

Economic Warfare in Twentieth Century History and strategy

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Abstract

In two world wars, both sides committed substantial resources to economic warfare. Before the event, influential thinkers believed that the threat of blockade (and later of bombing) would deter aggression. When war broke out, they hoped that economic action might bring the war to a close without the need for a conclusive military struggle. Why were they disappointed, and what was the true relationship between economic warfare and combat between military forces? The answer to this question depends on the effects of economic warfare, which can be understood only after considering the adversary's adaptation. When the full range of adaptations is considered, it becomes clear that economic warfare and combat were usually strategic complements; they acted together and did not substitute for each other. The paper examines this question both in breadth and more narrowly, focusing on the Allied air campaign against Germany in World War II. There are implications for history and policy.

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Economic Warfare in Twentieth-Century History and Strategy

A single cruiser let loose upon one of your great trade routes would send up the price of provisions enormously, and although no one could hope to blockade the English ports, any interruption in the supply of raw material, any interference with the stream of food products which are indispensable for the sustenance of your people, would endanger you far more than the loss of a pitched battle (Bloch 1899: lx, interviewed by the journalist W. T. Stead).

Economic warfare was the inevitable counterpart of wars of resources. Wars of resources were a feature of the twentieth century, in which armies reached unprecedented sizes and shares of national populations (Onorato et al. 2014: 459), and supplying a mass army in wartime could cost a country anything from one third to two thirds of its national resources (Harrison 1998: 15; Broadberry and Harrison 2005a: 21).

Wars of resources took time (Broadberry and Harrison 2005b: 2). Time was needed to mobilise the resources required and transform them into fighting power. Through combat, each side aimed to overcome the adversary's fighting power directly, in battles and campaigns. But each side must reckon with the adversary's fighting power not only today but tomorrow. To the extent that the fighting power available to me tomorrow depends on my resources, the adversary's counteraction may not be limited to direct attacks on my fighting power today and tomorrow; it may extend to trying to weaken me tomorrow, indirectly, by attacking my resources today.

This was economic warfare: to damage or destroy the enemy's fighting power, not directly by means of combat, but indirectly by attacking the supply chains that produced it.

Before the twentieth century there was economic warfare, which sometimes conformed to this definition, but sometimes it did not. In the Napoleonic Wars, for example, Napoleon's Continental System amounted to a "self-blockade," designed to exclude British goods from the markets controlled by France and her allies (Davis and Engerman 2006: 31). Such measures belong to the general subject of trade wars or protectionism, under which nations seek to grab the demand side of the market for themselves, whereas modern economic warfare aims to limit or destroy the adversary's supply side.

If economic warfare paid off in the era of total war, it was only because total war took time. There was no point to it if the duration of the war was expected to be less than the production cycle of fighting power. Economic

warfare took time too, and for similar reasons: time was needed to identify and attack the enemy's resources, and more time was needed for the attack to have its effect on the enemy's fighting power.

As the legitimate target of economic warfare, the supply chain of fighting power has been understood narrowly and broadly. A narrow interpretation limited the target to the supply of "war goods" – munitions, whether shipped from abroad or made at home. This exempted a considerable sphere of civilian economic activity from attack – food, for example. When the whole economy was mobilized for war, however, a broader interpretation became necessary, because all parts of the economy became implicated in supply of the direct-plus-indirect requirements of fighting power – including food.

What did an economy look like that was wholly mobilized for war? At the height of Britain's war effort in June 1943 (Table 1), nearly one quarter of the working population was in the armed forces and another quarter in the industries directly engaged in specialized war production or supplying its needs at one remove. A third quarter was engaged in basic industries, utilities, and government services. The last quarter – perhaps a little more – was all that was left to supply the food, clothing, and distributive and financial services that maintained society. Not included in the scope of the table are those who were employed in wartime supply of the British economy in the Dominions and Colonies and in the United States; their contribution was reflected in the large UK wartime trade deficit. By that stage of the war, hardly anyone of working age stood outside the supply of chain of fighting power and the food of everyone was part of that supply chain. Vickers (1943) provides the canonical précis of how this was achieved.

Table 1 near here

In the broader interpretation of economic warfare, therefore, when nothing was left that did not contribute to fighting power, anything and everything could be a target.

How did economic warfare work, and how well did it work, in the era of mass warfare? The use of economic warfare has often been based on claims that it can be a strategic substitute for combat. In other words, that economic warfare can starve the enemy out, or destroy the enemy's morale, or cause a favourable regime change, independently of the winning or losing of battles between the opposed troops. But historical descriptions of economic warfare have tended to conclude that in practice the degree of substitutability between economic warfare and combat was rather low.

I have taken care to refer to "strategic" substitutes and complements. One reason is that much of the history of economic warfare is

preoccupied with investigation of the more salient tactical level, which involved ships, planes, bombs dropped, cargoes sunk, and shipments or factories destroyed. This knowledge is very important – indispensable, in fact – because a strategy that sets up the adversary’s economy as a target is without effect unless the tactical means, the ships and planes, are available to support it. The strategic goal can only be reached through the tactical means, and the tactical effects must be measurable if the strategic effects are ever to be identified. Nonetheless, the strategic goal, which is to weaken the enemy’s fighting power, should be our ultimate focus.

Another reason to be careful about distinguishing the strategy and tactics of economic warfare is that the tactics of economic warfare also gave rise to substitution processes. For example, when a factory was bombed, could other resources be substituted for its products? I will call the latter “economic” substitution (or Olsonian substitution, because it was first described as such by Olson 1962).

In Section 1 of this paper I offer a thumbnail sketch of economic warfare across the twentieth century. This section sets out to distil the co-evolution of ideas and technologies of economic warfare, and to identify the aspects that have caused surprise or puzzlement. The adaptation of the economy to economic warfare is identified as a key issue.

The Allied air offensive against Germany in World War II merits special attention. Section 2 sets out the broad objectives of the campaign – not all of which were economic – and what is known about the costs of seeking them. As for effects, Section 3 reviews them against the objectives. (a) The air war succeeded in forcing Germany to incur major costs to defend against it, but the terms were unfavourable. (b) The air war failed to undermine German morale. (c) The air war against production had, at best, only small effects on the supply of Germany’s war effort. (d) In contrast, the air war against transportation may have had far-reaching effects once it reached a certain scale. Section 4 sums up, concluding that the air campaign succeeded in complementing the wars on land and at sea, but it did so inefficiently.

In that light, Section 5 returns to the main question: was economic warfare a strategic substitute for combat? Not in the case of the air offensive against Germany, nor in any other case that we have been able to identify. While it is intuitively convenient to think of economic warfare and combat in separate boxes, they acted as strategic complements. Going further, this section argues for a new view of economic warfare that blends in ideas from political science (Pape 2014) and military history (O’Brien 2015a). Economic warfare that worked was not separable from combat; rather, there was a continuum of warfare, with economic warfare occupying a part of the spectrum. Section 6 concludes.

Further evidence that economic warfare and combat went together is that it was unwise to prepare for either one without the other. This result is extended to the use of economic sanctions in peacetime, an argument that takes us from history to policy. Specifically, many appear to believe that economic sanctions can achieve foreign policy goals without war. This might be an illusion.

While it is agreeable to think, in a self-serving way, that history can have a few practical lessons for how we go about foreign policy today, I offer no lessons for the conduct of economic warfare. Economic warfare as discussed in this paper belongs to the past, to a bygone era of mass warfare, and that is where it should stay. The international laws of war no longer allow for the incidental starving or killing of hundreds of thousands of enemy civilians to be justified as proportional to war aims. If history doesn't encourage optimism about compliance with the laws of war in life-or-death situations, that will have to be another story.

1. A century of advocacy

In history, advocates of economic sanctions against an adversary tended to claim two advantages: speedy effect and low cost. The speedy effect meant that the adversary would quickly comply with demands in some dimension of policy that was of interest. Low cost meant that the adversary's compliance could be secured putting blood and treasure at risk. All that was required for its success was some kind of pre-existing advantage of economic size or influence over the adversary. Because of this, sanctions have tended to be the stock-in-trade of the great powers, their alliances, and encompassing global organizations from the League of Nations to the UN.

Anyway, that's what history shows—or does it? Certainly, lots of people have thought so, starting from the banker Ivan Bloch (1899). Independently observing the first wave of globalization, Bloch noted the growing trade dependence of the European powers and pointed to implications for contemporary conflict. Modern war, he thought, would begin and end with the interruption of trade. Most immediately affected would be the industrialised, food-importing countries of Western Europe (Table 2). The breakage of their import-reliant supply chains would spread famine among the people and this – not the hunger of the soldiers – would destroy their capacity for resistance (Bloch 1899: xlix-l). As a result, he concluded, modern war was now impossible.

Table 2 near here

Such ideas were widely held up to 1914. Those who shared them included two advisers to the Committee of Imperial Defence, the naval officer Maurice Hankey and the economist Robert Giffen. Hankey, who

later served in the war cabinets of both Lloyd George and Churchill, believed not only that blockade would be a war-winning weapon against Germany but that the threat of it would sufficiently deter German aggression. Giffen, who emphasized the dependence of global trade on the British capital market, was an early proponent of credit sanctions. The naval strategists Julian Corbett (in Britain) and Alfred Thayer Mahan (in the United States) pursued different visions of the uses of naval power, but they concurred in seeing blockade of the enemy as the endgame (Offer 1989: 285-99; Lambert 2010: 2-5, 102-137). The public bought two million copies of a book (Angell 1910) that maintained, in the spirit of Bloch, that modern war was now too horrible and costly to contemplate.

At the common core of these ideas, modern economies were imagined as fragile structures, unable to adapt to sudden interruptions of supply. Their complexity made them weak: complex supply chains would transmit external shocks from one part of the economy to all parts, amplifying them until the entire structure would fail.

World War I allowed much scope to test this way of thinking. Modern war was certainly horrible, it turned out, and this was hardly a surprise. What was surprising was that war of this character was not impossible. When faced with years of mobilization under external blockade, modern economies adapted and did not collapse. They were resilient, not fragile. Subjected to tragic circumstances, their people did not give up; they fought on despite hardship and grief. These things were unforeseen.

In the war, the efficacy of blockade was also tested. Germany and Britain attacked each other's trade. Both sides took time to overcome the legal, political, and moral obstacles to unrestricted blockade. From that point, the two blockades were asymmetric. More reliant on imported calories than Germany, Britain could exploit naval superiority to protect its surface shipping and to blockade German ports. But Germany could trade overland with allies and neutral neighbours, so a naval blockade could not be complete. The restriction of Germany's overland trade cost Britain much political capital at first but was greatly eased when America entered the war. As a result, German trade declined. So did food availability – possibly as a result, but the causal chain is something to which we will return.

Unable to use its surface fleet, Germany used submarines to attack British trade. It was costly to build a submarine fleet, and it took nerve to use it because submarine warfare threatened neutral cargoes and passengers and made enemies of neutral powers – especially America. Once the restraints were removed, the German high command expected to starve Britain out in weeks (Hardach 1987: 35-52; Offer 1989: 357-360). The submarines made real inroads into Allied shipping and for a time met their targets for sinking cargoes. Effects on the scale and

composition of British trade were dramatic. Yet the British did not go hungry and the war effort was not disrupted.

Why did the German blockade of Britain fail? The defeat was to some extent tactical: even without American entry into the war, British ships continued to sail while the submarine offensive was increasingly blunted by naval countermeasures. But there were also strategic setbacks. For one, British farmers and consumers adapted to the blockade. Price signals, the direction of land and labour into home production, and eventually rationing to consumers worked together, shifting the national diet from meat and sugar to bread and potatoes without loss of nutrition (Olson 1963: 73-116). And the other strategic setback: America was alienated and entered the war, turning Britain's most important neutral supplier and lender into a *de facto* ally.

The advocates of blockade relied for their case on the Germany experience as a target. As the Allied blockade tightened, hunger spread through German cities. By the autumn of 1918 the supply chain of the German war effort was exhausted. Germany's leaders agreed a ceasefire at a point where the defeat of its armed forces was foreseeable, but before that defeat had been accomplished. To preclude a return to the battlefield, the Allied powers maintained the blockade from the ceasefire to the treaty that ended the war in 1919.

The blockade weapon was not, it seemed, without power. Various authorities declared that the blockade had won the war or at least shortened it (for the range and evolution of informed opinion see Davis and Engerman 2006: 211-214; also Offer 1989 and Cox 2015).

Whether all was as it seemed has been challenged, however (Hardach 1987; Kramer 2013; Harrison 2016). The blockade was not the only cause of the disruption of German food supplies, and perhaps not even the main cause. One neglected fact is that Germany chose to make enemies of its major suppliers of imported foodstuffs, so in this respect the disruption of trade was self-imposed. For another, Germany's own war mobilization diverted substantial resources from domestic farms, and this was arguably of greater importance for overall food supplies than the loss of imports. Thus, while no one would deny that the Allied blockade had consequences, their role compared to other factors remains uncertain.

The presumed effectiveness of the Allied wartime blockade of Germany had major consequences. Its influence was felt in the setup of the League of Nations, one purpose of which was to assure collective security. How could aggressive threats be deterred, if not by war? The answer was sought in the use of trade sanctions (Dehne 2019). In practice League of Nations sanctions were invoked only once, against Italy in 1935, and then only for a few months and to no avail. Examples of economic sanctions outside the League of Nations framework are also rare. One to

which we will return is the sanctions that the United States and other powers imposed on Japan in 1940 in response to Japanese aggression in China.

Based on what they took to be the experience in World War I, the future aggressors of World War II also took seriously the risks of blockade. Far from deterring them, fear of blockade fuelled their aggression (Collingham 2014: 23-26). The leaders of the Axis powers planned a future in which colonial settlers would yield a protected supply of the food and raw materials needed by their empires. Until that time was reached, the war plans of Germany and Japan embraced the idea of “providing for the war by war” (Paine 2012: 134): if supply chains could not be assured beforehand, the war itself should secure them by invasion. To Japan this meant Korea and China; to Germany, Ukraine.

The interwar period added fear of bombing to fear of blockade. The fear of bombing was built on the heavy civilian casualties in a few episodes of World War I, the Italian campaigns in north Africa, and the Spanish Civil War. In Britain it was projected that, in two months of war, German bombing would kill 600,000 and injure 1.2 million (Titmuss 1950: 13). Like the anticipations of blockade before World War I, the bombing of cities was expected to push entire nations over a precipice. In turn, the Allied powers pinned their hopes of preventing Axis aggression not on air defence, which was thought impracticable, but on developing their own long-range bombers for deterrence.

In World War II, sea power reprised its performance in World War I. German submarines blockaded the British Isles and the Allied navies blockaded Germany. The German blockade had no more success than before (Olson 1963: 117-131). The Allied blockade of Germany, extended to Italy in 1940, and joined by the United States in 1941, has received little attention (except Milward 1967: 306-314). In World War II, as in World War I, Germany made effective use of trade with neutral neighbours over land and across the Baltic. Another workaround was expansion into neighbouring territories; by 1942 Germany could draw on the resources of half of Europe.

In the Pacific, US Navy submarines blockaded Japan from 1942. There is considerable agreement on the effects, which were gradually increasing. By 1944, Japan’s inter-island shipping and trade with its occupied territories had been largely suppressed. The view of the United States Strategic Bombing Survey (USSBS 1946: 15) was that the blockade alone would have halved Japanese war production by August 1945. This “most effective naval blockade in history” (Davis and Engerman 2006: 377) was economic warfare’s “greatest success” (Milward 1977: 317).

But bitter arguments still rage around the novel dimension of economic warfare in World War II – strategic bombing. While British

industrial centres and ports were blitzed from the air from 1940, the RAF, joined in 1942 by the USAAF, did the same back to German and Japanese cities on a far greater scale. At various times it was hoped, although not planned, that long-range bombing might be a war-winning weapon. But this time Germany fought to the end. In contrast the Pacific war ended without a final invasion of Japan, although only after the use of the atomic bomb.

If at first sight our literature on economic warfare is broad and diverse, then closer inspection suggests that most of what we think we know can be traced back to Germany in two world wars. The air campaign against Germany in World War II remains especially salient for our topic and the next sections will review it in more detail.

Turning to the postwar period, the years after 1945 saw the United Nations take over the League of Nations tradition of using economic sanctions to punish international rule-breakers by means short of war. A US-led ban on the export of strategic materials and technologies to the Soviet bloc was instituted in 1948 and formalized under the Coordinating Committee for Multilateral Export Controls (CoCom) from 1950. The United States placed Cuba under a trade embargo in 1960. UN sanctions were used first against North Korea in 1950, against South Africa in 1960, and on many occasions since then. The Cold War is over, but it remains hard to imagine a crisis arising anywhere in the world without Western calls for economic sanctions against the parties deemed to be at fault.

Sanctions technologies have moved on since the 1940s. Two developments are of note. One is credit sanctions, based on the globalization of credit markets and their cross-border regulation. The other is smart sanctions, designed to target wealthy or influential persons and their interests rather than entire nations.

Despite these developments, there is little strong evidence on the effectiveness of sanctions for achieving foreign policy goals. A comprehensive survey (Hufbauer et al. 2007) lists and analyses 174 cases of economic sanctions from 1915 to 2003 (but only 12 cases go back before 1945 and only two are from the world wars themselves). It concludes that sanctions achieved their goals in part or whole in just one third of cases; success was more likely if the aim was narrowly defined, if the target country was relatively weak, and if there was no history of previous antagonism.

Responding to a previous edition of the same survey with similar findings, Robert Pape (1997) disputed them bitterly, maintaining that the true number of successes was near zero. In a similar vein, a recent book subtitled "Exploring how international economic sanctions (do not) work" (Jones 2015) argues that we mistake the true point of trade sanctions: governments use them to win domestic support, not to influence the

foreign adversary. Their only purpose, he suggests, is to show voters that something is being done, however ineffective it may be; any results in line with purported goals are accidental.

Can an attack on the economy win a war? No case has been more significant for the development of the subject than the Allied air campaign against Germany in World War II.

2. Bombing Hitler's Germany

During World War II, the Allied air forces dropped approximately two megatons of high explosives on Germany (Figure 1). Of the total effort, 31 per cent went into the so-called "area raids" that targeted cities, 27 per cent to attacks on railways and waterways, and 14 per cent to attacks on factories and shipyards (Table 3). A substantial residual, 28 per cent, falls outside our remit because it was allocated to operational targets such as airfields. On the German side there were a million civilian casualties of which three hundred thousand were killed (USSBS 1945a: 1), something that might be considered a war crime now, but was not then. One fifth of Germany's residential capital was destroyed, as was one sixth of the industrial fixed capital stock on the future territory of West Germany (USSBS 1945a: 1; Abelshauser 1998: 168).

Figure 1 near here

Table 3 near here

All this was achieved for the loss of around 40,000 Allied planes and 160,000 aircrew (USSBS 1945a: 1). On the British side, the direct-plus indirect requirements of RAF Bomber Command was put at around 5 per cent of the total war effort measured in person-years (BBSU 1998: 38-39), implying half that as a share of wartime GDP. (Fahey 1994: 451-454 finds a larger share, based on summing nominal outlays across different years.)

As for the American side, I do not know of comparable estimates. Whether measured by "bomb-lift" or aircraft lost, the US and British contributions were on a par, while the US war economy was at least four times the size of Britain's. The cumulative cost of the VLR bomber programme, which produced the B-29, and which notoriously ran to \$3 billion (Craven and Cate 1953: 7), amounted to less than one per cent of US GDP in the year 1944.

The goals of the air campaign evolved throughout the war (e.g. Webster and Frankland 1961, vol. 4: 107-184). Over the three years from April 1942 to March 1945, which saw more than 90 percent of Allied bombing activity, it is possible to distinguish four aims that were pursued continuously and had measurable objectives, at least in principle.

- To damage or destroy a rotating set of production facilities including armaments (such as submarines and aircraft) and “essential” materials (ball-bearings and synthetic oil and rubber).
- To disrupt transportation, especially by rail.
- To undermine civilian morale by attacking entire towns.
- To divert German military resources from the Eastern front to air defence, and from other war work to air raid precautions and bomb repair.

These objectives were distinct in concept more than in practice. To select a building or railway yard as a target was one thing; it also had to be reached, identified, and accurately bombed from 15,000 feet. This could be done in daylight if unopposed, but German air defences made the daytime journey to the target and back too dangerous up to the end of 1943. At night a plane could fly towards the target and return home, but it was not possible to find anything smaller than a town, and any chance of damaging a particular facility within its boundaries relied on destroying the entire neighbourhood. This is how industrial towns and their civilian populations became targets as well as the industrial facilities that employed them. Because of this, night raids on towns were commonly justified in terms of twin objectives, one being damage to the industries located in them, and the other the presumed damage to civilian morale, which the British tended to see as joint products.

The war against Germany’s industrial towns was a British preoccupation; by the end of the war, RAF Bomber Command had carried out more than 90 per cent of Allied town raids (BBSU 1998: 68). American policies differed in principle, but until 1944 they were subject to the same practical constraint: precision bombing required daylight, and daylight raids suffered unsustainable losses. What changed in 1944 was that long-range fighter escorts became available in the European theatre; these overwhelmed German air defences and made possible the more precise targeting of daylight raids.

As for the goal of forcing the diversion of German resources from other war priorities to air defence and bomb repair, it was necessary to attack something. What and why became secondary.

3. Effects of bombing: a review

Seventy-five years on, in search of data and analysis, we start from the postwar reports of the British and American bombing surveys. The American team was set up first and reported first. It was independently led and amply staffed; its veterans included Paul Baran, Edward F. Denison, John Kenneth Galbraith, and Nicholas Kaldor. Its summary reports on the European and Pacific wars were published within months

of the end of the war (USSBS 1945a, 1946). The staff of the British group was smaller by an order of magnitude. It considered only the war in Europe. Born amid much infighting, it lacked independence: the British report's lead author was Sir Solly Zuckerman, who had been responsible for the wartime plan to target the railway system of occupied France (Cox 1998a). It had the advantage of access to the American data and analysis. Its report, apparently completed in 1947, remained classified until 1956, and waited another four decades for publication (BBSU 1998).

The two reports set out to evaluate the effects of bombing on the German war effort by quantitative reasoning. Both are treasure troves of data. They shared a common view of the German war economy as under-mobilized. This aspect was important at the time and has been rightly criticized since (Overy 1994: 233-256; Cox 1998b: xxviii-xxx) but does not complicate our task. The American report relied more on expert opinion and narrative to establish causes and effects. On some issues, British findings look more statistically informed, at least by the standards of the time, exemplified by the use of differences-in-differences to identify causation. The British findings may well have tended to support the principals' priors; this does not make them wrong, but they may have been prejudged.

a) Diversion of German resources

The Allied air offensive forced Germany to defend its air space and to respond to the damage caused. The effect on Germany's allocation of military and civilian resources was large. Air defence required fighter planes. Of the 93,000 military aircraft that Germany produced after 1941, more than half were fighters; this compares with just one quarter of the much smaller number built in 1939 and 1940 (USSBS 1945b: 276). Moreover, the needs of air defence in the West stripped the German Army of its air resources in the East. From 1942 more fighter aircraft were deployed in the West and over Germany and, from September 1943, more aircraft of all types (O'Brien 2015a: 290-291).

In an essay on the bombing campaign Brauer and van Tuyl (2007: 214) are scathing of the idea that the diversion of German air resources from the Eastern front and their attrition in the West might have justified the bomber offensive. They argue that, if this was the intention, the Allied offensive would have been differently designed, with fewer resources for vulnerable bombers and more for the long-range fighters that would eventually overcome German air defences.

This seems a fair point. Nonetheless, the diversion of German resources from the East *was* an explicit goal of the Allied bombing campaign in 1942 and 1943 (Webster and Frankland 1961, vol. 4: 236). Allied leaders sold the bomber offensive to Stalin as a way of relieving

German pressure on the Red Army in the waiting time before D-Day, and Stalin accepted it as such despite his eternal suspicions (Beaumont 1987).

In addition to aircraft, Allied air raids also drew German labour resources and armament into air defence and bomb repair. Albert Speer recalled that German air defence in 1944 required proportions of Germany's output of armament, heavy ammunition, and optical and electronic products varying from one fifth to one half. He put the numbers engaged in air raid precautions and bomb repair in 1944 at 1 to 1.5 million (Webster and Frankland 1961, vol. 4: 381, 393-394; for similar figures see USSBS 1945b: 40).

At first sight, this outcome of the Allied bombing campaign looks like a great success. The success should be qualified for two reasons. One, it was warfare, not economic warfare. Two, it accounts for attrition on the German side, but the Allies also suffered attrition. Both sides lost in the region of 40,000 aircraft. Plane for plane, the Allies lost more aircrews and more valuable machinery. If this was a war of attrition, the Allies' advantage lay in their greater economic capacity to sustain losses.

b) Undermining German morale

The idea of using bombing to attack German civilian morale emerged in 1941 (Webster and Frankland 1961, vol 4: 194-197; O'Brien 2015a: 189-191), at a stage when it was too difficult to attack anything smaller than a town with the means at hand. Alongside the war on industry, the war on morale provided an important motivation for the town raids which eventually took up nearly one third of the overall Allied bombing effort.

It is generally agreed that the morale effect of the area raids was negligible or perverse. Data collected by the USSBS (Brauer and van Tuyl (2007: 223-224) show that German civilian morale was not high in the first place, even without air raids. In communities that were not exposed to bombing, around 40 per cent reported mistrust of leaders, or low morale; up to half were willing to surrender rather than fight on. Such feelings did not translate into shirking or absenteeism. Light or medium exposure to bombing reduced morale by a few percentage points more. Lowered morale did not reduce productivity. Heavy bombing restored morale, even if not quite to the level of communities not exposed to air raids.

Under relentless bombing, the German people did not rise up or persuade the rulers to surrender before final defeat. Town raids took lives and destroyed property, but they also gave the survivors new reasons to hate the enemy. Those that did not hate became preoccupied with survival, which dominated any thought of combining with others to overthrow the state and abandon the war. "In so far as the offensive against German towns was designed to break the morale of the German

civilian population, it clearly failed,” the British Bombing Survey Unit concluded (BBSU 1998: 79).

Was it ever the case that a direct attack by one side could destroy the morale of the other? The Eastern front offers a useful contrast. In September 1941, Leningrad was besieged. Over the next 900 days, 800,000 civilians died, many of hunger. To live, friends and neighbours condemned each other to death by stealing food or food entitlements. Some killed for food; a few ate the dead, and a few killed to eat the dead (Belozerov 2001). But that was behind closed doors; in public, order was maintained, and the city’s resistance did not break.

A month later in October 1941, Moscow was approached by the invader. The government was partly evacuated. Believing they had been abandoned, many civilians tried to flee. There was looting; public order broke down. Once it became clear that Stalin remained in the Kremlin, the panic subsided (Barber 1995). The comparison suggests that when Soviet morale crumbled, the deciding factor was perceptions of their own leaders, not of the attacker.

In the following year 1942, the Red Army continued to retreat, the civilian economy continued to shrink, and hunger gripped much of the Soviet population. The Soviet state did not collapse. But it did collapse in 1991, when there was no real external threat and no widespread internal privation.

No doubt there are ways of demoralizing the population of an enemy society. Attacking it directly does not seem ever to have been one of those ways. While the proportionality of civilian losses to the air campaign’s strategic objectives has been rightly debated, it is also the case that one of those objectives was designed to impose civilian losses and the same losses guaranteed that it would fail.

c) The war on production

When the war was over, the occupying powers asked German insiders what they thought had been the direct effects of Allied bombing on war production. Under interrogation Hitler’s minister of munitions Albert Speer suggested that in 1944 German war production would have been higher in the absence of bombing by “30/40%” (Webster and Frankland 1961: vol. 4: 381). But the factual basis of claims such as this one might be questioned, and also their motivation. More evidence was needed.

The Allies devoted substantial resources to the war on production. On a narrow interpretation of the data (Table 3), just 14 per cent of the Allied bombing effort was directed to raiding submarine yards and specialised facilities for aircraft, armament, rubber and oil products, and ball-bearings. This figure is too low, however. Another 31 per cent, allocated to town raids, was intended to contribute as much to the war on

production as precision attacks on specialized facilities. The main difference was that, given a factory target, the British drew a much larger ring around it than the Americans. Based on Germany's clustering of industrial activities by urban district, the larger ring drawn by the British was likely to include other facilities that might usefully be attacked. As a result, the practical differences between the town raids and the "war on production" narrowly defined became blurred. A more realistic figure for Allied air resources devoted to the war on production therefore combines the 14 per cent for factory raids with the 31 per cent for town raids to make 45 per cent in total.

At first, specialized facilities were thought to present the kind of target that, if destroyed, could suddenly plunge Germany's war effort into crisis. But experience did not live up to the expectation. The canonical case is the 1943 raids on Schweinfurt where Germany's ball-bearing factories were concentrated. The attack destroyed up to half the existing capacity. Yet "there is no evidence that the attacks on the ball-bearing industry had any measurable effect on essential war production" (USSBS 1945a: 6).

It was basic to the thinking of those who advocated the bombing of factories that the adversary's economy was rigid and unable to flex under attack. Mançur Olson (1962) later showed how Germany's war effort adapted quickly to what was expected to be a devastating blow: by a ripple of economizing and substitution. Before the Schweinfurt raids, he argued, Germany's ball-bearing supplies were already more than adequate, which meant that ball-bearings had found many inessential uses; it was not difficult to concentrate remaining supplies where they were most needed, while substituting other types of bearing where possible.

Beyond that, there was a cost to the German economy, but losses of fixed capacities were relatively limited and the effect was widely diffused. As already noted, around one sixth of industrial fixed capital in the future British-American occupation zone was destroyed in the war, but damaged capacities could be quickly rebuilt – and were rebuilt on a surprising scale. In spite of wartime destruction and the still larger costs of normal depreciation, by 1945 the gross value of fixed industrial assets in the West German occupation zone was 20 per cent larger than in 1936 – and one third of this gross value was less than five years old (compared to only 9 per cent in 1935) (Abelshauser 1998: 167-168).

The capital built in wartime, although newer, was not necessarily as productive as the capital that it replaced. When damaged capacities were rebuilt, they were often relocated and dispersed to reduce vulnerability to repeated raids. This greatly impeded the concurrent efforts aimed at cost-cutting through rationalisation and centralisation. German sources estimated large production losses from this alone – for example, up to half

of the potential supply of Messerschmitt fighters from the summer of 1943 to early 1944 (O'Brien 2015a: 78). The dispersed facilities were also more exposed to disruption of railway transportation (USSBS 1945b: 158-159), so they had to carry larger stocks (Overly 1994: 373).

The case of ball-bearings suggests a key to the uncertainty and lack of consensus surrounding this issue. The problem was that the effect of any one raid on the German war economy could not be understood in partial equilibrium. It was a general-equilibrium problem, and a general-equilibrium model of the German war economy was needed to test the counterfactual hypothesis against which the effects of any particular loss could be estimated.

No one has made such a model. Moreover, such a model would have to be tested against the data. Here the aggregate data are remarkably unhelpful. Month by month, Germany's war production rose nearly in step with the intensity of Allied bombing. The only deviation was a pause from the summer of 1943 to early 1944. The pause was temporary, and by the summer of 1944 war production reached more than three times the level of early 1942. The co-variation of the measures of German war production and the intensity of Allied bombing underpinned decades of scepticism about the effectiveness of the latter. On the most optimistic reading, up to the summer of 1944, the bombing could only have prevented German war production from increasing by more than it did.

Against this unpromising background, the Allied survey teams were able to reach more detailed findings. The first was that area raids did somewhat depress the German economy's total output. In 1945 the US bombing survey team estimated the overall effects of area raids on the Germany economy from a sample of ten cities. Based on the known destruction of these towns and their contributions to industrial production, the US survey estimated losses of total ("Reich") production year by year. The lost production was thought to have peaked at 17 per cent in 1944 (Table 4).

Table 4 near here

This was Germany's loss of total output, but the degree to which war production was protected from the overall effect could not be ascertained. This was unsatisfactory, given that the purpose of economic warfare was not to bring about generalized economic damage but to damage the enemy's fighting power. The British survey unit aimed to fill the gap, providing a second finding. They compared 21 towns that were heavily bombed to 14 that were largely unscathed – an early use of differences-in-differences, although the detail remains unpublished. The untreated towns were the control group. Monthly data by town and by industrial branch from April 1943 to June 1944 showed that total output rose

everywhere over the period, but in the bombed towns it fell short of the control group by 13.7 percent. The war production lost through bombing was much less – only 6 per cent, and the loss diminished over time. This suggested that “with increasing experience of air attack, the Germans became more skilled at diverting the effects of air attack onto the civilian sector of industry” (BBSU 1998: 95). Generalized to Germany as a whole, these findings suggested modest losses of overall war production (Table 4 again).

The findings discussed so far are confined to the year 1944. A third finding relates to the pause of 1943. As Figure 2 showed, the *Wagenfuhr* index of finished German armaments, 100 in the first months of 1942, and a little over 230 in mid-1943, stopped there and remained at the level through early 1944. To what extent did the pause reflect a fall below potential, perhaps attributable to bombing? The British survey unit estimated potential output (or capacity) of every plant in every specialized branch of German war industry month by month through the war and aggregated each sector up on the same basis as the *Wagenfuhr* index. Comparison of the two (Figure 2) shows that German war production first fell short of potential in the third quarter of 1943 and paused there until 1944.

Figure 2 near here

Was Allied bombing the cause? In his history of the German war effort, Adam Tooze (2007: 596-598) based a narrative answer on the documented concerns of Speer during the “Battle of the Ruhr,” an offensive pursued against a dozen towns and the dams of the Ruhr district from March to July 1943 (see also USSBS 1945b: 146; Biddle 2015: 501-503). On that basis, Tooze concluded that the Battle of the Ruhr was the decisive factor in the pause.

While the pause is beyond doubt, and the link is reasonable, the underlying data suggest a more complex story. A major factor in the pause was a slowdown of aircraft production. This was due partly to the destruction of Germany’s main aluminium processing plant in Ludwigshafen, far from the Ruhr (O’Brien 2015a: 298), and partly to the ongoing dispersal of the aircraft industry. Both were results of Allied bombing, although not of the Ruhr district.

The fourth finding relates to the bombing of Germany’s synthetic oil plants. The industry was created before the war to insure against a blockade that would deny Germany access to imported oil. By 1944 nearly all German aviation fuel was obtained from specialized chemical plants that turned plentiful domestic coal into hydrocarbons. The industry was also a source of numerous chemical by-products.

Requiring the precision of daylight bombing, the oil campaign began only in May 1944. It took on a large scale – more than 10 per cent of the Allied bombing effort by the end of the war (Table 3). According to the data, it was highly effective in stopping fuel production in the short term (see the Appendix, Figure A-4). The impact on fighting power was blunted by two factors. One, the German economy held large stocks, so the loss of output did not translate into immediate shortages. Two, oil plants could be rebuilt more quickly than thought. Repeated bombing could have prevented this but was not undertaken.

The American and British survey groups drew different conclusions. The USSBS (1945b: 82-83) concluded that the oil industry should have been bombed sooner and at higher frequency. The BBSU (1998: 153-154) maintained that the decisive factor in the eventual collapse of fuel supplies was not so much the bombing of the oil plants as of the railways (discussed below), which cut off inter-industry supplies and prevented the distribution of stocks.

To summarize, heavy bombing of German production facilities and their neighbourhoods evidently had economic effects, but it is not easy to trace consequences for the German war effort that were sizeable or persistent, let alone decisive. The German economy was flexible and adaptive. Adaptation was not costless (as Olson 1962 emphasized) but the National Socialist dictatorship was able to shift most costs onto the civilian sector, where civilians put up with them. Effects on war production were negligible in 1942, became modest during 1943, and did not develop further through much of 1944.

Was the bombing of Germany's oil industry the one exception to Olson's principle that substitution would mitigate the consequences? Arguably no: the oil industry was developed under the prewar Four-Year Plans in order to mitigate the consequences of the expected Allied blockade by substituting for imported fuel. By implication, the marginal value of its products was already high. For the same reason, German leaders insured against interruptions of supply by maintaining large stocks.

As for the other elements of the Allied war on production, the area raids and the attack on factories and shipyards, were they entirely wasted? That might be too sweeping. While Germany adapted to these aspects of the air offensive with considerable success, adaptation cannot have been costless. Olson (1962) was at pains to emphasize that the substitutes and workarounds adopted when a resource was suddenly denied always placed an additional burden on some party or other. But the German success was to diffuse the burdens and shift them largely onto the civilian economy.

Thus, while the air offensive should have cumulatively increased the costs of the adversary's war effort, it also increased the willingness of the adversary to bear them. For a considerable period, and certainly well into 1944, the adversary's adaptation to the air offensive largely mitigated its effects on fighting power.

d) The war on transportation

The campaigns against oil and the railways "were the only two that achieved their essential object" (BBSU 1998: 163; see also USSBS 1945b: 146-148; BBSU 1998: 161-167; O'Brien 2015a: 349-357). The attack on German rail transport began in the early months of 1944. It intensified in September as Allied control of France was consolidated, eventually taking more than a quarter of the overall Allied bombing effort (Table 3).

The attack on transportation received special attention in the British bombing survey report. The campaign began just as Allied forces on both sides began to encroach on Reich territories. To understand the effects, it was necessary to begin by controlling for the direct effects of territorial losses on German war production. This first step can already be seen in Figure 2 above, in the gap between actual and potential war production for each period. The direct effect of territorial losses on war production was found to be insubstantial before the beginning of 1945; this was six months after German war production peaked and began to turn down. It followed that territorial losses did not contribute directly to the decline of war production.

Could the onset of the collapse of the German war industries be linked to the Allied campaign against the railways? This required two more steps. One was to establish the direct effects of bombing on German railway shipments. Starting from time-plots for 31 railway districts and monthly data through 1944, the British survey unit again used differences-in-differences to identify the relationship. Railway shipments declined precipitately from August 1944. The decline was found exclusively in the 23 districts (three quarters of the total) that were attacked from the air. Districts that were not attacked showed no loss of performance (Figure 3). (See also the Appendix, Figure A-3.)

Figure 3 near here

The final step was to link the disruption of the railways to the decline of war production. Over the ten months up to the end of the war, the decline of German war production appeared to respond to the decay of railway shipments with a lag of one or two months (Figure 4). This was taken as sufficiently showing that bombing the railways was the thing that finally collapsed the German war economy. Ten data points from a

period when everything was collapsing at once might be less than ideal for explanatory power, but that was the data to hand.

Figure 4 near here

The BBSU interpretation is contradicted by Brauer and Tuyll (2007: 216) who maintain that the attack on the railways damaged German fighting power directly, not through the economy; it “did not make Germany’s arms production potential decline . . . the crucial point concerned the disruption of translating stocks into flows, the delivery of materiel and troops to the front.” But the idea that production was unaffected can be rejected on ample evidence of the induced paralysis of the industries of the Ruhr district (O’Brien 2015a: 349-357).

Why did the attack on German transportation have its effect when everything else seemed to fail? An answer takes us back to Bloch’s concept of the modern economy. Modern economies, he observed, are based on a division of labour that creates long, complex supply chains and relies on the continuous cooperation of all their component parts. What would happen if one part was knocked out? Bloch, and many after him, believed that, under those circumstances, the entire structure would fail. The mistake he made was to see the economy as a mechanical structure. A better model for the German economy would have been a cooperative, self-adjusting and self-repairing network. Even though the economy was already highly mobilised much earlier in the war than the Allies thought, it remained adaptable. This was the essence of Olson’s perception: when one part was suddenly knocked out, the other parts moved to fill the gap in a semi-automatic way. They pulled in resources from elsewhere, found substitutes and workarounds, made sacrifices, and got by.

But what if the component that was knocked out was the part that bound all others together? In 1940s Germany it was railways and waterways that carried inter-industry supplies of ores, metals, fuels, and bulk agricultural produce. If one bridge was knocked down or one canal was blocked, resources would find a way round. By the summer 1944 the Allied air forces had sufficient air superiority and resources to attack not one but many. As many bridges and junctions were taken out and many waterways were blocked by wreckage, production was impeded far more effectively than when many factories were attacked. Materials could not be moved from mine to factory, components could not be brought together for assembly, and weapons could not be delivered to the front. Because railways and waterways were the element that enabled the division of labour and cooperation of all other parts, there was no clear substitute for them and no workaround except the rundown of stockpiles. When connections were attacked everywhere at once, there were no

channels by which alternative resources could be pulled over to cover the deficits.

Two aspects of this outcome are notable. One is that it closely paralleled that of the Allied attack on Japanese shipping, which similarly brought about the disintegration of Japan's war economy.

The other notable aspect is that the outcome of the transport campaign rested on previous success in air combat. Allied bombers could not attack the transport system across the length and breadth of German territory before 1944, when German air defences were strong enough to cause unsustainable losses to daylight raids.

4. The Allied air offensive: a summary

The Allied air offensive succeeded in greatly diverting German resources, especially from the Eastern front, but did so on unfavourable terms. It did little or no damage to German morale. The attack on production had some effects but these were small compared with the resources and efforts involved. The supply of aviation fuel was eventually reduced, but this was already very late in the war. The greatest disruption of Germany's war production appeared to stem from the attack on railways and waterways. This effect arose because the attack directly unravelled the inter-industry linkages of the German economy, and because it was on a large enough scale to take place nearly everywhere at once.

Given the mixed accomplishments of the Allied air offensive, the official histories concurred that it was a qualified success. "Allied air power," the USSBS (1945a: 15-16) concluded,

made possible the success of the invasion. It brought the economy which sustained the enemy's armed forces to virtual collapse, although the full effects of this collapse had not reached the enemy's front lines when they were overrun by Allied forces."

Even if the air campaign did not win the war, it worked with the war on the ground to shorten the war (BBSU 1998: 161-162). When it came, victory was due to "a combination of all the different forms of attack which could be brought to bear on the enemy by sea, land, and air" (Webster and Frankland 1961, vol. 3: 289).

The same authorities invariably acknowledged, sometimes in the next breath, that not everything went right. For example (USSBS 1945a: 16):

Hindsight inevitably suggests that [air power] might have been employed differently or better in some respects.

(See also BBSU 1998: 163-164; Webster and Frankland 1961, vol. 3: 288.)

This seems like an understatement. The area raids and the attack on production, which together made up nearly half of the total Allied bombing effort, had only small effects on the supply chain of Germany's war, or none that could be readily identified.

Some scholars have concluded that the Allied air offensive failed. Robert Pape (2014: 254-313) distinguishes between victory and coercion. The purpose of coercion is to secure the adversary's compliance by means short of victory. The Allied air offensive fell into the category of coercion, which has two strategies, punishment and denial. The air war aimed to reduce the will to fight by punishing Germany's urban communities. It also aimed to deny Germany's industrial resources to the war effort, reducing the capacity to fight. Punishment failed unambiguously. Denial also failed because, although coercion was applied, Germany did not comply with Allied terms before its military forces were overrun. Therefore, Pape maintains, the Allied air offensive failed.

In the same spirit, Brauer and van Tuyl (2007: 200) ask: "if strategic bombing was not meant to achieve victory by itself . . . then what was it to achieve?" While the air offensive might have achieved more limited objectives such as the diversion of German resources to air defence and facilitation of the D-Day landings, they rate these as mere *post hoc* rationalisations of failure.

These judgements seem to miss the target. The idea that strategic bombing might win the war on its own was sometimes a hope, never a plan. Sir Arthur Harris, C-in-C of RAF Bomber Command, may have nursed the ambition of ending the war by this route, but other authorities had more modest expectations. As an example the "Pointblank" directive of 14 May 1943, which framed the goals of the Combined Bomber Offensive, mentioned the aim of "undermining of the morale of the German people to a point where their capacity for resistance is fatally weakened" but immediately qualified this as "meaning so weakened as to permit initiation of final combined operations on the Continent" (Webster and Frankland 1961: vol. 4, 273-283). In other words, area bombing would be counted a success if it allowed D-Day to happen. Perhaps this was a low bar. However, to have shortened the war does not seem like a failure.

There remains the question that all authorities, including Brauer and van Tuyl, were correct to pose: could the war have been shortened by as much, but with fewer losses of blood and treasure? With hindsight this seems beyond doubt, leading directly to a further question: why was much of the weight of the Allied offensive spent without results?

The novelty of the air war cannot be ignored. Strategic bombing had not previously been tried against a modern industrial society (Overy 2014: 610-611). Both sides began the war with many illusions about air power. Then, trial and error were costly, and learning was slow. Leaders

were reluctant to discard their illusions in the face of experience. Frictions, departmental interests, and reputational concerns, which can be found everywhere in war, politics, and complex hierarchies, reduced the capacity to learn and raised the costs of victory and defeat.

In this regard, World War II was much more like World War I than is sometimes recognized. For mythmakers it will always be the case that World War II saw faster movement and more dramatic reversals, and this has made it the more attractive story. But the glamour was never deserved. World War I suffered from the comparison. But the fact is that World War II was won by attrition on a scale even grimmer than World War I, and attrition was never anything but wasteful.

To sum up, the air war against the German economy complemented the wars on land and at sea. It did so wastefully and inefficiently, but it is hard to separate that from the nature of a war of attrition.

5. Economic warfare: what was it good for?

Before the event, economic warfare and combat often seemed to offer independent routes to the same goal. To attack the enemy's fighting power through combat was direct and was best done quickly, but perhaps at high cost. The alternative was to attack the economic foundations of the enemy's power, and the action would be relatively indirect and delayed, but it might pay off if the costs of direct confrontation were avoided as a result.

In fact, both the indirectness and the delay militated against the independent action of economic warfare. First, indirectness. In contrast to combat, where the first impact was on combatants, economic warfare was mediated through the economy where non-combatants lived and worked. Therefore, the first impact of economic warfare was always "collateral damage" to the lives and ways of life of "innocent" civilians. Or, in other words, the strategies of denial and punishment may be conceptually separable, but in practice there was no denial without punishment. Then, although punished, the civilians were not passive. Time and again, non-combatants who were punished by enemy action were shown to become more willing to suffer hardship, tighten their belts, and buckle down to the tasks of supporting the combatants.

The delayed action of economic warfare was its other critical limitation. For the planner of economic warfare, time was a limiter because there was no point in it if combat would finish the war before economic warfare had time to work. For the adversary, time was an enabler. In the face of economic attack, civilians would have time to mitigate the effects and protect the war effort by means of economizing and Olsonian (economic) substitution.

All evidence suggests that economic warfare was usually a poor substitute for combat. Being indirect and slow acting, it set in motion countervailing processes. Whether or not economic warfare was designed for denial, punishment could not be dissociated from it, and those that were exposed to it experienced it as punishment.

If the effect of economic warfare was not what was hoped, it does not follow that it was ineffective. The effect was to force the adversary to incur the costs of adaptation, and this limited future capabilities in a slow, cumulative way over months and years. Moreover, a few uses of economic warfare turned out to be more effective than the rest. When applied not to production but to transportation, on enough scale and with enough persistence, economic warfare had a paralysing effect – not on the adversary’s will, but on their capability. Therefore, when combat became protracted, it was not sensible to refrain from economic warfare, just because it did not avoid the need for combat.

Economic warfare and combat worked together, not separately. We should think of them as strategic complements. This implies that, if the availability of means of one of them increased, it raised the return on the means of the other. While it is not obvious how to show such a thing directly, it can be shown indirectly in various ways.

First, between economic warfare and combat there was a continuum of action. In fact, the binary distinction between the two simplifies, even if the simplification is intuitively convenient. To simplify a little less, Robert Pape thinks of economic warfare as one phase of the strategy of denial. Denial, he suggests, has three phases (Table 5), from strategic interdiction through operational interdiction to the attrition of military forces. Economic warfare in our terms corresponds with strategic interdiction. In Pape’s view, economic warfare is one phase in the process of denial. Military action can be applied to any phase or all phases.

Table 5 near here

Pape agrees that the time available for action to have its effect should be the deciding factor in whether to apply fighting power to earlier phases. The reasoning that I used above was that earlier action is slower and less direct in its results. Later action is more direct and brings quicker results. The problem with later action is that, if the results don’t immediately end the war, the adversary can offset them over time by compensating mobilizations into the war effort. Intuitively, this supplies the case for action to be applied to all phases at once.

Second, from a related perspective, economic warfare was one phase of the war of equipment. Writing about World War II, Phillips O’Brien contrasts the war of battles fought on land to the war of equipment, which took place largely at sea and in the air. On both sides, most equipment by

value took the form of ships and planes, while guns and armour were reduced to relatively small budget items. Both soldiers and equipment faced attrition, but the attrition of equipment followed a distinct pattern. The great land battles accounted for most human casualties, but only for relatively small fractions of equipment lost (and most of the equipment produced in wartime was lost). Far more equipment was lost in a vast air-sea battle that was waged continuously through the war.

O'Brien maintains that the strategic goals of an army cannot be realised without movement, and the purpose of military equipment was to enable movement on one side, or to suppress it on the other. It was when armies lost mobility that they suffered their greatest defeats and heaviest losses of personnel. On that basis, he argues for a more equipment-centred view of World War II, with more emphasis on the production and attrition of the equipment element of fighting power, and less emphasis on battles and casualties, which took place only as and when the war of equipment allowed them to happen.

O'Brien divides the attrition of equipment into four phases (Table 6): pre-production losses, production losses, losses in deployment, and losses in battle. Losses in production and pre-production imply some notion of hypothetical fighting power that was not realized because of enemy action, and these two phases have a natural fit to what we mean by economic warfare.¹

Table 6 near here

Pre-production, production, and deployment losses were all quantitatively important, O'Brien argues: together they accounted for the greater part of the decline of German and Japanese fighting power in the decisive stage of World War II. Because of them, he concludes (2015: 87), "By 1944, only a minority of the war-making potential of Japan and Germany was actually able to be put into 'battle'."

More insights into the underlying complementarity of the phases of attrition can be found in O'Brien's characterization of World War II on the

¹ For the non-hypothetical components of the attrition of German aircraft, USSBS (1945b: 159) gives graphic statistics: "(1) The losses on the ground were very heavy, especially after mid-1944 . . . a case where of 1,000 planes produced by an aircraft factory, all but 92 were destroyed on the airfield after acceptance . . . most of the fighters turned out in September 1944 were destroyed on the ground. (2) Destruction in transit flight . . . accounted for the loss of as much as one-quarter of production in the later months . . . (3) Losses at forward operating airfields were very heavy after the beginning of the invasion . . . Wastage rates in Fighter Corps II were averaging 600 a month, with reinforcements not exceeding 580."

Eastern front. There, both the contending armies relied exclusively on frontal attack and defence. Neither side made any serious efforts at operational interdiction to prevent the supply of weapons from the factories to the front (O'Brien 2015a: 84).² In 1941, the advance of the German forces into the Soviet borderlands relied on supplies carried by a small number of poorly equipped mainline railways across former Poland. The supply chain could have been broken, slowing or stopping the German advance. By not striking behind German lines, Soviet commanders gave their opposite numbers the freedom of action to plan offensives and deploy reserves (O'Brien 2015b; personal communication, 22 August 2019).

To summarize, economic warfare belongs to wars of attrition, when the attrition of firepower is decisive, and it is understood better as one phase of the war of attrition than as a battle in its own right.

If that is the lesson from history, does it bear on the present? The uses of trade sanctions today appear to suffer from two types of limitation, and these are very like the limitations encountered by economic warfare in history. First, history seems to show that economic warfare always involved some element of punishment, and punishment was counterproductive because it favoured the mobilization of national feeling. Similarly, far from forcing authoritarian rulers to mend their ways, sanctions might even help them consolidate their regimes.

The international sanctions imposed on Russia after the annexation of Crimea and invasion of Eastern Ukraine are a case in point. Smart sanctions were designed to punish only business interests close to the Putin regime. They were imposed without violence. Thus, collateral damage to civilian interests was minimized. Did this avoid a counterproductive effect?

Aleksandra Peeva (2019) analyses the effects of these sanctions on voting in the presidential election 2018, compared to 2012. She finds that the marginal effect of a sanctioned employer close to a polling station was to boost support for President Putin by more than 1.5 per cent. Even where sanctioned firms reduced employment between the two events, voters did not reduce their support for the authorities. This result implies that, even when the punishment element was scaled back to an absolute

² The same is not true of strategic interdiction, which entered the calculations of both sides. The German war plan aimed to seize the most important regions for Soviet war industries and food supplies. On the Soviet side, while many responses to surprise attack were lamentable, an improvised programme succeeded in saving the greater part of the threatened industrial facilities by railway evacuation to the remote interior (Barber and Harrison 1991: 127-32).

minimum, sanctions were counterproductive: they stiffened national feeling in favour of the sanctioned regime. If they raised the cost of regime policies, they also increased the willingness of society to bear them.

Second, the twentieth century suggests that economic warfare was not decisive on its own. Similarly, do economic sanctions resolve interstate disputes on their own, that is, by means short of combat? Drury and Parker (2004) and Letzkian and Sprecher (2007) address this issue, based on pairs of countries in the Correlates of War conflict dataset and earlier versions of the Hufbauer et al. (2007) sanctions dataset. Both papers find that on average the use of trade sanctions does not lead to a resolution of the dispute but significantly predicts the onset of militarized conflict.

Drury and Parker conclude that sanctions are more often a step to war than a means of avoiding it. Noting that the main users of sanctions are democracies, Letzkian and Sprecher argue that, for electoral reasons, democratic leaders usually prefer types of sanction that are less costly to domestic interests. For the same reason the leaders of targeted countries, they suggest, tend to interpret sanctions as a signal of weakness, and are emboldened by them. In response, democratic leaders find themselves compelled to escalate to violence in order not to look incompetent.

Preparations for World War II suggest a different causal mechanism, at least at first sight. Fear of sanctions or blockade did not deter the aggressors. Instead it prompted them to accelerate their war plans and widen the war (Collingham 2014: 23-26). Germany's attack on the Soviet Union in 1941 was driven partly by the fear of blockade in the West and the need to feed the German population at war (although other motives were also involved).

Japan's decision to attack the United States a few months later was driven by the American policy of seeking to constrain Japanese aggression in China by oil sanctions (described by Milward 1977: 296-297). Mapped onto the space of economic and military capabilities (Figure 5), the United States was superior to Japan in economics, while Japan held the military advantage – by much more than the figure suggests, if we allow for the relative qualities of their armed forces at the time. Washington chose the trade weapon over the risks of immediate combat. For Tokyo the better odds were seen not in waiting for years while its economy was eroded, but in exploiting its military advantage to attack the United States as soon as possible.

The deeper commonality between the historical narratives and the modern political science is that Allied preferences for blockade and sanctions did indeed signal military weakness, and Axis leaders accurately understood the situation as inviting conflict-resolution by force. What they underestimated was the Allied economic advantage and

the extent to which Allied resolve would harden under the pressure of early defeats.

Figure 5 near here

We learn from this that Olsonian economizing was not the only way to get around economic warfare. Because the effects of economic warfare took time, soldiers could also offset them by escalation. Thus economic warfare could hasten the resort to violence: it did not avoid the need for combat and was not an alternative to it. On the other side, to threaten an embargo or plan a blockade without a strong defence and combat-readiness was to indulge in wishful thinking.

What de Jonge Oudraat (2000: 121) has to say about postwar sanctions versus the use of force can be applied retrospectively, and with similar force, to economic warfare in history:

First, sanctions need to be part of a comprehensive coercive strategy that includes the threat and use of military force. Thus, sanctions should be seen as part of a coercive continuum.

6. Conclusion

This survey points to seven conclusions. (1) It was often hoped that economic warfare would act as a substitute for combat, but experience showed that this was largely an illusion. The complementarities between economic warfare and combat were much stronger.

(2) The most important effect of economic warfare was to raise the overall costs of the adversary's war effort. This was a gradual process, one that gave the adversary ample opportunity for countermeasures.

(3) The main countermeasures were Olsonian substitution, nationalism, and the escalation of violence. Substitution and nationalism did not nullify the effects of economic warfare, but they redistributed them and postponed them. Heightened violence aimed to pre-empt the effects of economic warfare by breaking out. Whichever of the three routes was taken, the one thing that was certain was that economic warfare found its logic only in protracted wars of resources.

(4) Wars of resources evoked vast productive efforts, and it was easy to conclude from this that the objective of economic warfare should be to attack production. The example of the Allied air war against the German economy in World War II suggests that the most effective way to prevent production from taking place was not to attack production facilities directly, but to demolish the transport system, which provided the means of supply-chain cooperation and coordination. This had to be done at many points at once, which could not be done without air superiority. Thus, success in economic warfare relied on success in combat – another aspect of their complementarity.

(5) Wars of resources were also wars of attrition. Economic warfare was sometimes seen as a way to avoid the attrition of armed forces. Instead, economic warfare turned out to be a phase of the war of attrition. This too emphasizes the complementarity between economic warfare and combat, because the resources available to each side for attrition in deployment and combat were limited to those that survived the attrition arising from the other side's economic warfare. From another perspective it suggests that economic warfare and combat were not so much separable elements of warfare as neighbouring bands on the continuum of warlike activities.

(6) The complementarity of economic warfare and combat is further illustrated by cases in which choosing one over the other carried high costs. It was inefficient to engage in combat without considering the possibility of striking at the enemy's supply chain, as the Soviet Union did in 1941. It was reckless to embark on economic warfare without the readiness to engage in combat, as the United States did in 1940; this encouraged the adversary to respond by aggression.

(7) While the age of mass warfare is hopefully over, similar lessons may apply to the peacetime use of trade sanctions to resolve disputes. When an economy is sanctioned, losses to civilians are inevitable. A country under siege can exploit Olsonian substitution and nationalism to mitigate the effects. If sanctions raise the cost of resistance by enough, violence may become an attractive option. If trade sanctions heighten the risks of militarized conflict, strong defences or credible deterrents are required to manage them.

Tables

Table 1. The UK working population, June 1943

	Thousands
Armed forces and civil defence	5,085
Group I (war related) industries	5,233
Group II (basic) industries	5,027
Group III (other) industries	6,861
Unemployed or awaiting work	80
Total	22,286

Source: Hancock and Gowing (1949: 351).

Group I: metal manufacture, engineering, motors, aircraft and other vehicles, shipbuilding and ship-repairing, metal goods manufacture, chemicals, explosives, oils, etc.

Group II: agriculture, mining, government, gas, water and electricity, transport and shipping.

Group III: food, drink and tobacco, textiles, clothing and other manufacturers, building and civil engineering, distribution trades, commerce, banking and other services.

Table 2. Days on which food will be lacking after the exhaustion of local products, 1888-91 and 1894-95: selected countries, according to Bloch

	1888-91	1894-95
Germany	69	102
France	32	36
England	178	274
Italy	76	75
Austria	2	7

Source: Bloch (1899: 296). The countries shown were all food importers. Russia, not included, sent large food surpluses abroad.

Table 3. The Allied air offensive: bombs dropped on Axis Europe by strategic air forces, 1940-1945, by class of objective (per cent of total)

	Per cent
Area raids	30.6
Production	14.5
Of which:	
—Factories and shipyards	3.6
—Oil products	10.9
Transport	26.7
Other targets	28.3
Total	100

Source: Data from USSBS (1945b: 2-5). Figures cover the 1.99 megatons of bombs dropped by RAF Bomber Command and the U.S. 8th and 15th Air Forces.

Table 4. German production, 1942-1945: reduction attributed to Allied area bombing, alternative estimates (per cent of estimated potential)

	USSBS Reich production	BBSU	
		All industry production	War industry production
1942	2.5	0.7	0.5
1943	9.0
First half	..	3.5	3.3
Second half	..	10.5	6.9
1944	17.0
First half	..	5.7	2.4
Second half	..	9.0	*2.6
1945 (Jan.-April)	6.5	*12.2	*3.7

Sources: Webster and Frankland (1961, vol. 4: 482-483); see also BBSU (1998: 93,96).

USSBS (United States Strategic Bombing Survey): Over a sample of ten German cities, an index is constructed to show the intensity with which a city was bombed and the months of lost output associated directly and indirectly with the bombing. The loss of 2.71 percent of annual Reich production over the ten cities is averaged over the 39.9 thousand tons of bombs dropped on them. Extrapolation to area bombing of the Reich as a whole yields the figures shown.

BBSU (British Bombing Survey Unit): The “estimated percentage loss attributable to all town area attacks allowing for the lag in effects on industry . . . All percentages are in terms of the corresponding estimated potential production in the absence of town raids.” Figures for the first four months of 1945 are calculated “as though they took place over a six months’ period.” Figures marked with an asterisk (*) are “particularly conjectural, as they assume that war production could be maintained relative to all production as well as it was in January-June 1944.”

Table 5. Three phases of denial, according to Robert Pape

	Action	Purpose
1. Strategic interdiction	“Destroys production of military equipment and national transportation networks.”	“To reduce available quantities of weapons, munitions, and other military supplies.”
2. Operational interdiction	“Destroys logistic networks, reinforcements, and command headquarters behind the front lines.”	“To stop the movement and coordination of forces throughout the theater.”
3. Attrition of military forces	[Combat]	[Victory]

Source: Pape (2014: 75, 77). In the third row, the words in square brackets are my interpretation.

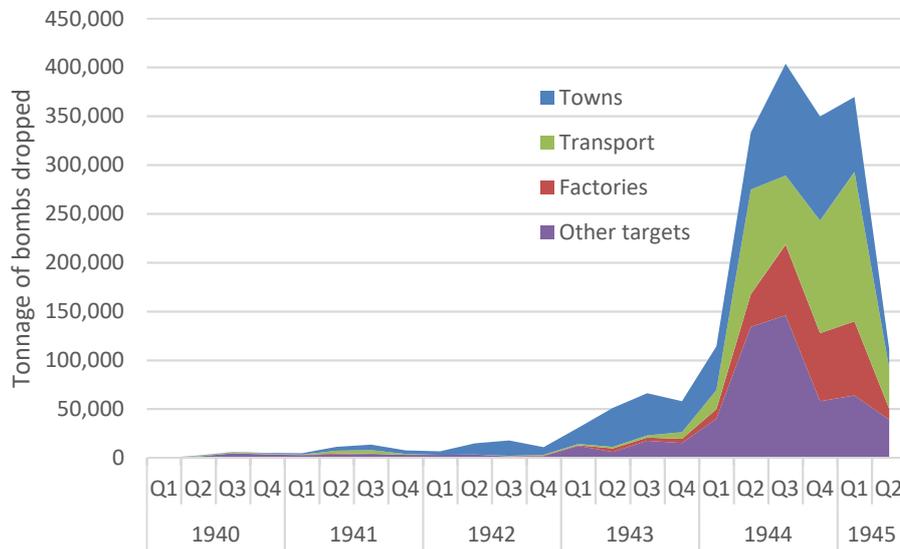
Table 6. Four phases of the attrition of military equipment, according to Phillips O'Brien

Phase	Description
1. Pre-production	“Destroying equipment . . . by preventing it from being built in the first place.” This involved “depriving the Axis powers of the raw materials, workers, or necessary economic systems needed to produce war material.” It extended to diverting workers from war production to bomb damage repair.
2. Production	Destroying equipment where it was being built. This included production losses arising from temporary closure or dispersal of production facilities.
3. Deployment	Destroying equipment between production and use in combat operations, by military action against the transport system or in accidents arising from deficient training, fuel, or facilities.
4. Battle	[Destroying equipment by military action in battles.]

Source: O'Brien (2015: 67-87). In the fourth row, the words in square brackets are my interpretation.

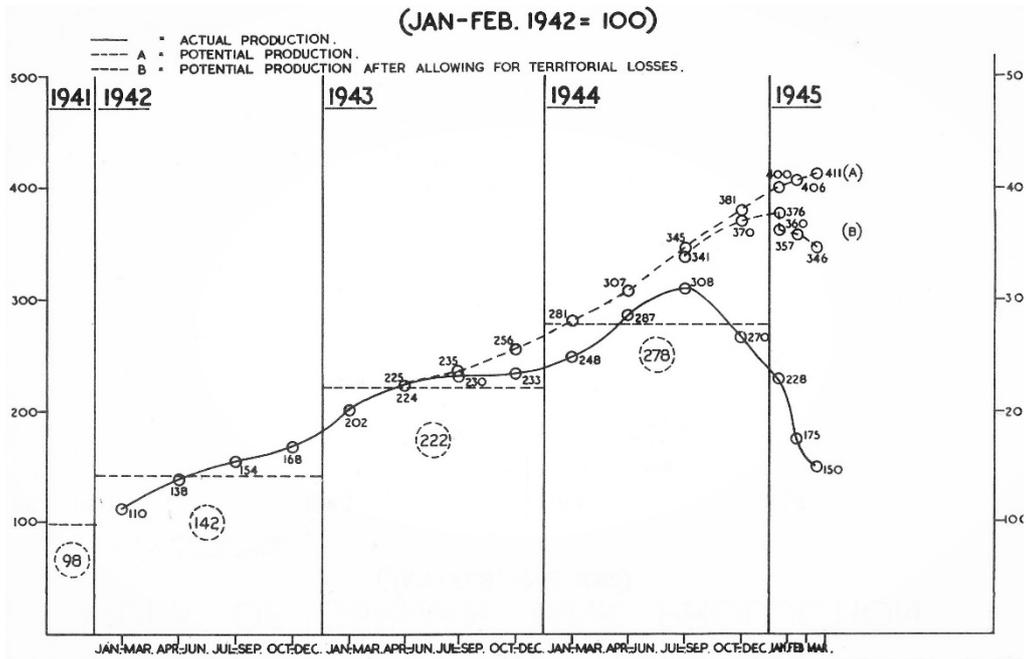
Figures

Figure 1. The Allied air offensive: bombs dropped on Axis Europe by strategic air forces, 1940-1945 (tons per quarter)



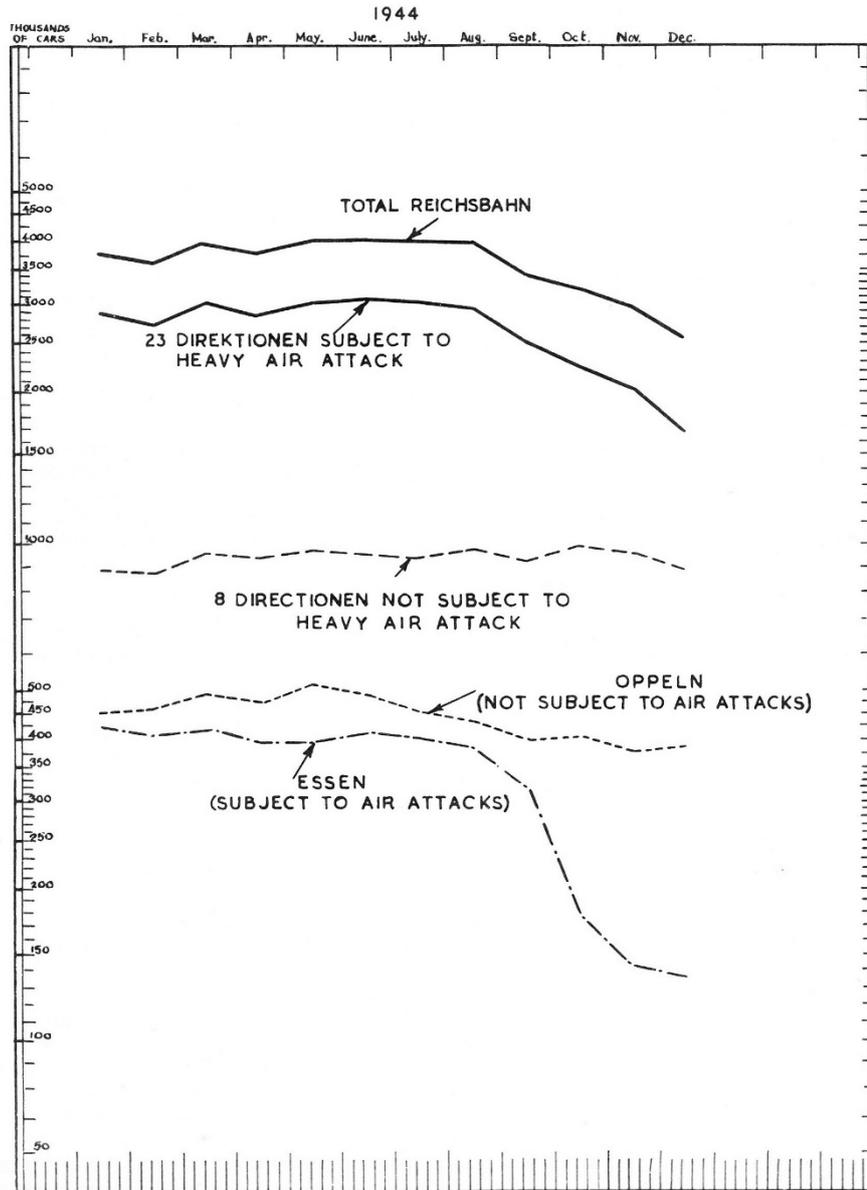
Source: Data from USSBS (1945b: 2-5). Figures cover the 1.99 megatons of bombs dropped by RAF Bomber Command and the U.S. 8th and 15th Air Forces. "Other targets," such as airfields, were attacked in support of military operations.

Figure 2. German armaments production, 1942-1945: potential, actual, and the role of territorial losses (per cent of Jan.-Feb. 1942)



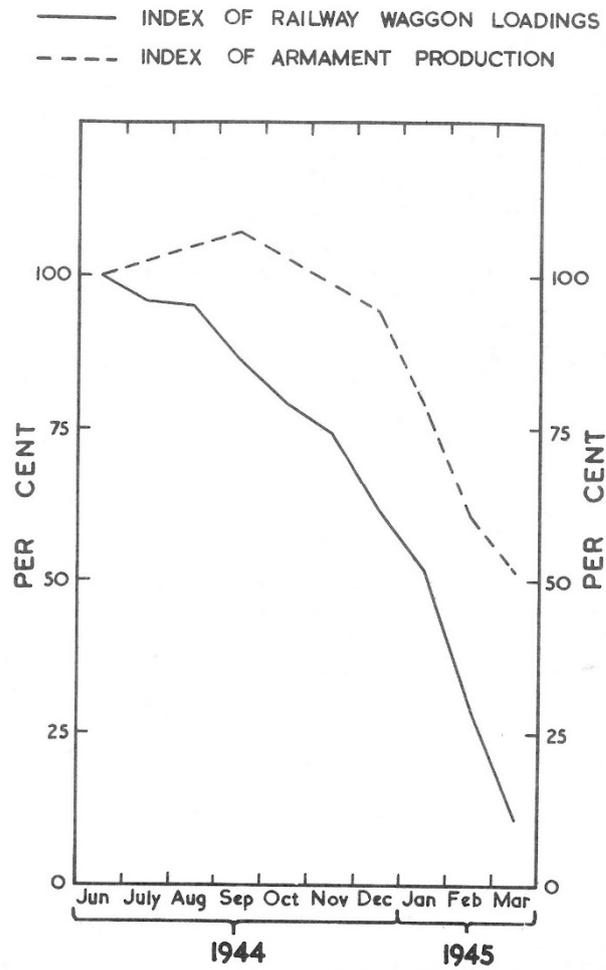
Source: BBSU (1998: Figure 20, facing page 90).

Figure 3. Allied bombing and the German railways: "comparison of waggon loadings in bombed and unbombed R.B.D.'s," January to December 1944



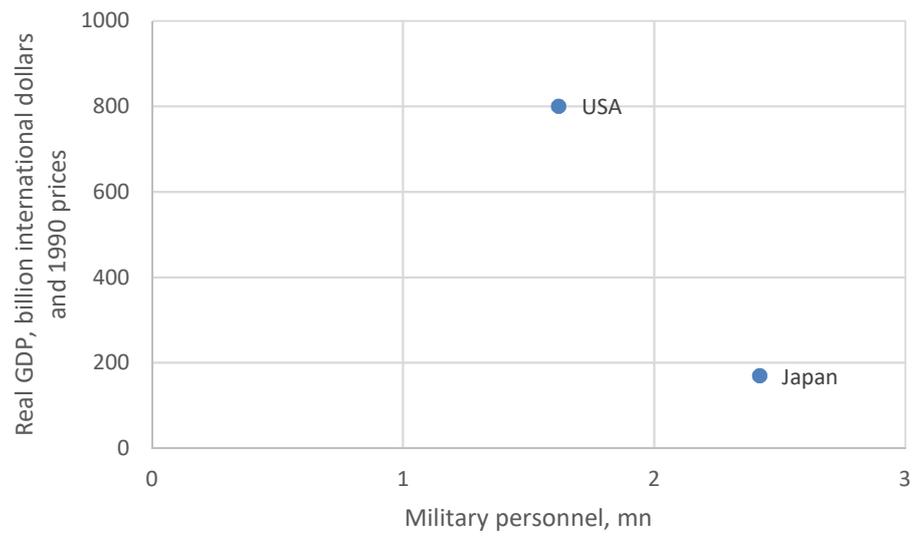
Source: BBSU (1998: Figure 47, facing page 129). RBD: State railway regional administration (*Reichsbahn Direktion*).

Figure 4. The German railways and war production: "comparison of indices for waggon loadings and armament production, June 1944 – March 1945 (June values = 100)"



Source: BBSU (1998: Figure 42, facing page 134).

Figure 5. Economic and military capabilities: USA versus Japan, 1941



Source: Data from Harrison (1998: 10, 14).

Appendix. The returns to bombing in 1944

In this note I will briefly describe and illustrate the work of Jurgen Brauer and Hubert van Tuyll (2007: 197-236) – hereafter BVT – on the microeconomic “returns” to Allied bombing of German industry and transport. Their study concluded that the returns were generally diminishing, and sometimes negative; and that the relationship was often confounded by poor choices as well as by leaps in the technological race between the two sides.

For illustration, BVT tested a sector model in which the loss of monthly sector output in 1944 below the peak (used as a proxy for potential output) depends on the level of bombing of sector facilities in the same month. They tabulated data for four sectors (aircraft, chemicals, railway transport, and aviation fuel), and provided a cross-plot for one of them, aircraft.

In the case of aircraft, the relationship (reproduced in Figure A-1) might look basically flat. That is not how BVT described it. They wrote (pp. 211-12): “if one were to draw a line through the scatter plot, it evidently would be at first steeply upward-sloping but then bending and flattening out [as predicted in an earlier passage] . . . before bending downward (which would signal negative returns).”

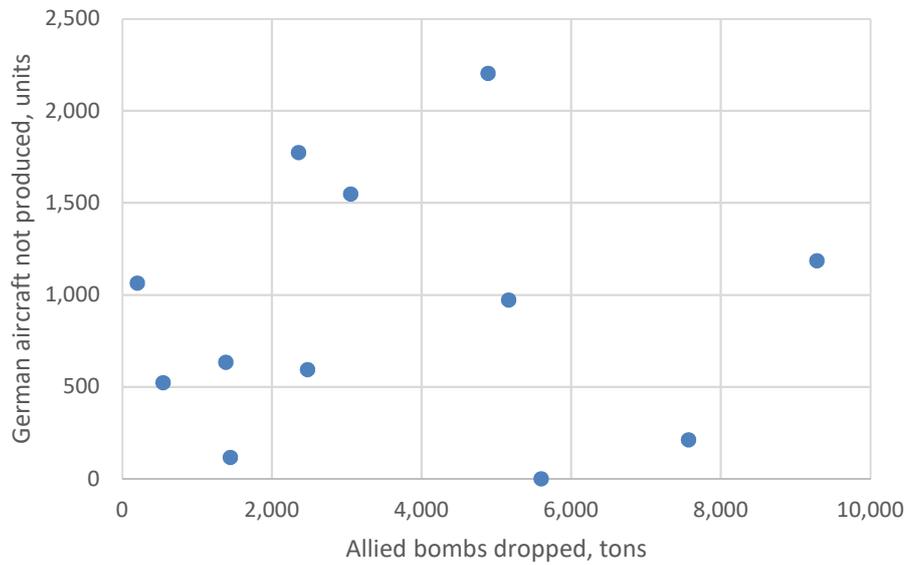
For chemical products, BVT tabulated the figures but did not plot them. They described the result as “seemingly different, yet much the same” (p. 212; see Figure A-2). They acknowledged the upward slope of the relationship, noted that it rested largely on data points at the extremes, and emphasized the high variance in the middle of the range.

Under “supply chain bombing,” BVT considered aviation fuel and railway freight. They tabulated figures for both sectors through April 1945 but did not plot them. They argued (p. 217) that data for the early months of 1945 should be ignored because by then “the game was up,” so I plot only the data from 1944 (Figures A-3 and A-4).

Concerning the railways (Figure A-3), BVT concluded (p. 217): “it would appear that the more bombing, the larger the desired effect . . . Diminishing marginal returns to increasing loads of bombing of the railroad system are clearly apparent, especially from September to December” (this refers to the four north-easterly data points). As for aviation fuel (Figure A-4), BVT drew attention to the upward slope coupled with high variance.

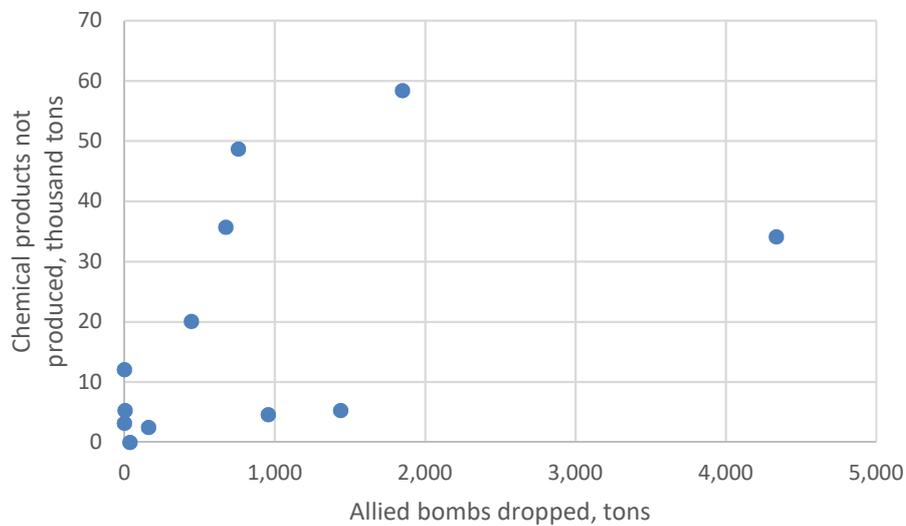
The BVT model of cause and effect is reduced-form, to say the least. It relies on bivariate cross-plots that make no allowance for omitted variables, lags, or spillovers. The model could hardly be simpler – but the simplest model must struggle for explanatory power when based on a dozen monthly data points.

Figure A-1. Allied bombs dropped and German aircraft not produced, 1944 (monthly data)



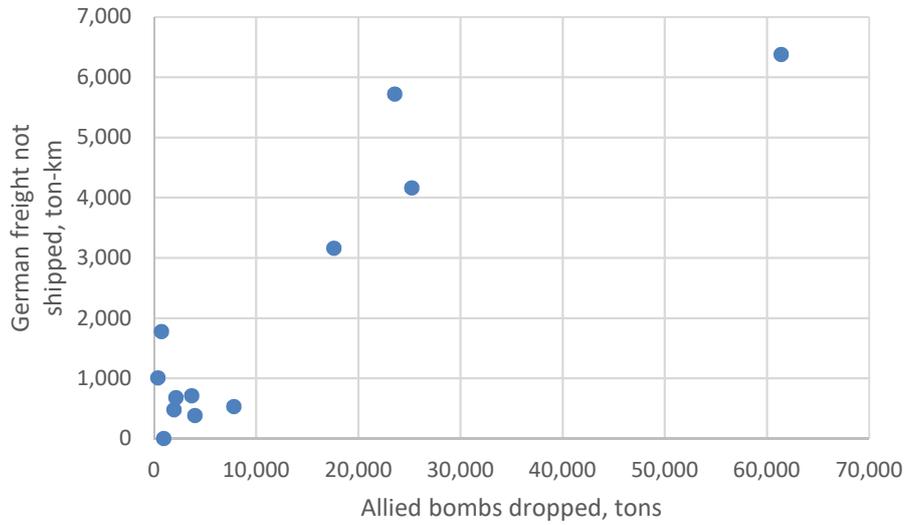
Source: Data from Brauer and van Tuyl (2007: 210). The figure reproduces their cross-plot on page 211.

Figure A-2. Allied bombs dropped and German chemical products not produced, 1944 (monthly data)



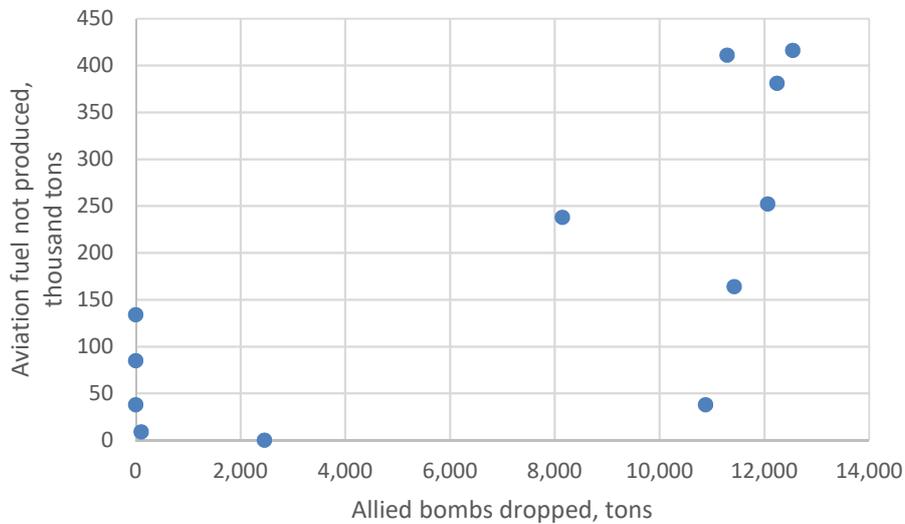
Source: Data from Brauer and van Tuyl (2007: 212).

Figure A-3. Allied bombs dropped and German railway freight not shipped, 1944 (monthly data)



Source: Data from Brauer and van Tuyll (2007: 216).

Figure A-4. Allied bombs dropped and German aviation fuel not produced, 1944 (monthly data)



Source: Data from Brauer and van Tuyll (2007: 216).

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