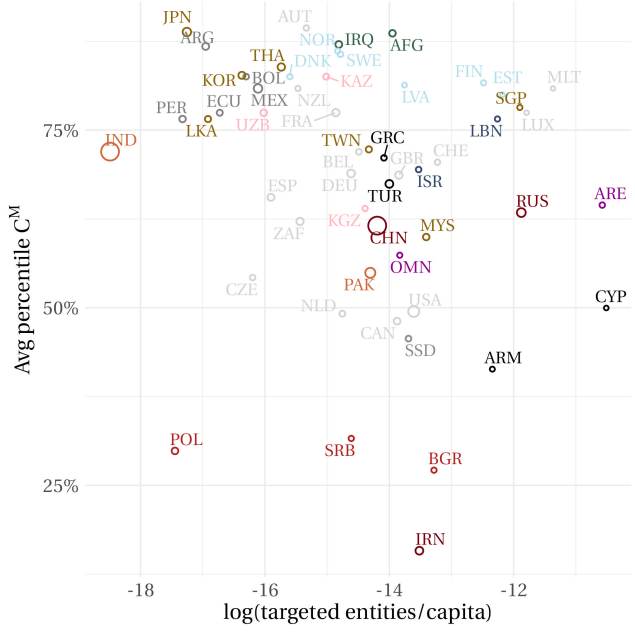
HS code	Description	ISO	chg (%)
880240	Aeroplanes and other aircraft; of an unladen weight exceeding 15,000kg	USA	-9.89
901380	Optical devices, appliances and instruments; n.e.c. in heading no. 9013 (including liquid crystal devices)	KOR	-4.28
901380	Optical devices, appliances and instruments; n.e.c. 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

China: country-goods reverse

HS code	Description	ISO	chg (%)
841112	Turbo-jets; of a thrust exceeding 25kN	HKG	1.91
851770	Telephone sets and other apparatus for the transmission or reception of voice, images or other data, via a wired or wireless network; parts	VNM	1.65
854239	Electronic integrated circuits; n.e.c. in heading no. 8542	TWN	1.49
852990	Reception and transmission apparatus; for use with the apparatus of heading no. 8525 to 8528, excluding aerials and aerial reflectors	KOR	1.02
720260	Ferro-alloys; ferro-nickel	IDN	1.01
260111	Iron ores and concentrates; non-agglomerated	AUS	0.95
851712	Telephones for cellular networks or for other wireless networks	VNM	0.93
854232	Electronic integrated circuits; memories	KOR	0.83
890520	Floating or submersible drilling or production platforms	SGP	0.67
271111	Petroleum gases and other gaseous hydrocarbons; liquefied, natural gas	AUS	0.67
260300	Copper ores and concentrates	CHL	0.60
710813	Metals; gold, semi-manufactured	GBR	0.59
851712	Telephones for cellular networks or for other wireless networks	KOR	0.57
760320	Aluminium; powders of lamellar structure, flakes	MYS	0.54
760120	Aluminium; unwrought, alloys	MYS	0.47
854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	VNM	0.46
710812	Metals; gold, non-monetary, unwrought (but not powder)	CHE	0.45
854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	IRL	0.42
740311	Copper; refined, unwrought, cathodes and sections of cathodes	COD	0.41
271111	Petroleum gases and other gaseous hydrocarbons; liquefied, natural gas	QAT	0.38

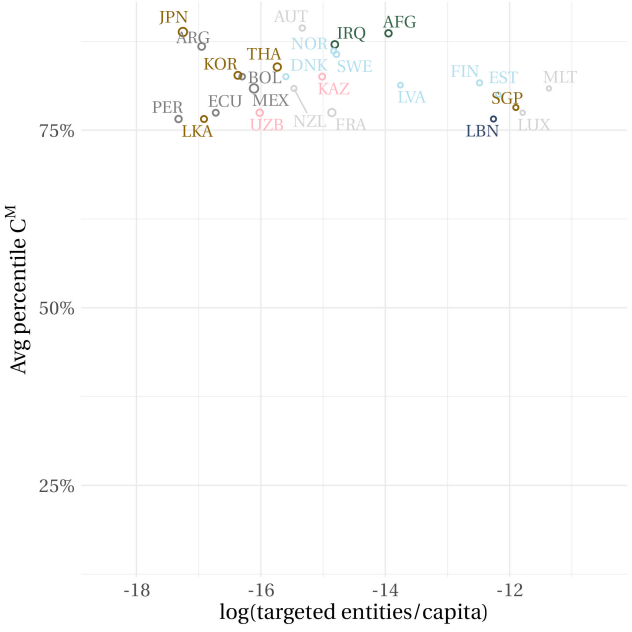
back

BIS lists: Entities per capita



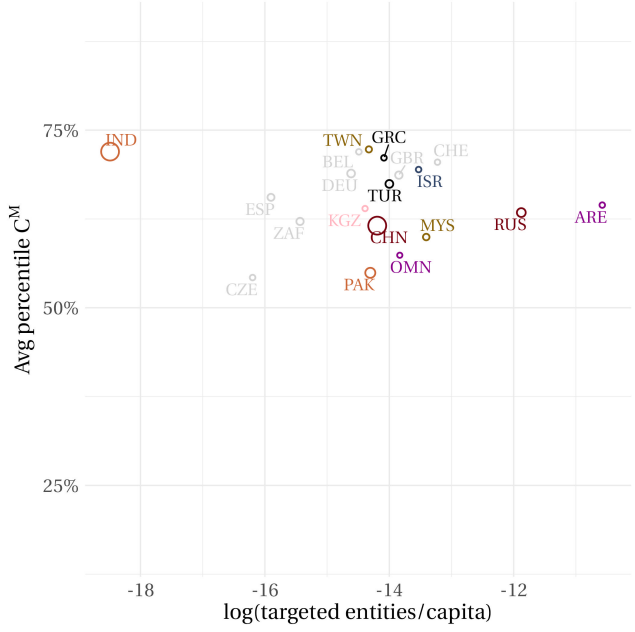
back

BIS lists: Entities per capita



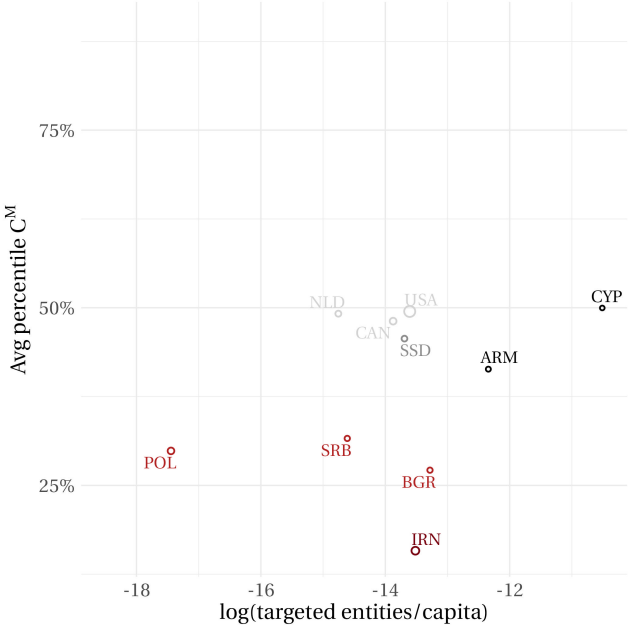
back

BIS lists: Entities per capita



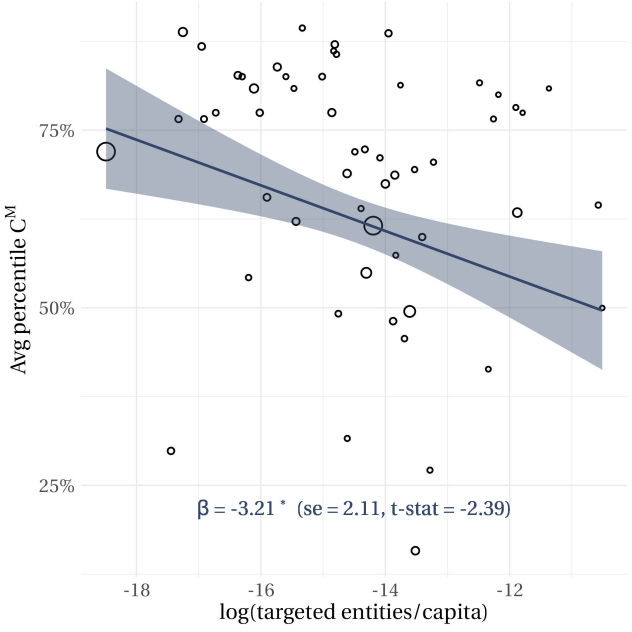
back

BIS lists: Entities per capita



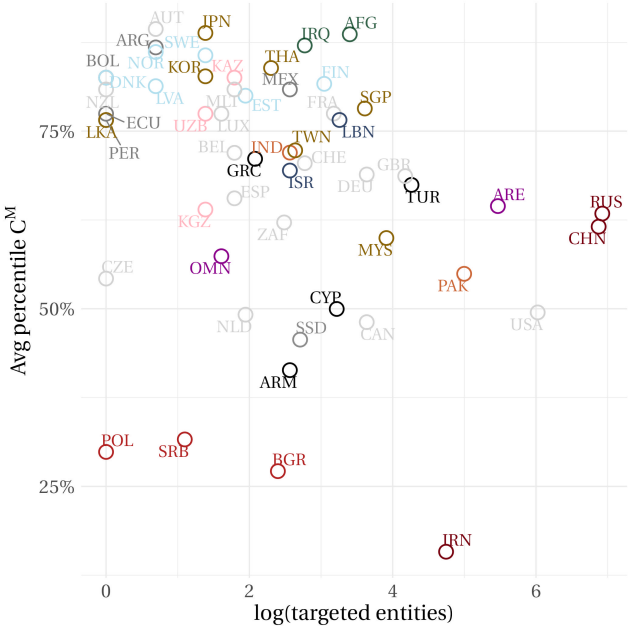
back

BIS lists: Entities per capita



back

BIS lists: Total entities

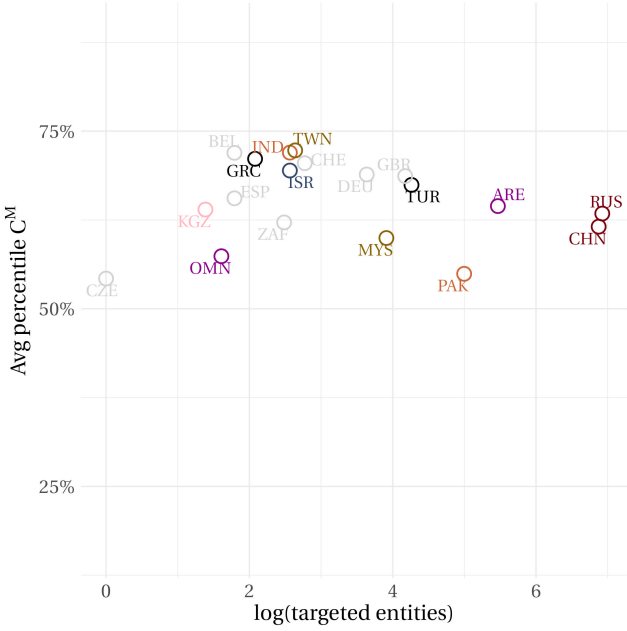


back

BIS lists: Total entities

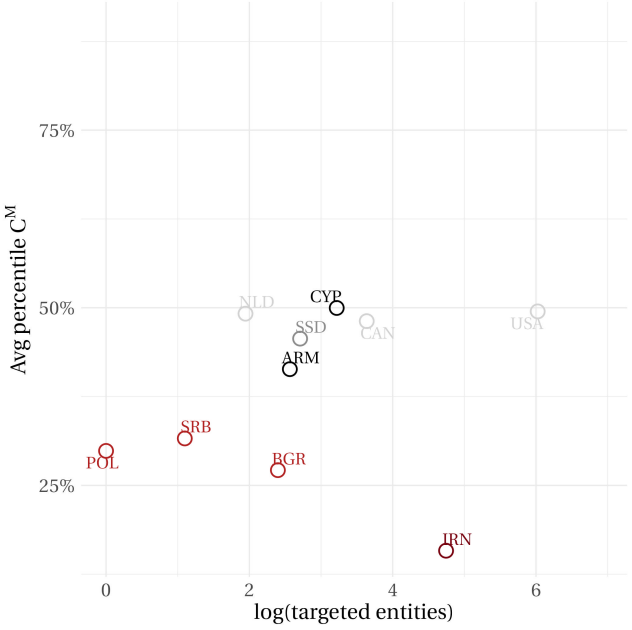
back

BIS lists: Total entities



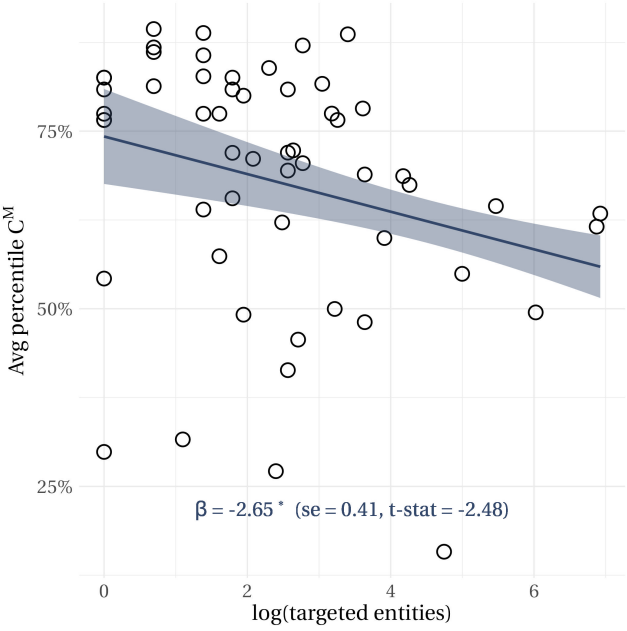
back

BIS lists: Total entities



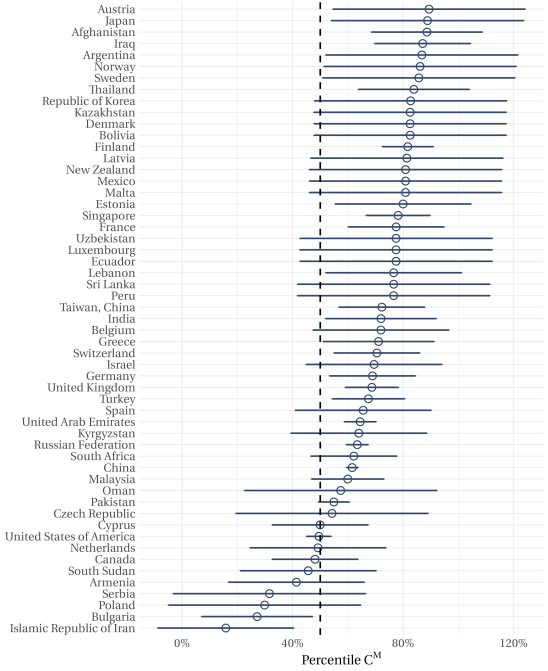
back

BIS lists: Total entities



back

BIS country list



back

Evaluation

U.S. entity lists details Sources: Bureau of Industry Security, Orbis

- List evaluation:
  - military end use (76%; N = 72), unverified list (72%; N = 167), entity list (62%; N = 2889), denied persons list (52%; N = 637)
- Country groups:
  - >75%: LatAm, Northern Europe, Iraq + Afghanistan, South China Sea
  - 50%-75%: Turkey, UAE, Russia, China
  - <50%: Armenia, Serbia, Iran

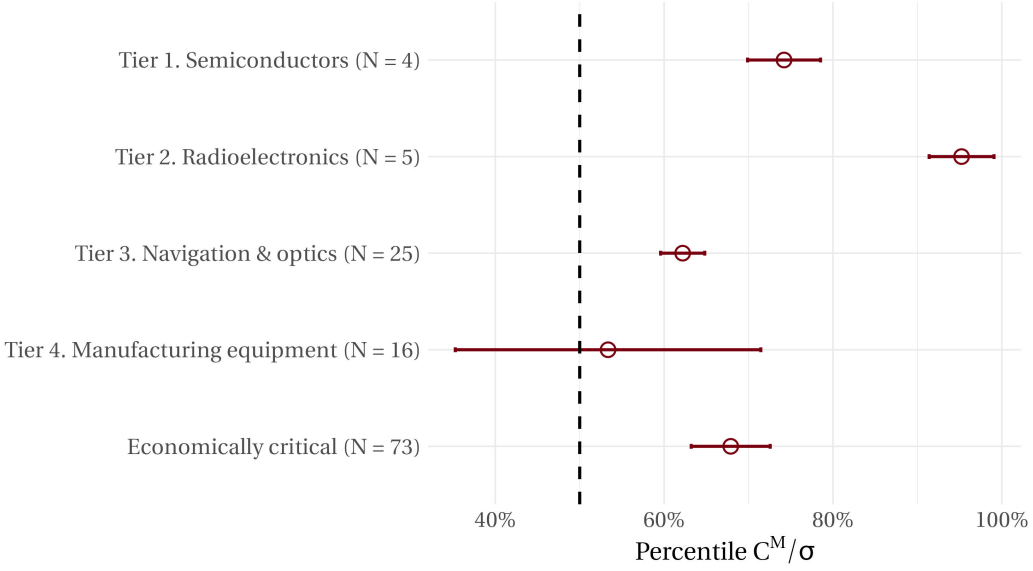
Similar exercises for EU critical goods lists ... details Sources: EU Commission

- Tier evaluation:
  - radioelectronics (95%; N = 5), semiconductors (74%; N = 4), smuggled (68%; N = 73), navigation & optics (62%; N = 25), manufacturing equipment (53%; N = 16)
- D-U list was improved in 2015 (65.9% →66.9%); expanded in 2022 (66.3% →63.1%)

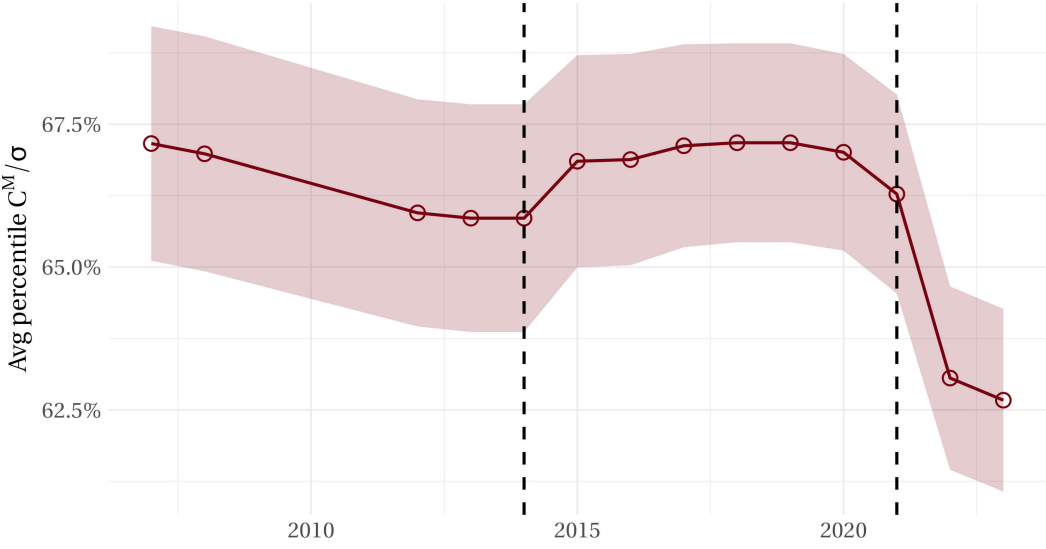
... and sanctions against Russia details Sources: OpenSanctions, EGRUL

- Sanction groups
  - >65%: Navalny-35, UK Investment bans, U.S. Legislative Exclusions
  - 50%-65%: Japan, Poland, Canada, EU, Ukraine, Austrlia, NZ, Monaco sanctions
  - <40%: Kazakh anti-terror list, Lithuanian sanctions, Moldova people of interest

EU Commission critical goods lists



EU Commission dual-use lists



Evaluation

U.S. entity lists ▸ details Sources: Bureau of Industry Security, Orbis

- List evaluation:
  - military end use (76%; N = 72), unverified list (72%; N = 167), entity list (62%; N = 2889), denied persons list (52%; N = 637)
- Country groups:
  - >75%: LatAm, Northern Europe, Iraq + Afghanistan, South China Sea
  - 50%-75%: Turkey, UAE, Russia, China
  - <50%: Armenia, Serbia, Iran

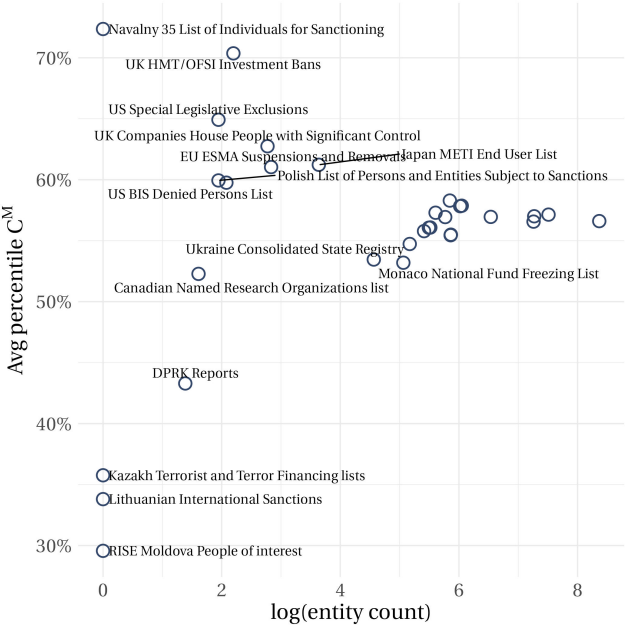
Similar exercises for EU critical goods lists ... ▸ details Sources: EU Commission

- Tier evaluation:
  - radioelectronics (95%; N = 5), semiconductors (74%; N = 4), smuggled (68%; N = 73), navigation & optics (62%; N = 25), manufacturing equipment (53%; N = 16)
- D-U list was improved in 2015 (65.9% →66.9%); expanded in 2022 (66.3% →63.1%)

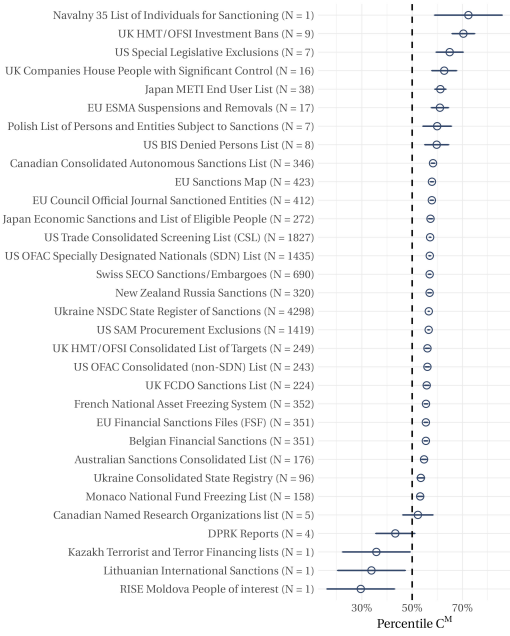
... and sanctions against Russia ▸ details Sources: OpenSanctions, EGRUL

- Sanction groups
  - >65%: Navalny-35, UK Investment bans, U.S. Legislative Exclusions
  - 50%-65%: Japan, Poland, Canada, EU, Ukraine, Austrlia, NZ, Monaco sanctions
  - <40%: Kazakh anti-terror list, Lithuanian sanctions, Moldova people of interest

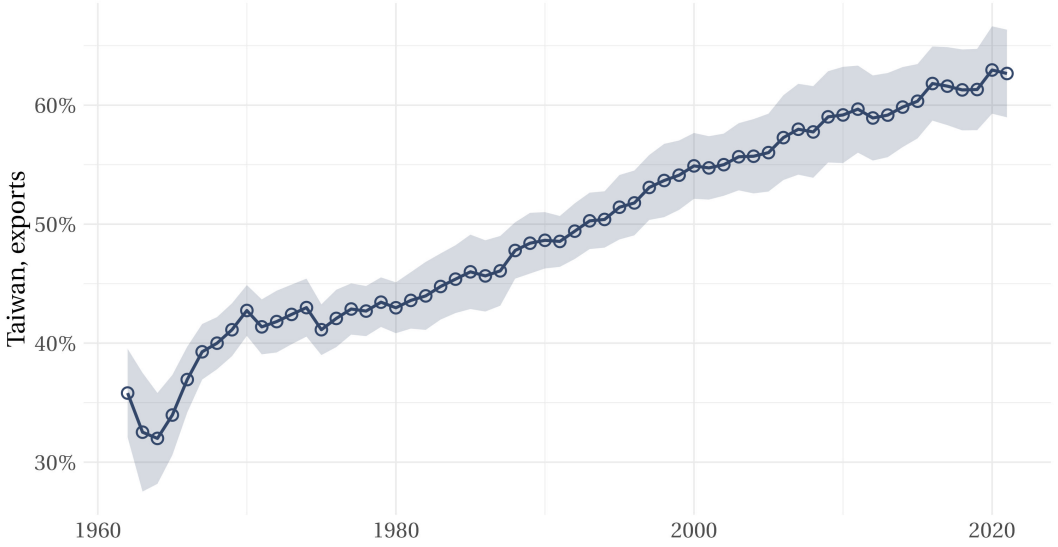
Sanctions against Russia



Sanctions against Russia

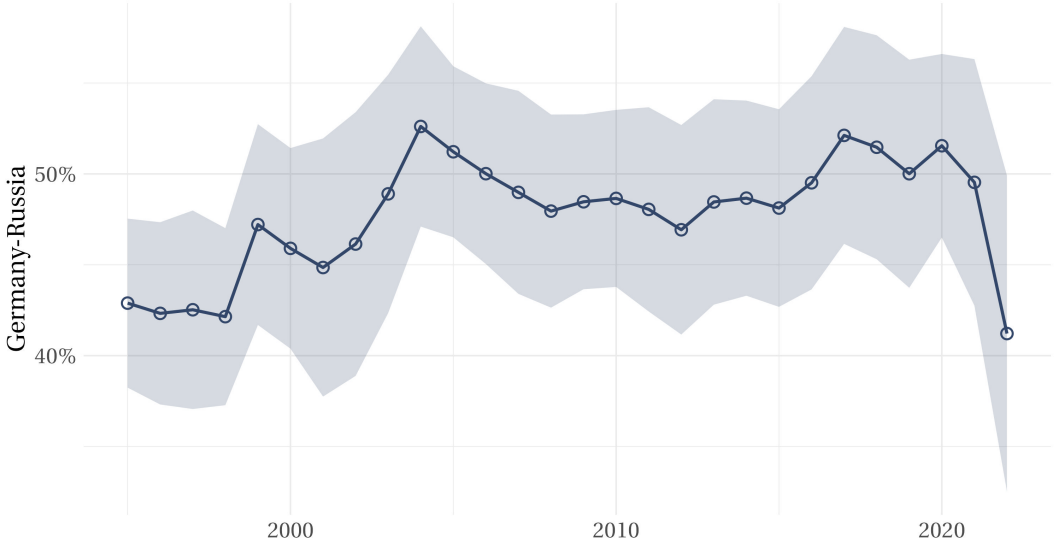


Taiwan exports



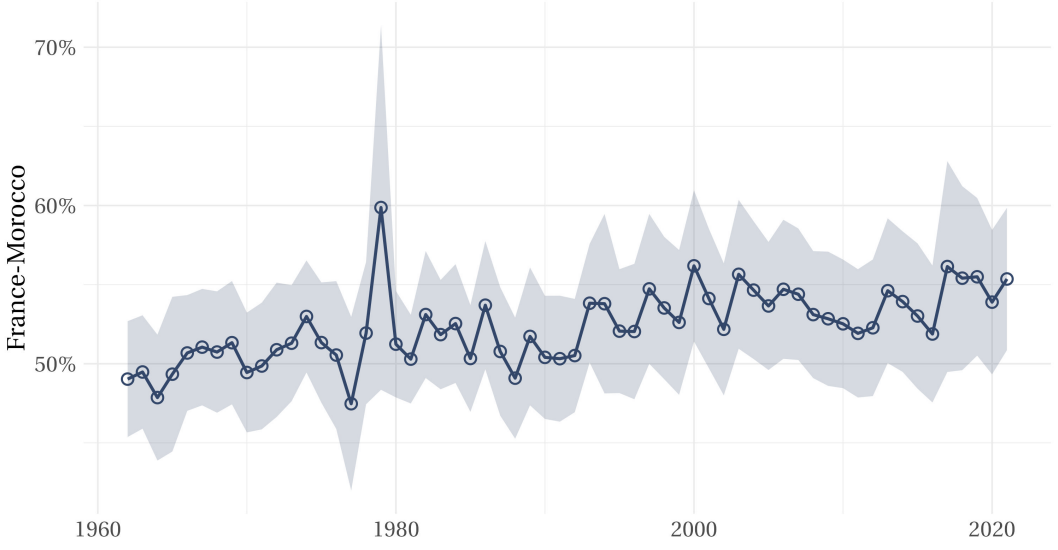
back

Germany-Russia



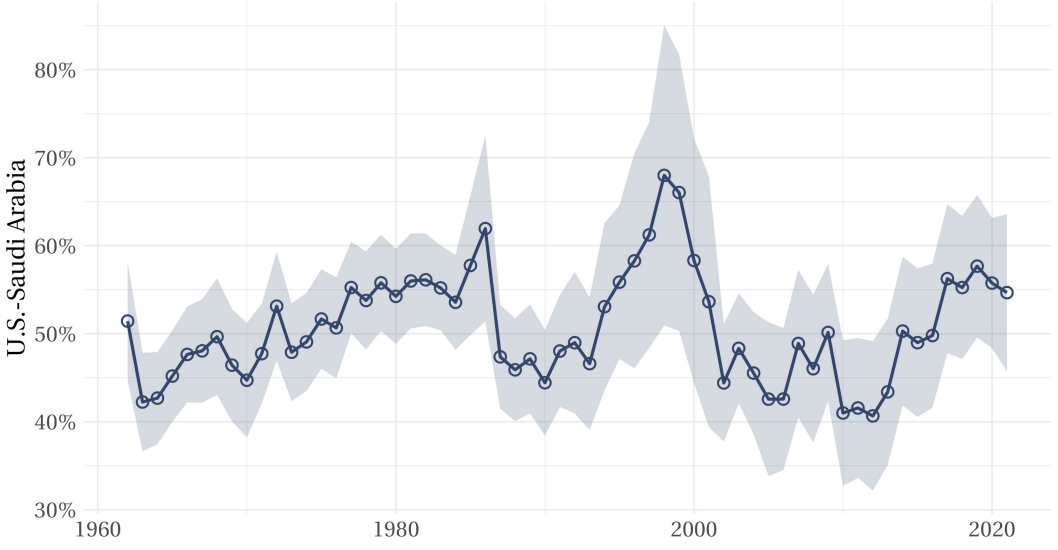
back

France-Morocco



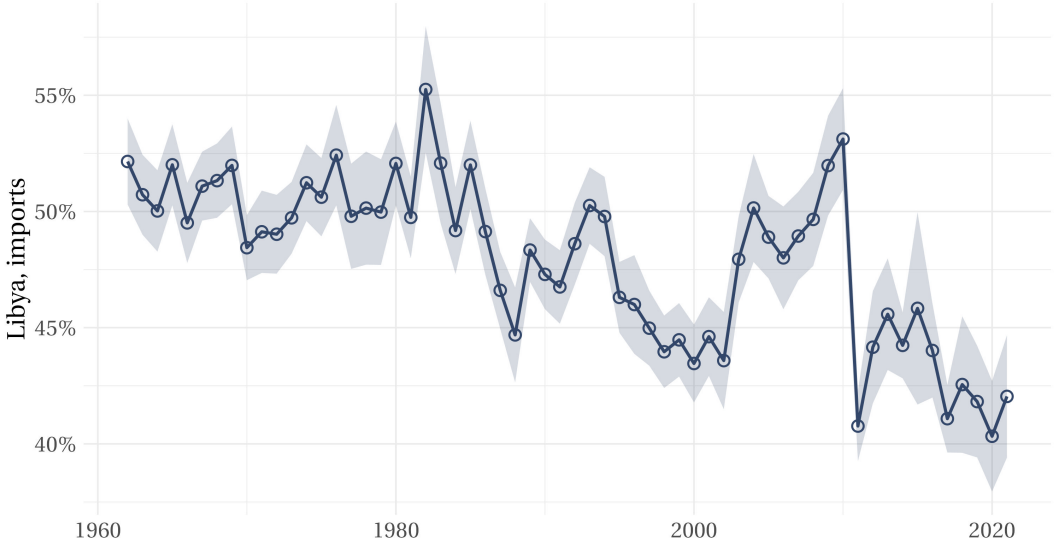
back

United States-Saudi Arabia



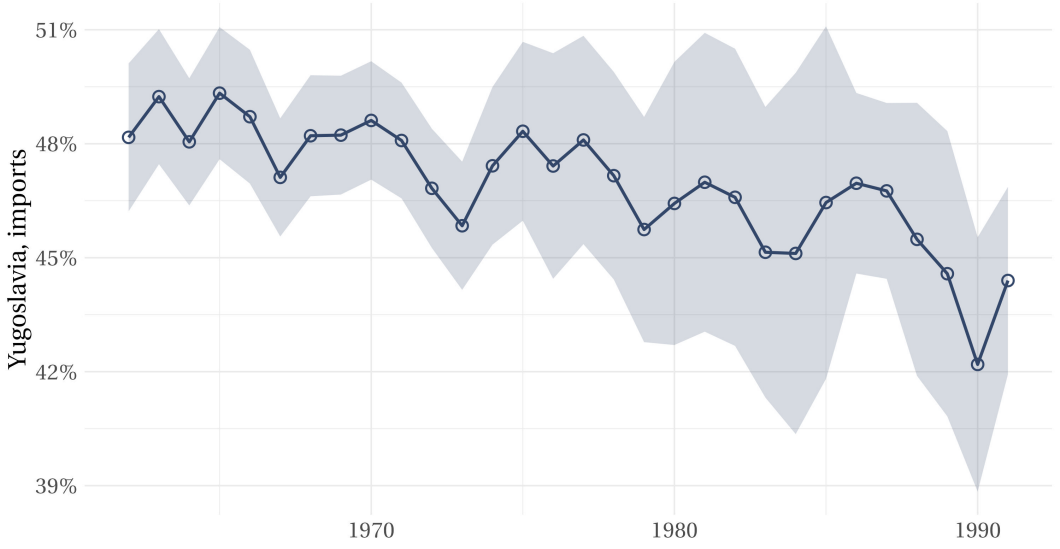
back

Libya imports



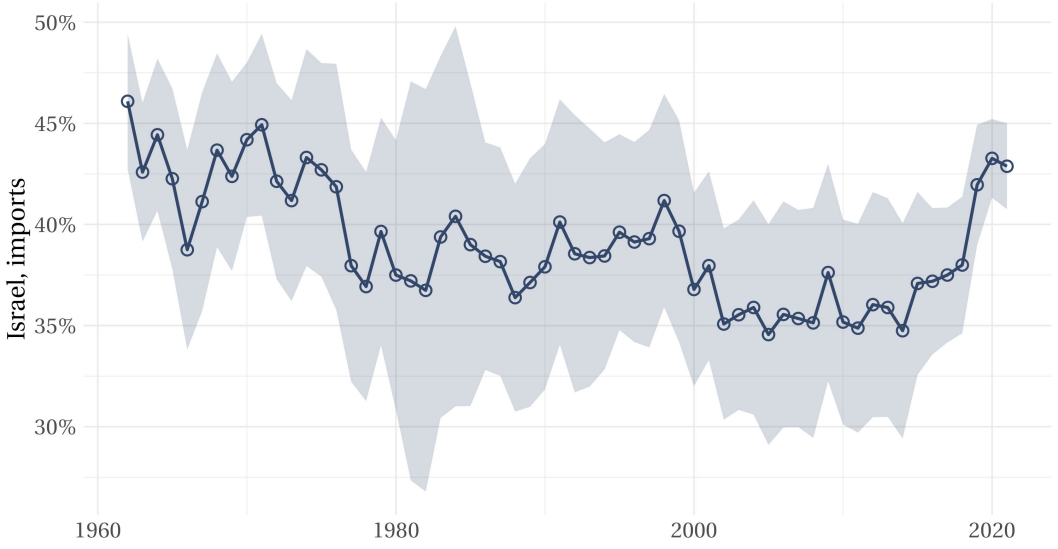
back

Yugoslavia imports



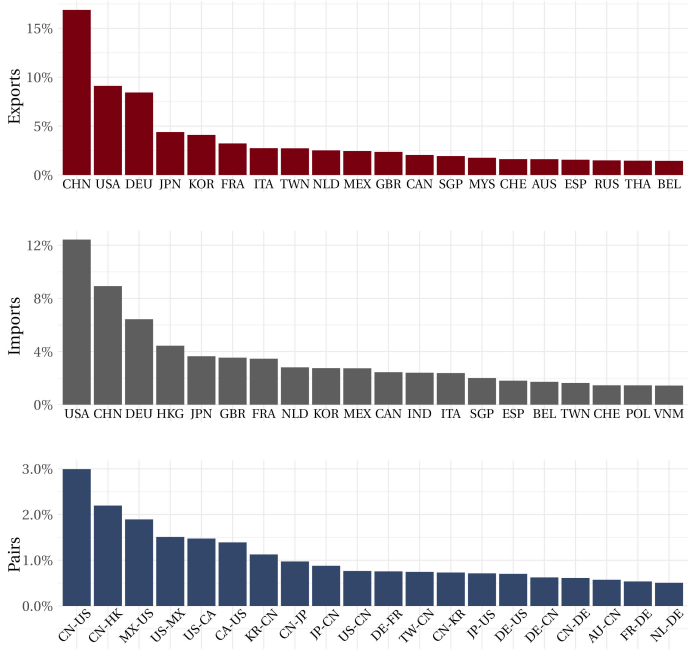
back

Israel imports



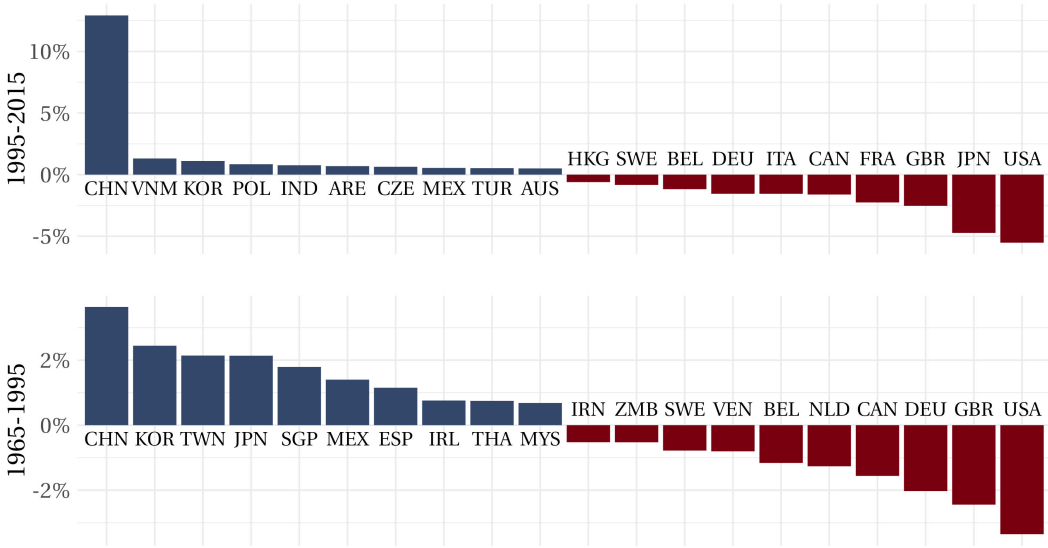
back

Cross-section



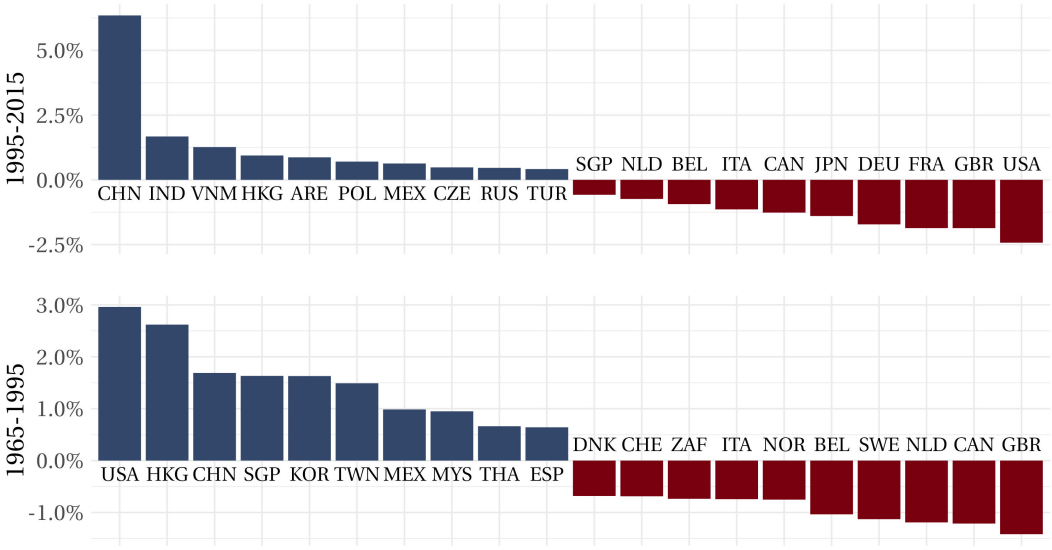
back

Exports



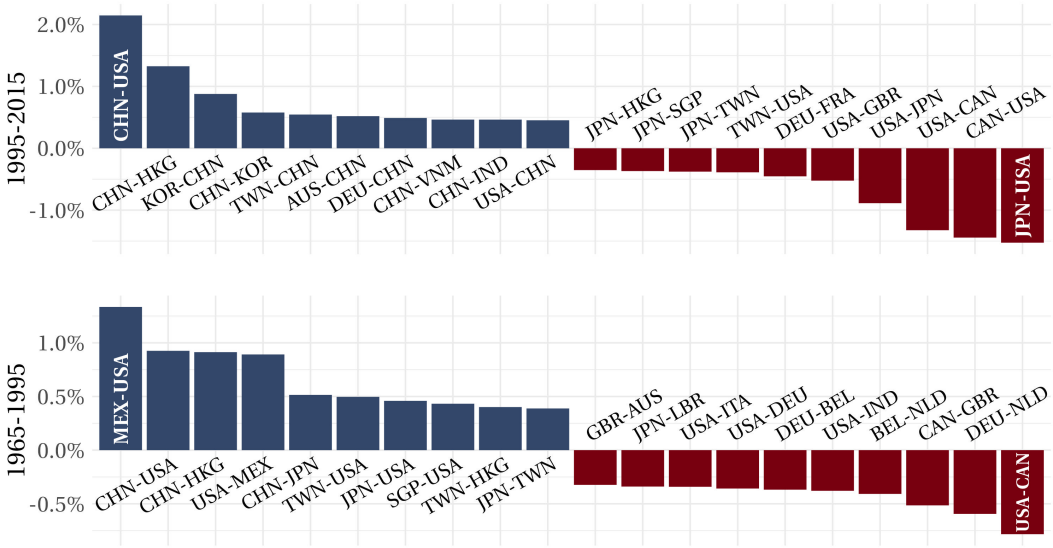
back

Imports



back

Pairs


1995-2015
2.0%
1.0%
0.0%
-1.0%
CHN-USA
CHN-HKG
KOR-CHN
CHN-KOR
TWN-CHN
AUS-CHN
DEU-CHN
CHN-VNM
CHN-IND
USA-CHN
JPN-HKG
JPN-SGP
JPN-TWN
TWN-USA
DEU-FRA
USA-GBR
USA-JPN
USA-CAN
CAN-USA
JPN-USA
1965-1995
1.0%
0.5%
0.0%
-0.5%
MEX-USA
CHN-USA
CHN-HKG
USA-MEX
CHN-JPN
TWN-USA
JPN-USA
SGP-USA
TWN-HKG
JPN-TWN
GBR-AUS
JPN-LBR
USA-ITA
USA-DEU
DEU-BEL
USA-IND
BEL-NLD
CAN-GBR
DEU-NLD
USA-CAN

back

Theory extension

$$U_i(\{c_j\}_{i=1}^N, \{m_j\}_{i=1}^N), \quad C_i = w_i L_i + D_i + R_i - M_i$$

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

Compact representation of factor market-clearing condition

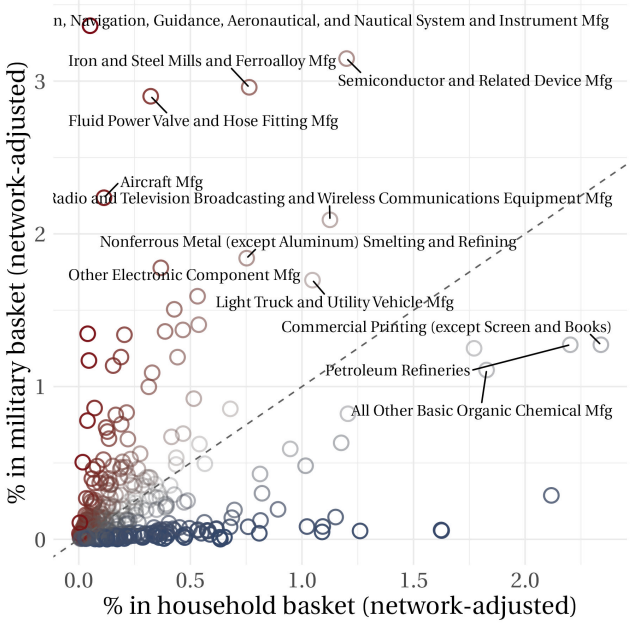
$$\boldsymbol{\Lambda^L w L} = \boldsymbol{\Omega'_L \Lambda_X^{-1} \tilde{\Psi}'} (\boldsymbol{s^C}(-\boldsymbol{D} - \boldsymbol{M}) + \boldsymbol{s^M M}),$$

$$\boldsymbol{R} = \boldsymbol{\Lambda^R X}, \quad \boldsymbol{\Lambda^X} = (\boldsymbol{I} - \boldsymbol{\tilde{\Psi}'} \boldsymbol{s^C \Lambda^R}), \quad \boldsymbol{\Lambda^L} = (\boldsymbol{I} - \boldsymbol{\Omega'_L \Lambda_X^{-1} \tilde{\Psi}'} \boldsymbol{s^C})$$

allows us to express $\mathcal{J}$ closed-form

back

China input-output table

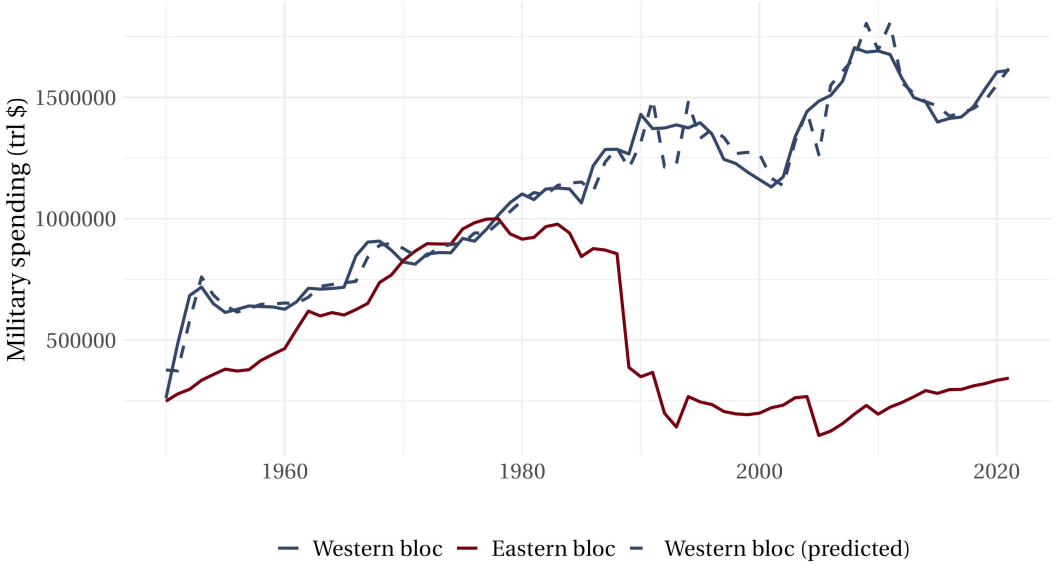


back

Conflict elasticity

back

$$\log m_t - \log(\nu_t(\gamma)(1-\nu_t(\gamma))) = \varepsilon_t, \quad \varepsilon_t \equiv \log\left(\gamma\beta_t\kappa_t P_t^C / P_t^M\right)$$



Security weight

back

General equilibrium:

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

	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

The difference between partial and general equilibrium:

- $M_{CHN} \uparrow \rightarrow w_{CHN} \downarrow$
  - Military more dependent on imports than consumers (38% and 25.8%)
- $M_{USA} \uparrow \rightarrow w_{USA} \uparrow$
  - Military less dependent on imports than consumers (19% and 31%)

Takeaways

Trade-off $(m_{\text{HOME}}/m_{\text{FRGN}})$–$(c_{\text{FRGN}}/c_{\text{HOME}})$:

(1) China has an upper hand when it comes to unilateral export policies

(2) U.S. impact is three times larger when it acts with a coalition

(3) Smuggling halves impact magnitudes

(4) Drawdown of stockpiles makes trade policy more aggressive

(5) Import tariffs are a powerful tool for the U.S. but act through budget constraints

Notes:

- Fixed tax as % budget; 0.3% and -1.4% under flexible defense spending
  - Under internal redistribution, need to squeeze the economy-wide budget constraint
- 0.2% welfare improvement for the U.S., 1.5% for China
  - Consumption base effect
- Industrial policy yields 11% and 0.7% via an indirect terms-of-trade manipulation
  - Redistribution from export-oriented sectors towards military

back