

# The Military Multiplier

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## Defense spending on the rise

- ▶ Pledge by several NATO members (e.g. Germany, Sweden, Netherlands) to raise core defense spending from 2 to 3.5 pts of GDP: **+75%**
- ▶ How effective is the spending increase in *raising military capabilities*?

## Defense spending on the rise

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## Spending targets frequently specified in nominal terms / share of GDP

- ▶ More spending *may* buy more equipment (= capacity)
- ▶ But (relative) price of military goods likely to rise, too (limit: only prices rise)

# What determines the effectiveness of military spending?

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## **This paper introduces the concept of the Military Multiplier (MM)**

- ▶ Measures the effectiveness of military spending ( $\neq$  fiscal multiplier)
- ▶ Provides estimates for *MM* in the U.S. across sample periods
- ▶ Multi-sector real business cycle model with IO & investment networks: determinants of *MM*

## **Main results**

- ▶ Cost of military procurement up by 60% post Cold War
- ▶ Shrinking industrial base of the U.S. economy explains the decline in *MM*
- ▶ Economic strength  $\neq$  military capacity; industry structure is key

## Related Literature

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- ▶ **Military buildups & costly reallocation** Ramey and Shapiro (1998); Ramey (2011); survey in Ilzetzki (2025).
- ▶ **Fiscal policy in multi-sector / network models** Cox et al. (2024); Bouakez et al. (2023); Bouakez et al. (2025); Acemoglu et al. (2016); Devereux et al. (2023); Flynn et al. (2022); Ramey (2019).
- ▶ **Sectoral shock propagation and production–investment networks** Long and Plosser (1983); Horvath (2000); Foerster et al. (2011); Atalay (2017); Acemoglu et al. (2012); Baqaee and Farhi (2019); Vom Lehn and Winberry (2022).
- ▶ **Capital reallocation frictions** Eifeldt and Rampini (2006); Eifeldt and Rampini (2007); Cooper and Schott (2013); Rampini (2019); Wang (2021); Lanteri and Rampini (2023).

## 2. Introducing the Military Multiplier

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- ▶  $X_t$  dollars of military spending buys  $G_t$  of equipment at price  $P_t$ :  $X_t = P_t \cdot G_t$
- ▶ Let  $\hat{x}$  denote percentage change in military spending (in units of output):

$$\hat{x} = \underbrace{\hat{g}}_{\text{Equipment}} + \underbrace{\hat{p}}_{\text{Price}}$$

### Definition (Military multiplier)

$$MM = \frac{\hat{g}}{\hat{x}} = 1 - \frac{\hat{p}}{\hat{x}} \quad (1)$$

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### Differs from fiscal multiplier

$$M = \frac{\hat{y}}{\hat{x}} = \frac{\hat{x} + \hat{i} + \hat{c}}{\hat{x}} = 1 + \frac{\hat{i} + \hat{c}}{\hat{x}} \quad (2)$$

Price response  $\hat{p}$  is a **sufficient statistic** for  $MM$

# Cumulative Military Multiplier

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## Cumulative MM (adapting Mountford and Uhlig, 2009)

$$\text{Cumulative } MM(k) = 1 - \frac{\sum_{j=0}^k p_j}{\sum_{j=0}^k x_j}$$

### Key distinction from fiscal multiplier

- ▶ Fiscal multiplier: how does *private* spending respond to government spending?
- ▶ Military multiplier: how does the *relative price* of defense goods respond?
- ▶ In one-sector models:  $\hat{p} = 0 \Rightarrow MM = 1$  always

# Partial-Equilibrium Perspective

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## Market for military goods

$$y_g = \epsilon^s p \quad (\text{supply}), \quad y_g = -\epsilon^d p + g \quad (\text{demand})$$

## Policy specified not in terms of $g$

- ▶ Sets budget increment  $x = p + g$  (measured in numéraire good)
- ▶ Substituting for  $g = x - p$  gives transformed demand curve

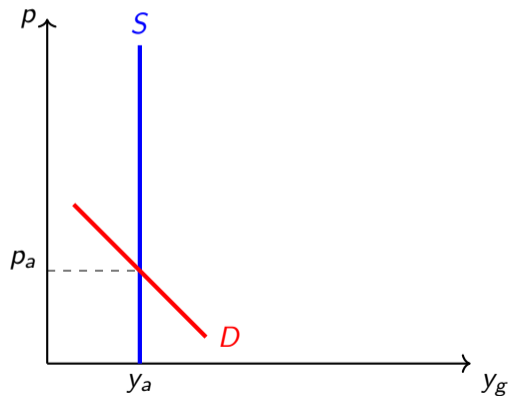
$$y_g = -(1 + \epsilon^d) p + x,$$

with slope  $-(1 + \epsilon^d)$  and “nominal” spending shifter  $x$

# Supply and demand in the market for military goods

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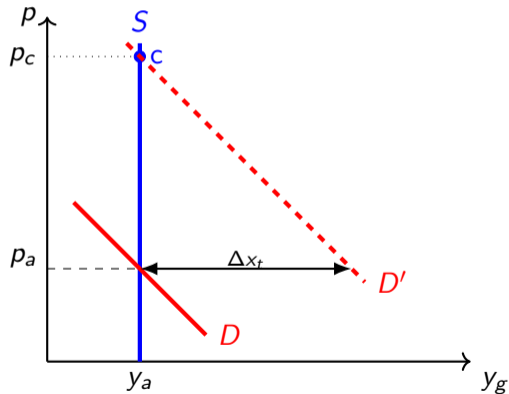
(a) Inelastic private demand



# Supply and demand in the market for military goods

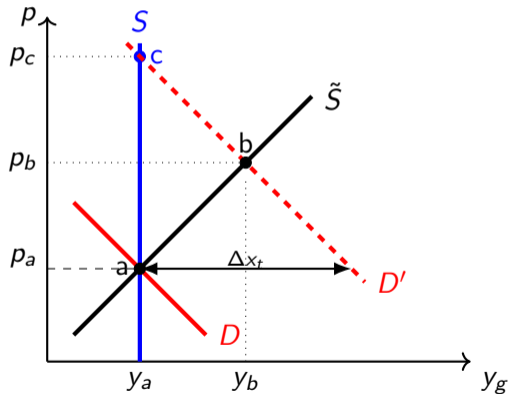
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(a) Inelastic private demand



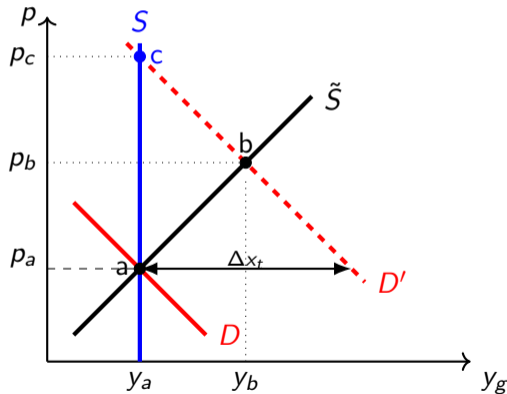
# Supply and demand in the market for military goods

(a) Inelastic private demand

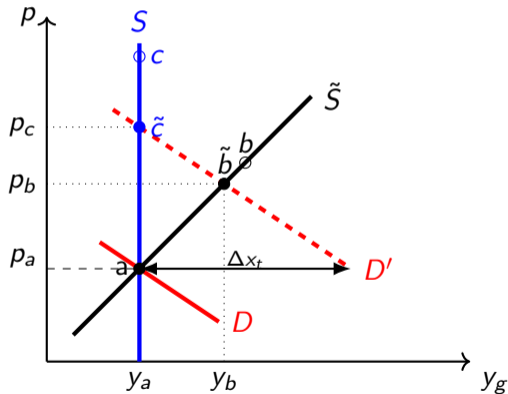


# Supply and demand in the market for military goods

(a) Inelastic private demand



(b) Elastic private demand



# Elasticities determine MM

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## Price response and hence MM fully determined by elasticities

- ▶ Higher elasticities on **either** side  $\Rightarrow$  smaller price rise  $\Rightarrow$  larger  $MM$

$$MM = 1 - \frac{p}{x} = \left[ 1 + \frac{1}{\epsilon^d + \epsilon^s} \right]^{-1}$$

# Elasticities determine MM

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## Price response and hence MM fully determined by elasticities

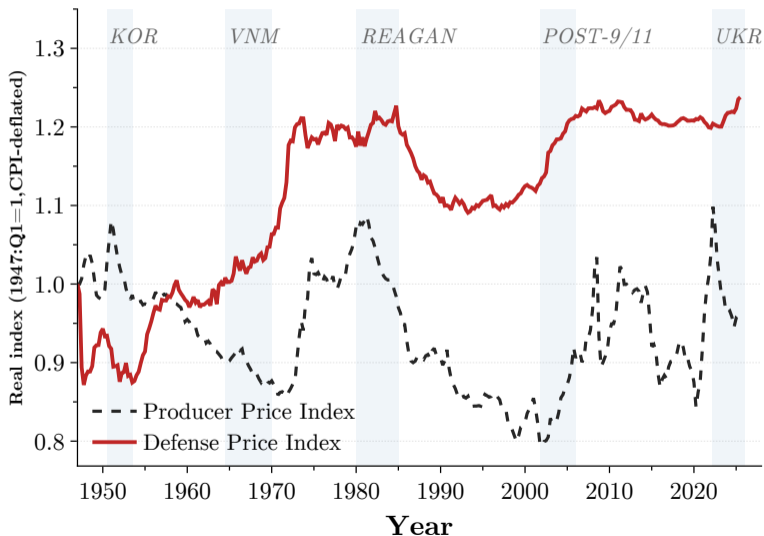
- ▶ Higher elasticities on **either** side  $\Rightarrow$  smaller price rise  $\Rightarrow$  larger *MM*

$$MM = 1 - \frac{p}{x} = \left[ 1 + \frac{1}{\epsilon^d + \epsilon^s} \right]^{-1}$$

## What determines elasticities?

- ▶ Over time: reallocation of resources to military sector
- ▶ From partial to (dynamic) general equilibrium  $\rightarrow$  multi-sector model

### 3. Evidence: Military prices vs. producer prices



### 3. Evidence: Price Response to Defense Shocks

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#### Military spending moves defense-sector prices

- ▶ Use defense-spending “news” shocks (Ramey, 2016; Ramey and Zubairy, 2018)
- ▶ Estimate local projections (Ramey and Shapiro, 1998) ▶ LP specification
- ▶ Cold War period (1947 Q1–1990 Q4) vs. post-Cold War (1991 Q1–2018 Q4)

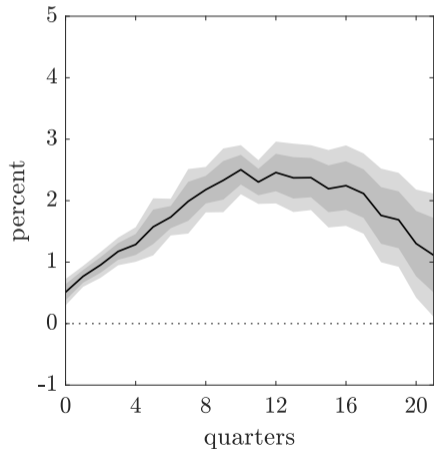
#### Price response as sufficient statistic for MM

- ▶ Response of defense goods prices and manufacturing PPI
- ▶ Manufacturing absorbs bulk of DoD procurement ( $\approx 40\%$ )
- ▶ Compute cumulative *MM*:

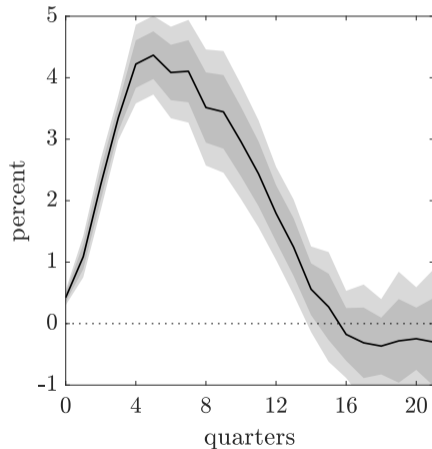
$$MM(k) = 1 - \frac{\sum_i^k p_{t+i}}{\sum_i^k x_{t+i}}$$

# Response to military buildups: defense spending

(a) Post-Cold War



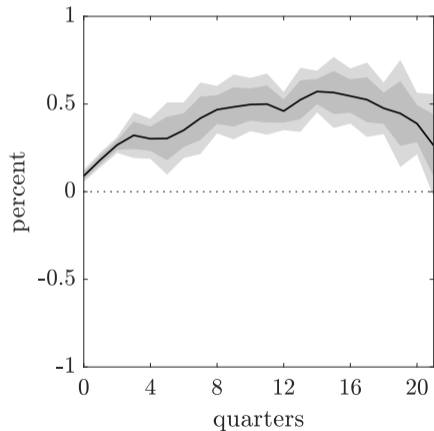
(b) Cold War



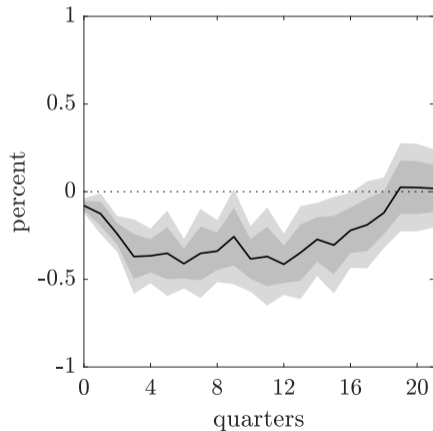
Notes: Response of government defense spending to military spending news (Ramey, 2016). Hump-shaped buildup; post-Cold War:  $\approx 2\%$  increase,

# Response to military buildups: defense-goods prices

(a) Post-Cold War

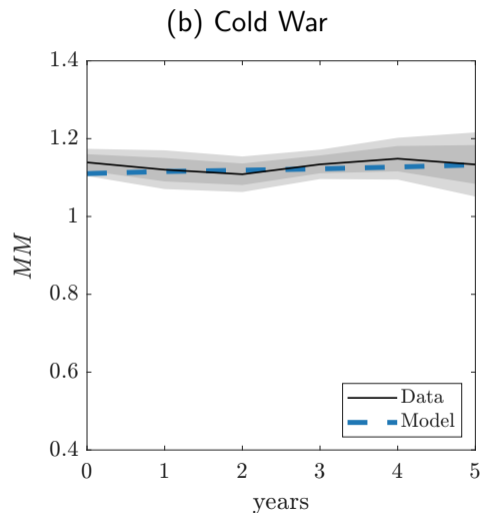
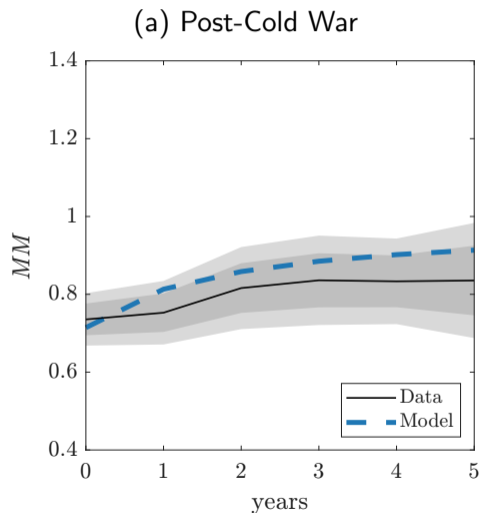


(b) Cold War



Notes: Response of real defense-goods prices (deflated with GDP deflator) to military spending news (Ramey, 2016). Post-Cold War: prices rise

# Cumulative Military Multiplier



Notes: Cumulative MM over first 5 years. Gray: empirical estimates (with CI). Blue dashed: model predictions.

# Takeaway: Price evidence

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## Post-Cold War

- ▶ Defense-goods prices rise strongly ( $\approx 0.5\%$ ); manufacturing PPI rises  $\approx 0.2\%$
- ▶ Implies short-run  $MM \approx 0.7$

## Cold War

- ▶ Defense-goods prices *fall*  $\rightarrow MM > 1$
- ▶ Consistent with productivity gains during buildups (Ilzetzki, 2024)

## Markups not the driver

- ▶ No markup response in post-Cold War; mild increase during Cold War ▶ Markup IRFs
- ▶ Arms & ammunition prices  $\approx 4\times$  more responsive than defense deflator ▶ Arms prices

## 4. Model

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### From partial to (dynamic) general equilibrium

- ▶ Price elasticities reflect how quickly factors of production can be reallocated across sectors

### Framework: $N$ -sector RBC model (Vom Lehn and Winberry, 2022)

- ▶ Input–output linkages & investment network
- ▶ One period = one year: labor mobile, **capital is the limiting factor**
- ▶ Costly capital reallocation (immediate) vs. one-year time-to-build for new capital
- ▶ Perfect competition (markups unresponsive, consistent with evidence)

# Model – Household

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**Representative household maximizes expected lifetime utility**

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \log(C_t) - \frac{L_t^{1+\gamma}}{1+\gamma} \right]$$

subject to the budget constraint  $C_t + Q_{t,t+1}B_{t+1} = B_t + W_tL_t + T_t$

- ▶  $C_{t,i}$  is consumption of sector- $i$  good and  $C_t = \bar{b} \prod_{i=1}^N C_{t,i}^{b_i}$
- ▶  $L_{t,i}$  labor supplied to sector  $i$  and  $L_t = \sum_{i=1}^N L_{t,i}$

## Model – Generic sector $i$

### CES production function

$$Y_{t,i} = \bar{\omega} A_{t,i} \cdot \left[ \theta_i (\alpha_i \hat{K}_{t,i}^{1-1/\epsilon_i} + (1 - \alpha_i) L_{t,i}^{1-1/\epsilon_i}) + (1 - \theta_i) \sum_{j=1}^N \omega_{ij} X_{t,ij}^{1-1/\epsilon_i} \right]^{\frac{\epsilon_i}{\epsilon_i - 1}}$$

with  $A_{t,i}$  sector-specific productivity,  $\hat{K}_{t,i}$  capital input,  $L_{t,i}$  labor,  $X_{t,ij}$  intermediates

### Capital accumulation

$$K_{t,i} = (1 - \delta) \hat{K}_{t,i} + \bar{\lambda} \prod_{j=1}^N I_{t-1,ij}^{\lambda_{ij}}$$

$$\hat{K}_{t,i} = K_{t-1,i} + \underbrace{\sum_{j=1}^N R_{t,ij} - \frac{1}{2} \sum_{j=1}^N \phi_{ij} R_{t,ij}^2}_{\text{reallocation (immediate, costly)}}$$

# Model – How to expand productive capacity

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## Capital accumulating firms

$$\max E_0 \sum_{t=0}^{\infty} Q_{0,t} \left[ r_{t,i} \hat{K}_{t,i} - P_{t,i}^l I_{t,i} - \sum_{j=1}^N P_{t,ij}^o R_{t,ij} \right]$$

where  $P_{t,ij}^o$  price of reallocated capital;  $Q_{0,t}$  is stochastic discount factor

## Optimality requires

$$P_{t,i}^l = E_t Q_{t,t+1} \left[ r_{t+1,i} + (1 - \delta) P_{t+1,i}^l \right] \quad (3)$$

$$P_{t,ij}^o = \left[ r_{t,i} + (1 - \delta) P_{t,i}^l \right] \cdot (1 - \phi_{ij} R_{ij}) \quad (4)$$

# Model – Reallocation and market clearing

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**Sector-pair-specific reallocation flows** depend on **sectoral prices**

$$R_{t,ij} = \frac{P_{t,i}^o - P_{t,j}^o}{\phi_{ij}P_{t,i}^o + \phi_{ji}P_{t,j}^o}$$

Capital reallocated from  $j$  to  $i$  as long as  $P_{t,i}^o > P_{t,j}^o$ ; amount decreasing in  $\phi_{ij}$

**Market clearing**

$$Y_{t,i} = C_{t,i} + \sum_{j=1}^N X_{t,ji} + \sum_{j=1}^N I_{t,ji} + G_{t,i} \quad (5)$$

## 5. Elasticities in general equilibrium

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**Proposition.** Under simplifying assumptions, the GE elasticities are:

**Demand elasticity:** sum of private-use shares in defense output

$$\epsilon^d = \sum_{f \in F} v_f^D$$

**Supply elasticity:**

$$\epsilon^s \approx \underbrace{\epsilon_D \cdot \frac{1 - \alpha_D}{\alpha_D}}_{\text{factor substitution}} + \underbrace{\sum_{j=1}^N \frac{1}{1 + \tilde{\phi}_{Dj}} \cdot \frac{\xi_j}{\xi_D}}_{\text{capital reallocation}}$$

where  $\tilde{\phi}_{jD} = \phi_{jD} R_{Dj,t}$  are marginal reallocation costs

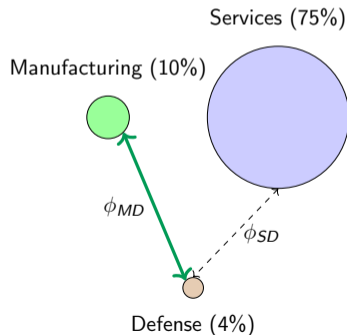
**Key insight:** supply elasticity depends on *size-weighted* reallocation costs → “effective reallocation costs”

# Industry structure and the MM

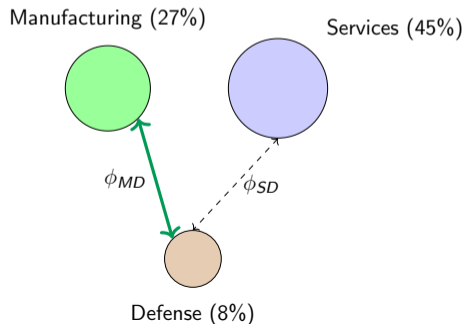
Leontief case ( $\epsilon_D \rightarrow 0$ ), three sectors:

$$\epsilon^S \approx \frac{1}{1 + \tilde{\phi}_{DM}} \cdot \frac{\xi_M}{\xi_D} + \frac{1}{1 + \tilde{\phi}_{DS}} \cdot \frac{\xi_S}{\xi_D}$$

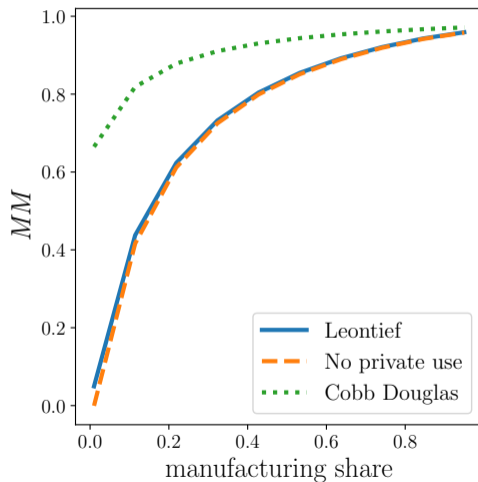
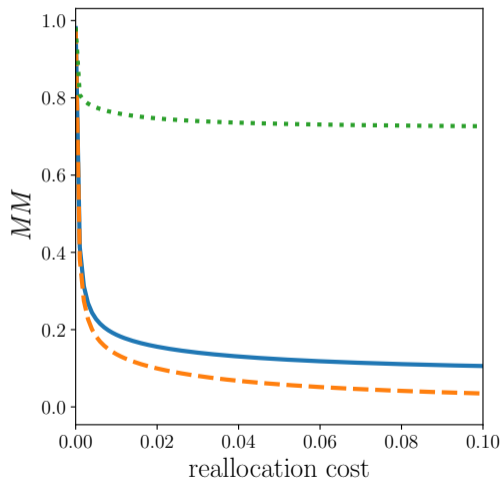
(a) Post-Cold War economy



(b) Cold-War economy



# MM determinants: industry share, reallocation cost



## 6. Calibration: 64-sector model

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### Target BEA “use tables” for two time periods

- ▶ Post-Cold War: 2023 table → 1 defense sector + 63 other sectors
- ▶ Cold War: 1947 table (43 sectors; missing sectors set to zero)
- ▶ Consumption shares  $b_i$ : sectoral shares in personal consumption expenditures
- ▶ Capital shares  $\alpha_i$ : ratio of compensation to employees to value added
- ▶ Primary input shares  $\theta_i$ : ratio of intermediate input to final output
- ▶ Input-output shares  $\omega_{ij}$ : share of sector  $j$  input in total input of  $i$
- ▶ Defense sector linkages [▶ Details](#)

### Investment network (Vom Lehn and Winberry, 2022)

- ▶ Map 37 sectors to our 63 non-military sectors (year 2018)
- ▶ Own-sector investment  $\lambda_{ii} = 0.35$ : maintenance & repair (Atalay, 2017)
- ▶ Defense investment shares from BEA 2023 table

# Defense sector: IO and investment linkages

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## Largest intermediate input: Other transportation equipment (33640T)

- ▶ Aggregates aerospace, shipbuilding, and military vehicle manufacturing
- ▶ Accounts for 24.5% of all intermediate inputs to defense
- ▶ Other key inputs: real estate (23.6%), computers & electronics (7.1%), petroleum (5.8%)

## How inputs into 33640T have changed

- ▶ *Electrical equipment* (avionics, sensors): input share rose **10**× (1.7% → 17.5%)
- ▶ Traditional inputs declined: fabricated metals (14.5% → 5.1%), machinery (10.4% → 8.1%)
- ▶ Knowledge-intensive services (IT, management): absent in Cold War, now > 6%
- ▶ ⇒ Defense production increasingly **technology- and service-intensive**

Full linkage tables: [▶ Details](#)

# Reallocation costs

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## Reducing degrees of freedom ( $N^2$ sector pairs)

- ▶ Defense sector can expand **only at expense of manufacturing sectors** (19 sectors)
- ▶ Reallocation from non-manufacturing to defense: prohibitively costly
- ▶ Among non-defense sectors: no reallocation
- ▶ Heterogeneous  $\phi_{D,i}$  for each of 19 manufacturing sectors

## Identification

- ▶ Target 1-year *MM* in post-Cold War economy
- ▶ Target price responses of each of 19 manufacturing sub-sectors
- ▶ Minimize distance between model and data, weighted by inverse variance

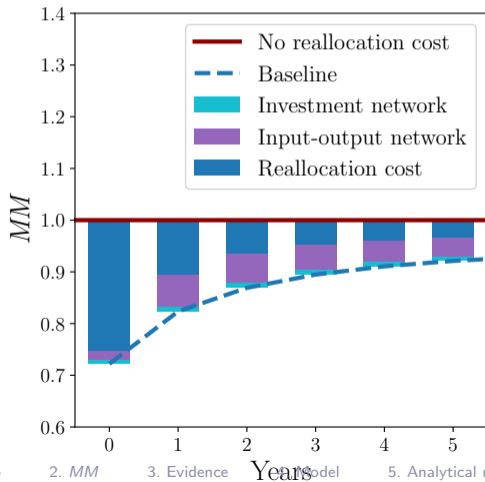
## Reallocation costs: results

| BEA Code | Industry Description             | Model   | Data    | $\phi_{D,i}$ |
|----------|----------------------------------|---------|---------|--------------|
| 327      | Nonmetallic minerals             | 0.2627  | 0.4218  | 0.0002       |
| 3364OT   | Other transportation equipment   | 0.2630  | 0.1996  | 0.0002       |
| 311FT    | Food, beverage, and tobacco      | 0.1858  | 0.5939  | 0.0056       |
| 324      | Petroleum and coal products      | 0.1499  | 0.1545  | 0.0176       |
| 313TT    | Textiles and textile products    | 0.1130  | 0.1071  | 0.0247       |
| 331      | Primary metals                   | 0.1559  | 0.1586  | 0.0294       |
| 3361MV   | Motor vehicles and parts         | 0.1205  | 0.3715  | 0.0324       |
| 335      | Electrical equipment             | 0.1127  | 0.1074  | 0.0363       |
| 325      | Chemicals                        | 0.0480  | 0.0579  | 0.0400       |
| 333      | Machinery                        | 0.0847  | 0.1199  | 1.0895       |
| 334      | Computer and electronic products | 0.0567  | 0.1053  | 2.8088       |
| 339      | Misc. manufacturing              | -0.0677 | -0.2499 | 19.8606      |

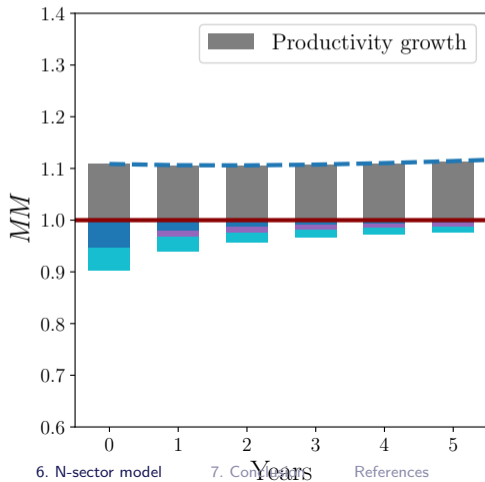
Notes: Price elasticities of sectoral prices to a defense spending shock (averaged over 5 years). Selected sectors shown.

# Decomposition of MM

(a) Post-Cold War economy



(b) Cold War economy



# Takeaway: Decomposition

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## Post-Cold War economy (panel a)

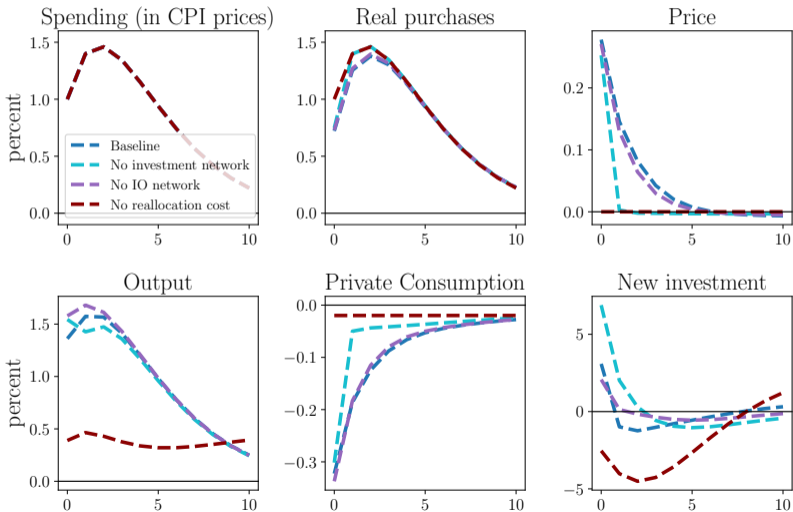
- ▶ Reallocation costs are the dominant force driving  $MM$  below 1
- ▶ IO and investment networks contribute modestly
- ▶ Without reallocation costs  $\rightarrow$  economy behaves like 1-sector model ( $MM = 1$ )

## Cold War economy (panel b)

- ▶ Networks and reallocation costs play a noticeably smaller role
- ▶ Larger industrial base  $\Rightarrow$  lower *effective* reallocation costs
- ▶ With defense production efficiency gains: model matches  $MM > 1$

**Key: same reallocation costs for both periods; only sector sizes differ!**

# Dynamic adjustment in the defense sector

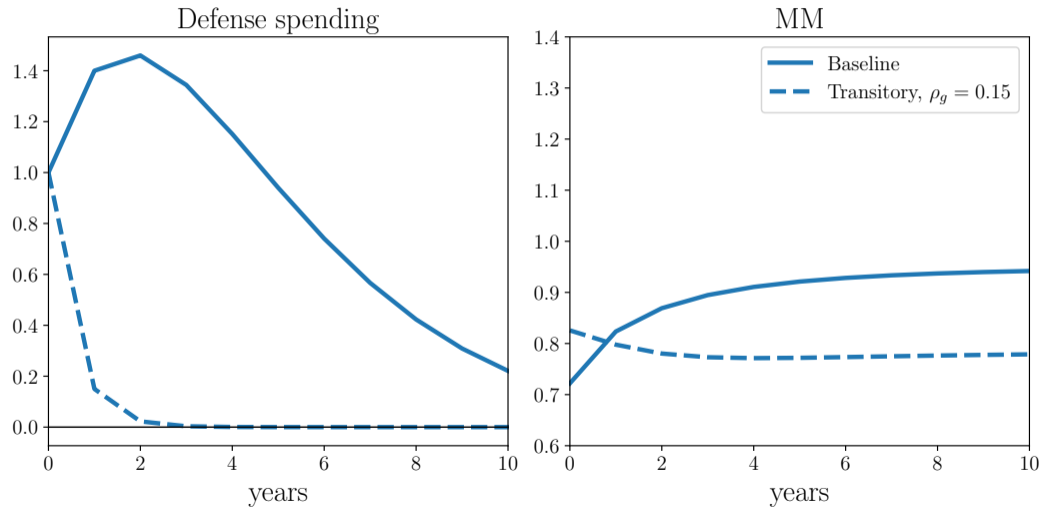


## Takeaway: Defense sector dynamics

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- ▶ Real purchases rise less than spending (in output units) because relative price rises
- ▶ Without reallocation costs: purchases = spending (no price increase)
- ▶ Capital returns in defense sector increase  $\Rightarrow$  drives reallocation dynamics
- ▶ Private consumption of defense goods is crowded out

# MM and buildup persistence

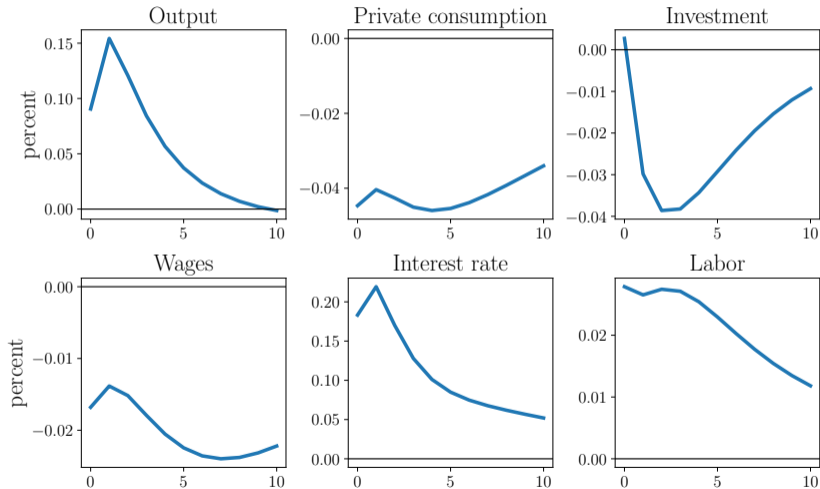


## Takeaway: Persistence

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- ▶ More persistent spending lowers the **impact** *MM* but raises the **cumulative** *MM*
- ▶ Mechanism: persistent buildup signals sustained demand  $\Rightarrow$  sharper initial price response
- ▶ Over time: higher investment expands capacity, making spending more efficient
- ▶ **Policy implication:** credible long-term commitment improves cumulative effectiveness

# Aggregate responses to military buildup



Notes: IRFs of macroeconomic aggregates to military buildup. Output rises; consumption and investment are crowded out. Fiscal multiplier below

## Takeaway: Aggregate dynamics

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- ▶ Output rises on impact, driven by government demand
- ▶ Aggregate consumption declines—crowding out as resources shift to defense
- ▶ Investment rises on impact, then falls as defense sector draws capital
- ▶ Fiscal multiplier below unity, smaller than one-sector benchmark
- ▶ Price pressure from buildup reduces real procurement *and* depresses private activity

## 7. Conclusion

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### Military Multiplier

- ▶ Concept: % increase in military equipment from additional unit of output
- ▶ Evidence:  $MM > 1$  during Cold War,  $\approx 0.7$  post-Cold War
- ▶ Mechanism: reduced industrial base raises effective reallocation costs

## 7. Conclusion

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### Military Multiplier

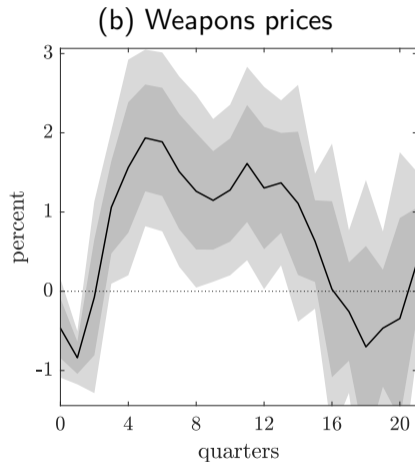
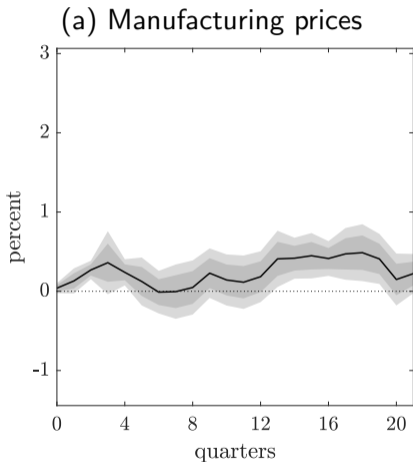
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### Implications

- ▶ Economic strength  $\neq$  military capacity; industry structure is key
- ▶ Credible long-term commitments improve cumulative effectiveness
- ▶ Multi-country extension: coordinated procurement within EU

# Appendix

# Real weapon price response to military shock



Response of manufacturing and weapon prices to the military buildup shock in the post-Cold War period

## Local projection specification

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For each horizon  $h$ , estimate (Ramey and Shapiro, 1998):

$$y_{t+h} = \alpha_0 + \alpha_1 t + \sum_{i=1}^8 b_i y_{t-i} + \sum_{i=0}^8 c_i D_{t-i} + \varepsilon_t$$

- ▶  $y_{t+h}$ : outcome variable  $h$  periods ahead
- ▶  $D_{t-i}$ : military spending news shock (Ramey, 2016)
- ▶ Linear trend  $\alpha_1 t$ ; 8 lags of outcome and shock

Cumulative MM standard errors via LP-IV (Ramey and Zubairy, 2018):

$$\sum_{j=0}^h p_{t+j} = \alpha_0 + \alpha_1 t + b \sum_{j=0}^h x_{t+j} + \sum_{i=1}^4 c_i X_{t-i} + \varepsilon_t$$

where  $x_{t+j}$  is instrumented with spending news shocks

# Defense sector linkages

## A) IO Links (Intermediate Inputs to Defense)

| Code   | Share  | Description             | Code | Share  | Description       |
|--------|--------|-------------------------|------|--------|-------------------|
| 3364OT | 0.2452 | Other transport equip.  | 332  | 0.0365 | Fabricated metals |
| ORE    | 0.2359 | Other real estate       | 324  | 0.0578 | Petroleum & coal  |
| 334    | 0.0706 | Computers & electronics | 23   | 0.0457 | Construction      |
| 3361MV | 0.0367 | Motor vehicles          | 5411 | 0.0237 | Legal services    |
| 335    | 0.0166 | Electrical equipment    | 481  | 0.0233 | Air transport     |

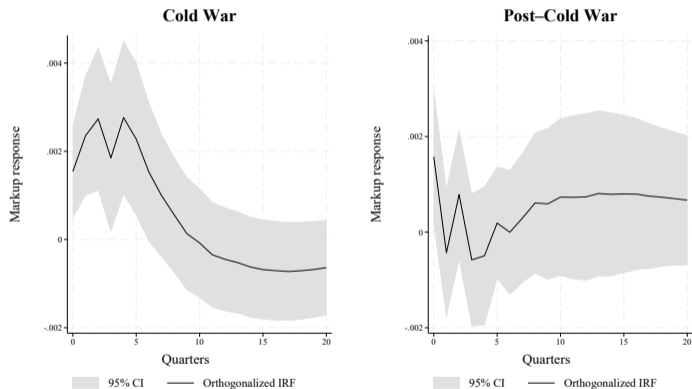
## B) Investment Links (Investment Goods for Defense)

| Code | Inv. share | Description          | Code   | Inv. share | Description            |
|------|------------|----------------------|--------|------------|------------------------|
| 524  | 0.3694     | Insurance            | 3364OT | 0.0889     | Other transport equip. |
| 337  | 0.2497     | Furniture            | 321    | 0.0672     | Wood products          |
| 335  | 0.0920     | Electrical equipment | 523    | 0.0613     | Securities             |

Notes: Top inputs to defense sector by share. IO links from BEA 2023 use tables; investment links from Vom Lehn and Winberry (2022).

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# Markup response to government spending shocks

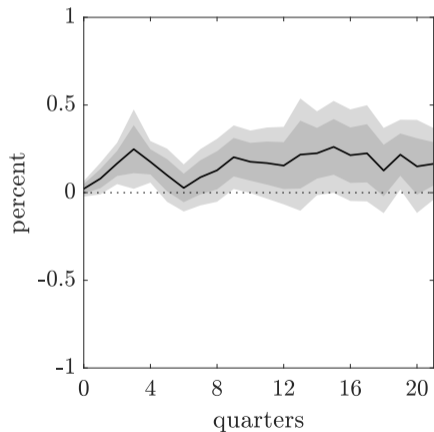


Notes: Markup IRFs following Nekarda and Ramey (2020). Cold War: modest, short-lived rise. Post-Cold War: weak and statistically insignificant.

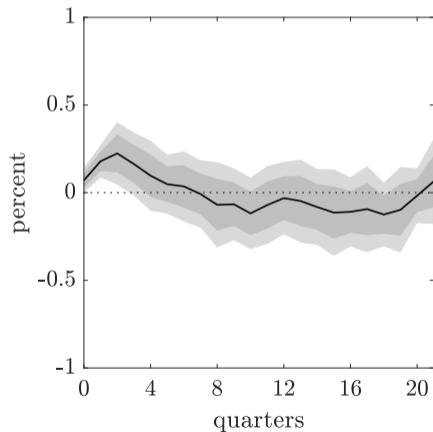
Price responses in our estimates are not driven by markup changes.

# Response to military buildups: manufacturing prices

(a) Post-Cold War



(b) Cold War



Notes: Response of real manufacturing PPI (deflated with GDP deflator) to military spending news (Ramey, 2016). Manufacturing absorbs  $\approx 40\%$

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