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Guns and Growth: The Economic Consequences of Defense Buildups

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Executive Summary

This paper investigates how an increase in military expenditures affects an economy. It is written in the context of rising geopolitical tensions that have spurred increased military spending in the United States, Europe, and other economic areas. It draws on a large literature in macroeconomics, public finance, defense and peace studies, economic history, and the study of productivity to evaluate the short- and long-run consequences of rearmament. The paper's main conclusions are as follows.

- There is broad consensus that the economy expands to accommodate at least part of the increased defense spending, production, procurement, and employment. There is some disagreement on the magnitude of this expansion and whether military spending crowds out or stimulates the private sector. The effects will depend on the context, including the ECB's response and the source of financing. A conservative estimate is that the Europe-wide GDP will grow by 0.9% to 1.5% if defense spending increases from 2% to 3.5% of GDP. This implies only a limited tradeoff between armament and private consumption in the short run in the short run.

- GDP growth will be smaller, possibly negative, if the increases are financed with tax increases rather than borrowing. Increases in defense spending should be mostly financed through public debt. This is particularly true of temporary increases in spending. But permanent buildups should also be initially financed through public debt, because of the durable nature of defense procurement.

- The evidence is clear that military spending is no *more* harmful in recessions than in economic booms, so that spending should either be countercyclical or smoothed over the cycle.

- The long-run productivity gains from military spending may be substantial. The best examples of public research and development are for military applications and there is evidence of spillovers to the private sector. A transient 1% of GDP increase in military spending could increase long-run productivity by a quarter of percent both through learning-by-doing and R&D. The returns to public R&D are particularly high and may pay for themselves. R&D spending has been identified as one of the three main keys to addressing Europe's lagging productivity in the Draghi report.

- Nearly 80% of European defense procurement is imported from non-EU suppliers. Harnessing the long-run technological gains from military spending requires far more of European defense spending to be procured from Europe.

- Defense is a European public good and should be far more coordinated: organized and/or financed at the European level.
- European defense procurement is directed to larger firms relative to the US, on average. Smaller defense contractors are more likely to have "dual use" technologies and lead to larger spillovers to the private sector. Further, the doctrine of "dual sourcing" whereby the government contracts multiple suppliers for the same project or different parts thereof may foster competition and knowledge spillovers. In the European context, one can imagine a dual-sourcing policy across countries that has the added benefit of international knowledge spillovers and spreading procurement more evenly among EU member states.
- Setting percent-of-GDP targets for military spending is counterproductive. It may lead to procyclical macroeconomic policies and dis-incentivize efficient procurement. Instead, one should conduct a long-run cost-benefit analysis of the materiel and personnel requirements against their expected fiscal cost and allow procurement to achieve the highest quality at lowest cost possible.

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1 Introduction

Since Russia's invasion of Ukraine in 2022, the EU has committed more than €240 billion in financial, military, and humanitarian assistance, of which roughly €120 has been allocated (Ukraine Support Tracker, October 2024). The threat of Russian expansionism has also encouraged several member states to increase military spending to support Europe's defensive capabilities. The US defense budget for 2025 is forecast at $850 billion, up 20% since the onset of the war in Ukraine. [1]. The incoming UK government has committed to increase defense spending, already projected at 3.2% of GDP in 2024.[2] Nato members have committed to increase defense spending to 2% of GDP, with recent discussions of a 3% target.[3] [4]

With no end to the Ukraine war in sight, the war in Middle East at risk of spreading to a regional conflict, and tensions rising in the South China sea, it is likely that elevated defense spending will be the new normal of the second quarter of the 21st century. What will the economic effects of military expansions be? This article attempts to summarize a very diffuse and varied literature on the topic.

At the end of the Cold War, there was a widespread impression that wars will gradually become a thing of the past, will be limited to civil wars, or contained to specific regions. For this reason, the explicit study of the economic effects of military spending has declined over the past three decades. Nevertheless, military spending has been used as an instrument for government spending, as I discuss in Section 2, and has been used as an exemplar of industrial policy, as discussed in Section 3. This article attempts to piece together the evidence from these writings and from earlier, Cold-War era, studies.

The remainder of the paper is organized as follows. Section 2 summarizes the evidence on the short-run implications and Section 3 on the long-run implications of military buildups. The short-run literature draws on the literature on fiscal multipliers, which has often used military buildups to identify government spending shocks. There is broad consensus that fiscal multipliers are positive, meaning the economy expands when military spending increases. Estimates vary on whether military spending crowds out or stimulates economic activity, often depending on context. Few estimates are so large that the expansion pays for itself, implying there is a fiscal cost to bear. There is some evidence that the economy expands more when unemployment is high, suggesting that military

[1] https://www.defense.gov/News/Releases/Release/Article/3703410/department-of-defense-releases-the-presidents-fiscal-year-2025-defense-budget/

[2] https://commonslibrary.parliament.uk/research-briefings/cbp-8175/#:~%3Atext=How%20much%20does%20the%20UK,expenditure%20that%20meets%20NATO's%20definition

[3] https://www.nato.int/cps/en/natohq/topics_49198.htm#:~%3Atext=In%202014%2C%20NATO%20Heads%20of,instability%20in%20the%20Middle%20East

[4] https://www.reuters.com/business/aerospace-defense/europes-conundrum-how-fund-defence-spending-2024-12-18/

spending should increase, or at least not decline, when the economy slows down.

The evidence on the long-run effects of military spending is far more diffuse and variegated. I review a recent literature on the role of military spending on productivity growth. By inducing and concentrating demand, military spending may help exploit economies of scale, particularly in heavy industry. Evidence of government-induced learning by doing will be presented. I review the literature on research and development (R&D) externalities and ask whether military spending is a particularly fruitful category of government spending to address these externalities and for industrial policy.

Finally, I elaborate on other considerations for military spending in Section 4. I discuss the best way to finance it (mostly debt financing for a temporary buildup), tradeoffs between domestic and international procurement, and whether numerical targets are a good way to encourage higher defense spending (they aren't).

Before embarking on this survey, it is worth quoting General Sherman, who, following the US Civil War stated that "war is hell'. Whatever the economic side effects of military expansion by be, the primary concern should be strategic: how best to resolve international conflicts with minimal cost to human life and prosperity. (See Federle et al. (2024) for an empirical assessment of the cost of war.) Re-armament may be the best tool in the kit to achieve these aims at times, as indeed disarmament may be at others. It is beyond the scope of this paper to discern what the best strategic stance is at the current juncture. I will discuss only in passing the game-theoretic literature on arms races, but readers are advised to consult it, particularly the evidence that re-armament may increase, rather than decrease, the probability of war. This paper merely attempts to summarize the economic fallout of re-armament, without taking a stance on the optimal strategic posture.

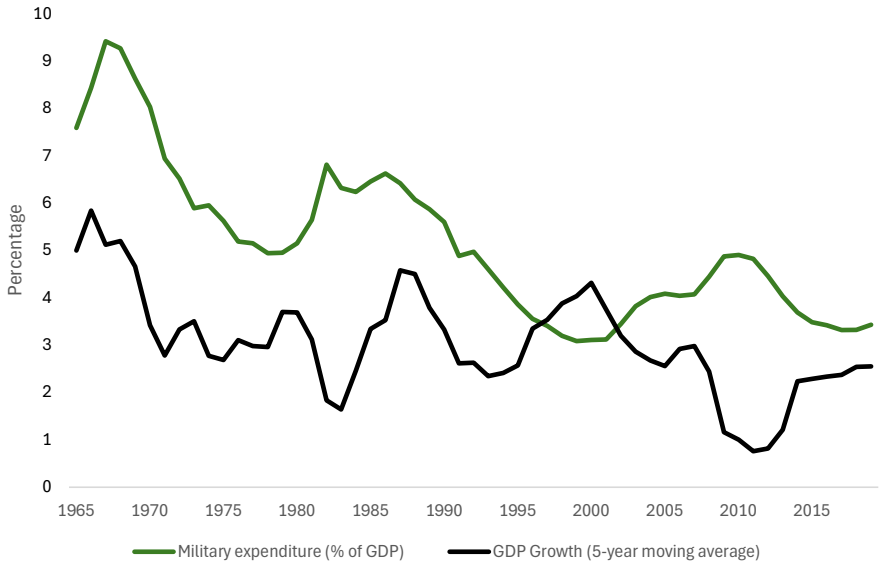
2 Military buildups and short-term economic performance

The relationship between military buildups and economic growth has long been a subject of debate. At the end of the Cold War, many commentators predicted a "peace dividend", whereby savings on defense expenditures will divert economic resources to better use. Although the US economy saw a healthy expansion in the decade following the fall of Berlin Wall, it difficult to attribute this directly to the peace dividend. Further, this boom was not sustained and other countries saw slower growth despite military spending cuts. More broadly, a large literature in political science and defense studies investigating the relationship between military spending and growth has found mixed evidence. Separately, economists have studied the fiscal multiplier–the effects of government expenditures on economic growth. Importantly for our discussion, shifts and shocks to military spending has often been used to evaluate the effects fiscal policy. In contrast to the "peace dividend" literature, increases

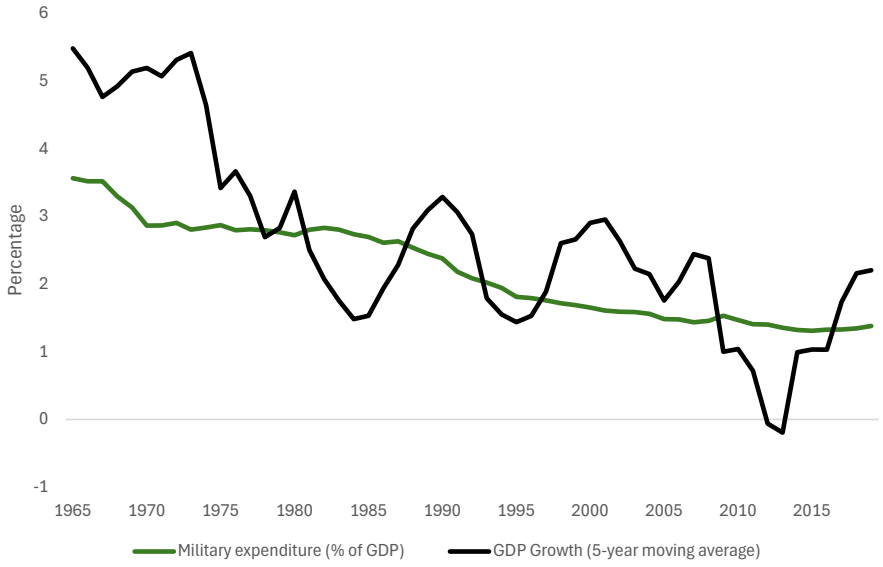
in military spending appear to have a positive impact on economic growth, with the magnitude of the effects differing across estimates and contexts.

Let's begin some simple facts. Figure 1 shows the annual growth in Gross Domestic Product (GDP) alongside the share of GDP dedicated to military spending, for the US in the top panel and the EU in the bottom one. US military spending declined dramatically following the Vietnam war, increased slightly during the Regan military buildup, falling again as the Cold War came to a close. A slight increase can be witnessed during the Afghanistan and Iraq wars. The overall trend is a decline in military spending from 8% of GDP in the 1960s to less than 4% before the recent period of rearmament following the Russian invasion of Ukraine. Over this period, US annual GDP growth has also declined from roughly 4% a year to below 3% a year. Similarly, military spending has steadily declined in the EU from 5% of GDP at the beginning of the period to below 1.5% before the Covid pandemic. The "peace dividend" era is clearly visible with the more precipitous decline after 1990. Yet the peace dividend itself is elusive, with GDP growth also steadily declining from over 4% a year in the 60s to roughly 2% today.

Figure 1: US and EU defense spending and growth



US defense spending (% of GDP) and annual GDP growth (%, rolling average)

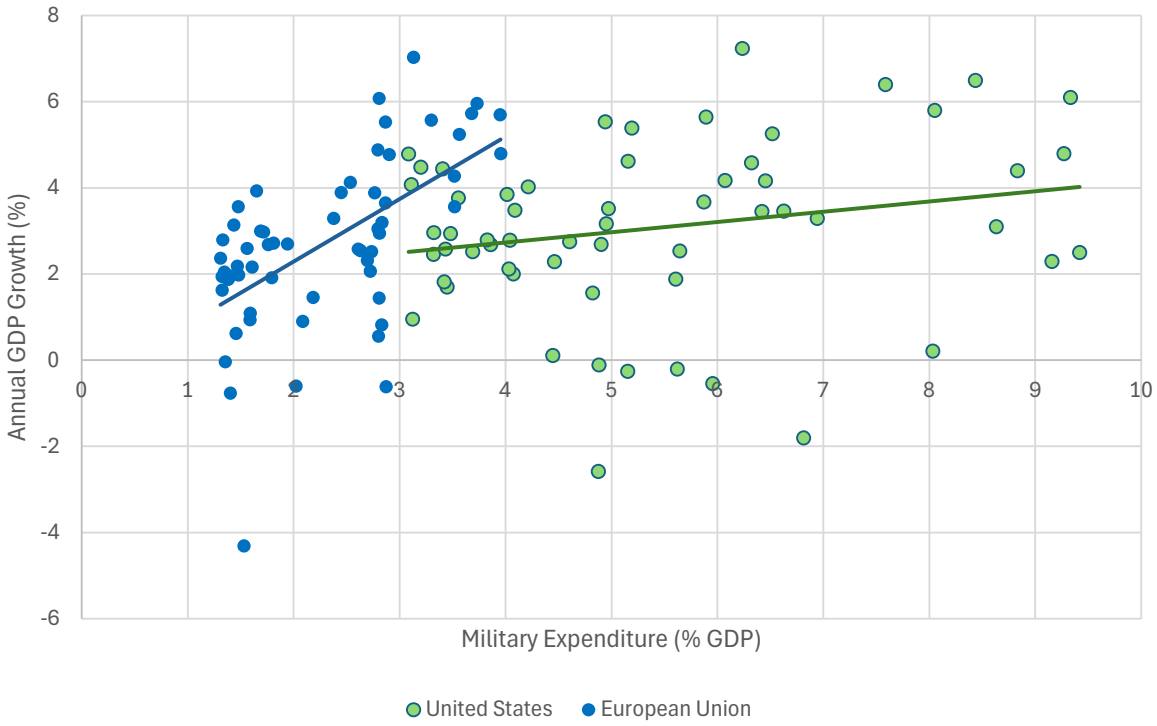


EU defense spending (% of GDP) and annual GDP growth (%, rolling average)

Source: Own calculation and presentation.

Figure 2 illustrates these correlations differently. The scatter plot shows that growth is *positively* correlated with the share of GDP devoted to military spending. This is true both when looking at a single economic area over time, as in Figure 1, and in the cross-section, comparing the high growth and military spending of the US to the lower readings on both metrics in the EU. This is true despite a mechanically *negative* relationship between these two variables: keeping military spending constant, higher GDP growth would lead the ratio of military spending to GDP to *decline*. These charts are far from conclusive evidence on the effects of military spending on economic growth: We will discuss causation in more detail below. However, the figures indicate that even if military spending were harmful to the economy–even if the peace dividend did exist–other drivers of GDP are dominant and rearmament is doesn't over-ride other engines of economic growth. In other words, the US and EU economies have been able to (more than) withstand military buildups in the past.

Figure 2: US and EU defense spending and growth



Source: Own calculation and presentation.

2.1 The elusive peace dividend

The peace dividend has also proven elusive in empirical studies using panel data that correlate military spending with GDP growth in larger samples of countries. In his Handbook article, Ram (1995) summarizes this voluminous literature with the disappointing conclusion that there is little correlation, positive or negative, between economic growth and changes in military spending. Benoit (1973) and 1978 spurred the Cold-War era literature on this topic, observing a positive correlation between military spending and GDP growth. He concluded that countries with the highest defense burden also had the highest growth rates. However, the subsequent literature showed a wide range of estimates, disagreeing even on the sign of the relationship: whether military spending has a positive or negative effect on economic growth. Two meta analyses of this large literature themselves disagree on the conclusions. Alptekin and Levine (2012) find a positive relationship between military spending and growth, but the updated sample of F. Yesilyurt and M. E. Yesilyurt (2019) shows no relationship. In a recent contribution, Dunne and R. P. Smith (2020) find no relationship between military, spending on one hand, and both growth and investment, on the other. Ram (1995) concludes that Benoit's (1973; 1978) results of a positive correlation between military spending and growth are "fragile", but that it is "also difficult to say that the evidence supports the view that defense outlays have an overall negative effect on growth".

Early studies on the effects of government spending on growth in empirical macroeconomics also took the form of panel regressions. In their textbook on economic growth, Robert J. Barro and Sala-i-Martin (2003) (p. 518) conclude that a higher share of government consumption to GDP reduces economic growth. However, their studies exclude military expenditures. Including military spending in their account of government expenditures (p. 536) is sufficient to invert this relationship and gives a substantial *positive* effect on growth (although only marginally statistically significant). They explain this discrepancy as follows (p. 526):

> The elimination of expenditures for defense and education–categories of spending that are included in standard measures of government consumption–was made because these items are not properly viewed as consumption. In particular, they are likely to have direct effects on productivity or the security of property rights.

It is worth taking a tangent to mention a related literature using Cold War data, studying the effects of military spending on the probability of conflict. Gibler, Rider, and Hutchison (2005), for example, show that "arms races", defined as multi-year growth episodes of large annual increases in defense expenditures by pairs of rivals, increase the probability of war. However, these results should be taken with a grain of salt as the reverse channel of causation is at least equally likely. Namely,

arms races emerge as rivals anticipate that war is on the horizon. Further, Garfinkel (1994) posits that democracy serves a credible commitment deviced to avoid wasteful arms races, implying that armament by a democracy is unlikely to spark an escalation and instead that democracies tend to under-invest in defense. The historical study of the First World War provides a canonical case study for this complex cycle of causation. Did the arms races of the rivaling European powers of the early 20th lead to a Thucydides trap that made war inevitable (Allison: 2017)? Or was war inevitable to begin with and armament merely reflected the powers' preparation for this inevitability. The jury is out even with a century of hindsight. (See Kennedy 1980; A. Taylor 1954 on the inevitability of the war and Clark 2012; MacMillan 2013; Tuchman 1962 for arguments that it was contingent on historical accidents.)

2.2 Military spending and fiscal multipliers

A more recent literature in empirical macroeconomics studies the impact of government consumption and investment on short-run economic growth, with greater attention to causal identification. The literature began with Blanchard and Perotti (2002), who used Structural Vector Autoregressive (SVAR) methods to estimate the response of GDP to government purchase shocks. The SVAR forecasts government spending based on past observations of a range of macroeconomic variables. The unforecasted residual of government spending is treated as a government spending "shock": government spending that was unpredictable from observable aggregate data merely a quarter in advance. The economy's response to this shock is then simulated through the vector autoregressive forecasting tool. Blanchard and Perotti (2002) conclude that a shock to government spending in the US leads to an increase in GDP that is roughly proportionate in dollar terms to the increase in government purchases.

Ilzetzki, Mendoza, and Végh (2013) extend this analysis to a panel of 44 high-, middle-, and low-income countries. They conclude that the US case masks a wide variety of responses to government spending shocks and important sources of heterogeneity. First, while the US is somewhat representative of high-income countries, multipliers in developing countries are far smaller, not obviously greater than zero. That is, the economy expands to accommodate government spending shocks, at least partially, in high income countries, but government spending fully crowds out private consumption and investment in lower income countries. Second, government spending has a greater impact on the economy in countries that are more closed to international trade–a point we revisit when discussing procurement policy. Finally, fiscal multipliers are far larger in countries with fixed exchange rates. This is because independent central banks tend to tighten monetary policy in face of government expansions but those with fixed exchange rates cannot do so as this would impact

the value of the currency.

A different methodology is employed by Robert J Barro (1979), Valerie A. Ramey and Matthew D. Shapiro (1998), Valerie A Ramey (2011), and Robert J. Barro and Redlick (2011). Useful for our discussion, this methodology relies on the fact that US military buildups are typically due to geopolitical tensions outside of US borders, so that they mostly reflect the economic effects of military buildups rather than the destruction of war itself (see Federle et al. 2024 on the cost of military conflict). Military spending comprises the lion share of government consumption and investment (as opposed to government transfers) in the US. Accordingly, the biggest swings in government consumption and investment have been driven by military spending. If the US increases military spending in response to geopolitical tensions, but global security conditions have no direct impact on the US economy, changes in military spending can be used to evaluate the effect of government spending on the economy.[5] Valerie A Ramey (2011) goes further and gives a narrative account of exogenous military buildups. In order to capture the economy's full response to military spending shocks, including to their anticipation, she also gives a narrative of the precise date when the private sector (the business media) realized military spending was forthcoming. Using this competing methodology, she nevertheless obtains a multiplier of roughly one, again indicating that the economy accommodates military expansions. In subsequent research that included the world wars of the early 20th century, Valerie A Ramey and Zubairy (2018) find multipliers closer to two-thirds, implying that military expansions decrease private consumption and investment by about a dollar for each three dollars spent.

A later literature used the location of public spending and procurement in the US to evaluate the effects of government spending. This "local fiscal multiplier" approach compares the increase in GDP in a locality (e.g. US state) in response to a local increase in public spending. This approach has the advantage of giving a more credibly causal estimate of the effects of public spending on GDP because it relies on the systemic allocation of public spending across US states that is often unrelated to local economic conditions. This approach also has a disadvantage, because the comparison across states may miss the general equilibrium response of the whole economy to the public spending boost. Nakamura and Steinsson (2014) use the distribution of military procurement across US states to estimate the effects of government spending and find multipliers of 1.5, substantially higher than those found in time series approaches. The magnitude of the multiplier implies that military spending doesn't crowd out private consumption and investment, but rather stimulates them. Chodorow-Reich et al. (2012), D. J. Wilson (2012), and Shoag (2013) find similar multipliers for health care, infrastructure, and local public expenditures.

[5] However, Caldara and Iacoviello (2022) show that geopolitical risk has had a direct effect on the US economy.

How can one reconcile estimates of the government spending multiplier estimated using time series and local multipliers approaches? Chodorow-Reich (2019) posits that the time series estimates should be seen as an average economic response to government spending shocks in the conditions that prevailed during the episodes studied (e.g. the six US military buildups since the beginning of the 20th century). The local multiplier approach instead controls for the monetary policy response (which is identical across US states) and the financing method (which is Federal rather than local in the empirical methods discussed above) to give a purified fiscal multiplier. Specifically, the Nakamura and Steinsson (2014) multiplier of 1.5 can be seen as the multiplier that would prevail absent a monetary policy tightening and if the military spending surge were financed mostly by debt with limited concurrent increase in taxation. These results are consistent with a multiplier of similar magnitude found by Ilzetzki, Mendoza, and Végh (2013) in countries with fixed exchange rates, who are unable to change interest rates due to their commitment to keep the exchange rate stable.

These results imply that the economy tends to expand to accommodate most of the increase in military spending: The lower bound on the fiscal multiplier reported in Valerie A. Ramey (2019) is 0.6, i.e. the economy expands to accommodate 60% of the military expansion. In certain contexts, the economy expands more, to accommodate the entire increase in military spending, or even stimulate the private sector further. Multipliers will be larger when monetary policy accommodates these shocks.[6] Given that a European military expansion is likely to be coordinated, it may require a response by the ECB, which is bound by it inflation targeting mandate. One might then predict that there will be a moderate decline in private economic activity due to rearmament. Private sector activity will be harmed further if the government attempts to pay for public spending with current taxation, a point we will revisit in Section 4.

2.3 Distributional implications

Even if GDP fully accommodates military spending surges, it doesn't necessarily follow that citizens are better off and certainly not all of them will be. The welfare implications of military spending depends first and foremost on the value of national defense as a public good. Higgs (1992) suggests removing military spending from GDP entirely because it is an "intermediate good" to the provision of national defense, but such an approach almost certainly goes too far. Nevertheless, it remains true that we don't have a price signal to value how much benefit citizens derive from public goods, including defense, and valuing them based on the government's expenditure on these goods may overstate or understate their value.

[6] Fujita, V. Ramey, and Roded (2024) shows that the economy can also adjust quickly to declines in military spending.

At one logical extreme, military expenditure affords nothing less than citizens' life and liberty. It is difficult to put a price tag on such lofty values, but most would agree that these provide good value for money at several percentage points of GDP. Alternatively, some may argue that military spending is often pure waste, in which case it is of little value even if it were nearly costless. Worse yet, some might argue that rearmament may accelerate rather than deter hostilities, in which case the spending may be outright harmful. The moderate to high multipliers on government spending reported above mean that the economic costs of military buildups are contained and that national security policy should be paramount in defense spending decisions. It is incumbent on defense authorities to make the case that they are providing good value for money. Less concern should be devoted to the economic fallout from these defense expenditures.

Another question is distributional: high multipliers don't necessarily imply a "free lunch". It is relatively uncontroversial that higher public (including military) spending creates more employment and output. However, it may also divert resources from civilian production to public good provision and public investment (in this case for the purpose of national defense). Valerie A Ramey (2011) shows that increased government spending slightly crowds out both consumption and private investment. Further, increased government spending reduces wages, implying that there are losers, not only beneficiaries from increased public investment. Perotti (2007) comes to a different conclusion for government spending as a whole, but concurs in Perotti (2014) that defense spending tends to crowd out private consumption.

The US experience in the Second World War is a particularly potent case study that illustrates how private consumption may be harmed by military expansions. Brunet (2024) finds multipliers substantially lower than one during World War II and Higgs (1992) claims the wartime prosperity of the 1940s was a myth. The latter shows that while the economy expanded dramatically to accommodate the wartime munitions program, private consumption decreased substantially. By some metrics this must certainly have been the case. The auto industry, producing the most important durable consumer good of the inter-war period, was fully converted to military production and sales of new autos were forbidden. Many other consumer goods were strictly rationed. There is no doubt that war production came at some expense to households. At the same time, one shouldn't overlearn the lesson from this relatively unique period. This was a period of a full-on war economy with a rationing regime in place. The economy was converted to wartime production in ways that are hard to conceive in 21st century US or Western Europe. Further, 20% of the US labor force was drafted to the army. These young adults were the core of the US consumer base and much of US consumption was realized by these soldiers in Europe and the Pacific.

There are other distributional considerations. Expansions in public spending must be financed

either through higher contemporary taxation or higher public debt, implying higher future taxation. Current taxation has distributional implications for current taxpayers, while future taxation raises questions of intergenerational equity. I discuss public finance implications of military buildups in Section 4. In addition, Kuziemko, Naidu, and Onorato (2024) show that US military spending during the Cold War benefited low-skilled workers, with a commensurate decline in inequality.

Military spending reallocates production across firms, with obvious distributional implications, but also with potential implications for aggregate economic efficiency. Valerie A. Ramey and Matthew D. Shapiro (1998) argue that military spending may harm the productive capacity of an economy because it misallocates expenditure to less productive firms. Field (2002) claims this was the case during the US production drive of World War II. However, Ilzetzki (2024) documents that productivity dispersion (among aircraft producers: the largest war industry) declined during the war, indicating that misallocation declined as procurement increased.

2.4 When to spend it

It is often said that World War II was the fiscal stimulus that ended the great depression (Gordon and Krenn: 2010). The veracity of this folk wisdom notwithstanding, it raises the question whether military buildups bring greater benefit when an economy is in recession and conversely whether they may harm economies that are already operating at full capacity. A conventional Philips curve logic posits that high demand will lead to both higher GDP growth and higher inflation in the short run, with a tradeoff between the two. It is plausible, however, that the Philips curve is non-linear, so that there is a difference between an economy at full employment and one with substantial slack. An economy with under-utilized resources can absorb a government expansion without rising inflation. In contrast, an economy facing capacity constraints will see elevated inflation with little growth in output when demand surges (Boehm and Pandalai-Nayar: 2022; P. Benigno and Eggertsson: 2024; Fornaro: 2024). However, Hazell et al. (2022) show that the Philips curve has historically been flat, indicating that strong demand alone is unlikely to cause substantial inflation, unless inflation expectations become unanchored.

The Philips curve describes a short-run tradeoff between inflation and output, but the "classical dichotomy" implies no such trade-off in the long run. A credible central bank can commit to achieving its inflation target eventually, even if it temporarily misses the mark in the short run. In addition, economies are resilient and the productive capacity of the economy–inelastic in the short run–may expand to accommodate a large demand surge through investment and innovation. It is more likely to do so if the surge is expected to be persistent (Fornaro: 2024) or large (Ilzetzki and H. Reichardt: 2020; Ilzetzki: 2024). Further, high demand can incentivize firms to innovate to overcome capacity

constraints, implying that large demand surges may not be as inflationary as is commonly perceived (Ilzetzki: 2024). I elaborate on the relationship between military spending and productivity growth in Section 3.

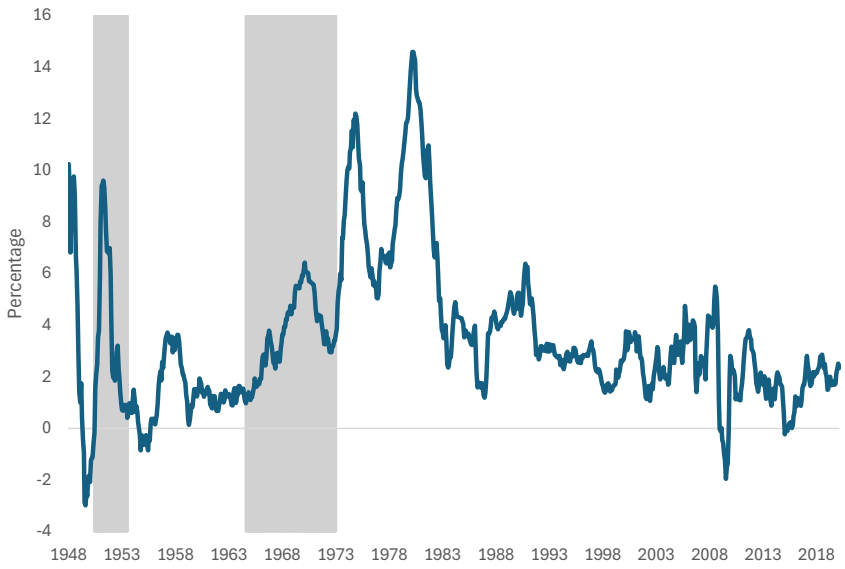
There have been several attempts to estimate whether government spending is more expansionary and less inflationary when the economy is slack, e.g. when unemployment is high. The results have been mixed. Alan J. Auerbach and Gorodnichenko (2012) and Alan J Auerbach and Gorodnichenko (2013) find that fiscal multipliers are higher in periods of greater "slack". Born et al. (2024) find that government spending is not only more potent in increasing GDP, but also less inflationary when unemployment is high. In contrast, Owyang, Valerie A. Ramey, and Zubairy (2013) and Valerie A Ramey and Zubairy (2018) find that US military spending shocks are no more expansionary in recessions that in economic booms. From a theoretical perspective, the Keyensian logic of countercyclical fiscal policy (cf. Kaminsky, Reinhart, and Végh 2005; Ilzetzki and Vegh 2008; Ilzetzki 2014) calls for increased public expenditure in recessions. The neoclassical view calls for public consumption to be smoothed over time. Combined, theory and evidence both call for no greater military spending in economic booms than in recessions. In contrast, setting targets for military spending as a percentage of GDP may precisely lead to these undesirable cyclical spending patterns, a point we will revisit in Section 4.

Then Korean and Vietnam wars on the US economy provide case studies of the inflationary impact of military buildups. There were no price controls during these wars, making them more suited than the Second World War for studying inflation .[7] At the onset of the Korean war, inflation was low at around 2% (although rising), and unemployment was high for the period at 5% (although declining; see Valerie A Ramey 2011 for a discussion of war dates). The logic of the non-linear Phillips curve suggests a lesser impact of government spending on inflation in this period. Nonetheless, inflation spiked (and was volatile) during the war (see Figure 3). However, parallels to the present should be drawn with caution for several reasons. First, the Korean War military buildup was far more dramatic than anything contemplated in the US or Europe these days. Government spending grew from 16% of GDP in to 24% of GDP within the first eighteen months of the war. For sake of comparison, this is larger than the Russian military buildup from 2022 to 2024 or Israel's increased military spending from 2023 to 2024, as a percent of their respective GDPs. Second, the causes of inflation had more to do with expectations of shortages than actual shortages. The beginning of war led to panic purchases of durable goods as households anticipated restrictions on the production of consumer goods, as occurred in the Second World War (Rockoff: 2012). Durable goods purchases

[7] Higgs (1992) estimates an effective 50% increase in the price level of consumer goods during the war (although there was an equally dramatic decline in the price of munitions), indicating that the war may have been inflationary, although the economy began with a great deal of slack.

then plummeted when no such restrictions were put in place, leading to deflation (and a recession; see Section 4 for a public finance explanation for the fluctuations during the war).

Figure 3: US inflation



Note: The figure shows monthly year-on-year inflation for US urban consumers. The shaded areas indicate the Korean and Vietnam wars.
Source: U.S. Bureau of Labor Statistics, Consumer Price Index for All Urban Consumers: All Items in U.S. City Average [CPIAUCSL], retrieved from FRED, Federal Reserve Bank of St. Louis; `https://fred.stlouisfed.org/series/CPIAUCSL`, January 9, 2025.

The war in Vietnam is perhaps a more relevant comparison, requiring smaller fiscal commitments. The war began with low inflation (below 2%) and relatively high unemployment for the period (5%). By 1970, inflation peaked at 6% (year-on-year, monthly) and it is entirely plausible that this was caused by the demand surge of the war (this was prior to the Middle East oil shocks). Like the Korean war, this example shows that a military buildup can be inflationary even when beginning from low inflation and substantial slack in the economy. However, two caveats should be considered. First, the war coincided with President Johnson's "Great Society" programs, reflecting a governmental attempt to provide guns and butter simultaneously. More prosaically, it is hard to disentangle how much these two public expenditures contributed individually or jointly to the inflation of the late 1960s. Second, the Federal Reserve operated under a different monetary framework that did not

require it to target inflation as strictly as it does today. F. Bianchi and Ilut (2017) claim that the debt buildup in this period was the spark that lit the inflationary fire of the 1970s, although it should be acknowledged that the Federal Reserve did raise interest rates in the late 1960s and the loose monetary stance followed only in the following decade.

2.5 Market power considerations

In reviewing the costs and benefits of a standing military industrial base, Sandler and Hartley (1995) point to a perception that military procurement contributes to military contractors' disproportionate market power. This is also a common public perception, often referenced as the "military industrial complex". Indeed, Cox et al. (2024) document that a small number of large corporations have received the majority of US defense contracts. However, the evidence on the relationship between military procurement and market power is still limited and the popular perception misses at least two points. First, while it is true that defense contractors are often oligopolistic, it is also a reality that the government is often a monopsonist in defense purchases. Thus the theoretical implications for market power depend on the complicated game-theoretic interactions between the government and the contractor, discussed in the industrial organization literature (cf McCall 1970; Laffont and Tirole 1988; Bajari and Tadelis 2001). Second, military buildups often push large producers to their capacity constraints and force the government to diversify its procurement to smaller firms. Thus, the government may end up reducing market power during military buildups.

In fact, O. H. Reichardt (1975) and Ilzetzki (2024) show that even in relatively concentrated market of aircraft, market concentration declined in the US during the Second World War. The war appears to have briefly paused what appears to be an inevitable historical trend towards a highly concentrated industry.

3 Military buildups and long-term economic growth

It has long been posited that military buildups–and even warfare itself–are catalysts for economic growth and economic development. Anecdotally, the US civil war appeared to promote industrialization of the US north. The war stimulated infrastructure investments, including the first transcontinental telegraph line and railroad expansions. Shipbuilding and weapons technologies were developed and improved. Further, the war effort required mass production and standardized products, which may have influenced subsequent private sector production processes and scientific approaches to management (C. A. Beard and M. R. Beard: 1927). Notably, the war led to labor shortages in agriculture and manufacturing, which spurred technological innovations in both these sectors (M. R.

Wilson: 2006). The war also affected private and public finance, with the national banking act of 1863 and currency reform that introduced the greenback and led to a more centralized approach to monetary policy. The Federal income tax was first introduced during the war, supporting a view that wartime finance has been an important factor in the development of fiscal capacity (Tilly: 2017; Besley and Persson: 2009; Besley, Ilzetzki, and Persson: 2013).

In the same era, the Franco-Prussian war may have also supported the nascent industrial base of newly unified Germany. Bismark introduced an explicit industrial policy to support industries important for national defense. This included railroad expansion, state support for heavy industry, and tariffs on industrial imports. Industrial giants including Krupp (Steel) BASF (chemicals) and Siemens (electrical engineering) emerged in the context of this support (Berghahn: 2005). In the following century, industrial policy became intimately linked with the German-British arms race, with the two nations attempting to outproduce each other in steel and shipbuilding production (Kennedy and Luttwak: 1990). This was also a period of financial development, with the emergence of banks that remain the backbone of the German financial system to this day. It is of course worth cautioning that some historians relate Bismark's Prussian militarism to Europe's 20th century catastrophes (Pflanze: 1971).

The World Wars revived the discussion of the role of military expansions for long-run economic growth. The US experience in the Second World War, in particular, led to several insights. First was the strong connection between economic and military warfare. It can well be argued that the allies won the war as much due to their ability to outproduce their adversaries as their ability to outmaneuver them on the battlefield (Herman: 2012; Klein: 2013). Second, US wartime production greatly outstripped predictions of US productive capacity and massive productivity growth was carefully documented in several sectors, most notably in aircraft and shipbuilding. Third, wartime necessity led to several innovations including in the areas of radar technology, crypography, synthetic rubber, and most famously nuclear power.

Several theoretical frameworks have been proposed to make sense of the linkages between state investments and economic growth. First, there is a tradition that dates back at least to Marshall (1890) that posits economies of scale in production, whether internal to the firm or within an entire industry or economy. While Marshal did not himself advocate for widespread government intervention to address these externalities, others in the Cambridge school recognized the potential for tax policy to address externalities. We will see that government demand can play a similar role in both internalizing these externalities and absorbing some of the fixed costs that may cause increasing returns.

Second, studies in the inter-war and post-Second-World-War periods emphasized learning by

doing, a form of dynamic economies of scale whereby costs decline with production over time.

Third, one form of external economies arises from spillovers from research and development. A large literature has studied the government's, and the military's, role in stimulating R&D.

Fourth, a revitalized literature studies the government's role in industrial policy. This is somewhat of a catch-all phrase for the myriad actions governments take to steer the structure of the economy. I will link this literature to the aforementioned rationales for government intervention and the particular role of military expenditures.

3.1 Economies of scale

The idea of economies of scale is as old as the field of economics and is implicit in Adam Smith's analysis of the division of labor, which also included a precursor to learning by doing (A. Smith: 1776). This becomes more explicit in Say (1803) and Marx (2018). Early writings on industrial production processes (Babbage: 1832; Ure: 1835) relatedly emphasized the importance of mass production in efficiency. Similarly, many of these writings pointed to efficiency gains due to practice and experience, what we would now call learning by doing.

Marshall (1890) was perhaps the first to formalize the idea and made an important distinction between internal economies of scale that could lead to market power and natural monopolies and external economies of scale which might do the exact opposite because they allow firms to free-ride on the investments of other firms. While Marshall understood the implication that such externalities lead to market inefficiencies, he advocated for only light-touch government interventions. Later, A. A. Young (1928) was more explicit that external economies of scale justified public investments, while Pigou (1920) advocated using tax policy to encourage firms to internalize these externalities. Sraffa (1926) evaluated the role of internal economies of scale and advocated regulation to counter firms' market power. These ideas were later canonized in the Samuelsonian post-war consensus on externalities, public goods, and non-competitive markets. The modern literature on R&D subsidies and public R&D, which I discuss below, build on these foundations.

Not all theories of endogenous growth explicitly feature increasing returns to scale, but knowledge externalities are implicit in all of them. The modern literature on endogenous growth begins with a production function that posits that a firm's output is determined by factors of production (labor, capital) and productivity. Productivity, in turn, could be a technology or knowledge possessed by the firm, or more general knowledge that isn't rival: it can be used simultaneously by multiple firms. The key question in this literature is how individual firms or entrepreneurs generate knowledge or new technologies and how other firms are affected by an individual firm's innovation.

K. J. Arrow (1962) introduced the concept of learning by doing and posited that firms learn

the more they invest. This means that a firm's knowledge is proportional to its capital stock. But while a firm's capital is excludable, knowledge diffuses freely in society. Thus firms' productivity is determined by the aggregate knowledge in society and thus by aggregate, not only their own, investment. Firms free-ride on other firms' investment in knowledge, leading to underinvestment in knowledge in aggregate.

Phelps (1966) and Paul M Romer (1986) instead argue that knowledge is created through research and development. Schumpeterian growth models as in Aghion and Howitt (1992) and Aghion and Howitt (1997) have a approach based on "creative destruction", but the rationale for R&D externalities is similar. In these frameworks, active investment in R&D causes productivity growth. But R&D isn't fully excludable, leading to underinvestment in R&D. Investment in knowledge is active here, in contrast the incidental accumulation of knowledge in Arrow's formulation. I elaborate on active vs. passive learning and on the role of R&D spillovers below.

In R. E. J. Lucas (1988), productivity is determined by human capital or individuals' education, experience, or know-how. Lucas argues that different sectors have different rates of learning, e.g. producing a high-tech good might lead to greater accumulation of general and transferable knowledge. In this case, there is insufficient production of the high tech good in the laisez faire economy. High-tech firms under-produce because they don't internalize the fact that they are expanding the knowledge frontier. Rather than investing directly in knowledge acquisition, the optimal tax policy would subsidize the high-tech industry.[8]

The implications of the endogenous growth model should be clear. Underinvestment in knowledge justifies public subsidies for, or direct public investment in, knowledge acquisition. Military spending can help address this externality insofar as government demand for military materiel helps society accumulate knowledge, either through learning by doing, the implicit R&D subsidy this demand provides, or through direct investment in R&D. Military spending may also may be tilted towards higher tech industries, where knowledge accumulation is greater. Military spending addresses the externality only incidentally and there are of course more direct, and less militaristic, ways to fund knowledge acquisition. However, insofar as public defense is a necessity, this is one positive side-effect. Further, I discuss below how investment in knowledge through public good provision may be a second best, when direct subsidization isn't politically feasible. In light of the R. E. J. Lucas (1988) model, consider the political feasibility of subsidizing large technology companies relative to procurement from these firms.

Murphy, Shleifer, and Vishny (1989) posit that modern industrial processes involve fixed costs and with two types of related inefficiencies. Fixed costs may cause increasing returns to scale in

[8] See also A. Young (1991) for a model of learning by doing and international trade.

production at the firm, industry, or economy level. As in standard textbook treatments, this leads to underproduction of industrial goods, which could be addressed through government intervention. If these involve economy-wide fixed costs, e.g. in the case of infrastructure, public investment can help resolve them.

The second inefficiency relates to the extent of the market. When facing fixed costs, a larger market allows producers in each industry to produce at lower average and/or marginal costs. The economy can be in one of two equilibria. One has low demand, more costly production, and less production, which leads to lower income and less demand. The other has high demand, cheaper production, thus greater production scale, higher income and high demand. A military buildup can help coordinate the economy on the high-demand, high-productivity equilibrium. Some have pointed to the US interstate highway system in the mid-50s, for example, as motivated to a great extent by military needs. Similar notions are central to theories of industrial policy, which I review below.

Krugman (1991) points to a similar case of multiple equilibria regarding the location of production. A possible example are communities in Southern California south of Los Angeles that may have benefited from good weather and geographical amenities, but also from the government's demand for locally produced aircraft (Valerie A Ramey and Matthew D Shapiro: 2001). Garin and Rothbaum (2024) gives empirical evidence that public investments during World War II had long and persistent positive impacts on the communities where they were made.

While it is tempting for the government to coordinate on what it perceives to be the "better" equilibrium (for example deciding that the auto industry, microchip industry, or AI is the industry of the future), a government's imperfect knowledge and potentially perverse incentives may coordinate on the "wrong" technology. However, even a well-intentioned and well-informed government may "lock in" the economy to what later turns out to be the "inferior" technology whenever static or dynamic returns to scale are present (Arthur: 1989). There is a risk that the government over-internalizes initial fixed costs and represses the information-gathering capacities of the private sector in the process. In the case of military spending, the government does so incidentally while providing a public good, but could nevertheless choose a technological path that is detrimental to long-run growth.

R. Hall (1988) distinguishes between market power arising because of fixed costs or other increasing returns and that arising because of regulatory or other barriers to entry. In the first case, markets are competitive and firms' markups exactly compensate them for these fixed costs. If this is the case, military or other procurement can expand the market and help push firms down their cost curve. In the latter case, however, military procurement merely contributes to firms' rents and it is the minutia of the procurement process that determines whether the government is reinforcing

or mitigating incumbents' market power.

Economies of scale are difficult to estimate in practice. R. Hall (1988) finds substantial returns to scale, particularly in heavy industry. Basu and Fernald (1997) find, in contrast, that the typical industry in the US has roughly constant returns to scale. However, durables manufacturing sectors do exhibit moderately increasing returns to scale.

A form of increasing returns that has gained importance in the 21st century arises due to network externalities. The success of a social network, for example, relies on the number of active users, leading to bandwagon effects, where the more popular social networks become increasingly popular. While this may indicate a first-mover advantage, this tells only part of the story. Facebook, for example, was able to leapfrog early entrants such as MySpace and Friendster because of its ability to "scale" and accommodate rapid growth in its user base. In some settings, the government has an advantage in defraying the fixed costs of such scaling. For example, David C. Mowery (2010) argues the UK and France were as advanced technologically as the US in proto-internet technologies (see the case of the Minitel in France). However, it was scale of the ARPANET (the Department of Defense precursor to the internet) that led to the primacy of the US-developed technology.

3.2 Learning by doing

An early literature in what would now be called scientific management and was then known as Taylorism (F. W. Taylor: 1911), documented empirical regularities of cost reductions over time in production processes. Aeronautical engineers at the Taylor-Wright aircraft corporation demonstrated a consistent decline in the cost (both labor and material) of aircraft production and the cumulative quantity produced, which is closely approximated by a straight line when plotted in log-log scale (T. P. Wright: 1936). This has since been called the "experience curve" (Thompson 2010 gives an overview of the terminology).

The experience of the US World War II production drive influenced subsequent views on the learning curve. Shipbuilders and aircraft manufacturers saw enormous decline in costs (and indeed unit prices) over the course of the war and this appeared to be correlated with their experience. Numerous post-war studies documented cost curves in the wartime aircraft (Middleton: 1945; Asher: 1956; Alchian: 1963) and shipbuilding (Montgomery: 1943; Searle: 1945) production and concurred that costs declined with experience. The Boston Consulting Group conducted a post-war large-scale and influential study across many industries, showing that costs declined by a predictable amount with every doubling of cumulative production. More recently, learning by doing has been evoked to explain the steady decline in the cost of solar panel technologies. K. J. Arrow (1962) gave theoretical foundation for the cost curve as "learning by doing" (see also Thompson 2001; Thompson 2010;

Thompson 2012).

Readers familiar with the literature on firm growth will know well that young firms tend to be more productive than older incumbents. This would appear inconsistent with learning by doing, which predicts older firms being more productive with experience. Jensen, McGuckin, and Stiroh (2001) reconciles these facts through vintage capital: older incumbents are stuck with older vintages of capital and technology, a drag on productivity that outweighs their experience. If learning is in part learning how to use a specific vintage of capital, as Bahk and Gort (1993) assert, then lock-in to older vintages is inextricable from the learning process as in Arthur (1989).

Learning by doing has concrete implications for public policy. A firm facing fixed costs underproduces relatively to the social optimum and the problem is exacerbated with learning by doing. Now the firm is not only underproducing in a static sense but is also learning more slowly than the social optimum. Insofar as there are learning spillovers across firms, firms will underproduce, and under-learn (see Thompson 2010 for a discussion).

Thornton and Thompson (2001) find small but substantial learning spillovers in the production of World War II ships, across both plants and designs. Irwin and Klenow (1994) find steep learning curves in microchip production, with costs dropping by 0.2% per each percent experience gained. They also find substantial spillovers, with other firms reducing costs by about a third as much as the firm gaining experience. These spillovers are equally large internationally as they are nationally. However, they find minimal spillovers across generations of products even within the same firm. Mansfield (1985) documents rapid spillovers across firms, with firms acquiring competitors' new knowledge within 12 to 18 months. Lieberman (1989) shows that despite steep learning curves in chemical industries, experienced incumbents don't deter new entrants, who expect to be able to learn from incumbents' experience.

In reviewing the literature, Thompson (2010) concludes that it is difficult to find concrete evidence of purely passive learning and that an omitted variable could potentially explain the productivity gains with experience. Where data is available, there are clear suggestions that that firms' progress with experience may be driven by R&D (Sinclair, Klepper, and Cohen: 2000) or process improvement and changes in workers' incentives (Lazonick and Brush: 1985).

One reason firms may "actively learn" is *induced innovation*, whereby firms' direction of innovation responds to price and demand incentives. Fellner (1971) describes induced innovation in terms of scarcity: firms have incentives to economize in the factor that is scarce at the macroeconomic level. It is, of course, factor prices that communicate this scarcity to individual firms (Samuelson: 1965), although they may also learn of factor scarcity through its high utilization (Hickman: 1957). These incentives lead firms to substitute from an expensive factor of production to cheaper ones, e.g.

invest in labor-saving innovation when labor is scarce/expensive.[9] These ideas have a long pedigree in economic history. Rothbarth (1946) and Habakkuk (1962) argued that 19th century US labor productivity growth was stimulated by labor scarcity (relative to land and capital), while G. Wright (1978) argues that the US south failed to develop at the same pace because of abundance of labor extracted from the enslaved population. Allen (2009) proposed labor scarcity as an explanation for the British industrial revolution. E. Jones (2003) explains Europe's emergence in the Renaissance because European natural disasters (the black death) in the Middle Ages lead to labor scarcity rather than capital scarcity as they did in Asia (with disasters such as earthquakes and typhons). See Fellner (1971) for explanations for different rates of productivity growth across US industries and Paul M. Romer (1987) on productivity cycles in the late 20th century.

In more recent contributions, Popp (2002) and Newell, Jaffe, and Stavins (1999) show that high energy prices induce energy-saving technological innovation. Acemoglu and Restrepo (2018) and Acemoglu and Restrepo (2019) update theories of induced innovation to a task-based framework and show that firms in US regions with higher wages tend to adopt industrial robots in grater numbers. They argue that labor has been more expensive than capital in the recent low-interest environment and this has tilted innovation towards labor-saving technologies. Research in international trade has long posited that expanding markets lead to higher productivity, whether because of competition (more productive firms survive trade liberalization, as in De Loecker 2007; De Loecker 2011), increasing returns to scale (Acemoglu and Linn: 2004; Atkin, Khandelwal, and Osman: 2017), or innovation (Finkelstein: 2004; Melitz and Redding: 2023).

G. Benigno and Fornaro (2018) and Anzoategui et al. (2019) relate these concepts to the business cycle in models where cyclical demand can have persistent effects on productivity. In these models, high demand relaxes borrowing constraints and/or increases the expected return to innovation through the higher expected demand for the products that innovation would deliver. Hence periods of higher demand will lead to more innovation, and to greater technology diffusion.

I provide a synthesis of several of the ideas exposited here in Ilzetzki (2024), where I use the term "learning by necessity" to refer to productivity growth that is induced by demand that outstrips existing productive capacity. Using archival data on US aircraft production in the Second World War, I show that total factor productivity (TFP) increases by 0.4% within a year of a 1% increase in aircraft demand. The effects are substantially larger when demand is directed towards production lines already operating at high rates of capital utilization. I argue that plants were incentivized to adopt new production methods when high demand confronted their limitted capacity. The implication is that while military purchases may be inflationary when an economy is at full employment, this is

[9] See Nordhaus (1973) for a critique of these early theories.

also when the long-run benefits for productivity growth are greatest.

How did plants increase productivity in face of higher demand in practice? I document several actions taken by aircraft plants. First, I show that plants with higher cumulative experience were more likely to adopt new production techniques, but only if they were already operating at high utilization. This shows concretely that plants modernize their production methods when demand is high relative to production capacity. Importantly, these line-production methods were new to the aircraft industry but mostly adapted from existing production techniques in the automotive industry.

The standardization of products and the move to new production line methods based on interchangeable parts with low tolerances allowed for another managerial innovation: the greater outsourcing of parts of the production process to (domestic) feeder plants. Outsourcing of this sort was commonplace in automotive production but was perceived as irrelevant for the more complex process of airframe production. Nonetheless, by the end of the war, airframe producers outsourced more than 30% of their work hours to feeder plants. I show that reliance on outsourcing responded to high demand and more so when plants were operating at high levels of capacity utilization, so that necessity was the mother of managerial innovations.[10]

Finally, necessity also appears to have spawned better labor relations. Not only did wages increase by 20% in the average aircraft plant during the war; but there were also non-pecuniary ways in which firms helped improve worker satisfaction. Absence rates among women workers was nearly twice that of men. Many women entered the workforce for the first time during the war and faced a difficult balancing act without adequate childcare facilities. Many plants funded childcare facilities to ameliorate this problem. Further, mass migration into tight labor markets created a housing shortage. Management encouraged new housing construction and paid for busses to transport workers to and from more distant places of residence.

Howard (1978) gives an earlier case study that suggests learning by necessity. The concept of interchangeable parts in gun manufacture was well understood in the civilian arms industry by the mid-19th century but didn't spread to the entire industry. It was only the immense demand for weapons and the demand for interchangeable products from multiple manufacturers during the civil war that allowed these processes to become the norm in the industry.

As I've noted, it is difficult to disentangle empirically the role of initial fixed costs, economies of scale, and learning by doing. David C Mowery and Rosenberg (1999a) talk of an initial debugging phase when introducing a new product which may appear in the data as an initial fixed cost or as a learning curve (that shows "satiation"). There is also a fine line between the economics of R&D

[10] In a related contribution, N. Bianchi and Giorcelli (2022) show that government-funded worker and management training programs during World War II increased firm productivity.

and increasing returns to scale. Some knowledge gained through R&D is not appropriable (e.g. it is product- or firm-specific) or patentable. It might nevertheless be under-provided because of economies of scale, as it is often involves a one-off fixed cost. We now turn to the importance of the military in R&D.

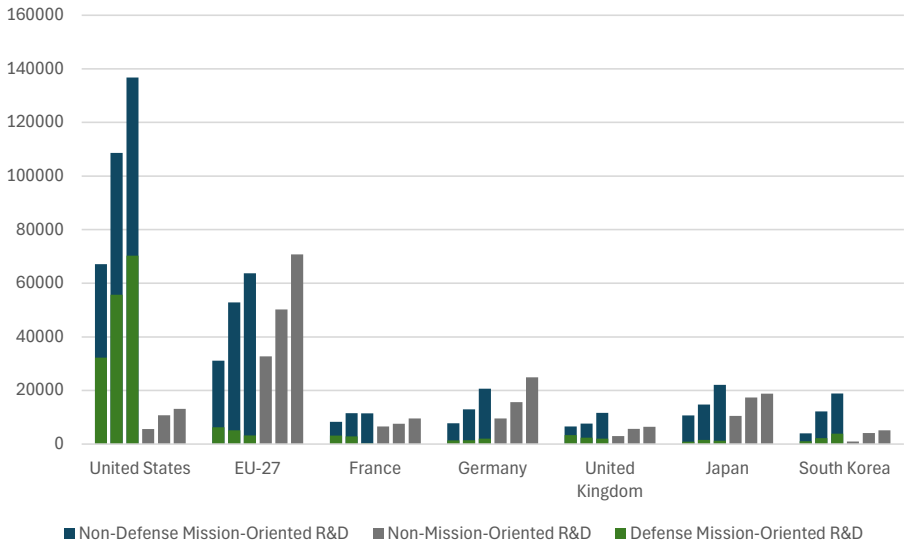
3.3 R&D

Research and development is often given as a textbook case of a positive externality that merits subsidization. But K. Arrow (1962) points out that tax subsidies alone may be insufficient to incentivize innovation. Instead, the entire institutional infrastructure supporting research needs to be considered, including universities, non-profit organizations, the government, and quasi-government institutions. Summarizing US technological advancements during World War II, Bush (1945) advocated institutionalizing the support for civilian R&D through a public peer-review system. Some such support for science has been leveraged through private foundations and governments, e.g. the National Science Foundation, the National Institutes of Health, and the European Research Council. It is certainly more efficient to subsidize research based on merit alone. Military or other mission-oriented R&D risks biasing the direction of technological progress. Nevertheless, David C. Mowery (2010) shows that OECD governments spend at least as much on mission-oriented mission-oriented R&D as they do on non-oriented research.

Figure 4 compares the sums devoted to mission-oriented and open-ended research by several governments. The US devotes 10 times more to mission-oriented R&D–mostly defense related–than it does to non-oriented research. South Korea spends three times as much and the UK twice as much on mission-oriented R&D. Only EU countries spend less on mission-oriented R&D than on non-directed R&D funding. This is not to argue that EU funding to undirect research should decline, but rather that it under-provides mission-oriented R&D relative to its peers. Relatedly, Draghi (2024) documents that the US devotes 16% of its military spending on R&D compared to 4.5% in the EU, making US military R&D spending 12 times larger in euro terms.

R&D investments with a clear mission focus are easier to mobilize, possibly because it is difficult to garner public and political support for R&D investments that don't have a clear public "deliverable". While defense isn't the only mission for which R&D is mobilized, it is by far the largest category of R&D spending in the US and by anecdote appears to lead to the greatest innovation. In way of example, nearly three quarters of the US R&D for aircraft development was provided by the US government in the cold-war era (David C. Mowery and Rosenberg 1999b). If anything, direct military investment in R&D understates the government's role of in facilitating R&D. According to David C. Mowery (2010), some of the most important breakthroughs in the early-Cold-War

Figure 4: Public research and development spending by country, year, and category



Note: The figure shows public spending on research and development in millions of US dollars, normalized to 2019 prices (at purchasing power parity). The bars are for the years 2000, 2010, and 2019 from left to right and are separated into mission-oriented (colored bars) and non-directed (gray bars) research. The mission-oriented research spending is separated into defense-related (green) and non-defense (gray).
Source: Own calculation and presentation.

semiconductor industry were due to *private* R&D investments, but these were done with an eye to military procurement contracts. There was an implicit "advance market guarantee" for new integrated circuit products that made these investments appear profitable. I note that military R&D has halved in the EU over the past 20 years and declined by a factor of 10 in France. This compares with a 50% increase in Japan, a doubling in the US, and a quadrupling in South Korea. Mazzucato (2021) calls for non-military mission-oriented public R&D. However, it is unclear whether this is politically feasible and whether it will lead to innovations and spillovers as large as those from the defense sector. I emphasize this isn't a call for more armament merely because of the innovation it garners, but rather an evaluation of a positive side-effect of military production insofar as it is necessary.

Revisiting the main arguments for public R&D support, it is useful to return to the seminal work of K. J. Arrow (1962). Assumptions undergirding free market efficiency are particularly tenuous when

considering information as a commodity. First, information is non-rival, as it can be disseminated at little cost. Selling knowledge is self-defeating because it breaks the seller's monopoly on this knowledge. It can be made excludable, i.e. through patents, but there are many forms of knowledge that aren't patentable. Second, and somewhat forgotten in modern economic discourse, the production of knowledge is risky, and more so the farther it is from a marketable state, e.g. basic science. If perfect financial markets existed to insure researchers against the risk of failure, the free market would create the optimal quantity of science and innovation. Of course, such insurance markets are unlikely to exist because of moral hazard and adverse selection: they would disincentivize innovators to exert research effort and the innovators least confident in their abilities would be most likely to purchase insurance.

David C. Mowery (2010) speaks of three mechanism through which military R&D can have positive effects on innovation. First "spinoffs" from military to civilian applications reflect the knowledge externalities discussed above. Second, procurement, which we discussed in the context of economies of scale and learning by doing, but also in the context of advance market guarnatees that may support innovation. Finally, military R&D supports human capital development. Beyond direct investments in human capital incurred in the process of military R&D and procurement, David C. Mowery (2010) discusses the research infrastructure that military investments help support, including academic and non-governmental institutions.

Estimated returns to private and public R&D are large. B. F. Jones and Summers (2022) estimate the total social returns to R&D spending at 67%. Fieldhouse and Mertens (2023) find even larger returns for public R&D, as high as 300%, although the returns are lower for military than non-military R&D. By these estimates, public R&D more than pays for itself through the tax revenues that are induced by its associated GDP growth. Antolin-Diaz and Surico (2022) show that short-term increases in defense spending can have long-lived effects and that this is mostly due to the R&D component of public spending. By their estimate, a temporary, 1% of GDP, increase in military spending leads to a persistent increase in TFP of around 0.3%. Dyevre (2023) shows that firms more exposed to spillovers from public R&D saw productivity gains and that public R&D has greater spillovers than private R&D. He argues that the decline in public R&D (and its replacement with private R&D) can explain a substantial share of the productivity slowdown of the past decade(s).

There are several lessons from US Cold-War procurement policies for technological innovation and spillovers. First, unlike European governments, whose procurement was concentrated in a small number of defense contractors, Department of Defense procurement was more widespread, reaching smaller civilian-oriented companies. This provided procurement support for smaller, younger, often more innovative companies. Spillovers to civilian technologies were more likely in these dual-use

firms. Second, the US Department of Defense had a procurement doctrine of "dual sourcing". This refers to the practice of maintaining multiple suppliers for identical or closely substitutable products. This fostered competition among suppliers and gave the military supply network greater resilience. This arguably also had the side benefit of technology-sharing among private firms, allowing for greater R&D spillovers. [11]

Howell et al. (2021) utilize a natural experiment whereby the Department of Defense used both conventional and open competitions for procurement. The former specifies a specific military product and allows firms to bid for contracts to design the product. The latter specifies a military necessity and allows private firms to propose solutions. They find that open competitions reached a broader set of firms that are smaller, younger, and more technology-oriented. These firms proposed better solutions for the military's needs, as evidenced by their higher probability of winning contracts and securing future procurement. The open contracts also led to more patents and dual-use spillovers.

A recent literature gives a growing body of evidence of the merits of military R&D or public R&D more broadly. In an international study of military R&D, Moretti, Steinwender, and Van Reenen (2019) show that a 10% increase in government-funded military R&D crowds in more than 4% of private R&D. Myers and Lanahan (2022) show that each patent funded by the department of energy leads to 3 additional private-sector patents, sometimes in very different fields. Gross and Sampat (2023) show that military R&D can have long-lasting effects on innovation and the creation of technology clusters. They study the US government's Office of Scientific Research and Development that supported R&D in firms and universities during World War II. This support had long-lasting effects on entrepreneurship and employment and shaped the direction of post-war innovation. Relatedly, Kantor and Whalley (2023) shows that Nasa's investments in technology spurred employment in high-tech sectors. (See also Levy and Terleckyj 1983; Griliches and Lichtenberg 1984; Griliches 2007.)

As a counterpoint, Nef (1950), Milward (1979), and Mokyr (1992) implore us to not fetishize the very visible technological advancements caused by military necessity. Milward (1979) warns that militaries take a conservative approach to technological development, favoring the fast gains of improving existing technologies than making discrete technological jumps. The anecdotal counterexamples are however, very compelling. It is difficult to imagine nuclear power emerging so early without World War II R&D or space exploration technologies in the 1960s without NASA.

The research cited above mostly draws on the US experience during the Cold War. Feiglin (2020) cautions that this was a unique historical period of "spinoffs" where technologies spilled over from

[11] However, C.J. Hitch warns, in his commentary of K. J. Arrow (1962), that dual sourcing disincentivizes product innovation at the prototype stage. A firm may be reluctant to invest large resources in developing a new product knowing that the knowledge and much of the procurement may be transferred to a competitor.

military to civilian uses. Historically, it was more common for militaries to co-opt civilian technologies for military purposes. He argues that the 21st century is better characterized by "spin-ons", with the prominent examples of cybersecurity methods, drone technologies, and even aerospace technologies developed in the private sector and adopted by militaries. There are two possible reasons for this shift with nearly opposite policy implications. On one hand, the cut in military R&D may have made militaries more reliant on civilian technologies. In this case, increased military spending with a focus on R&D could benefit not only armaments but also the private sector (Dyevre: 2023). On the other hand, increased globalization and the growth of the consumer economy may have dwarfed the armaments sector to such an extent that military R&D is relegated to a sideshow, in which case the spillovers from military R&D will be less important in the future.

Most studies on the effects of public R&D and military R&D on innovation and the economy use US data, raising the concern that they do not translate neatly to other countries. However David, B. H. Hall, and Toole (2000) summarize the evidence that public and private R&D are more substitutable in the US than elsewhere, suggesting more positive spillovers from private to public investment outside the US.

3.4 Industrial policy

Beyond Nato commitments, the EU has also anounced the European Defence Industrial Strategy (EDIS) and the European Defence Industry Programme (EDIP) in March of this year. It plans to increase joint defense procurement within EU structures. It also aims to increase the independence of the European defense industrial and technological base and improve the resilience of supply chains. Some form of industrial policy or strategy is part and parcel of almost any military expansion. Military expansions are therefore related to industrial policy.

Theories of industrial policy had a heyday in the mid-20th century (Rosenstein-Rodan: 1943; Hirschman: 1958), but were met with skepticisim, if not outright hostility, later in the century. In recent years, a revitalized literature has studied the economics of industrial policy and strategy. Juhász, Lane, and Rodrik (2024) define industrial policies as "those government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal". This seems to me too broad a definition, as it might apply to most government policies. Affordable housing policy, public health care provision, and increased defense spending all intend to transform the structure of activity in certain directions, but wouldn't normally be viewed as industrial policy. The definition should be refined, in my view, to focus on the long run and on the supply side, so as to state that these are government policies aimed at increasing *production* in a *specific economic sector* in the *long run* above and beyond *public good provision*. Thus, the mortgage interest deduc-

tion would not be considered industrial policy, because it isn't aimed at restructuring the economy towards more housing construction, even if it does so indirectly, although it intends to increase home ownership, and thus the structure of the economy on the demand side. Similarly, construction of military facilities using public funds would not be considered industrial policy, because the aim is to acquire the public good, and the assistance it provides to the construction industry is incidental. In addition, a broad-based subsidy for R&D would not, in my view, constitute industrial policy because it supports innovation writ-large, without attempting to direct the sectoral composition of innovation. In contrast, subsidies to the construction industry, or R&D tax benefits targeted to an industry would be considered industrial policy by this definition.

The main rationales for industrial policy echo the previous discussion in this section. They range from confronting economies of scale to addressing externalities, such as the under-provision of innovation from the private sector.

As Juhász, Lane, and Rodrik (2024) point out, subsidies are the most common industrial policy, but there is a broad range of policies that are employed in practice. Military spending is important in this regard, because it creates a portfolio of industrial policies aimed at shifting economic activity and innovation in directions consistent with military strategy. Importantly, a few of the most prominent examples of successful industrial policies were motivated by defense strategy. Industrial policy has been suggested as a reason for the emergence of the "East-Asian tigers" in the second half of the 20th century. Lane (2022) describes South Korea's support for the heavy chemicals industry as motivated by US President Richard Nixon's threat to withdraw US troops from the Korean peninsula. The need for domestic defense motivated the support military-relevant industries. Lane (2022) shows that these policies, mostly centered on directed credit, caused the industry to nearly double from the late 1960s to the mid-1980s. He also shows that these policies allowed the country to develop a comparative advantage in these industries. Choi and Levchenko (2021) show, using a structural model, that these policies were welfare-increasing for South Korean citizens.

Another example of military-driven industrial policy is the Defense Advanced Research Projects Agency (DARPA), a US agency supporting speculative research with high risks and high expected rewards. The agency was created to compete with the Soviet Union, following the successful launch of Sputnik into Earth's orbit. Although the agency's focus has been military applications, it has led to many spin-offs including lasers, the personal computer, the internet, and GPS (Azoulay et al.: 2019). Comprehensive empirical evidence on DARPA's innovative role is challenging, due to the program's secrecy.

A few common critiques of industrial policy include the difficulty to identify "winners", and the risk of political capture of government by the supported industries. On the first critique, Juhász,

Lane, and Rodrik (2024) argue that the problem is not so much the challenge in identifying winners, as this needs to be a trial and error process. In analogy, one doesn't expect every venture capital investment to succeed; instead, venture capitalists profit by identifying rare success among numerous failures. The problem with industrial policy is instead the government's possible inability to let go of "losers". New research gives guidance how to target industrial policies. Liu (2019) uses a network model and coins the phrase "distortion centrality" to refer to industries that are both distorted (in the senses described above) and are also central to the production network (see also Liu and Song 2021 on the allocation of R&D support in a similar context). The problem of weeding out losers may also explain the importance of mission-oriented R&D or industrial policy, as it is measured by the mission's ex-post success, not ex-ante speculation on its value.

3.5 Learning by importing

The long-run impacts of military buildups enumerated above depend on the domestic production of military materiel. Military production is concentrated in a small number of countries, with the US and Russia alone accounting for 53% of global arms exports and seven countries exporting 80% of all global arms (US, Russia, France, China, Germany, Italy and the UK).[12] For most countries, therefore, an expansion in defense expenditure entails substantial arms imports. EU member states import nearly 80% of their military equipment (Draghi: 2024). It is therefore crucial to understand the economic implications of imported military spending.

Burstein, Cravino, and J. Vogel (2013) investigate whether importing skill-biased technology increases domestic wages. They posit that the effects depend on how complementary high-skilled labor is with the capital imports and how complementary high- and low-skilled labor are with each other. They find substantial complementarities between high-skill labor and capital, so that importing capital-biased technologies, like military materiel, can boost high-skilled wages. The median country in the sample witnessed a ten percent increase in high-skilled wages because of increased imports in the late 20th century, but the effects differ across countries (see Table 3 in their paper). Low-skilled labor is only moderately complementary with high-skilled labor implying modest gains in low skilled wages: around four percent.

Lee (1996) shows that Korean importing firms have invest more in R&D historically and this may indicate technology transfer and learning by importing. Further, Bergeaud et al. (2024) show that a French firm's entry into a new market increases citations in the destination country, in fields related to, but not competing with, the exporting firm. In contrast, Almodóvar, Saiz-Briones, and Silverman (2014) find that importing firms patent no more frequently than other firms, but they are

[12] https://www.sipri.org/sites/default/files/2024-03/fs_2403_at_2023.pdf

more likely to introduce new products. A. Vogel and Wagner (2010) find that importing firms tend to be more productive, but they evaluate that this is primarily because more productive firms are those that import (selection), with little evidence of technology transfer or "learning by importing".

Poland provides a preliminary case study. Support for Ukraine and the heightened threat of a Russian invasion prompted Poland to increase military spending to 3.1% of GDP in 2024 and 4.8% in 2025. The majority of spending is focused on imported equipment. This includes substantial imports of Poland Apache helicopters, HIMARS rocket systems and precision strike units, M1A1 Abrams tanks, and integrated air and anti-missile defense command systems. Poland has also procured hundreds of K2 Black Panther and K9 Thunder tanks from South Korea. However, contracts for the latter will involve production and servicing by Polish companies and may lead to local investment in new facilities.

There are already indications of technology transfers and growth in Polish military manufacturing. Poland is preparing to sign a contract with South Korea to license the technology for K2 Black Panther tanks, with plans to to produce over 80% of the tanks in Poland. Polish companies can potentially incorporate elements of this technology into indigenous military hardware, such as the Borsuk Infantry Fighting Vehicle. Similarly, Polish lawmakers have floated the idea of designing the next generation of K2 tanks jointly with South Korea.

4 Other considerations

I now address several additional common questions that arise about military buildups and have not been addressed in the previous sections.

4.1 National vs. international procurement

I begin with a few thoughts on procurement policy, particularly in the European context. First, and most obviously, defense is a public good for the EU as a whole (and Nato more broadly). It therefore makes little sense for procurement strategy to be conducted at the national level. I will not elaborate on this point, which has been discussed in detail elsewhere (cf. Nicoli and Beetsma 2024; Draghi 2024).

Second, only few EU countries have a mature defense industry and the question arises whether countries should procure their munitions locally (domestically or from other EU member states) or internationally (for example from the US, the largest munitions producer). There is a tradeoff between domestic and imported procurement. A purely budgetary point of view would argue for choosing the most productive and highest quality suppliers, which may include substantial imports.

Imported materiel will often be cheaper and face shorter delivery times. We have seen that Poland's armament drive since 2022, with defense expenditures rising to 4% of GDP, mostly took the form of imports from the US and South Korea. Given the urgency of its defense needs, it was implausible for Poland to develop the productive capacity for domestic production and imports were inevitable in the short run.

Importing arms will also be less inflationary because it puts less pressure on the local economy. Conversely, fiscal multipliers will also be lower on imported materiel. For example, Ilzetzki, Mendoza, and Végh (2013) find nearly zero fiscal multipliers for countries that are relatively open to international trade and this is true even though the analysis is for government purchases that are mostly domestic. The argument for small multipliers for imported government purchases is even clearer. Finally, much of the discussion above regarding the productivity benefits of military spending become moot if the procurement is from overseas. However, there still may be knowledge spillovers, as we have seen in the discussion of learning by importing in Section 3.

When procurement needs are urgent, substantial imports of munitions may be inevitable. However, a long-run procurement strategy may call for domestic capacity building, with a greater home-bias of procurement. Policymakers should consider the tradeoff between the short term benefit of cheaper imported materiel and benefiting from dynamic economies of scale (learning by doing) whereby an economy can develop a comparative advantage in the long run that it doesn't posses at the onset. Preferring domestic procurement should be done with caution: governments should avoid becoming captive consumers of a small number of domestic producers. Procurement policies should leave foreign producers in the contest, when possible, to foster competition. EU member states procure nearly 80% of their military materiel from outside the EU and this almost certainly tilts the balance too far in favor of international sourcing (Draghi 2024, p. 8).

There is a related but separate question of local content requirements. Should governments put restrictions on its suppliers to procure intermediate goods from other domestic firms? Here the case is far less clear. Modern supply chains are complex and at times inflexible and these decisions are best left to the producers, unless when national security considerations are at play. Indeed, Acosta and Cox (2024) find that fiscal multipliers on "buy America" procurement in the US has smaller multipliers than unrestricted procurement contracts, despite the requirement that a majority of the production process of the former be in the US.

Finally, there is the question of how to spread procurement across EU member states. There may be a tradeoff between efficiency and equity. Economies of scale, learning by doing, and agglomeration economies argue for concentration of production in a few locales. The obvious counterpoint is that this concentration also concentrates the economic benefits of the spending while spreading the fiscal

costs. A possible middle ground is a conscious decision to allow member states to specialize in specific military materiel, depending on their size and their comparative advantage. Of course, such specialization would require EU-wide coordination in defense procurement, which is currently lacking (Draghi 2024, p. 7).

4.2 How to fund it

Economic theory has clear recommendations on the funding of military expenditures. The principle at play is "tax smoothing" (R. J. Lucas and Stokey: 1983; Chari and Kehoe: 1999) and wars are often used as a textbook case for the use of public debt to smooth the burden of taxation. The basic idea is as follows. Taxes impose a non-linear cost to the economy. Further, tax variability is harmful to the economy. Put simply, it is better to fund the public purse with a tax rate of 20% every year than at alternating rates of 10% and 30% every other year. (Further, the latter strategy would lead to higher debt in the long run, precisely because it is more harmful to the economy.) An optimal funding strategy demands policymakers to de-link fluctuations in funding needs from the *timing* of taxation. Of course, the *average* rate of taxation needs to be sufficient to fund expenditures in the long run and for debt to be sustainable.

An optimal funding strategy for a military buildup therefore distinguishes between temporary and permanent increases in military spending. A temporary increase in spending, a war, for example, should be funded almost entirely by public debt. Taxes might have to rise moderately to fund this increase in public debt eventually, but there is no cause to increase taxes in wartime.

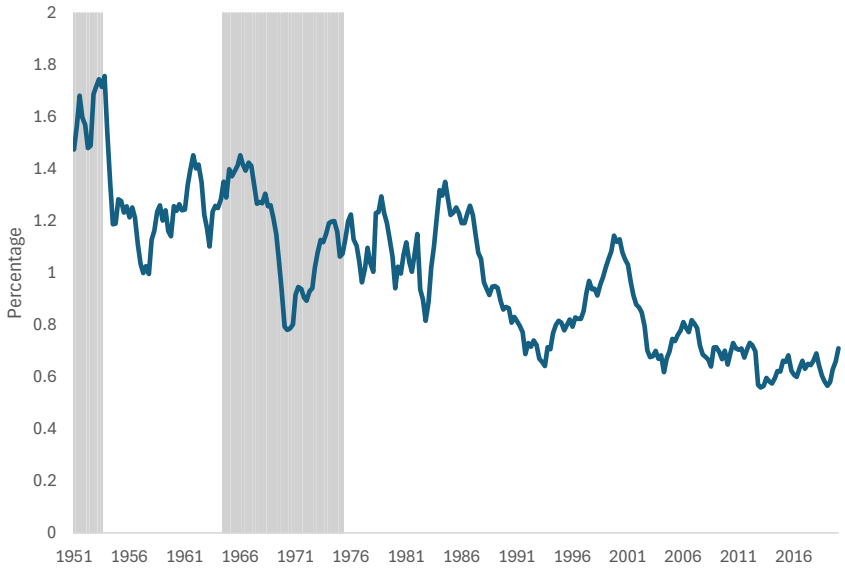
We have noted earlier that the size of fiscal multipliers depends on the financing of public spending. Baxter and King's (1993) modeling predicts that a balanced budget increase in government consumption is contractionary because the increase in taxation more than crowds out the positive impact of the increase in government consumption. C. D. Romer and D. H. Romer (2010) show that tax multipliers can be large to the point that multipliers can be negative if military spending is financed in a balanced-budget manner.

A permanent increase in military spending, in contrast, requires that tax revenues rise to fund these higher expenditures. However, this latter recommendation should be heeded with caution because much military expenditure takes the form of durable materiel. Building up a stock of munitions is an upfront cost. It is later followed by maintenance, replenishment, and upgrades of the stock of munitions, but these are expected to have a lower cost than the initial buildup.

The US experience during the Korean war gives a cautionary tale of a balanced budget armament strategy. Presidents Truman and Eisenhower both attempted to finance the increased war expenditures through higher taxation rather than borrowing (Kinnard: 1977; Eisenhower: 1965). Tax

revenues increased substantially during the war (although part of this was due to inflation), and the top marginal tax rate was raised to its highest post-World War rate of 92%. The consequence of volatile taxation was the the most volatile economic growth in post-war US economic history (see Figure 5).

Figure 5: Volatility of US GDP growth



Note: The figure shows the four-year moving average of the absolute value of US real GDP.
Source: The author and U.S. Bureau of Economic Analysis, Real Gross Domestic Product [GDPC1], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPC1, January 10, 2025.

If taxes don't rise in response to a military buildup, public debt accumulates. The counterpoint to a tax-smoothing strategy is that high public debt could lead to higher borrowing rates, inflation, or even a sovereign debt crisis. The US and European countries all enter this era of geopolitical tensions with high debt burdens. A prudent compromise is to legislate moderate, but credibly persistent increases in taxation. Given the estimated multipliers on government consumption and investment, required tax hikes are relatively small. Valerie A Ramey and Zubairy (2018) estimate that a (cumulative) 1% of GDP increase in military expenditure raises GDP (cumulatively) by around 0.7%. If the average tax rate is 25% (low for a European economy), taxes can be expected to increase

by almost 0.175% of GDP. The remaining revenues could be raised by increasing average tax rates by merely 0.1% of GDP over 8 years. The tax increase can be even smaller if public debt takes part of the burden. In addition, debt will erode further as a percent of GDP if the nominal interest rate is lower than the rate of economic growth, as it has been in high-income countries for much of the 21st century. None of this is to dismiss concerns about elevated public in high income countries or of debt sustainability. Sovereigns do require long-term plans to live within their means. Instead, the message is that a temporary increase in public spending is unlikely to be the straw that breaks the camel's back and can be funded with moderate tax increases in the long run.

Marzian and Trebesch (2025) show that governments have largely followed these prescriptions. In a study of roughly 100 military buildups from 1800 to today, they find that government haves financed wars mostly through borrowing. When tax rates rose, these were typically because of substantial tax reforms that expanded the tax base, consistent with the theories of Tilly (2017), Besley and Persson (2009), and Besley, Ilzetzki, and Persson (2013). These tax reforms led to persistently higher revenues that allowed for expansions of the welfare state in the longer run.

4.3 It's what you get, not what you spend

The objective of procurement is to obtain the highest quality public goods or assets at the lowest cost. This is generally well understood, but when it comes to setting Nato defense targets, the objective is typically set in terms of percent of GDP objectives. Following the Russian invasion of Ukraine, European Nato members reiterated their commitment to setting defense spending at 2% of GDP, with some recent calls to aim for 3%. Yet such targets may achieve the exact opposite of the commonly understood objective of procurement. By setting spending targets, the objective becomes "getting the money out of the door',' which neither ensures the procurement of appropriate armaments nor incentivizes cost savings.

A percent-of-GDP target has several disadvantages. First, it may lead to pro-cyclical public spending, which is suboptimal from a macroeconomic demand-management perspective. When GDP declines, this means that military spending declines in euro terms, rather than remaining constant or increasing to boost the economy. Section 2 discussed how both economic theory and empirical evidence call for either counter-cyclical or a-cyclical public spending.

Second, it ignores the fact that armaments are durable. The lifecycle of durables is such that there may be some larger up-front procurement costs with lower maintenance, replenishment, replacement, and upgrade costs. A percent-of-GDP that is constant over time leads to under-spending in the early armament stages and incetivizes wasteful spending later in the cycle.

Third, productivity gains due to learning-by-doing can lead to long-run cost savings that imply

lower costs for the same quality of materiel over time. For example, Figure 6 shows the average unit costs of aircraft in the US production drive of World War II. The figure controls for the type of aircraft, so simply shows cheaper a given aircraft model became over time. Unit costs declined by more than 30% over merely 5 years. The US government (War Production Board) set quantitative targets for aircraft and quality targets for their improvement. Imagine if instead the government had set *spending* targets. Would aircraft producers have had the same incentives to increase production and improve productivity? Worse yet would have been a percent-of-GDP target, which would have guaranteed increased defense expenditures as the economy expanded. Thanks to the massive productivity gains of this period, GDP roughly doubled, which would have required military spending to double regardless of strategic objective. These were admittedly years with unprecedented volumes of production and government support for this industry. Nevertheless, the figure illustrates that setting quantitative targets incentivize productivity and allow governments to pocket the savings due to productivity growth (which in this case the government mostly spent on larger quantities and new varieties of military equipment).

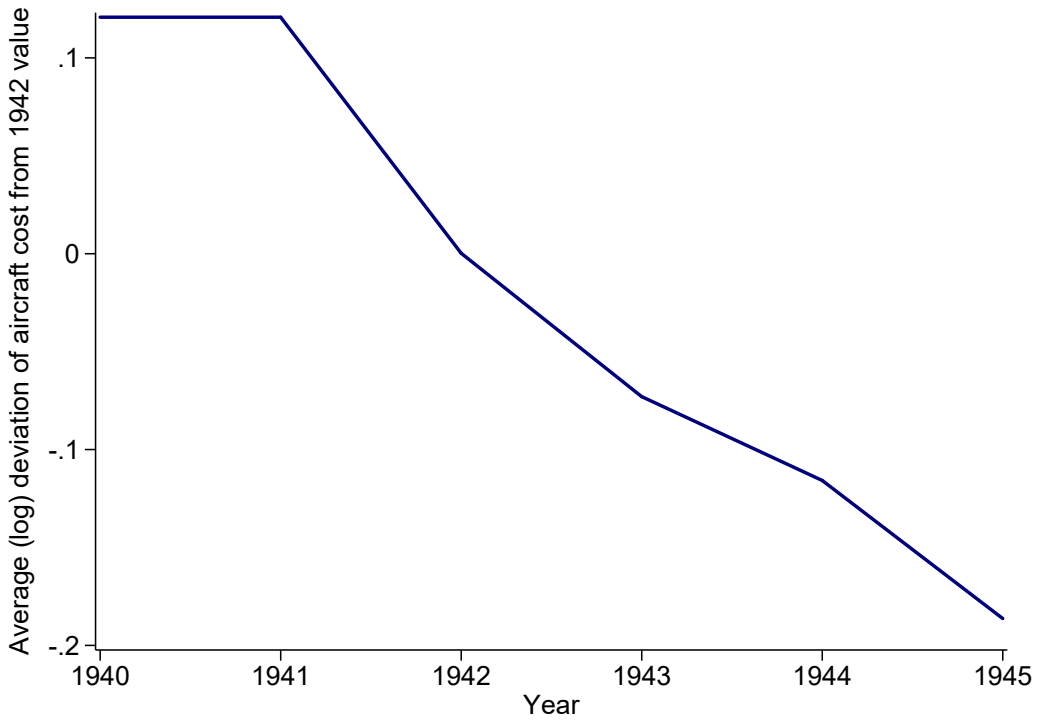
Finally, targeting expenditure rather than the quantity and quality of armaments may create inappropriate incentives to in procurement policies. Anyone experienced with public procurement is familiar with the culture of "getting the money out of the door" at the end of fiscal years.

How then, should Nato members set measurable targets for defense buildups without setting spending targets? Here too, lessons can be drawn from the US production drive in World War II. In May 1940, after the fall of France, President Roosevelt set an ambitious objective of producing 50,000 planes during the war (Fireside chat, May 26 1940). Economists Robert Nathan and Simon Kuznetz estimated that the US didn't have the productive capacity to meet this aim. Yet the US aircraft industry produced twice this number of aircraft in 1944 alone (War Production Board 1945 p. 10). Similarly, I recommend that countries and alliances set targets for the size of armed forces personnel and the stock and operational quality of munitions. These cannot be divorced from fiscal considerations, but policymakers should be allowed to benefit from cost savings that may arise in the process. One possible exception is R&D, where results are uncertain and expenditure targets may be inevitable. Here, too, procurement competitions, as in Howell et al. (2021) may be able to set objectives for outcomes rather than expenditures.

5 Conclusions

This paper has examined the economic implications of military buildups, with attention to their short- and long-run effects on economic growth, productivity, and fiscal sustainability. Reviewing

Figure 6: Unit costs of US aircraft during World War II



Note: The figure shows the log deviation of the cost of an aircraft produced in the US during World War II in the average production line. The range is equivalent to -20% to 10% deviations from 1942 costs. Values obtained by regressing the logarithm of unit costs on production line fixed effects and then averaging across production lines.
Sources: Ilzetzki (2024) and the author.

a broad literature on the topic, the evidence suggests that, in the short run, military spending typically stimulates economic economic growth, though the extent of this expansion depends on the broader economic context, financing strategies, and monetary policy responses. While the empirical literature remains divided on whether military expenditures crowd out private sector activity, the consensus is that the economy is generally resilient to such shocks, with fiscal multipliers ranging from moderate to substantial under appropriate conditions. However, achieving optimal outcomes requires a carefully calibrated approach to funding, with temporary expenditures ideally financed through debt and permanent commitments possibly requiring fiscal adjustments to ensure sustainability.

Turning to the long-run effect, military-driven investments in R&D and large-scale procurement have historically catalyzed significant technological advancements and allowed for productivity gains through economies of scale and learning-by-doing. There is evidence of positive spillovers to the civilian sector. Yet, the strategic focus of these investments poses risks of misallocation or entrenchment

in suboptimal technologies. To maximize the long-term economic benefits while minimizing distortions, policymakers should prioritize procurement policies that foster competition, encourage dual-use innovations, and carefully balance domestic and international production considerations. Additionally, transitioning from rigid spending targets as a percent of GDP to capability-based objectives could enhance efficiency while accommodating dynamic cost reductions and evolving geopolitical needs. Ultimately, while military buildups can yield positive economic externalities, their justification and implementation must remain rooted in strategic imperatives, mindful of both the economic and human costs they entail.

References

Acemoglu, Daron and Joshua Linn (2004). Market Size in Innovation: Theory and Evidence from the Pharmaceutical Industry. *The Quarterly Journal of Economics* 119.3, pp. 1049–1090. https://ideas.repec.org/a/oup/qjecon/v119y2004i3p1049-1090..html.

Acemoglu, Daron and Pascual Restrepo (2018). The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *The American Economic Review* 108.6, pp. 1488–1542. https://www.jstor.org/stable/26528016 (visited on 07/10/2024).

— (2019). Automation and New Tasks: How Technology Displaces and Reinstates Labor. *The Journal of Economic Perspectives* 33.2, pp. 3–30. https://www.jstor.org/stable/26621237 (visited on 07/10/2024).

Acosta, Miguel and Lydia Cox (2024). "The Effects of "Buy American" Restrictions on Government Purchases". Working Paper.

Aghion, Philippe and Peter Howitt (1992). A Model of Growth Through Creative Destruction. *Econometrica* 60.2, pp. 323–351. http://www.jstor.org/stable/2951599 (visited on 12/26/2024).

— (Apr. 1997). *Endogenous Growth Theory*. Vol. 1. MIT Press Books 0262011662. The MIT Press. ISBN: ARRAY(0x8b65b840). https://ideas.repec.org/b/mtp/titles/0262011662.html.

Alchian, Armen (1963). Reliability of Progress Curves in Airframe Production. *Econometrica* 31.4, pp. 679–693. http://www.jstor.org/stable/1909166.

Allen, Robert C. (2009). *The British Industrial Revolution in Global Perspective*. Cambridge, England: Cambridge University Press.

Allison, Graham (2017). *Destined for War: Can America and China Escape Thucydides's Trap?* Boston: Houghton Mifflin Harcourt. ISBN: 9780544935273. https://www.amazon.com/Destined-War-America-Escape-Thucydidess/dp/0544935276.

Almodóvar, Paloma, Javier Saiz-Briones, and Brian S Silverman (2014). Learning through foreign market participation: the relative benefits of exporting, importing, and foreign direct investment. *The Journal of Technology Transfer* 39, pp. 915–944.

Alptekin, Aynur and Paul Levine (2012). Military expenditure and economic growth: A meta-analysis. *European Journal of Political Economy* 28.4, pp. 636–650. DOI: https://doi.org/10.1016/j.ejpoleco.2012.07.002.

Antolin-Diaz, Juan and Paolo Surico (2022). The Long-Run Effects of Government Spending. *CEPR Discussion Paper* 17433. https://cepr.org/publications/dp17433.

Anzoategui, Diego et al. (2019). Endogenous technology adoption and R&D as sources of business cycle persistence. *American Economic Journal: Macroeconomics* 11.3, pp. 67–110.

Arrow, Kenneth (1962). "Economic Welfare and the Allocation of Resources for Invention". *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton University Press, pp. 609–626. http://www.nber.org/chapters/c2144.

Arrow, Kenneth J. (1962). The Economic Implications of Learning by Doing. *The Review of Economic Studies* 29.3, pp. 155–173. http://www.jstor.org/stable/2295952.

Arthur, W. Brian (Mar. 1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal* 99.394, pp. 116–131. DOI: 10.2307/2234208.

Asher, Harold (1956). *Cost-Quantity Relationships in the Airframe Industry*. Santa Monica, CA: Rand Corporation.

Atkin, David, Amit K. Khandelwal, and Adam Osman (Feb. 2017). Exporting and Firm Performance: Evidence from a Randomized Experiment. *The Quarterly Journal of Economics* 132.2, pp. 551–615. DOI: 10.1093/qje/qjx002.

Auerbach, Alan J and Yuriy Gorodnichenko (2013). "Fiscal multipliers in recession and expansion". *Fiscal policy after the financial crisis*. University of Chicago Press, pp. 63–98.

— (May 2012). Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy* 4.2, pp. 1–27. DOI: 10.1257/pol.4.2.1.

Azoulay, Pierre et al. (2019). Funding Breakthrough Research: Promises and Challenges of the "ARPA Model". *Innovation Policy and the Economy* 19, pp. 69–96. DOI: 10.1086/699933.

Babbage, Charles (1832). *On the economy of machinery and manufactures*.

Bahk, Byong-Hyong and Michael Gort (1993). Decomposing Learning by Doing in New Plants. *Journal of Political Economy* 101.4, pp. 561–583. http://www.jstor.org/stable/2138739 (visited on 07/03/2024).

Bajari, Patrick and Steven Tadelis (2001). Incentives versus Transaction Costs: A Theory of Procurement Contracts. *The RAND Journal of Economics* 32.3, pp. 387–407. http://www.jstor.org/stable/2696361 (visited on 03/21/2024).

Barro, Robert J (Oct. 1979). On the Determination of the Public Debt. *Journal of Political Economy* 87.5, pp. 940–971. DOI: 10.1086/260807.

Barro, Robert J. and Charles J. Redlick (Feb. 2011). Macroeconomic Effects From Government Purchases and Taxes. *The Quarterly Journal of Economics* 126.1, pp. 51–102. DOI: 10.1093/qje/qjq002.

Barro, Robert J. and Xavier I. Sala-i-Martin (2003). *Economic Growth, Second Edition*. Boston, MA: MIT Press.

Basu, Susanto and John G. Fernald (1997). Returns to Scale in U.S. Production: Estimates and Implications. *Journal of Political Economy* 105.2, pp. 249–283. http://www.jstor.org/stable/10.1086/262073.

Baxter, Marianne and Robert G. King (1993). Fiscal Policy in General Equilibrium. *The American Economic Review* 83.3, pp. 315–334. http://www.jstor.org/stable/2117521 (visited on 12/26/2024).

Beard, Charles A. and Mary R. Beard (1927). *The Rise of American Civilization*. The Macmillan Company.

Benigno, Gianluca and Luca Fornaro (2018). Stagnation traps. *The Review of Economic Studies* 85.3, pp. 1425–1470.

Benigno, Pierpaolo and Gauti B Eggertsson (Feb. 2024). *The Slanted-L Phillips Curve*. Working Paper 32172. National Bureau of Economic Research. DOI: 10.3386/w32172. http://www.nber.org/papers/w32172.

Benoit, Emile (1973). *Defence and Economic Growth in Developing Countries*. Boston, MA: D. C. Heath.

— (1978). Growth and Defense in Developing Countries. *Economic Development and Cultural Change* 26.2, pp. 271–280. http://www.jstor.org/stable/1153245 (visited on 04/16/2024).

Bergeaud, Antonin et al. (2024). *Exporting Ideas: Knowledge Flows from Expanding Trade in Goods*. Discussion Paper 19260. DP19260. CEPR. https://cepr.org/publications/dp19260.

Berghahn, Volker Rolf (2005). *Imperial Germany, 1871-1918: economy, society, culture, and politics*. Berghahn Books.

Besley, Timothy, Ethan Ilzetzki, and Torsten Persson (2013). Weak states and steady states: The dynamics of fiscal capacity. *American Economic Journal: Macroeconomics* 5.4, pp. 205–235.

Besley, Timothy and Torsten Persson (2009). The origins of state capacity: Property rights, taxation, and politics. *American economic review* 99.4, pp. 1218–1244.

Bianchi, Francesco and Cosmin Ilut (Oct. 2017). Monetary/Fiscal Policy Mix and Agent's Beliefs. *Review of Economic Dynamics* 26, pp. 113–139. DOI: 10.1016/j.red.2017.02.011.

Bianchi, Nicola and Michela Giorcelli (2022). The Dynamics and Spillovers of Management Interventions: Evidence from the Training within Industry Program. *Journal of Political Economy* 130.6, pp. 1630–1675. DOI: 10.1086/719277.

Blanchard, Olivier and Roberto Perotti (Nov. 2002). An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output*. *The Quarterly Journal of Economics* 117.4, pp. 1329–1368. DOI: 10.1162/003355302320935043.

Boehm, Christoph E. and Nitya Pandalai-Nayar (Dec. 2022). Convex Supply Curves. *American Economic Review* 112.12, pp. 3941–69. DOI: 10.1257/aer.20210811.

Born, Benjamin et al. (2024). Mr. Keynes Meets the Classics: Government Spending and the Real Exchange Rate. *Journal of Political Economy* 132.5, pp. 1642–1683. DOI: 10.1086/727707.

Brunet, Gillian (Mar. 2024). Stimulus on the Home Front: The State-Level Effects of WWII Spending. *The Review of Economics and Statistics*, pp. 1–46. DOI: 10.1162/rest_a_01432.

Burstein, Ariel, Javier Cravino, and Jonathan Vogel (2013). Importing skill-biased technology. *American Economic Journal: Macroeconomics* 5.2, pp. 32–71.

Bush, Vannevar (1945). *Science, the Endless Frontier*. Princeton University Press.

Caldara, Dario and Matteo Iacoviello (Apr. 2022). Measuring Geopolitical Risk. *American Economic Review* 112.4, pp. 1194–1225. DOI: 10.1257/aer.20191823.

Chari, V.V. and Patrick J. Kehoe (1999). "Chapter 26 Optimal fiscal and monetary policy". Vol. 1. Handbook of Macroeconomics. Elsevier, pp. 1671–1745. DOI: https://doi.org/10.1016/S1574-0048(99)10039-9.

Chodorow-Reich, Gabriel (May 2019). Geographic Cross-Sectional Fiscal Spending Multipliers: What Have We Learned? *American Economic Journal: Economic Policy* 11.2, pp. 1–34. https://ideas.repec.org/a/aea/aejpol/v11y2019i2p1-34.html.

Chodorow-Reich, Gabriel et al. (Aug. 2012). Does State Fiscal Relief during Recessions Increase Employment? Evidence from the American Recovery and Reinvestment Act. *American Economic Journal: Economic Policy* 4.3, pp. 118–145. https://ideas.repec.org/a/aea/aejpol/v4y2012i3p118-45.html.

Choi, Jaedo and Andrei A Levchenko (Sept. 2021). *The Long-Term Effects of Industrial Policy*. Working Paper 29263. National Bureau of Economic Research. DOI: 10.3386/w29263. http://www.nber.org/papers/w29263.

Clark, Christopher (2012). *The Sleepwalkers: How Europe Went to War in 1914*. Allen Lane.

Cox, Lydia et al. (2024). Big G. *Journal of Political Economy* 132.10, pp. 3260–3297. DOI: 10.1086/730426.

David, Paul A., Bronwyn H. Hall, and Andrew A. Toole (2000). Is public RD a complement or substitute for private RD? A review of the econometric evidence. *Research Policy* 29.4, pp. 497–529. DOI: https://doi.org/10.1016/S0048-7333(99)00087-6.

De Loecker, Jan (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics* 73.1, pp. 69–98. DOI: https://doi.org/10.1016/j.jinteco.2007.03.003.

De Loecker, Jan (2011). Product Differentiation, Multiproduct Firms, and Estimating the Impact of Trade Liberalization on Productivity. *Econometrica* 79.5, pp. 1407–1451. DOI: https://doi.org/10.3982/ECTA7617.

Draghi, Mario (2024). *The future of European competitiveness: A competitiveness strategy for Europe*. Policy Report. Accessed: 2025-10-01. European Commission. https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en.

Dunne, J. Paul and Ron P. Smith (2020). Military Expenditure, Investment and Growth. *Defence and Peace Economics* 31.6, pp. 601–614. DOI: 10.1080/10242694.2019.1636182.

Dyevre, Arnaud (2023). *Public R&D spillovers and productivity growth*. Tech. rep. Working Paper.

Eisenhower, Dwight D. (1965). *Waging Peace: The White House Years, 1956–1961*. Garden City, NY: Doubleday.

Federle, Jonathan et al. (2024). *The price of war*. Tech. rep. Kiel Working Paper.

Feiglin, Guy (2020). "New developments affecting military industries". *The Israeli defense indusry and US assitance*. INSS, University of Tel Aviv, pp. 89–104.

Fellner, William (1971). Empirical Support for the Theory of Induced Innovations. *The Quarterly Journal of Economics* 85.4, pp. 580–604. http://www.jstor.org/stable/1882269 (visited on 07/10/2024).

Field, Alexander J. (2002). *The Economic Consequences of U.S. Mobilization for the Second World War*. New Haven, CT: Yale University Press.

Fieldhouse, Andrew J and Karel Mertens (2023). *The Returns to Government R&D: Evidence from US Appropriations Shocks*. Federal Reserve Bank of Dallas, Research Department.

Finkelstein, Amy (May 2004). Static and Dynamic Effects of Health Policy: Evidence from the Vaccine Industry. *The Quarterly Journal of Economics* 119.2, pp. 527–564. DOI: 10.1162/0033553041382166.

Fornaro, Luca (2024). Fiscal Stimulus with Supply Constraints. *BSE Working Paper* 1458.

Fujita, Shigeru, Valerie Ramey, and Tal Roded (2024). "Why Didn't the U.S. Unemployment Rate Rise at the End of WWII?" Working Paper.

Garfinkel, Michelle R. (1994). Domestic Politics and International Conflict. *The American Economic Review* 84.5, pp. 1294–1309. http://www.jstor.org/stable/2117773 (visited on 12/22/2024).

Garin, Andrew and Jonathan L Rothbaum (Mar. 2024). *The Long-Run Impacts of Public Industrial Investment on Local Development and Economic Mobility: Evidence from World War II*. Working

Paper 32265. National Bureau of Economic Research. DOI: 10.3386/w32265. http://www.nber.org/papers/w32265.

Gibler, Douglas M., Toby J. Rider, and Marc L. Hutchison (2005). Taking Arms against a Sea of Troubles: Conventional Arms Races during Periods of Rivalry. *Journal of Peace Research* 42.2, pp. 131–147. http://www.jstor.org/stable/30042270 (visited on 04/17/2024).

Gordon, Robert J and Robert Krenn (2010). The end of the great depression 1939-41: Policy contributions and fiscal multipliers. *National Bureau of Economic Research Working Paper* 16380.

Griliches, Zvi (2007). *R&D, patents and productivity*. University of Chicago Press.

Griliches, Zvi and Frank Lichtenberg (1984). R&D and Productivity Growth at the Industry Level: Is There Still a Relationship?

Gross, Daniel P. and Bhaven N. Sampat (Dec. 2023). America, Jump-Started: World War II RD and the Takeoff of the US Innovation System. *American Economic Review* 113.12, pp. 3323–56. DOI: 10.1257/aer.20221365.

Habakkuk, John (1962). *American and British technology in the nineteenth century: the search for labour-saving inventions*. Cambridge, England: Cambridge University Press.

Hall, Robert (1988). Increasing Returns: Theory and Measurement with Industry Data. *Working paper*.

Hazell, Jonathon et al. (Feb. 2022). The Slope of the Phillips Curve: Evidence from U.S. States. *The Quarterly Journal of Economics* 137.3, pp. 1299–1344. DOI: 10.1093/qje/qjac010.

Herman, Arthur (2012). *Freedom's Forge: How American Business Produced Victory in World War II*. New York, NY: Random House.

Hickman, Bert G. (1957). "Capacity, Capacity Utilization, and the Acceleration Principle". *Problems of Capital Formation: Concepts, Measurement, and Controlling Factors*. NBER. Chap. c5590.

Higgs, Robert (1992). Wartime Prosperity? A Reassessment of the U.S. Economy in the 1940s. *The Journal of Economic History* 52.1, pp. 41–60. http://www.jstor.org/stable/2123344.

Hirschman, Albert O (1958). *The Strategy of Economic Development*. Yale University Press.

Howard, Robert A. (1978). Interchangeable Parts Reexamined: The Private Sector of the American Arms Industry on the Eve of the Civil War. *Technology and Culture* 19.4, pp. 633–649. http://www.jstor.org/stable/3103762 (visited on 07/02/2024).

Howell, Sabrina T et al. (Apr. 2021). *Opening up Military Innovation: Causal Effects of Reforms to U.S. Defense Research*. Working Paper 28700. National Bureau of Economic Research. DOI: 10.3386/w28700. http://www.nber.org/papers/w28700.

Ilzetzki, Ethan (2014). *Centre for Macroeconomics Lecture*. Video, YouTube. Delivered at the Centre for Macroeconomics, London School of Economics, on 26 February 2014. https://www.youtube.com/watch?v=vBjOjlGyoS4.

— (Aug. 2024). Learning by Necessity: Government Demand, Capacity Constraints, and Productivity Growth. *American Economic Review* 114.8, pp. 2436–71. DOI: 10.1257/aer.20230033.

Ilzetzki, Ethan, Enrique G. Mendoza, and Carlos A. Végh (2013). How big (small?) are fiscal multipliers? *Journal of Monetary Economics* 60.2, pp. 239–254.

Ilzetzki, Ethan and Hugo Reichardt (Apr. 2020). Ramping up ventilator production: Lessons from WWII. *VoxEU*. https://voxeu.org/article/ramping-ventilator-production-lessons-wwii.

Ilzetzki, Ethan and Carlos A. Vegh (July 2008). *Procyclical Fiscal Policy in Developing Countries: Truth or Fiction?* NBER Working Papers 14191. National Bureau of Economic Research, Inc.

Irwin, Douglas A. and Peter J. Klenow (1994). Learning-by-Doing Spillovers in the Semiconductor Industry. *Journal of Political Economy* 102.6, pp. 1200–1227. http://www.jstor.org/stable/2138784 (visited on 07/03/2024).

Jensen, J. Bradford, Robert H. McGuckin, and Kevin J. Stiroh (2001). The Impact of Vintage and Survival on Productivity: Evidence from Cohorts of U.S. Manufacturing Plants. *The Review of Economics and Statistics* 83.2, pp. 323–332. http://www.jstor.org/stable/3211610 (visited on 07/03/2024).

Jones, Benjamin F. and Lawrence H. Summers (2022). "A Calculation of the Social Returns to Innovation". *Innovation and Public Policy*. Ed. by Austan Goolsbee and Benjamin Jones. University of Chicago Press, pp. 13–59.

Jones, Eric (2003). *The European Miracle: Environments, Economies and Geopolitics in the History of Europe and Asia*. 3rd ed. Cambridge University Press.

Juhász, Réka, Nathan Lane, and Dani Rodrik (2024). The New Economics of Industrial Policy. *Annual Review of Economics*. DOI: https://doi.org/10.1146/annurev-economics-081023-024638.

Kaminsky, Graciela L., Carmen M. Reinhart, and Carlos A. Végh (Jan. 2005). "When It Rains, It Pours: Procyclical Capital Flows and Macroeconomic Policies". *NBER Macroeconomics Annual 2004, Volume 19*. NBER Chapters. National Bureau of Economic Research, Inc, pp. 11–82. https://ideas.repec.org/h/nbr/nberch/6668.html.

Kantor, Shawn and Alexander T Whalley (2023). *Moonshot: Public R&D and growth*. Tech. rep. National Bureau of Economic Research.

Kennedy, Paul (1980). *The Rise of the Anglo-German Antagonism, 1860-1914*. Allen Unwin.

Kennedy, Paul and Edward N Luttwak (1990). The rise and fall of the great powers: An exchange. *The American Scholar* 59.2, pp. 283–289.

Kinnard, Douglas (1977). President Eisenhower and the Defense Budget. *The Journal of Politics* 39.3, pp. 596–623. DOI: 10.2307/2129645.

Klein, Maury (2013). *A Call to Arms: Mobilizing America for World War II*. Bloomsbury Publishing USA.

Krugman, Paul (1991). Increasing Returns and Economic Geography. *Journal of Political Economy* 99.3, pp. 483–499. http://www.jstor.org/stable/2937739 (visited on 07/02/2024).

Kuziemko, Ilyana, Suresh Naidu, and Danny Onorato (2024). "Revisiting Military Keynesianism: The Cold War and U.S. Labor Markets". Unpublished Manuscript.

Laffont, Jean-Jacques and Jean Tirole (1988). The dynamics of incentive contracts. *Econometrica: Journal of the Econometric Society*, pp. 1153–1175.

Lane, Nathan (2022). *Manufacturing Revolutions: Industrial Policy and Industrialisation in South Korea*. Manuscript.

Lazonick, William and Thomas Brush (1985). The "Horndal effect" in early US manufacturing. *Elsevier*.

Lee, Jaymin (1996). Technology imports and R&D efforts of Korean manufacturing firms. *Journal of Development Economics* 50.1, pp. 197–210.

Levy, David M and Nestor E Terleckyj (1983). Effects of government R&D on private R&D investment and productivity: a macroeconomic analysis. *The Bell Journal of Economics*, pp. 551–561.

Lieberman, Marvin B. (1989). The Learning Curve, Technology Barriers to Entry, and Competitive Survival in the Chemical Processing Industries. *Strategic Management Journal* 10.5, pp. 431–447. http://www.jstor.org/stable/2486471 (visited on 07/03/2024).

Liu, Ernest (2019). Industrial Policies in Production Networks. eng. *The Quarterly journal of economics* 134.4, pp. 1883–1948.

Liu, Ernest and Ma Song (2021). Innovation Networks and Innovation Policy. eng. *NBER Working Paper Series*.

Lucas, Robert E. Jr. (July 1988). On the mechanics of economic development. *Journal of Monetary Economics* 22.1, pp. 3–42. https://ideas.repec.org/a/eee/moneco/v22y1988i1p3-42.html.

Lucas, Robert Jr. and Nancy L. Stokey (1983). Optimal fiscal and monetary policy in an economy without capital. *Journal of Monetary Economics* 12.1, pp. 55–93. https://ideas.repec.org/a/eee/moneco/v12y1983i1p55-93.html.

MacMillan, Margaret (2013). *The War That Ended Peace: The Road to 1914*. Random House.

Mansfield, Edwin (1985). How Rapidly Does New Industrial Technology Leak Out? *The Journal of Industrial Economics* 34.2, pp. 217–223. http://www.jstor.org/stable/2098683 (visited on 07/03/2024).

Marshall, Alfred (1890). *Principles of Economics*. Great Minds Series.

Marx, Karl (2018). *Das kapital*. e-artnow.

Marzian, Johannes and Christoph Trebesch (2025). "Military Booms: A Macroeconomic History". Unpublished Manuscript.

Mazzucato, Mariana (2021). *Mission Economy: A Moonshot Guide to Changing Capitalism*. London: Allen Lane. ISBN: 9780241419735. https://marianamazzucato.com/books/mission-economy/.

McCall, John J (1970). The simple economics of incentive contracting. *The American Economic Review* 60.5, pp. 837–846.

Melitz, Marc J and Stephen J Redding (2023). "Trade and Innovation". *The Economics of Creative Destruction*. Harvard University Press. Chap. 6, pp. 133–174.

Middleton, Kenneth A (1945). Wartime Productivity Changes in Airframe Industry. *Monthly Labor Review* 61, pp. 215–225.

Milward, Alan S (1979). *War, economy and society, 1939-1945*. Vol. 5. University of California Press.

Mokyr, Joel (1992). *The lever of riches: Technological creativity and economic progress*. Oxford University Press.

Montgomery, Frances J. (1943). Increased Productivity in the Construction of Liberty Vessels. *Monthly Labor Review* 57.5, pp. 861–864. http://www.jstor.org/stable/41817271 (visited on 07/03/2024).

Moretti, Enrico, Claudia Steinwender, and John Van Reenen (Nov. 2019). *The Intellectual Spoils of War? Defense RD, Productivity and International Spillovers*. Working Paper 26483. National Bureau of Economic Research. DOI: 10.3386/w26483. http://www.nber.org/papers/w26483.

Mowery, David C and Nathan Rosenberg (1999a). *Paths of innovation: Technological change in 20th-century America*. Cambridge University Press.

Mowery, David C. (2010). "Chapter 29 - Military RD and Innovation". *Handbook of the Economics of Innovation, Volume 2*. Ed. by Bronwyn H. Hall and Nathan Rosenberg. Vol. 2. Handbook of the Economics of Innovation. North-Holland, pp. 1219–1256. DOI: https://doi.org/10.1016/S0169-7218(10)02013-7.

Mowery, David C. and Nathan Rosenberg (1999b). *Paths of Innovation*. New York: Oxford University Press.

Murphy, Kevin M., Andrei Shleifer, and Robert W. Vishny (1989). Industrialization and the Big Push. *Journal of Political Economy* 97.5, pp. 1003–1026. http://www.jstor.org/stable/1831884 (visited on 06/28/2024).

Myers, Kyle R. and Lauren Lanahan (July 2022). Estimating Spillovers from Publicly Funded RD: Evidence from the US Department of Energy. *American Economic Review* 112.7, pp. 2393–2423. DOI: 10.1257/aer.20210678.

Nakamura, Emi and Jón Steinsson (Mar. 2014). Fiscal Stimulus in a Monetary Union: Evidence from US Regions. *American Economic Review* 104.3, pp. 753–792. https://ideas.repec.org/a/aea/aecrev/v104y2014i3p753-92.html.

Nef, John U. (1950). *War and Human Progress: An Essay on the Rise of Industrial Civilization*. Harvard University Press.

Newell, Richard, Adam Jaffe, and Robert Stavins (1999). The Induced Innovation Hypothesis and Energy-Saving Technological Change. *The Quarterly Journal of Economics* 114.3, pp. 941–975. https://EconPapers.repec.org/RePEc:oup:qjecon:v:114:y:1999:i:3:p:941-975..

Nicoli, Francesco and Roel Beetsma (2024). *Joint Public Procurement as a Tool for European Union Industrial Policy*. Policy Brief 18/2024. Bruegel. https://www.bruegel.org/policy-brief/joint-public-procurement-tool-european-union-industrial-policy.

Nordhaus, William D. (1973). Some Skeptical Thoughts on the Theory of Induced Innovation. *The Quarterly Journal of Economics* 87.2, pp. 208–219. http://www.jstor.org/stable/1882184 (visited on 07/10/2024).

Owyang, Michael T., Valerie A. Ramey, and Sarah Zubairy (May 2013). Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data. *American Economic Review* 103.3, pp. 129–34. DOI: 10.1257/aer.103.3.129.

Perotti, Roberto (June 2007). *In Search of the Transmission Mechanism of Fiscal Policy*. Working Paper 13143. National Bureau of Economic Research. DOI: 10.3386/w13143. http://www.nber.org/papers/w13143.

— (2014). Defense Government Spending Is Contractionary, Civilian Government Spending Is Expansionary. eng. *NBER Working Paper Series*, pp. 20179–.

Pflanze, Otto (1971). *Bismarck and the Development of Germany: The Period of Unification, 1815-1871*. Princeton University Press.

Phelps, E. S. (1966). Models of Technical Progress and the Golden Rule of Research. *The Review of Economic Studies* 33.2, pp. 133–145. http://www.jstor.org/stable/2974437 (visited on 07/10/2024).

Pigou, Arthur Cecil (1920). *The Economics of Welfare*. London: Macmillan.

Popp, David (Mar. 2002). Induced Innovation and Energy Prices. *American Economic Review* 92.1, pp. 160–180. DOI: 10.1257/000282802760015658.

Ram, Rati (1995). "Chapter 10 Defense expenditure and economic growth". eng. *Handbook of Defense Economics*. Vol. 1. Elsevier B.V, pp. 251–274. ISBN: 0444818871.

Ramey, Valerie A (2011). Identifying government spending shocks: It's all in the timing. *The Quarterly Journal of Economics* 126.1, pp. 1–50.

Ramey, Valerie A and Matthew D Shapiro (2001). Displaced capital: A study of aerospace plant closings. *Journal of Political Economy* 109.5, pp. 958–992.

Ramey, Valerie A and Sarah Zubairy (2018). Government spending multipliers in good times and in bad: evidence from US historical data. *Journal of Political Economy* 126.2, pp. 850–901.

Ramey, Valerie A. (Spring 2019). Ten Years after the Financial Crisis: What Have We Learned from the Renaissance in Fiscal Research? *Journal of Economic Perspectives* 33.2, pp. 89–114. https://ideas.repec.org/a/aea/jecper/v33y2019i2p89-114.html.

Ramey, Valerie A. and Matthew D. Shapiro (June 1998). Costly capital reallocation and the effects of government spending. *Carnegie-Rochester Conference Series on Public Policy* 48.1, pp. 145–194. https://ideas.repec.org/a/eee/crcspp/v48y1998ip145-194.html.

Reichardt, Otto H. (1975). Industrial Concentration and World War II: A Note on the Aircraft Industry. *The Business History Review* 49.4, pp. 498–503. http://www.jstor.org/stable/3113172 (visited on 12/21/2023).

Rockoff, Hugh (2012). *America's Economic Way of War: War and the US Economy from the Spanish-American War to the Persian Gulf War*. Cambridge, UK: Cambridge University Press.

Romer, Christina D. and David H. Romer (June 2010). The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks. *American Economic Review* 100.3, pp. 763–801. DOI: 10.1257/aer.100.3.763.

Romer, Paul M (Oct. 1986). Increasing Returns and Long-run Growth. *Journal of Political Economy* 94.5, pp. 1002–1037. DOI: 10.1086/261420.

— (1987). "Crazy Explanations for the Productivity Slowdown". *NBER Macroeconomics Annual 1987, Volume 2*. NBER Chapters. National Bureau of Economic Research, Inc, pp. 163–210. https://ideas.repec.org/h/nbr/nberch/11101.html.

Rosenstein-Rodan, P. N. (1943). Problems of Industrialisation of Eastern and South-Eastern Europe. *The Economic Journal* 53.210/211, pp. 202–211. http://www.jstor.org/stable/2226317 (visited on 07/23/2024).

Rothbarth, E. (1946). Causes of the Superior Efficiency of U.S.A. Industry as Compared with British Industry. *The Economic Journal* 56.223, pp. 383–390. http://www.jstor.org/stable/2226046 (visited on 07/10/2024).

Samuelson, Paul A. (1965). A Theory of Induced Innovation along Kennedy-Weisäcker Lines. *The Review of Economics and Statistics* 47.4, pp. 343–356. http://www.jstor.org/stable/1927763 (visited on 07/10/2024).

Sandler, Todd and Keith Hartley (1995). *The Economics of Defense*. Cambridge University Press.

Say, Jean-Baptiste (1803). *A Treatise on Political Economy; or The Production, Distribution, and Consumption of Wealth*. Lippincott, Grambo & Co.

Searle, Allan D (1945). Productivity changes in selected wartime shipbuilding programs. *Monthly Labor Review* 61, pp. 1132–1147.

Shoag, Daniel (May 2013). Using State Pension Shocks to Estimate Fiscal Multipliers since the Great Recession. *American Economic Review* 103.3, pp. 121–24. DOI: 10.1257/aer.103.3.121.

Sinclair, Gavin, Steven Klepper, and Wesley Cohen (2000). What's Experience Got to Do With It? Sources of Cost Reduction in a Large Specialty Chemicals Producer. *Management Science* 46.1, pp. 28–45. http://www.jstor.org/stable/2634906 (visited on 07/03/2024).

Smith, Adam (1776). *The Wealth of Nations*. W. Strahan and T. Cadell.

Sraffa, Piero (1926). The Laws of Returns under Competitive Conditions. *The Economic Journal* 36.144, pp. 535–550. http://www.jstor.org/stable/2959866 (visited on 06/19/2024).

Taylor, A.J.P. (1954). *The Struggle for Mastery in Europe, 1848-1918*. Oxford University Press.

Taylor, Frederick Winslow (1911). Principles and methods of scientific Management. *Journal of Accountancy* 12.3, p. 3.

Thompson, Peter (2001). How much did the liberty shipbuilders learn? New evidence for an old case study. *Journal of Political Economy* 109.1, pp. 103–137.

— (2010). "Learning by Doing". *Handbook of the Economics of Innovation*. Ed. by Bronwyn H. Hall and Nathan Rosenberg. Vol. 1. Handbook of the Economics of Innovation. Elsevier, pp. 429–476. DOI: 10.1016/S0169-7218(10)010.

— (2012). The Relationship between Unit Cost and Cumulative Quantity and the Evidence for Organizational Learning-by-Doing. *The Journal of Economic Perspectives* 26.3, pp. 203–224. http://www.jstor.org/stable/41581138.

Thornton, Rebecca Achee and Peter Thompson (2001). Learning from Experience and Learning from Others: An Exploration of Learning and Spillovers in Wartime Shipbuilding. *The American Economic Review* 91.5, pp. 1350–1368. http://www.jstor.org/stable/2677929 (visited on 07/03/2024).

Tilly, Charles (2017). "Coercion, capital, and European states, AD 990–1990". *Collective violence, contentious politics, and social change*. Routledge, pp. 140–154.

Tuchman, Barbara W. (1962). *The Guns of August*. Macmillan.

Ure, Andrew (1835). *The Philosophy of Manufactures*. Charles Knight.

Vogel, Alexander and Joachim Wagner (2010). Higher productivity in importing German manufacturing firms: self-selection, learning from importing, or both? *Review of World Economics* 145, pp. 641–665.

War Production Board (1945). *War Production in 1944*. Tech. rep. War Production Board.

Wilson, Daniel J. (Apr. 2012). Fiscal Spending Jobs Multipliers: Evidence from the 2009 American Recovery and Reinvestment Act. *American Economic Journal: Economic Policy* 4.3, pp. 251–82. DOI: 10.1257/pol.4.3.251.

Wilson, Mark R (2006). *The business of Civil War: Military mobilization and the state, 1861–1865*. JHU Press.

Wright, Gavin (1978). *Political Economy of the Cotton South*. W. W. Norton & Company.

Wright, Theodore P (1936). Factors affecting the cost of airplanes. *Journal of the aeronautical sciences* 3.4, pp. 122–128.

Yesilyurt, Filiz and M Ensar Yesilyurt (2019). Meta-analysis, military expenditures and growth. *Journal of Peace Research* 56.3, pp. 352–363. DOI: 10.1177/0022343318808841.

Young, Allyn A. (1928). Increasing Returns and Economic Progress. *The Economic Journal* 38.152, pp. 527–542. http://www.jstor.org/stable/2224097 (visited on 06/19/2024).

Young, Alwyn (1991). Learning by doing and the dynamic effects of international trade. *The Quarterly Journal of Economics* 106.2, pp. 369–405.

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