Guns & Growth:
The Economic Consequences of Defense Buildups

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Defense Buildups

No Peace Dividend and No Free Lunch

Defense buildups: Potential Long Run Productivity Gains

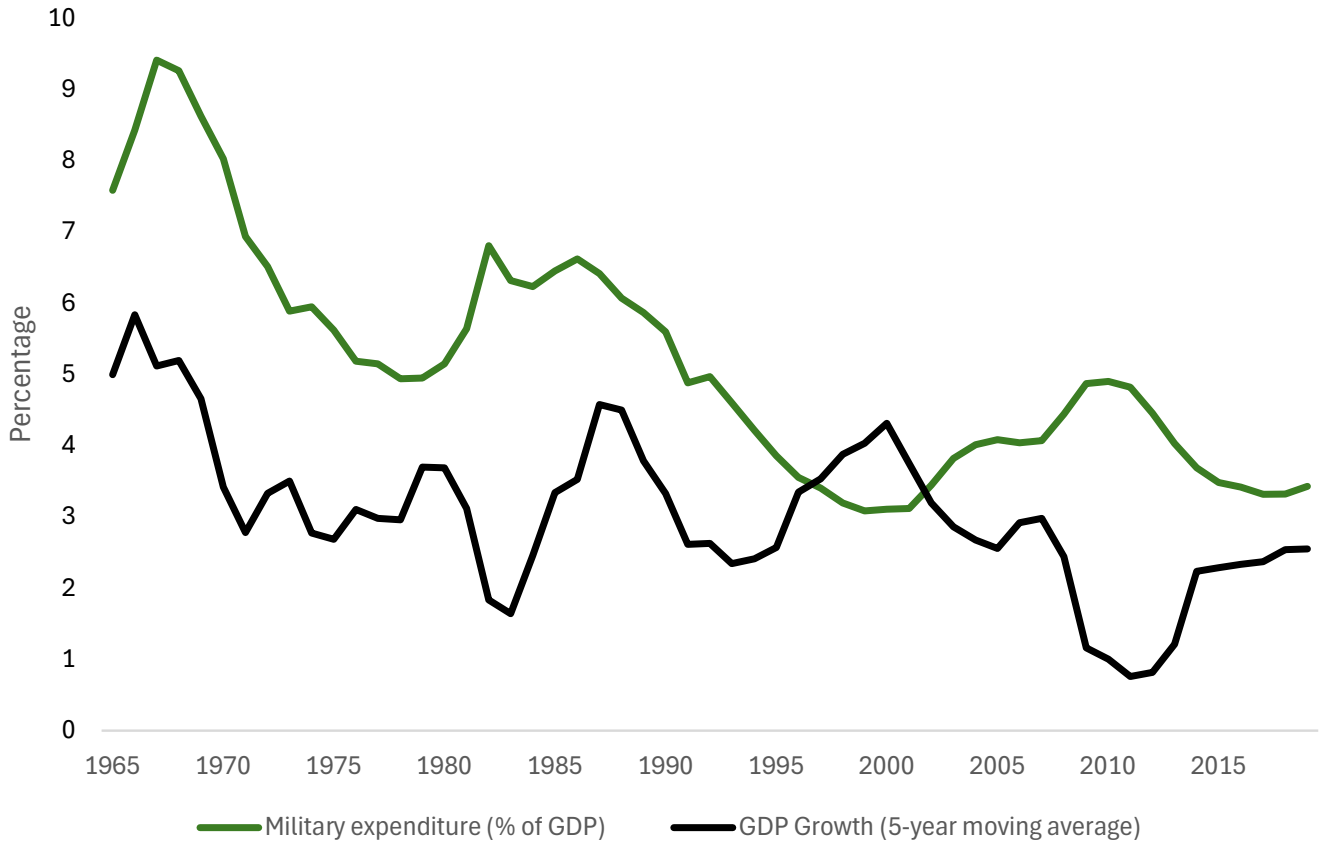
Finance with Debt–Within Solid Fiscal Frameworks

The Devil is in the Procurement Details

Capacity Targets not % GDP Targets

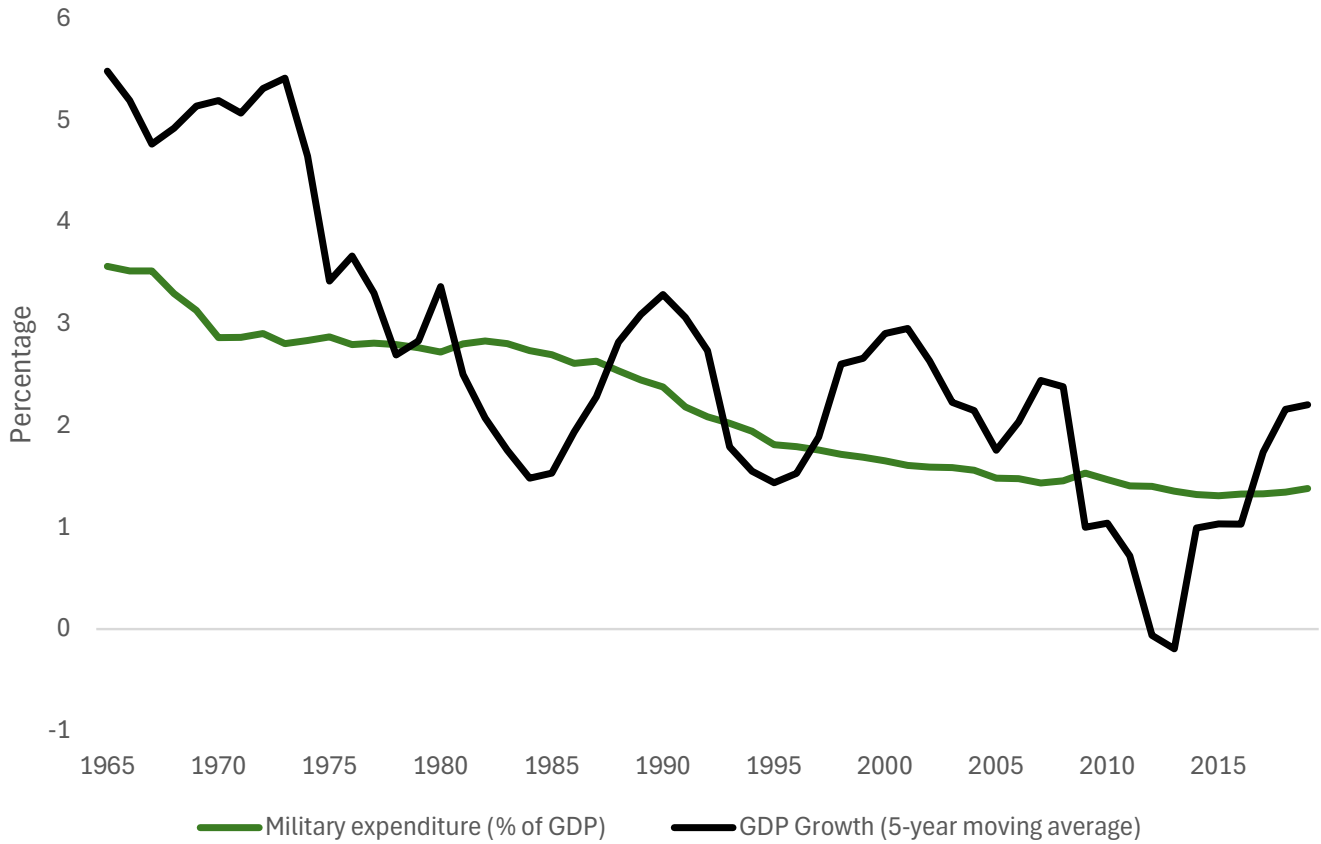
Peace Dividend or Military Keynesianism?

The Elusive Peace Dividend: US



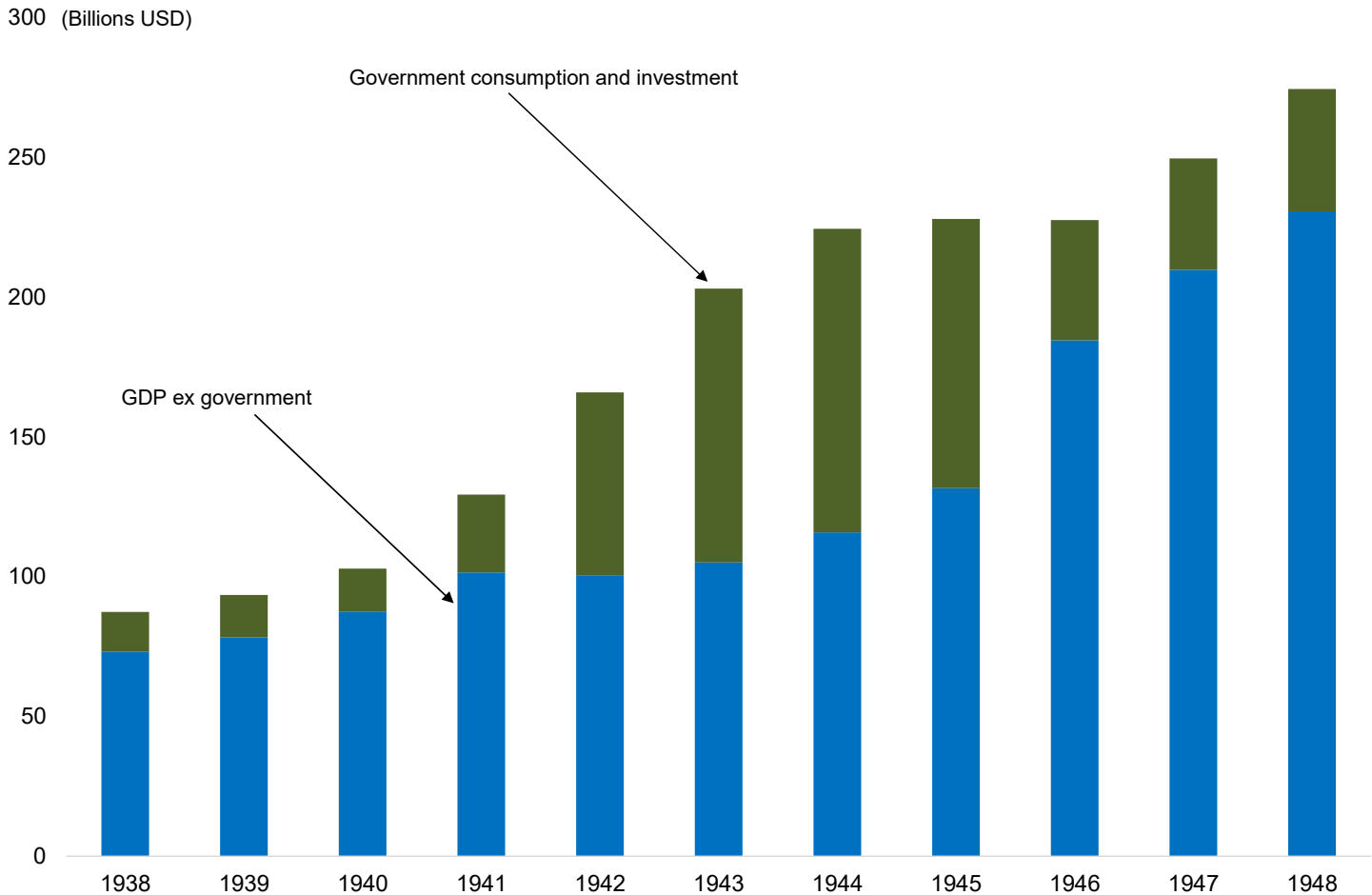
US Military Expenditure and GDP Growth

The Elusive Peace Dividend: EU



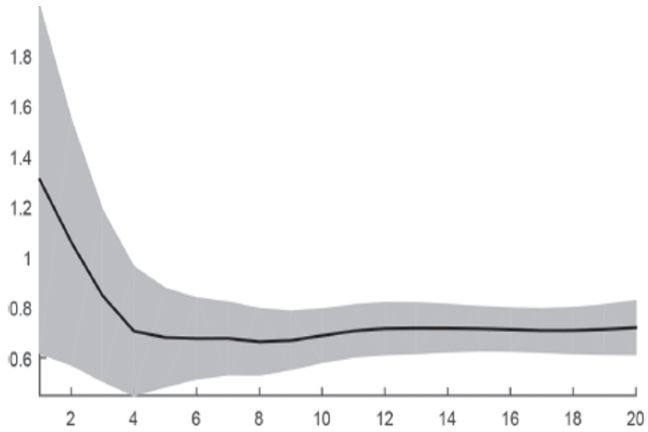
EU Military Expenditure and GDP Growth

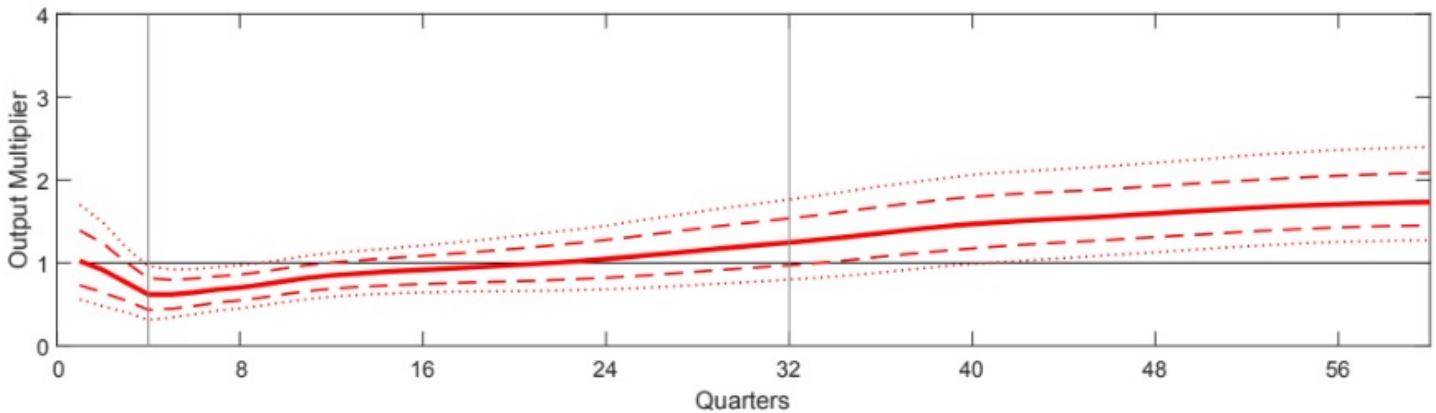
US Economy in WWII



Fiscal Multipliers

Medium-term **military spending multipliers**: 0.6 to 1.





Source: Ramey & Zubairy (2018), Antolin-Diaz & Surico (2025); see also Perotti (2014).

Factors determining size of fiscal multiplier

Tax vs. debt Financing

Baxter & King (1993), Nakamura & Steinsson (2014), Chodorow-Reich (2019), Angeletos *et al.* (2024) (debt)

Angeletos *et al.* (2023), Bianchi *et al.* (2023b), Bianchi *et al.* (2023a) (tax)

Monetary response

Christiano *et al.* (2011), Ilzetzki *et al.* (2013), Nakamura & Steinsson (2014)

Slack

Auerbach & Gorodnichenko (2012, 2013), Nakamura & Steinsson (2014), Born *et al.* (2024) (yes)

Ramey & Zubairy (2018) (no)

Trade openness

Ilzetzki *et al.* (2013)

Time Series vs. Cross-Sectional Multipliers

Time series multipliers typically ≤ 1: guns vs. butter.

Cross sectional multipliers typically ≥ 1: guns **and** butter.

Chodorow-Reich (2019); Wilson (2012); Nakamura & Steinsson (2014); Auerbach & Gorodnichenko (2013); Auerbach *et al.* (2020)

Ramey (2019): Time series gives us general equilibrium response in the average historical episode.

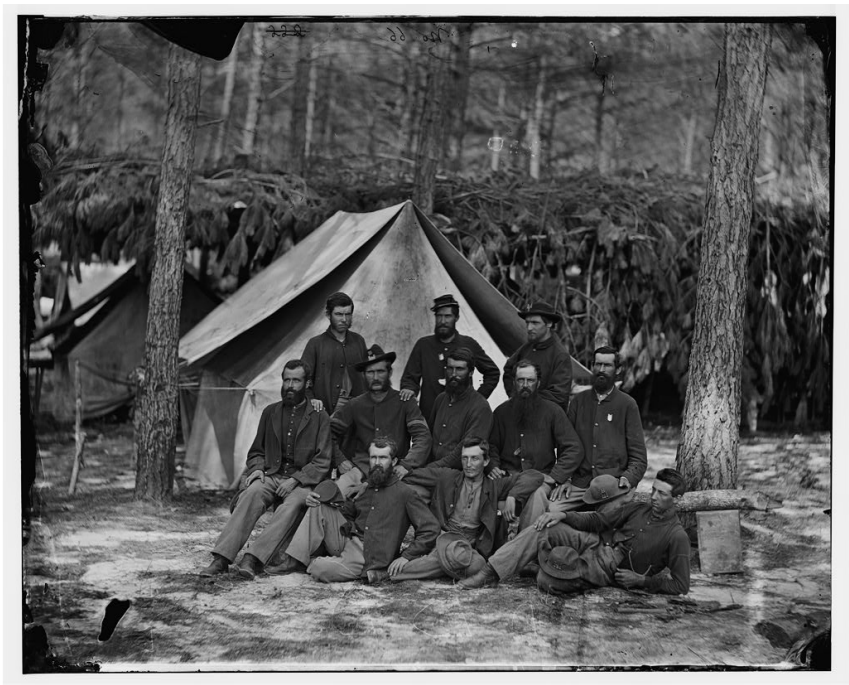
Chodorow-Reich (2019): Cross sectional gives us "pure"/"controlled" response.

Equivalent to 100% debt finance and full monetary accommodation.

Defense Buildups, Productivity & Long-Run Growth

Historical Antecedents

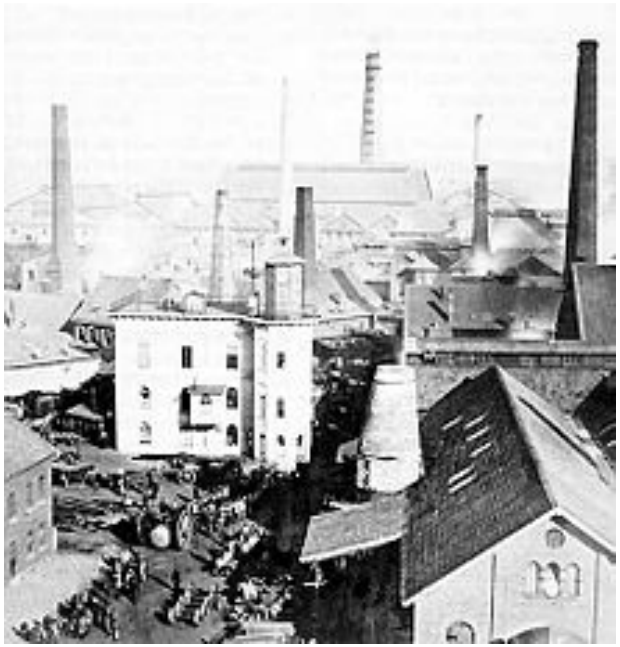
US Civil War



- Infrastructure: telegraph, railroads.
- Industry: ships, weapons, mass production, scientific management
- Currency reform, income tax.

Photo: NARA College Park. Readings: Beard & Beard (1927), Howard (1978), Wilson (2006)

Bismark and Kaiserreich



- Industrial policy: railroad expansion, state support for heavy industry, tariffs on industrial imports.
- State support helps create Krupp (Steel) BASF (chemicals) and Siemens (electrical engineering)
- Banking: Reformed to aid industry.

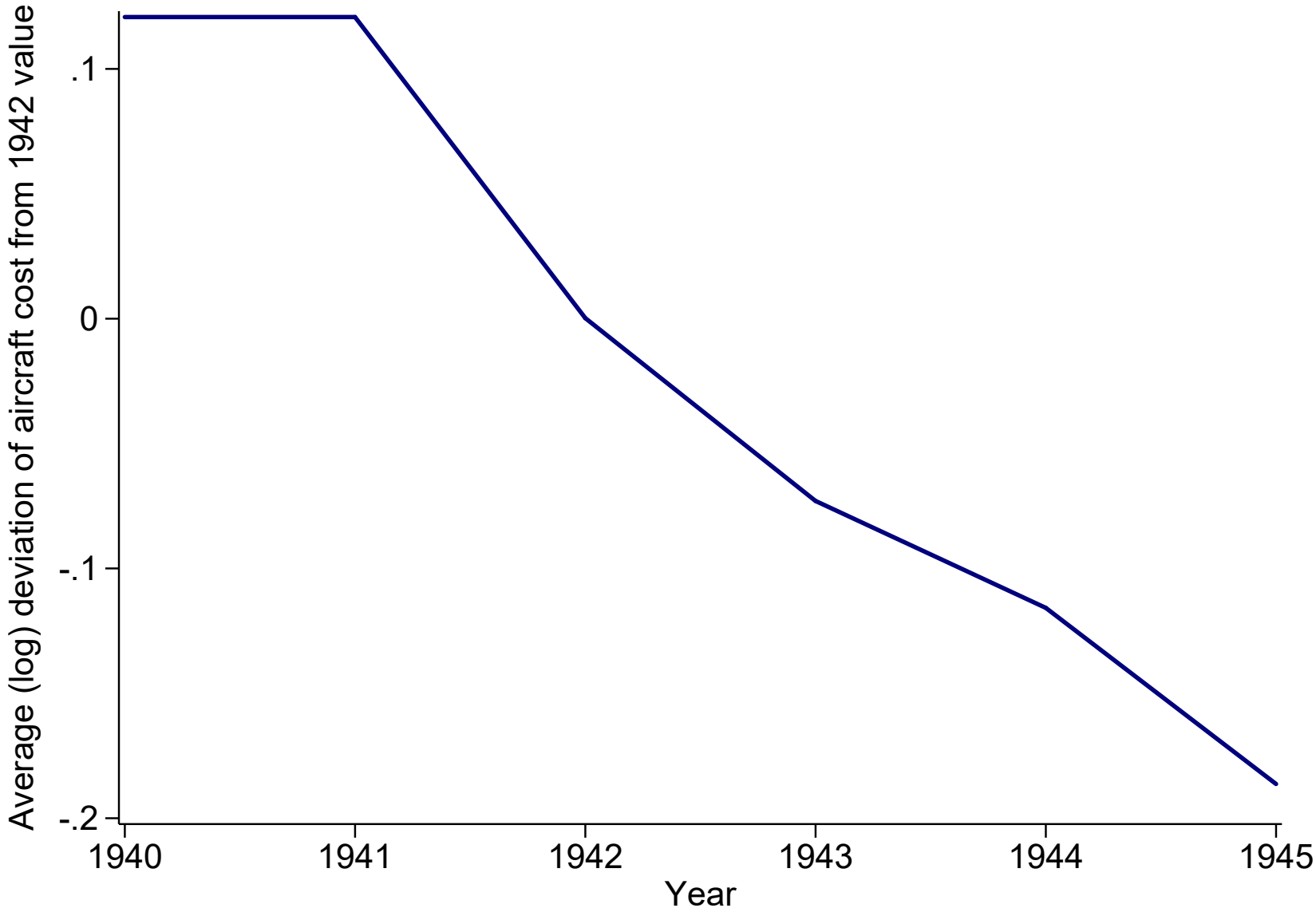
Photo: Krupp, 1964. http://www.preussen-chronik.de. Readings: Kennedy (1987), Berghahn (2005)

World War II

- Massive productivity gains.
- Atomic energy, synthetic rubber, radar

Photo: https://www.thehenryford.org/. Readings: Herman (2012), Klein (2013), Field (2002), references in Ilzetzki (2024)

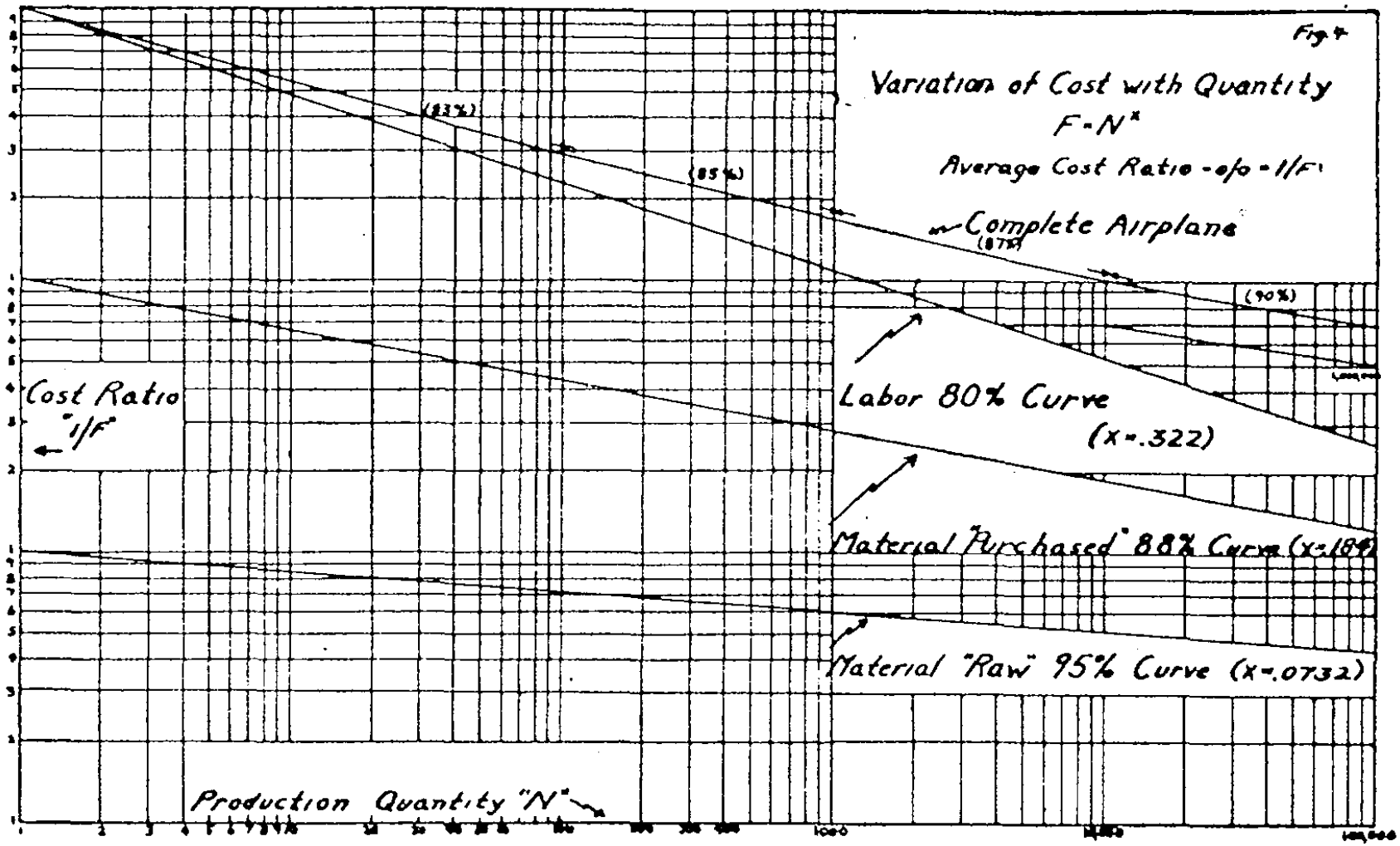
Cost Reductions in Aircraft Production



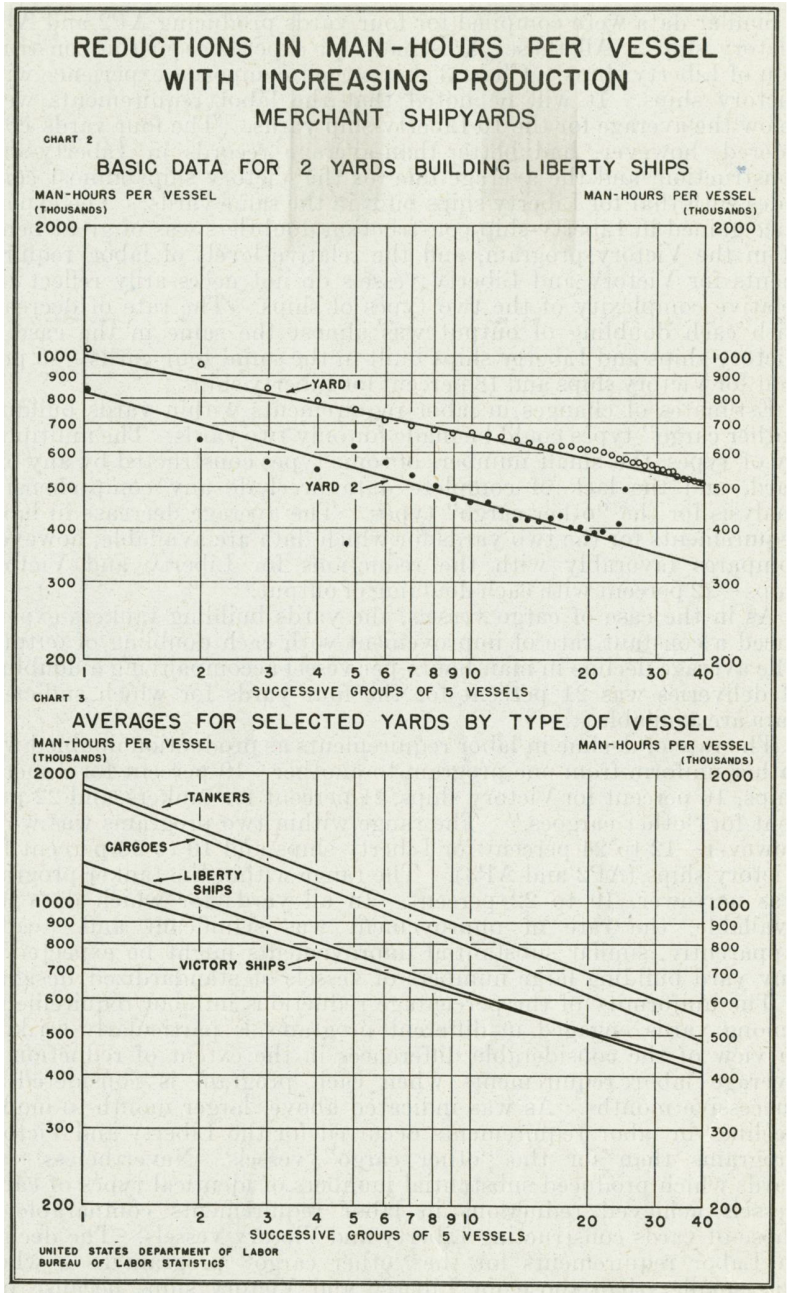
Decline in price of average model. Source: Ilzetzki (2024) GDP Targets

Learning by Doing

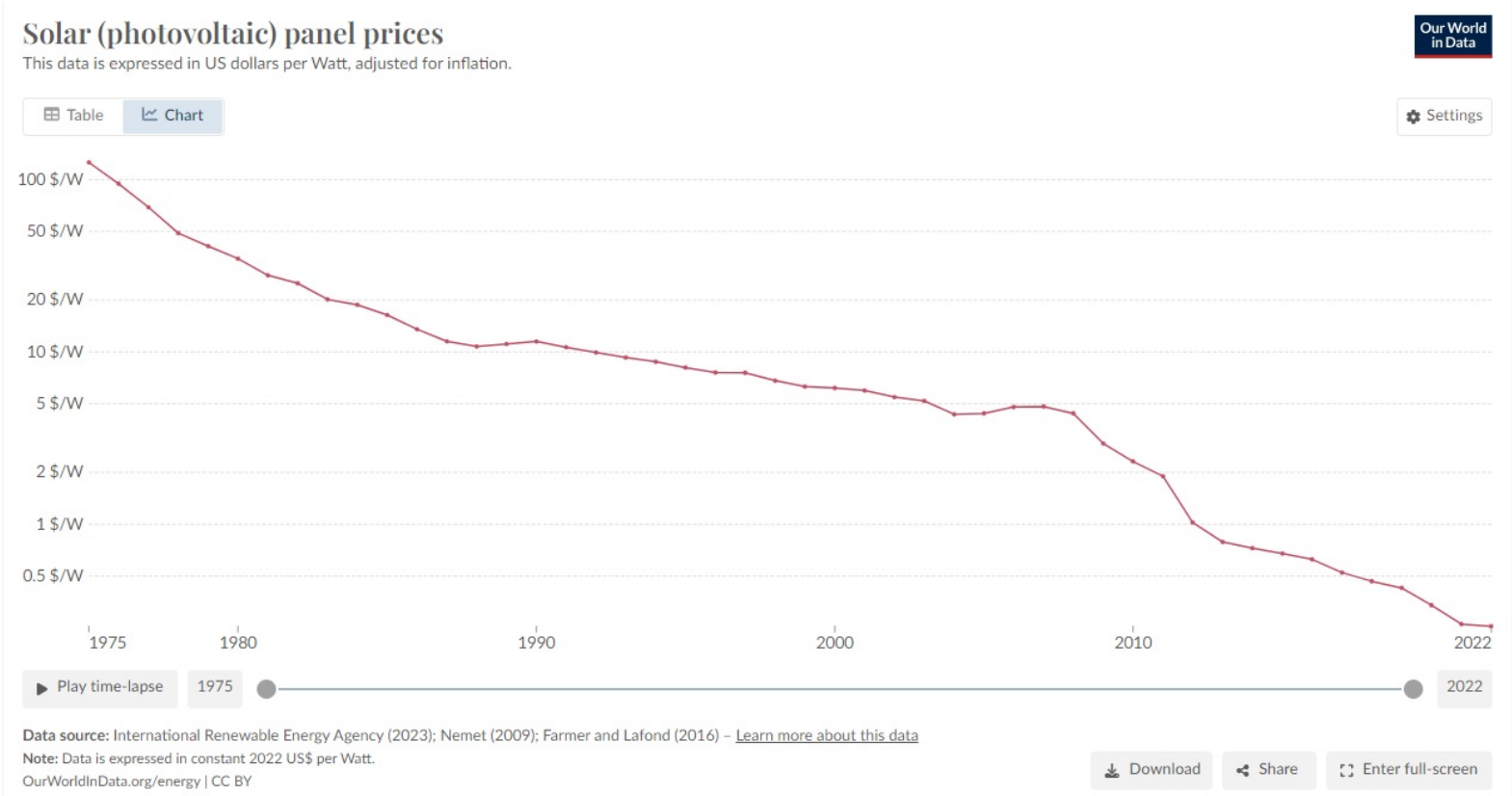
Wright (1936): Inter-war aircraft



Searle (1945): WWII ships



Declining prices of solar panels



Induced innovation

Directed technological change: Direction of technological change affected by relative factor prices. Rothbarth (1946), Habakkuk (1962), Wright (1978), Jones (2003), Allen (2009), Acemoglu & Restrepo (2018, 2019)

Induced Innovation: Innovation spurred because of key input price Hickman (1957), Fellner (1961, 1971), Romer (1987), Popp (2002), Newell *et al.* (1999)

Medium term cycles and scarring effects: Benigno & Fornaro (2018), Anzoategui *et al.* (2019)

Ilzetzki (2024), Learning by Necessity: A Synthesis

Theory of induced innovation where costly **high utilization** leads to **technology adoption**

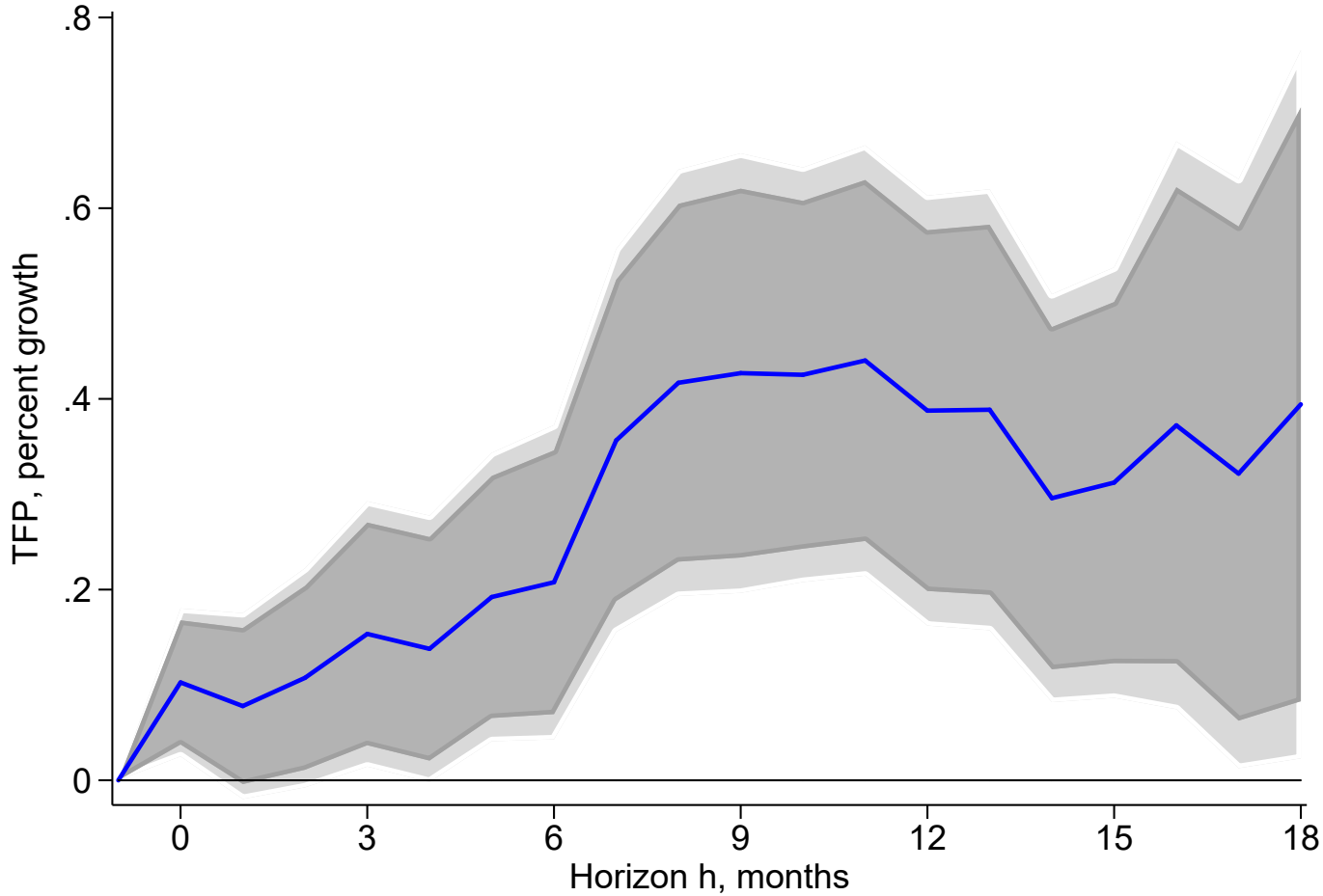
Theory: With convex costs to utilization, high demand will induce innovation and more so when utilization is high.

Empirical: Evidence from WWII aircraft production that demand induces TFP growth, and more so when utilization is high.

- Causal evidence
- Distinct from economies of scale.
- Suggests active learning.

TFP Response

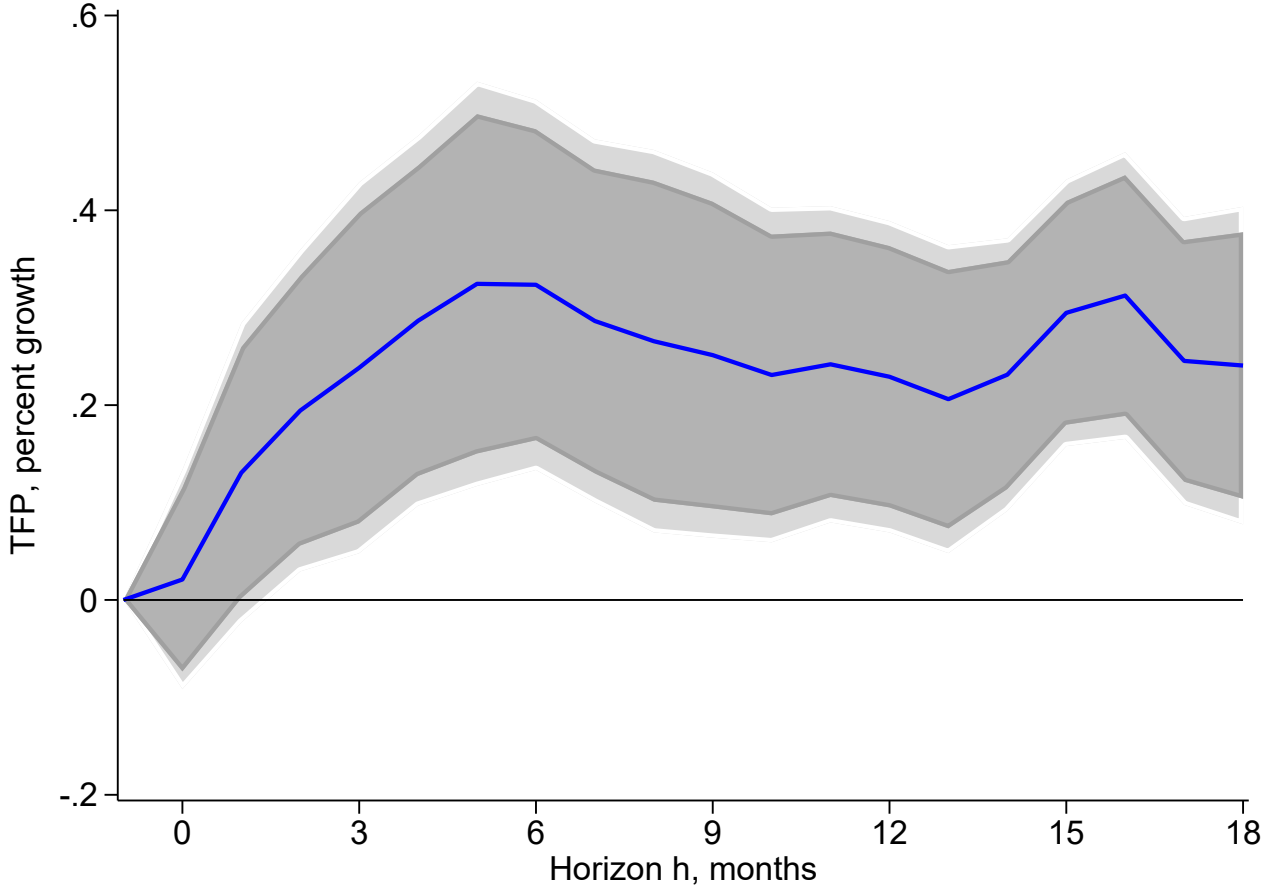
TFP Controlled for Capital Utilization



Local projections response of log output per hour worked to 1% shock to aircraft demand, instrumented with the ("leave one out") production of broad aircraft of the same broad type. Includes month and plant $\times$ model (production line) fixed effects, 6 monthly lags of output. 90% and 95% Newey-West standard errors shaded. First stage F-stat at 12-month horizon = 30.

TFP Response to Demand

High vs. Low Capital Utilization Plants



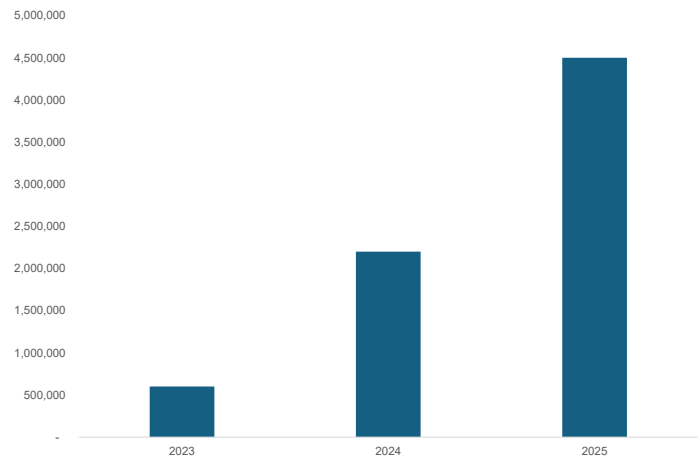
Local projections response of TFP to 1% shock to aircraft demand interacted with a dummy =1 if plant had above-median initial capacity utilization. These are instrumented with the ("leave one out") production of broad aircraft of the same broad type and its interaction with the capital utilization dummy. Includes month and plant $\times$ model (production line) fixed effects, 6 monthly lags of output. 90% and 95% standard errors shaded. F-stat at 12-month horizon = 15.

Mechanisms

The historical narrative points to several channels through which TFP may have increased.

1. Improved production methods: Most notably move from job-shop to production line methods
2. Greater reliance on production outsourcing
3. Labor relations reduced absenteeism and turnover

Ukrainian Drones



Sources: Forbes, David Axe, Mar 12, 2025; the Atlantic, Alan Taylor May 24, 2025

Public R&D

Public R&D Support: An intellectual history

Arrow (1962) gave an early, comprehensive, analysis of the multitude of market failures causing insufficient R&D.

Bush (1945) drew lessons from WWII R&D for the design of peacetime public infrastructure to support R&D

Endogenous growth literature
Romer (1986), Lucas (1988), Young (1991), Aghion & Howitt (1992)

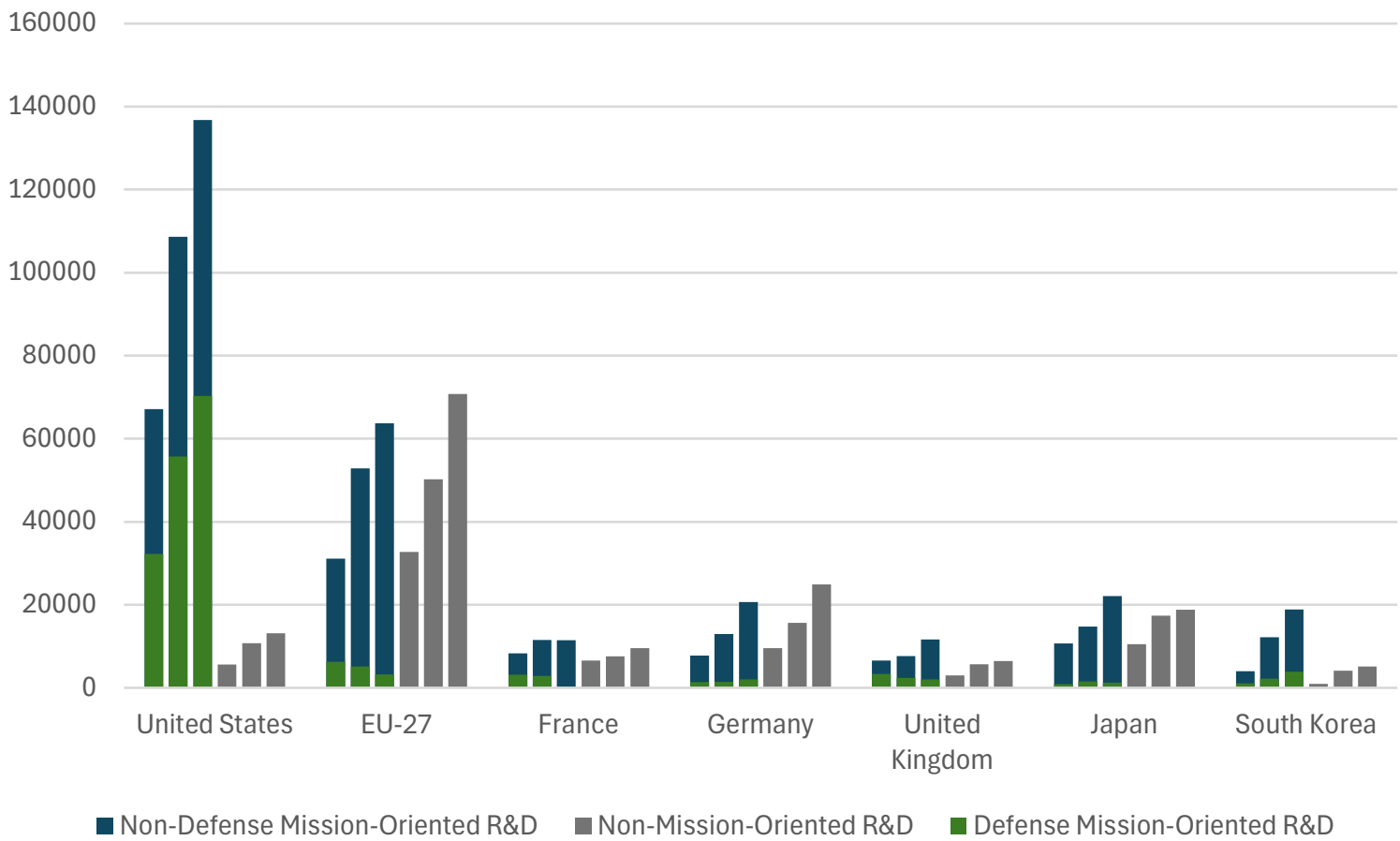
Modern view that R&D support should be **undirected** and supported through **tax policy.**

Why public support for R&D?

Arrow (1962), Mowery (2010) give a list of market failures:

- Knowledge is non-rival and can be disseminated at near zero-cost (public good)
  - Property rights could be created, but many forms of knowledge are non-patent-able.
- Production of knowledge is risky and is under-provided absent complete insurance markets.
- Human capital is fungible
- Fixed costs to knowledge production

The Importance of Mission-Oriented Public R&D



Is Defense Special?

The Arms-race nature of military R&D may make it uniquely suited to invest in frontier & general purpose technologies.

Being 20th country in green technology makes contribution to climate goals.

Being 20th country in military technology isn't even in the race.

Recent Evidence

Large multipliers on public R&D spending: Antolin-Diaz & Surico (2025), Fieldhouse & Mertens (2023)

The economic spillovers and benefits to R&D:

Moretti *et al.* (2019): government funded military R&D crowds in in private R&D. Myers & Lanahan (2022): DoE funded patents lead to 3$\times$ private-sector patents. Gross & Sampat (2023): long-lasting effects. Kantor & Whalley (2023): NASA spurred employment in high-tech sectors. Dyevre (2023).

Spin-offs or spin ons?: Feiglin (2020) warns that the cold war was unique in the extent of "spinoffs" and the 21st century is more suitable for "spin-ons"

ROI on Public R&D: Jones & Summers (2022) 67%; Fieldhouse & Mertens (2023) 300% (!)

Gross & Sampat (2023)

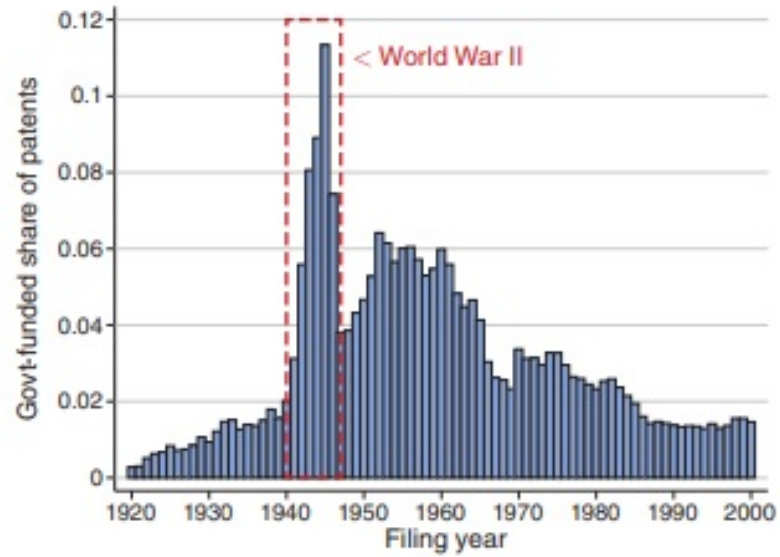
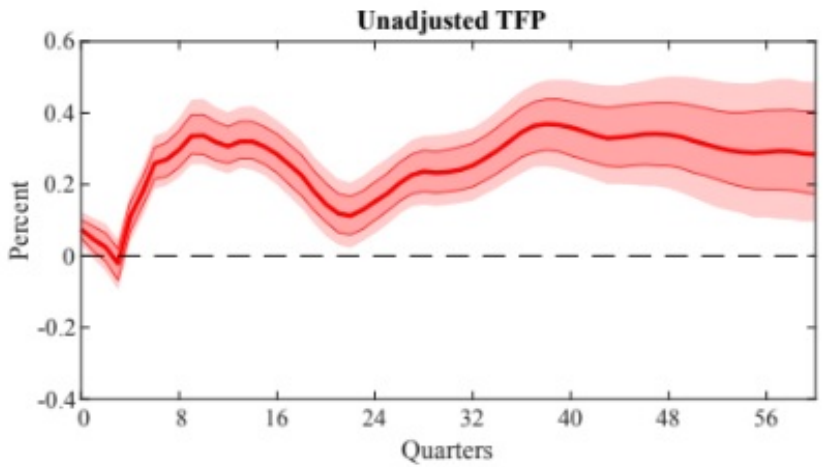
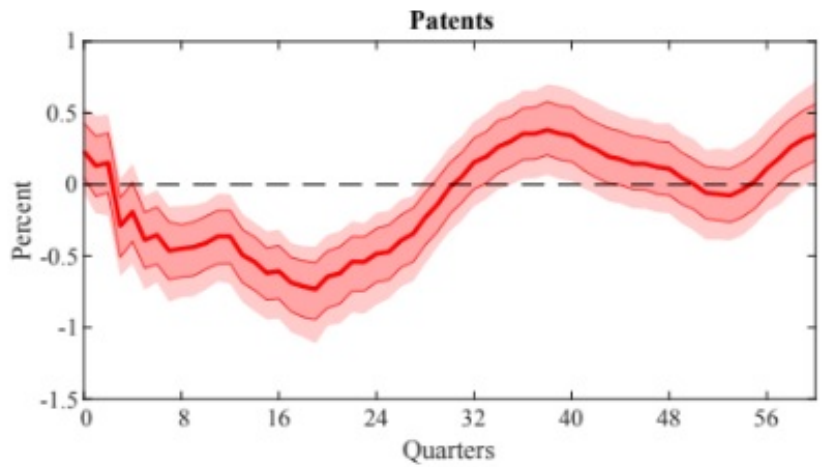


FIGURE 1. GOVERNMENT-FUNDED SHARE OF US PATENTS, 1920 TO 2000

FIGURE 2. GEOGRAPHY OF OSRD-FUNDED INVENTION IN WORLD WAR II

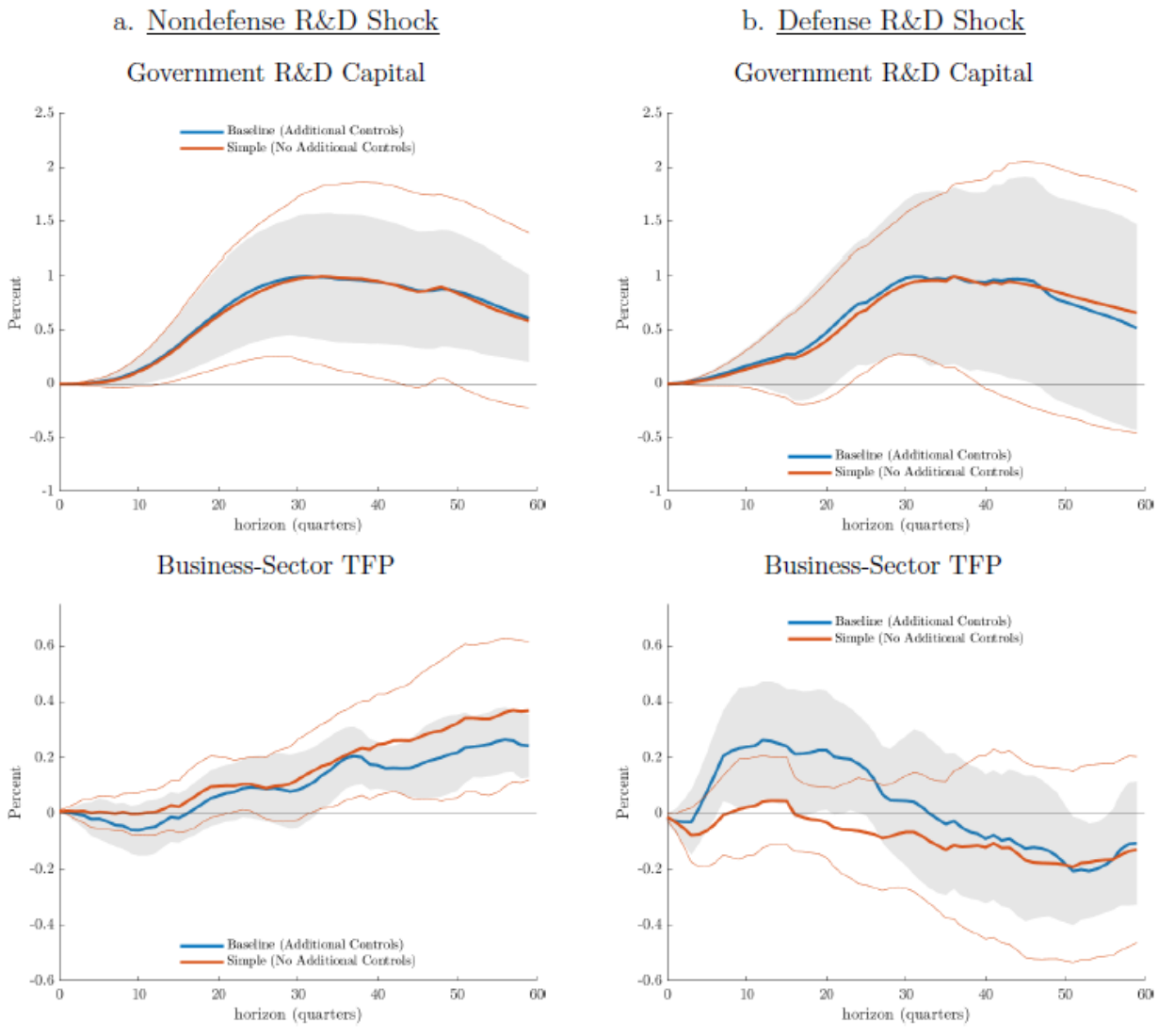
Antolin-Diaz & Surico (2025)





Fieldhouse & Mertens (2023)

Figure 6: Government R&D Capital And TFP Following an Increase in R&D Appropriations



Financing Defense Buildups

Military spending and optimal taxation

Optimal taxation models call for:

- Borrowing to finance temporary wars
- Increase taxes for permanent buildups
- Typical duration of a buildup: 5 years (Marzian & Trebesch, 2025)
- And defense buildups tend to be front-loaded
  - Durable procurement at first and maintenance costs later

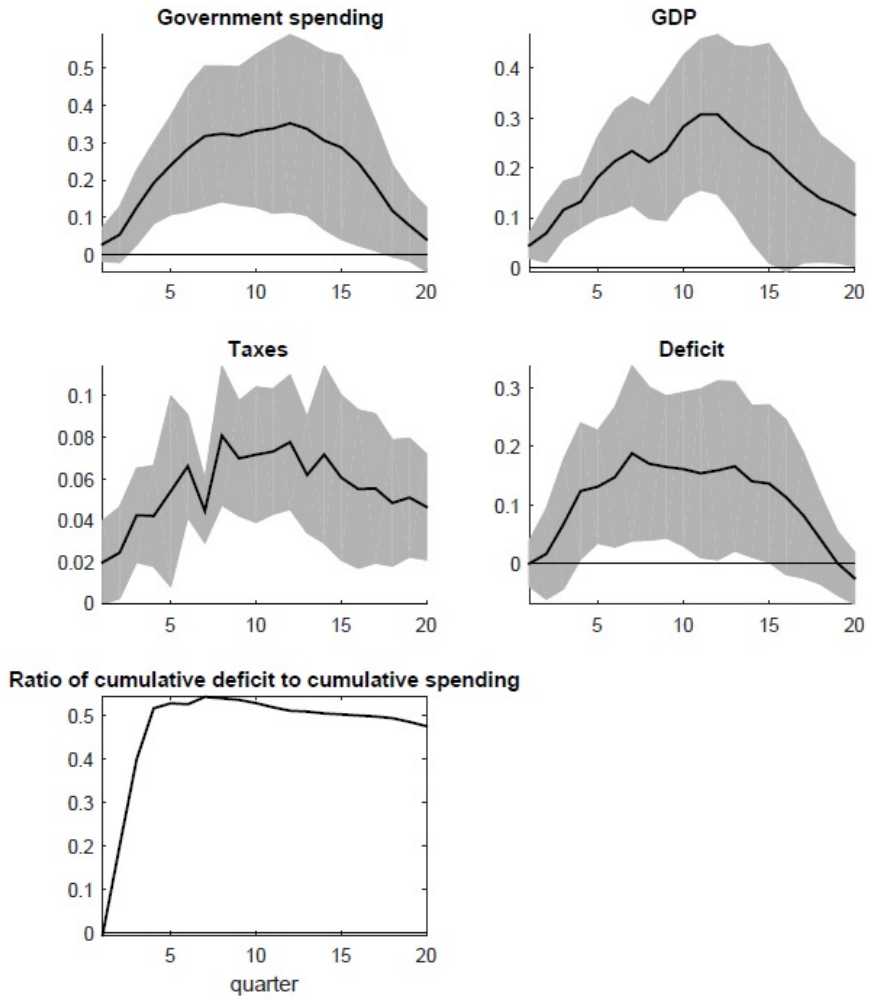
Optimal policy (Vietnam war sized shock):

- Increase taxes by 0.2% of GDP if $r - g = 3\%$

Ramey & Zubairy (2018): Past US buildups financed by

- 50% borrowing
- 30% endogenous revenue growth
- 20% tax increases

Financing in the Average US Military Buildup



Ramey & Zubairy (2018)

Procurement Considerations

How to Spend It?

Dual-use firms maximize private sector spin offs

- and “spin ons” (Feiglin, 2020)
- Antithetical to German post-War model

Dual-sourcing

- Across borders?

Support for SMEs

- US procures from far smaller firms than EU on average

“Open” procurement competitions (Howell *et al.*, 2021)

EU procurement far too fragmented

Learning by Importing

70% of EU defense procurement imported

Far too high for advanced economy

But imports can be used strategically. Case in point: **Poland**

- Military spending ↑ to 4.8% of GDP in 2025
- Most material imported from US and S. Korea, but
- Technology import from servicing the equipment
- Poland plans to produce 820/1000 S. Korean Black Panther tanks in the Military Automotive Works in Poznań.
- Contract for joint Korean-Polish joint venture to design next generation of tanks

Inter-operability Problems

Leclerc (France)

Leopard 2 (Germany)

Challenger 2 (UK)

Distinct spares / maintenance pipelines.

Incompatible ammunition limit cross-supply.

Different communication and IT systems.

Different driving, gunnery and maintenance procedures.

Capacity Targets vs. Percent of GDP Targets

% of GDP Targets

Nato practice: % of GDP targets

- Might be necessary to monitor members' contributions

Not ideal:

- Declining costs over time
- Defense buildups are front-loaded
- Perverse procurement incentives
- Encourages pro-cyclical spending

Instead:

- Begin with desired capabilities
- Exploit government's monopsonistic power
- Attempt to *minimize* costs and share of GDP

Summary

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Defense buildups: Potential Long Run Productivity Gains

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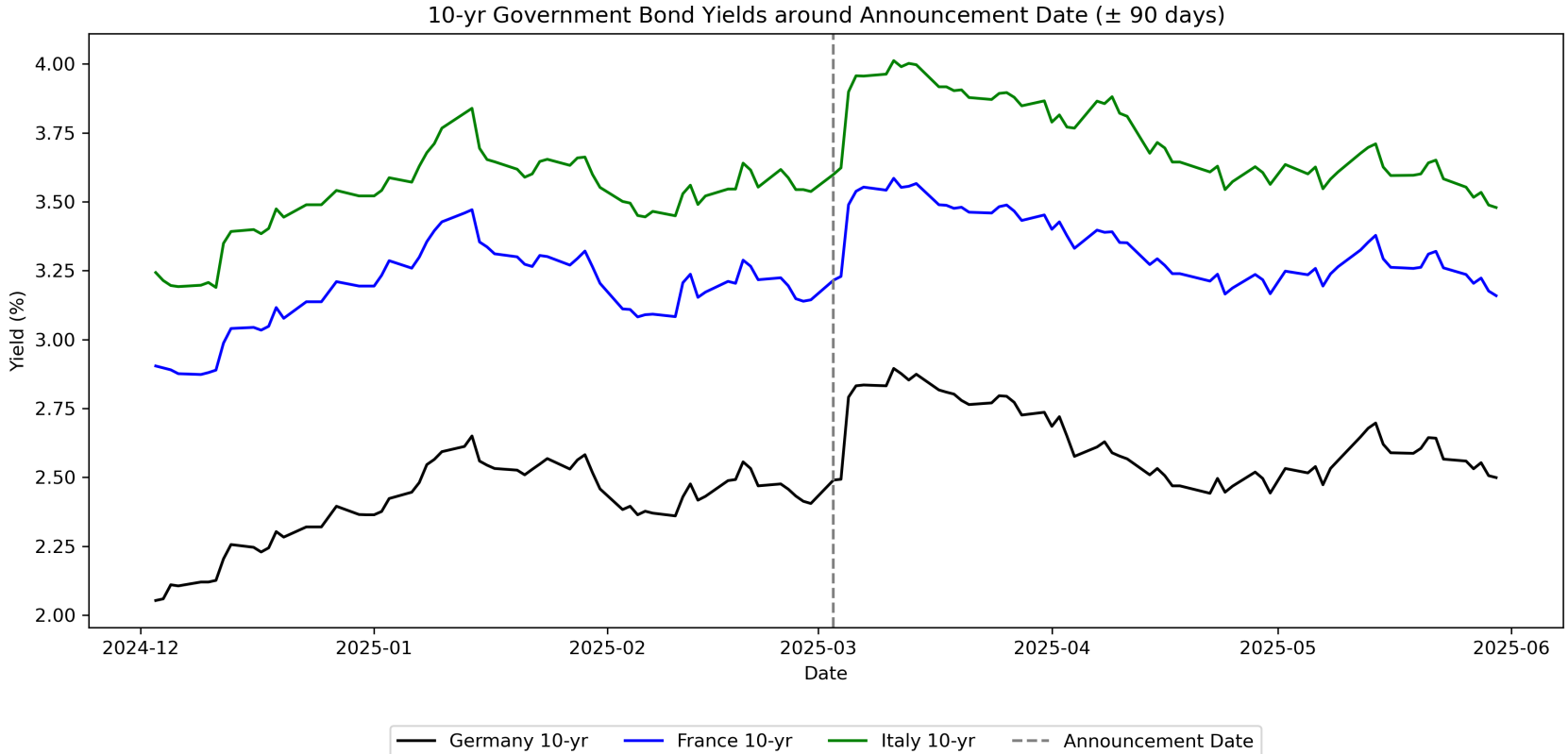
Additional Figures

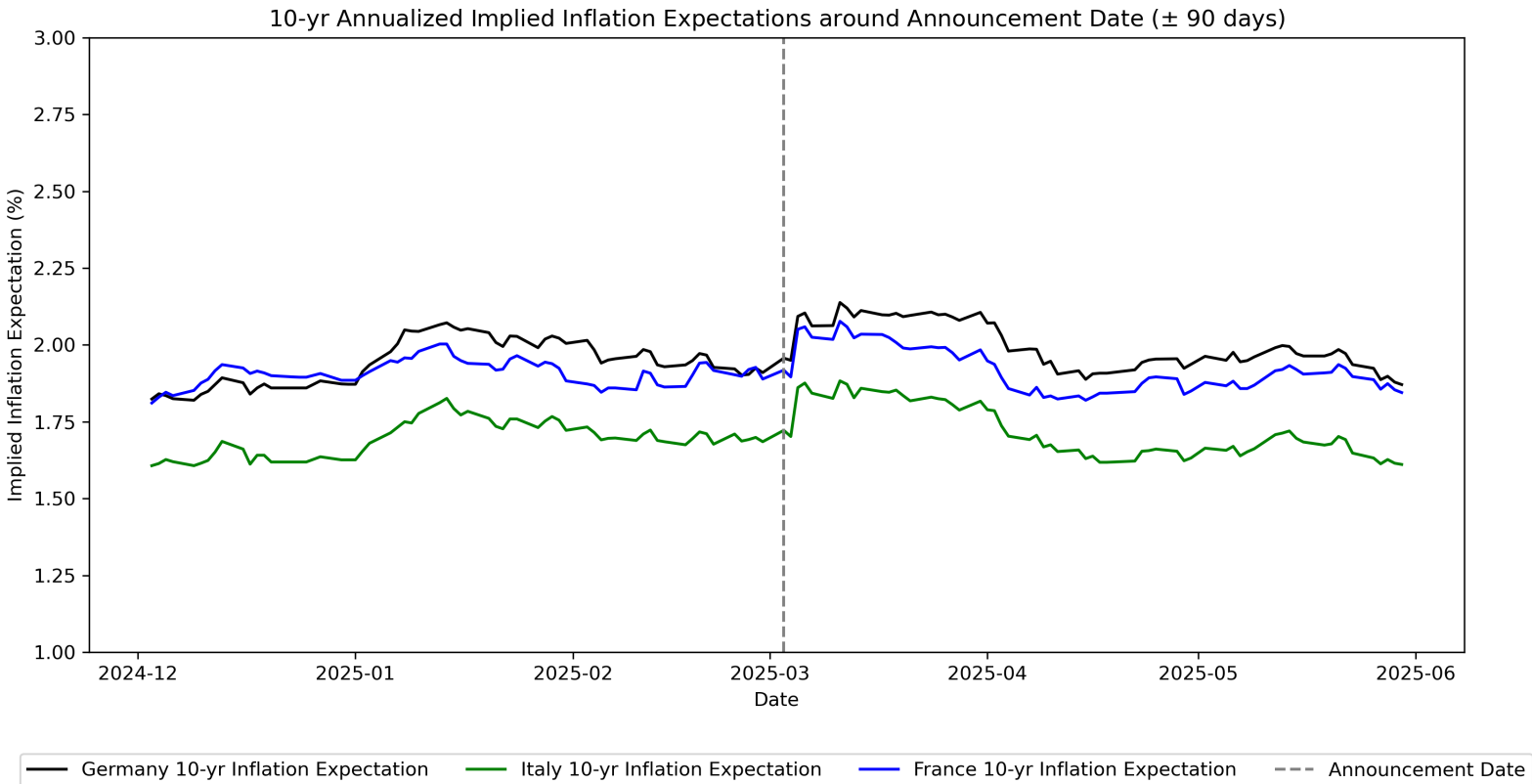
Reaction to German Constitutional Change

Borrowing Rates



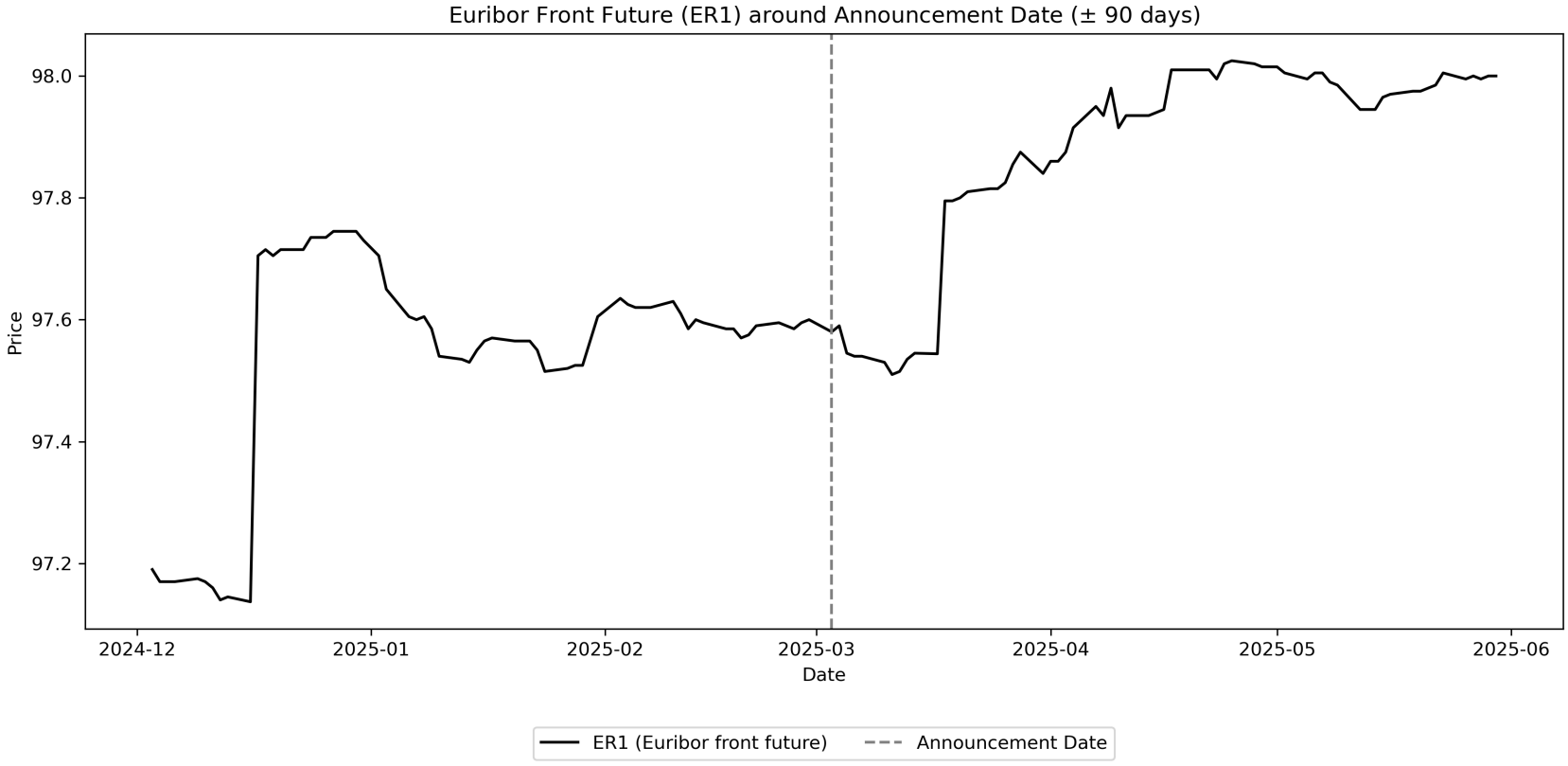
Reaction to German Constitutional Change

Inflation Expectations

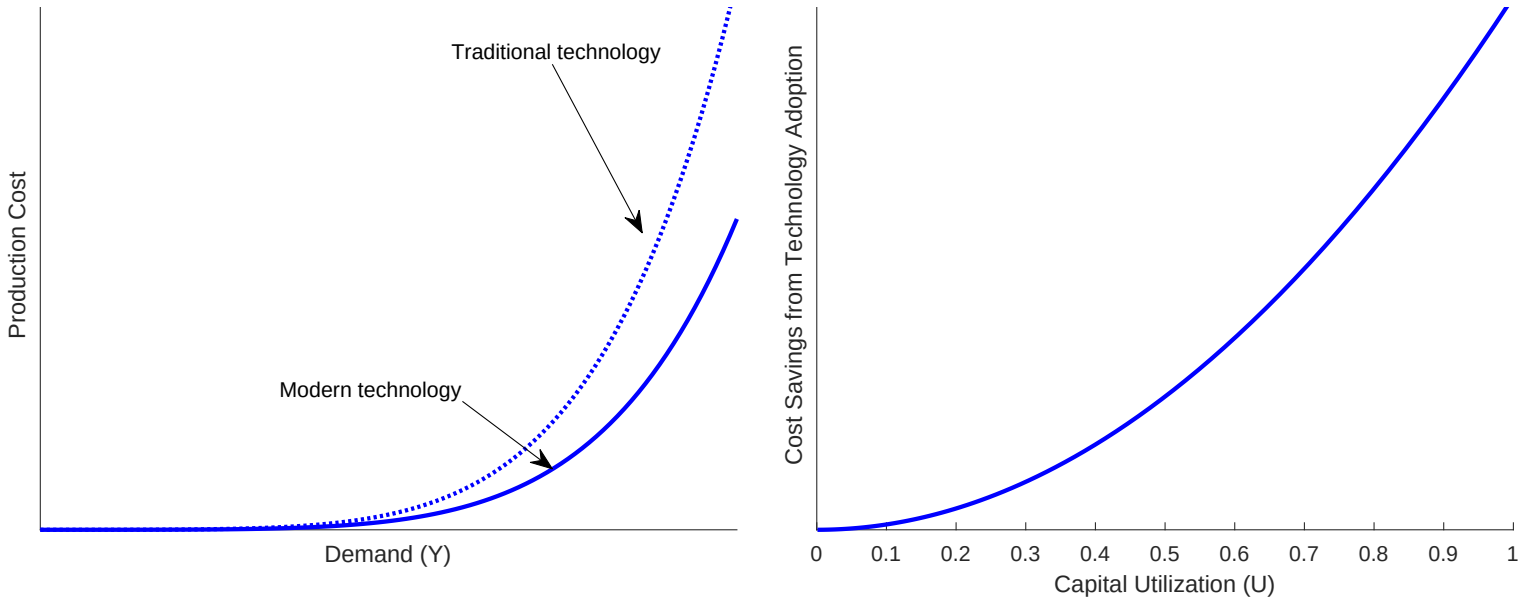


Reaction to German Constitutional Change

ECB Response

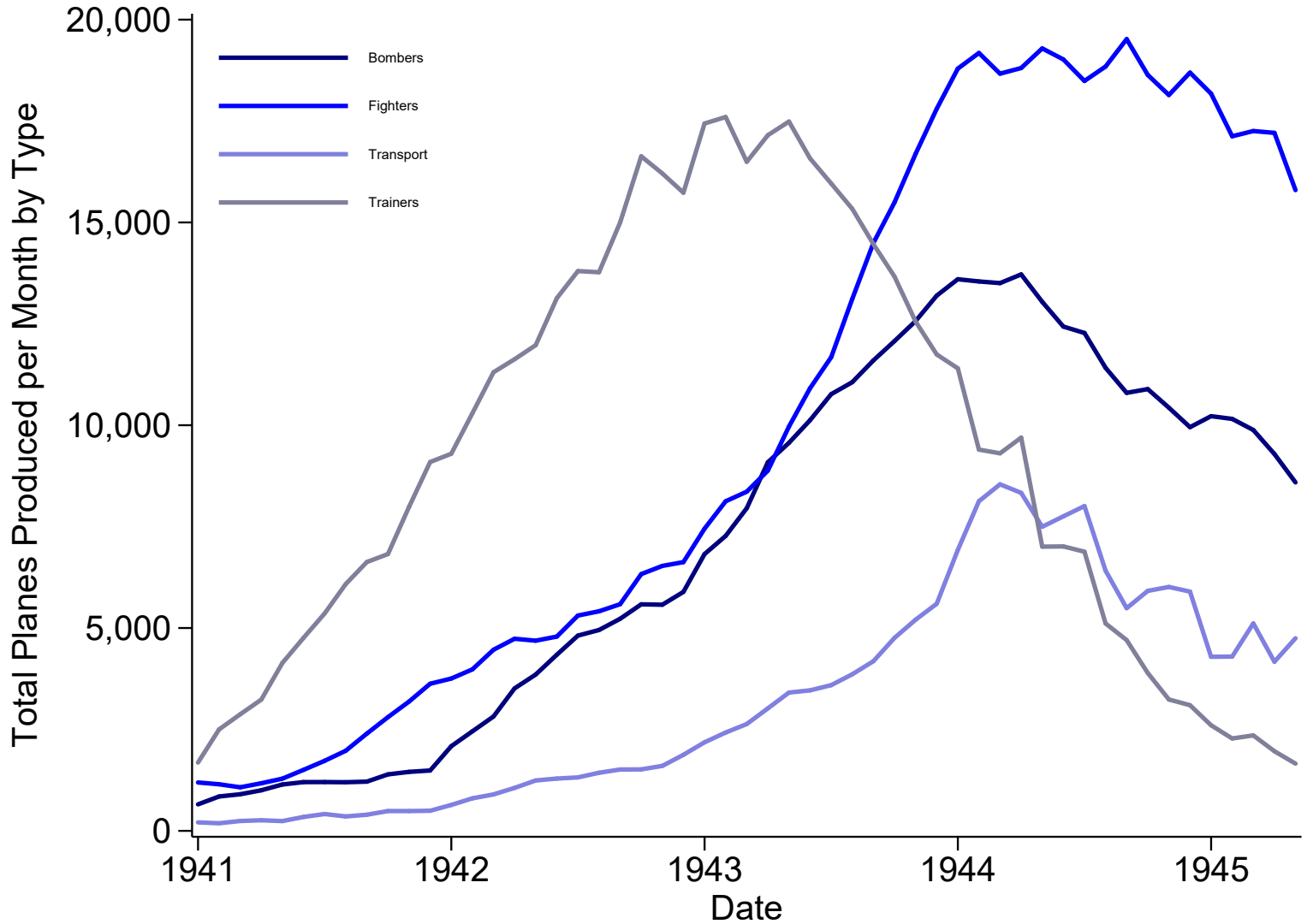


Learning by Necessity Theory in a Nutshell

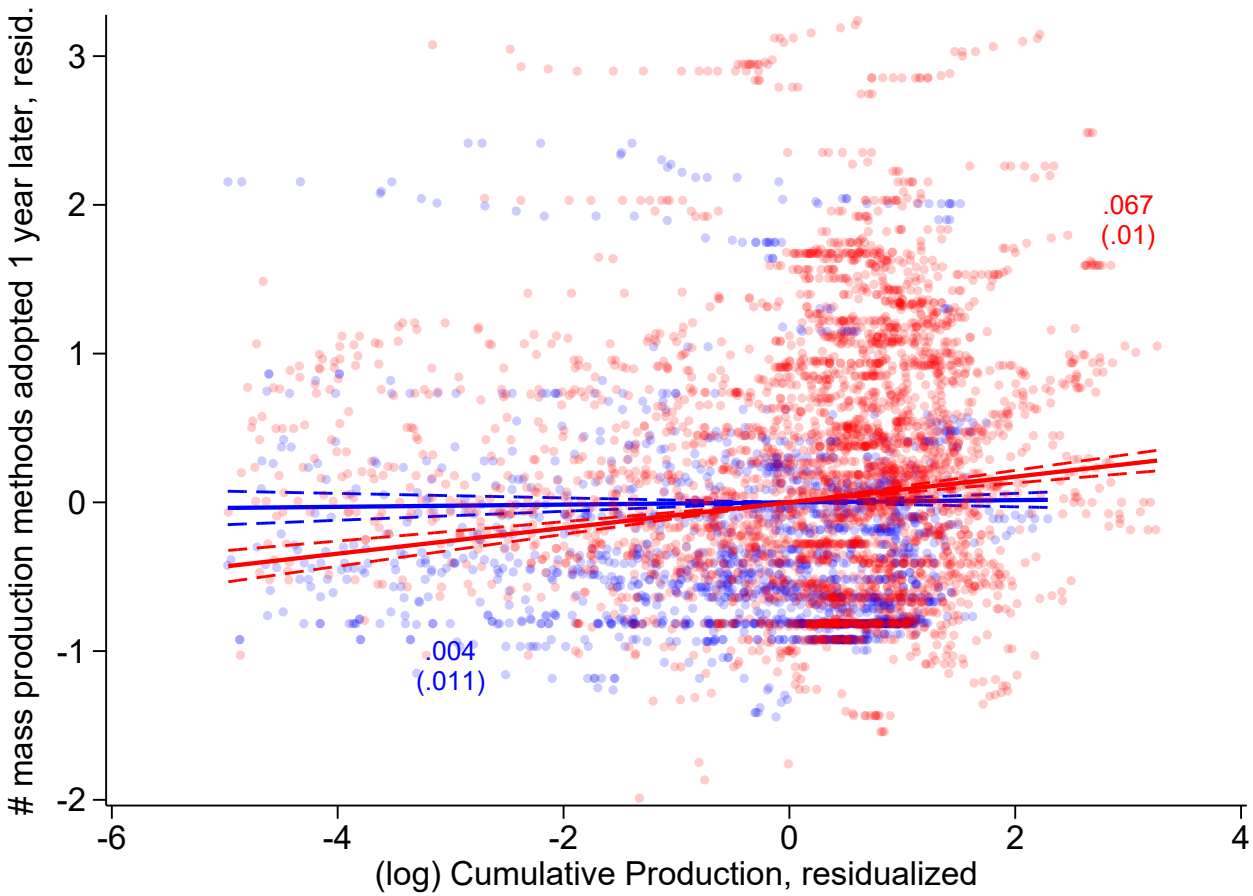


Production by Broad Aircraft Type

Monthly Number of Planes per Production Line



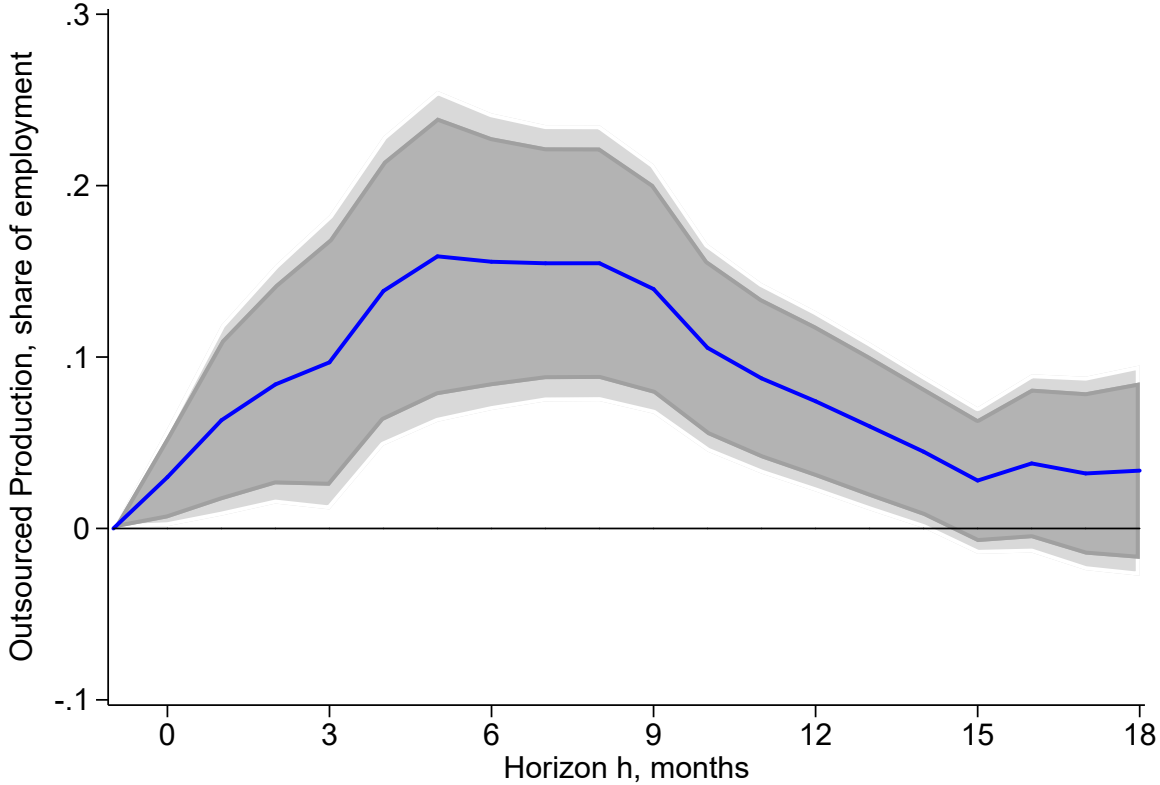
Mass Production Technique Adoption



Number of mass-production methods adopted plotted against log cumulative production 12 months earlier. Both series are residualized from time, plant, and aircraft model fixed effects. Red dots and regression lines are for plants with above median capital utilization at the beginning of the war. Blue dots and lines are for plants and below median utilization. Regression coefficients and standard errors for each subsample reported.

Outsourcing

Relative Response in High vs. Low Capital Utilization Plants

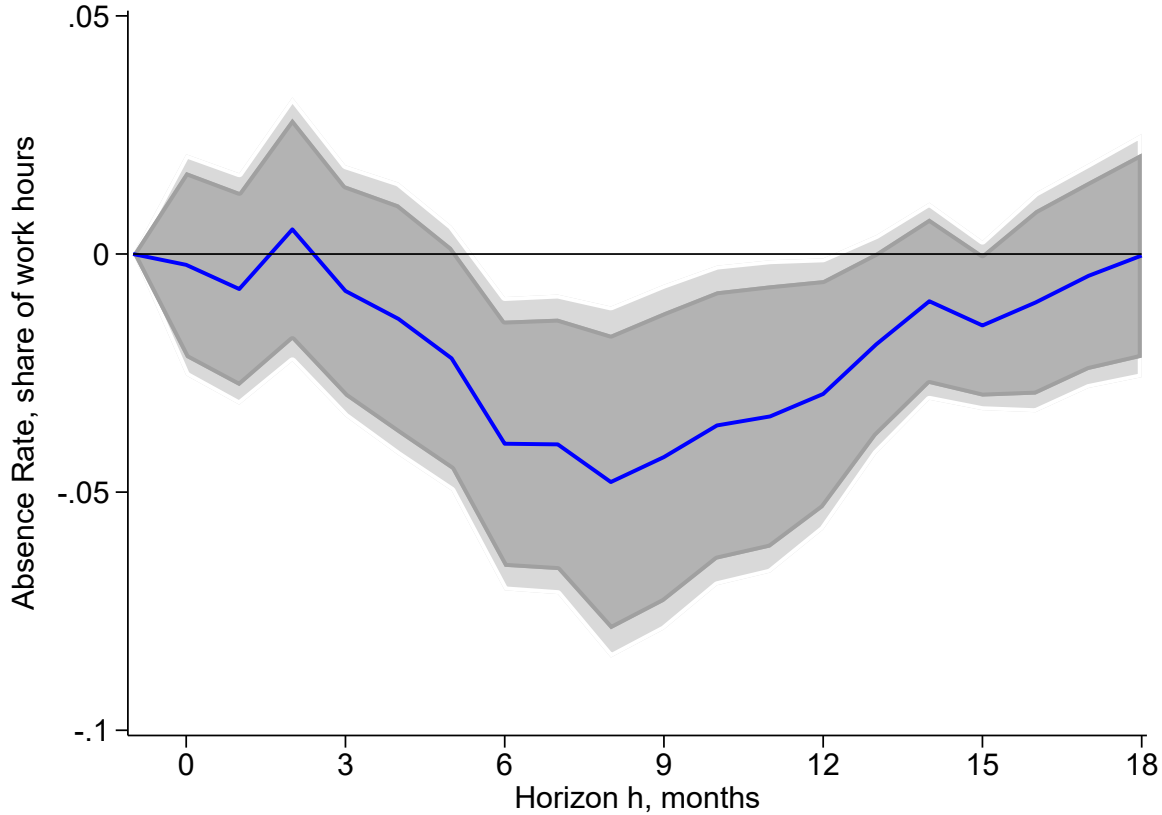


F-statistic at 12-month horizon = 13

Local projections response of percent outside production to 1% shock to aircraft demand interacted with a dummy = 1 if plant had above-median initial capacity utilization. These are instrumented with the ("leave one out") production of broad aircraft of the same broad type and its interaction with the capital utilization dummy. Includes month and plant $\times$ model (production line) fixed effects, 6 monthly lags of output. 90% and 95% standard errors shaded. F-stat at 12-month horizon = 13

Absenteeism

Relative Response in High vs. Low Labor Utilization Plants



Local projections response of monthly hours lost due to worker absence to 1% shock to aircraft demand interacted with a dummy = 1 if plant had above-median initial capacity utilization. These are instrumented with the ("leave one out") production of broad aircraft of the same broad type and its interaction with the capital utilization dummy. Includes month and plant × model (production line) fixed effects, 6 monthly lags of output. 90% and 95% standard errors shaded. F-stat at 12-month horizon = 6.


USED CARS
You sure took me for a ride