War of attrition: Economic warfare between Britain and Germany in World War II

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Abstract

In World War II, Britain and Germany fought each other using the instruments of economic warfare, chiefly naval blockade and aerial bombing. The blockades were anticipated, but the bombing war was novel and was poorly understood beforehand. Both sides undertook far-reaching measures of adaptation and defensive countermeasures. On each side, the priority given to the war effort required the costs of living, producing, and fighting under economic warfare to be displaced onto the civilian population. The modern industrialized economy proved to be a tough target. The British target was too tough: German leaders lacked the time, patience, and focus to crack it. The German target cracked eventually, but only after Allied expenditures of time and effort far exceeding what was anticipated. There, rising attrition and a deep fear of undermining civilian morale limited the resources that could be shifted from the civilian sphere to the military. Eventually, no additional sacrifices from civilians were forthcoming, and war production began to decline.

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Keywords: blockade, strategic bombing, economic warfare, war of attrition, World War I, World War II

JEL Codes: H56, N44

Acknowledgements: This is a chapter in preparation for *Economic Warfare and Sanctions since 1688*, edited by Stephen Broadberry and Mark Harrison. The authors thank all the participating co-authors, Richard Overy, and Duncan Weldon for comments, and Jonas Scherner for helpful advice.

This version: 18 January 2025

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Britain and Germany attacked each other's economy continuously from the start to the finish of World War II. The main forms of economic warfare were blockade and bombing.[1] Naval power was the primary instrument of blockade, sometimes supported from the air, and Britain and its Allies did their best to force Germany's neutral trading partners to comply with the blockade using diplomatic pressure and economic threats. Strategic bombing was the domain of long-range air power.

After the opening moves, World War II quickly became a war of attrition. Attrition was brought about by the simultaneous attack on the adversary's armed forces and its economy. The armed forces suffered attrition on and near the battlefield. The economy had to replace the losses of equipment, and civilians were drafted to compensate for casualties. At the same time the economy suffered attrition from blockade and bombing. These economic losses could be mitigated, but not eliminated, by adaptation – by the efforts of civilians to economize on lost supplies and capacities and find substitutes for them. Fighting power was diverted to defend the economy in the air and at sea, and these countermeasures led to further military losses.

There was a limit to adaptation. This limit was not well defined or readily observed. It was psychological as well as material, and this was captured by official worries about civilian morale. Neither side knew where its own limit lay and, for obvious reasons, no government wanted to risk finding out. Concerns over the limit of civilian endurance haunted the authorities long before morale began to sag. Eventually, even extraordinary civilian sacrifices might fail to release sufficient resources to sustain the country's fighting power.

Our chapter is divided into four main sections. In the first, we briefly outline the plans and preparations for economic warfare of Britain and Germany. In the second section, we discuss how economic warfare was conducted. In these first two sections, we consider separately blockade,

[1] Other forms of economic warfare, of equal interest but less importance, were the pre-emptive purchasing of neutral supplies and sabotage.

the traditional instrument of economic warfare, and the novel instrument, strategic bombing.

The third and fourth sections of our chapter address the adaptation of each country to the economic warfare of the adversary, first Britain and then Germany. We follow this order for two reasons. One is that blockade and bombing interacted in their effects on each country's economy; it would be confusing to discuss adaptation to either instrument out of the context created by the other. And the other reason is that each country's response to being blockaded and bombed was idiosyncratic, so that the country outcomes of economic warfare were entirely different.

Britain and Germany both had allies, and their contributions are discussed where appropriate. British cooperation with France (until June 1940), the Soviet Union (after June 1941), and the United States (after December 1941) was far closer and more substantial than the very limited coordination of the Axis powers.

Plans and preparations

The powers' previous experience of blockade, and inexperience of bombing, ensured that the two aspects of economic warfare proceeded quite differently. For blockade, the plans of each side were well prepared and largely anticipated by the other. The Allies, certain of naval dominance, planned to blockade Germany at sea, more or less on the lines of World War I.

German leaders feared the prospect of Allied blockade. In their minds, the events of 1918 cast a long shadow. Then, amid spreading malnutrition and a wave of industrial strikes, German morale had crumbled, and revolution had broken out. In public opinion, one important cause was the Allied blockade (Collingham 2011: 25-26; see also Chapter 3). But the fear of another blockade did not act as a restraint. Rather, it drove the National Socialists to bet on autarky (Scherner 2024: 11).

With Hitler in power, Germany prepared for blockade by two means. One was to make the German economy self-sufficient in deficit war materials including iron ore (for steel), oil, and rubber (Overy 1994; Toprani 2020). These measures were far from fully effective; food remained a major deficit commodity. The National Socialist authorities supported agriculture and controlled the market, but food self-sufficiency remained beyond their reach. The result was that Germany's economic war preparation became a plan to "feed the war by war." This meant to bring forward the conquest of the region to Germany's East with the genocidal

intention of diverting its food surplus to German mouths (Dallin 1957; Tooze 2006: 476-485). It was an accident of the war's evolution that in 1940 Hitler found himself occupying Western (not Eastern) Europe. When the war in the West became stalemated, his attention turned naturally to the East.

As soon as war broke out in the West, both sides put their plans for blockade into effect. From the start, the Allies exercised the same naval dominance as in the previous war. They largely closed the North Sea and the Atlantic to German vessels and placed neutral shipping under close control.

While German warships made periodic attempts to break out onto the high seas, the war at sea relied largely on ocean-going submarines to a large extent. Bizarrely, given the effectiveness of U-boats during World War I, the strength of the Royal Navy, and the certain expectation of renewed blockade, Nazi Germany invested more in its surface fleet than in submarines. Battleships were built that saw little or no action (von der Porten 1969). Germany entered World War II with just 56 operational submarines, barely more than a third of its strength in 1918.[2] Nonetheless, it launched a U-boat offensive with the aim of cutting off Allied trade and isolating the British economy. As the war progressed, it pursued it with growing seriousness.

By contrast, plans for economic warfare from the air did not exist in 1939. This is not because air power was underestimated. Rather, it was overestimated. Public opinion everywhere was convinced of the power of airplanes to attack suddenly, wreck cities, kill very large numbers of civilians, and terrorize the survivors (Overy 2014: 18-57). For this reason, long-range bombers were valued for their deterrent value more than as a means of victory. In the opening months of the war, both sides were mutually deterred, each fearing to strike the first blow.

When deterrence failed, airmen were ordered to take the offensive. What form it should take was far from clear. On the German side, following the poor results of Gotha and Zeppelin raids during WWI, air rearmament had been focused on close air support. Hitler was prepared to consider independent air operations including the bombing of economic and civilian targets, but he was naturally sceptical and easily dissuaded by

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[2] Each battleship cost 40 Type VII U-boats. The submarine fleet could have been three times larger without the Bismarck and the Tirpitz, the two great battleships of the German Navy.

poor initial results. The German air force never acquired a fleet of four-engined strategic bombers. Later in the war he authorized the V-weapon campaign against British and West European cities under Allied control, when massive Allied bombardments had become a source of embarrassment.

On the Allied side, the independent role of air power was taken for granted. Beyond that, a division opened up between the advocates of indiscriminate versus selective or "precision" bombing (e.g. Webster and Frankland 1961, vol. 1: 337-363; Overy 2014: 307-321; Biddle 2015: 495-499).

The division was formed by the gap between apparent technological possibilities and limited practical experience. Charles Portal, chief of Britain's Air Staff from 1940, and Arthur Harris, head of RAF Bomber Command from 1942, laid emphasis on the psychological effects of bombing on civil communities. They favoured the relatively indiscriminate bombing of industrial cities and ports, with the aim of "dehousing" and demoralizing Germany's war workers (and incidentally killing them in considerable numbers).

By contrast, American air force generals such as Carl A. Spaatz, commander of the USAAF in Europe from May 1942, and Ira C. Eaker, commander of the US Eighth Air Force from December 1942, advocated the precision bombing of selected production facilities. Pre-war doctrine had led the USAAF to early investment in heavy bombers like the B-17 "Flying Fortress." American airmen also put much trust in the Norden bombsight, claiming unprecedented accuracy from high-altitude (Pardini 1999). With proper target selection, the resulting shortages of key commodities were expected to ripple through the supply of war, inducing a progressive collapse.

The story is sometimes oversimplified. Two qualifications are essential. For one, the British tried precision bombing in 1939 and 1940. Portal saw Germany's oil industry as a particularly attractive target. But the British experience was that precision required daylight, and in daylight aircraft losses were prohibitive. In darkness, nothing smaller could be hit than a city. Learning the same lesson in 1943, the Americans shifted their bombsights when necessary to more feasible but less discriminating targets such as cities (Biddle 2015: 492, 514).

A second qualification, essential in hindsight, concerns the selection of targets for precision bombing. The dominant framework started from the economics of inter-industry linkages created between the wars by

Wassily Leontief, whose wartime employment was with the Office of Strategic Services (Bollard 2019: 190-196). Under this influence, American targeting looked for facilities supplying the intermediate goods most in demand for a range of final war products and for military activity. Ball-bearing factories and synthetic oil plants became the canonical cases.

An alternative framework existed, however – one that emphasized the spatial character of inter-industry linkages. The German economy relied heavily on railways and waterways to distribute coal and ores to its metallurgical, chemical, and engineering plants and to deliver war products to the Western and Eastern front lines which, by 1942, were far from Germany's borders (Mierzejewski 1984: 22-60). The idea of targeting transport linkages also found expert advocates on both sides of the Atlantic, and eventually a high-level British convert in Arthur Tedder, chief of Air Staff from 1940 and deputy Supreme Allied Commander from January 1944 (Mierzejewski 1984: 80-81).

The conduct of economic warfare

The blockades

At first the Allied blockade of Germany followed closely the lines of World War I (described in Chapter 3). The first instrument of the blockade was "control at sea," which relied on Britain's naval dominance. German warships and flag shipping were driven from the North Sea, leaving only the Baltic for German maritime trade. As exceptions go, the Baltic was far from insignificant because it allowed Germany to trade with the Soviet Union, then an ally, and neutral Sweden. On its own, therefore, the Royal Navy could not prevent Germany from trading with allies and neutrals, or from using the neutral neighbours as intermediaries for trade with the rest of the world.

The situation was greatly worsened in June 1940 by Italy's entry into the war and the fall of France. The Royal Navy could no longer control maritime shipping off the entire coastline of Western Europe and North Africa. This sealed the shift from "control at sea" to "control at source," in other words the direct regulation of neutral exports to Germany (Medlicott 1952: 415-417).

The blockade's second instrument, "control at source," drew the Allies into the direct regulation of neutral trade. The underlying purpose was to support Allied economic warfare of Germany, but the means were coercive sanctions on Germany's neutral friends and neighbours, based

on Allied naval and commercial dominance, diplomatic pressure, and veiled threats (Golson 2016).

Allied regulation of neutral trade began with the prior certification of vessels and cargoes; only this could avert seizure (not indefinitely, but pending arbitration by an international prize court), so the so-called navicert became the essential prerequisite for neutral shipping to pass the Allied blockade. A related instrument was the capacity to "black-list" (or sanction) supposedly neutral agents as hostile. A vessel without a navicert, or a blacklisted agent, would be denied market access anywhere in the world under Allied control.

Even these arrangements left room for Germany to benefit from neutral trade. Navicerts and blacklisting could not stop Germany's neutral neighbours such as Switzerland and Sweden from exporting or re-exporting war materials to Germany. Germany's access to Swedish iron ores was a particular source of concern (Milward 1977: 308-313).[3] As in the previous conflict, the answer was sought in war trade agreements with Germany's neutral neighbours. The Anglo-Swedish agreement of 1939 committed Britain to allow Swedish imports up to the prewar level, while Sweden was not to exceed the prewar level of its exports to Germany (and not to re-export goods to Germany that had potential war uses) (Medlicott 1952: 141-152). While the German prospect of victory remained alive, however, British diplomatic pressure was not all-powerful, and Germany was able to import Swedish ores through most of the war.

While the wartime evolution of the Allied blockade of Germany is not without interest, its greatest effects were arguably felt even before the war began. As discussed below, anticipation of the blockade drove Germany's war preparations and channelled its aggression in two directions, overland towards the wheatfields of Ukraine and under the sea around the British coastline.

The German blockade of Britain began in the early weeks of the war, but it did not become fully effective until the fall of France in the summer of 1940. While warships and planes played a role, the main burden fell on

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[3] The concern of the time was heightened by the belief that the German economy was fragile, so that its industry would collapse in weeks if the supply could be cut (Salmon 1981). Twenty years after the war, the idea was revived by Karlbom (1965), before being buried by Milward (1967).

submarines. During the war, Germany produced approximately 1,100 submarines (USSBS 1945a: 69). Operational numbers averaged 118 through the war, ranging from a low of 22 in January 1940 to 240 in April 1943 as the Battle of the Atlantic reached its turning point (Davis and Engerman 2006: 295-296).

The main protection of merchant shipping against submarines was found, as in World War I, in escorted convoys. An advantage was that, while the number of escort vessels required increased with the perimeter of the convoy, the number of vessels protected increased with its square. This advantage of convoys more than compensated for the disadvantage that each had to proceed at the speed of the slowest vessel (Davis and Engerman 2006: 262).

At the beginning of the war, the main Allied and neutral nations (Britain, France, the United States, and Norway) had more than 30 million gross tons of shipping capacity (almost 20m tons were under a British flag). During the war, 21.5m tons were lost to enemy action. Submarines accounted for three quarters of sinkings (Davis and Engerman 2006: 268-270). More than 30,000 merchant seamen died. From 1943, however, the rate of American shipbuilding was more than enough to cover losses.

Figure 6.1 shows the monthly losses of Allied and neutral shipping to submarines against the numbers of German submarines operating at sea. There were three turning points in the campaign. The first two were favourable to the U-boats: the fall of France in mid-1940, which removed an adversary and provided new Atlantic bases; and US entry into the war in December 1941, which greatly increased the number of unescorted shipping targets for submarine attack. The overall situation turned in the Allied favour only in the summer of 1942 after American shipping was placed under an escort regime and Eastern seaboard towns under a blackout.

Figure 6.1 here.

Figure 6.2 here.

The German ocean-going submarines of World War II were far more capable than those of World War I. However, the Allies too improved the organization and technology of anti-submarine warfare, especially from the air, and air cover was extended from the coasts to the mid-Atlantic (Davis and Engerman 2006: 266-286). As a result, Figure 6.1 shows, between each of the turning points, the level of sinkings gradually declined. The growing disadvantage of the U-boats is represented more

starkly in Figure 6.2, which captures the attacker's gain (the Allied and neutral ships sunk), relative to the cost (the number of submarines lost). Each advance made by the submariners soon disappeared.

While we will focus below on how Britain adapted to the German blockade, there were implications beyond the British predicament. By 1942 the newly Allied powers were engaged in a cooperative project that had begun with aid from Britain to the Soviet Union in 1941 and now continued, on a much larger scale, with American aid to both Allies (Harrison 1996: 128-154). This increased the value of Atlantic shipping as a target for German submarines.

Economic cooperation among the Allies was essentially the same process as economic warfare among enemies, but with opposite sign (Harrison 2024). Where economic warfare destroyed resources and disrupted supply chains, Allied cooperation created them. Where economic warfare forced societies up against their limits, economic cooperation allowed breathing space. Control of the Atlantic was the essential condition for Allied cooperation. If the German submarine campaign had succeeded in isolating Europe from America, more would have been at stake than the future of Britain.

By contrast, Germany and Italy failed to integrate their war economies because they were allies: neither could coerce the other, so cooperation disappeared into the space between them (Scherner 2022).

The bombing offensives

The war's first months were unexpectedly characterized by a mutual reluctance to send bombers against each other's cities. The equilibrium was upset by the Battle of Britain, which ended German hopes of a speedy victory over the United Kingdom. By this point, each side had begun to raid the other's towns, aiming directly at port facilities and military-industrial targets. Each soon discovered how difficult it was to hit anything with precision. At this time, each side deployed relatively lightweight bomber aircraft in relatively small numbers. Thus, the first blows exchanged in 1940 and 1941 were relatively minor.

More important were the effects on the leaders' thinking. On the German side, Hitler concluded that bombing the British war industries was a waste of effort. Since daylight mastery of the air over Britain was out of reach, making impossible, he shifted focus to the Eastern front (Overy 1977: 47). By contrast, the British, shortly joined by the Americans, came up with a different answer: to try much, much harder (e.g. Webster and

Frankland, vol. 4, 1961: 259-260). Attacking Germany by air was also important for morale: it showed that Britain and America were indeed at war with Germany – and it showed their Soviet ally that they were committed to the cause . The consequences are visible in the tonnage of bombs that each side went on to drop on one other (Table 6.1). At first these were nearly equal. In 1942 a large Allied advantage emerged and widened thereafter. By the end of the war, Allied bomb tonnage on Germany exceeded the German total on Great Britain by more than 25 times.

Table 6.1 here

The Allied air offensive evolved over time in several dimensions. Between the fall of France and US entry into the war, British strategy remained caught between over-ambition and lack of means. In his Cabinet memorandum of September 1940, Churchill remarked: "the Bombers alone provide the means of victory": the goal he set for them was to "pulverise the entire industrial and scientific structure on which the war effort and economic life of the enemy depends." But the means available at the time gave no realistic prospect of that.

Several steps led to more realistic ambitions. June and December 1941 saw the Soviet Union and the United States enter the war. While the plight of the Soviet Union presented new demands for military aid, the United States offered immense resources. In January 1942, the Washington Conference committed the newly allied British and Americans to open a "second front" on the continent of Europe in 1943. A year later, the Casablanca conference of January 1943 committed their bombers to "the progressive destruction and dislocation of the German military, industrial and economic system, and the undermining of the morale of the German people to a point where their capacity for armed resistance is fatally weakened"; but it also postponed the invasion of France to 1944. The Combined Chiefs of Staff defined "fatal weakening" as "meaning so weakened as to permit initiation of final combined operations on the Continent" (Webster and Frankland 1961: vol. 4, 273-283).

At the start of 1940 RAF Bomber Command had 438 bombers available, none of them of the heavy four-engined type (BBSU 1945a: 41). By 1943 (all figures are for January) the number had risen to 839, of which 551 were heavy bombers; and by 1945 the numbers were 1,617 and 1,096 respectively. Meanwhile the numbers of heavy bombers available to the

8th and 15th US Air Forces in Europe had grown from 156 at the start of 1943 to 3,115 in 1945.[4]

The early years provided opportunity to learn. In 1940 and 1941 RAF Bomber Command was focused on attacks on U-boat facilities, the oil industry, and railways centres. The British learned that German air defences made daylight bombing prohibitively dangerous. At night the bombers could fly more safely, but in darkness they could not find any target smaller than a town (BBSU 1998: 2-9, 53-54). From this grew the British practice of nighttime town raids or "area bombing," set out in a directive of February 1942. The logic was that, given the difficulty of hitting particular facilities, the best way to suppress production was to destroy the workers' neighbourhoods, including housing and essential public services.

Arriving in Europe during 1942, the US Eighth Army Air Force brought with it the belief that night raids were ineffective and a renewed commitment to precision bombing in daylight. The Allied Pointblank directive of June 1943 set the priority for the combined bomber offensive as German fighter production, alongside submarine shipyards and the industries for military vehicles, ball-bearings, and synthetic oil and rubber. The Americans began daylight operations against Germany's ball-bearing and fighter plants in the summer of 1943 but suffered heavy losses. Precision bombing required not only daylight but the suppression of German fighter cover. Until German airspace could be made safe for daylight bombing, the RAF would continue to pound the built-up areas of the industrial towns by night (BBSU 1998: 10-16). This began to change in 1944, when long-range fighters began to cover long-distance daylight raids. German air power weakened, and the scope of Allied operations against Germany widened. The RAF did not stop raiding German towns by night, but it also began to share the effort of daylight raids on German manufacturing and transport facilities.

The British and American approaches to the bombing war never fully converged. The American commitment to precision bombing in daylight was visible whenever circumstances appeared to permit. By contrast the British left the path of area bombing reluctantly and only when pressed (Biddle 2015: 516). Nonetheless, pressure and circumstances were

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[4] The greater number of the American bombers was offset by lighter bomb loads; this was a consequence of their heavier armament and armour, which turned out to be of less utility than expected.

sufficient to bring about a rough convergence of the two national efforts in the closing stages of the war (O'Brien 2015: 321-325).

Figure 6.3 shows the main developments of the Allied air offensive. There were two turning points. Through the first quarter of 1943, although already horrifying for those living under it, the bombing of Germany was just a foretaste. The quarterly average of bomb tonnage up to then was just 7 thousand tons. The second quarter of 1943 saw the RAF open the Battle of the Ruhr, a new campaign against the industrial towns of Western Germany. This was the first turning point, described by Tooze (2006) and Biddle (2015). The quarterly average of bomb tonnage stepped up by an order of magnitude, to more than 50 thousand tons. American daylight raids on industrial targets began at the same time but were curtailed after heavy losses.

The second turning point arrived in the second quarter of 1944. American bombers gained access to southern Germany from the Italian base of Foggia. The problem of daytime bombing was solved by long-range fighter escorts. As a result, German fighter strength was rapidly degraded, while Allied bombers ranged over all German air space by night and day. Now the quarterly average of bomb tonnage rose by another order of magnitude, this time to 225 thousand tons. While town raids continued to increase in scale, they were more than matched by the scale of attack on other targets: a new carousel of industrial facilities, and a vast campaign against German transportation.

Figure 6.3 here

Figure 6.4 here

It was only in this final phase that Allied bombing became decisively less costly to the Allies. Figure 6.4 shows the monthly bomb tonnage dropped by RAF Bomber Command per aircraft lost. For most of 1941 and 1942, the RAF was able to deliver barely 50 tons of bombs for every aircraft lost. In 1943, the number rose towards 100, but did not exceed it decisively until April 1944, rising thereafter to almost 500 tons in the autumn.

Adapting to economic warfare: Britain

War production and bombing

Britain entered the war with a relatively large, diversified, and rapidly growing defence industry (e.g. Edgerton 2006: 15-58). Shipyards were beside major harbours (Barrow, Birkenhead, Belfast, Glasgow, Southampton). Factories for guns, shells, planes, and military vehicles

were in population centres already specialized in engineering and metallurgy (London, the Midlands, Manchester). As a result, there was no shortage of potential targets.

The prewar growth of the defence industry was governed by competing considerations (Hornby 1958: 203-208; 285-298). Rearmament presented opportunities for dispersal of war production to the North and West of the country. Even before rearmament became urgent, the government's regional policy of levelling up was one factor promoting greater dispersal. As the threat of war increased, with it arose fear of bombing, and in 1935 London and the East of England were designated a "danger zone" from which war production should be removed.

Unsurprisingly, powerful frictions worked against these seemingly compelling considerations to keep war production where it was. The urgency of rearmament focused decision makers on quick results. Economies of scale and agglomeration would be lost if scattered small factories took the place of large ones and if new capacity was located at a distance from specialized suppliers, habituated workers, and experienced managers. Finally, the increasing range of modern aircraft caused the safe areas to shrink.

As a result, the main progress in dispersal of the defence industry was limited to a few ammunition plants and ship repair facilities. Many new establishments, including "shadow" factories and dispersal factories, were based around London and the Midlands.

In 1940 and 1941, the Luftwaffe paid considerable attention to the main centres of wartime production and distribution (especially ports). In the year to July 1941 there were 41,000 deaths and a similar number of serious injuries, and a million people were made homeless (Webster and Frankland 1961, vol. 4: 258). The effects on production were modest and, for the most part, transient. Figures for electricity consumption in cities that experienced bombing suggested that economic activity fell immediately by 10 to 25 per cent, but in nearly all cases returned to normal within ten days. Coventry was an exception: after the raids of November 1941, the city took six weeks to recover (Overy 2014: 114).

Other effects were more persistent. Most important was the diversion of major resources to air defence and the emergency services. The numbers engaged in air raid precautions and emergency responses rose to 700,000 full-time and 1.5 million part-time personnel by 1941 (Overy 2014: 115). Resources were diverted from Britain's war effort in other theatres: the Mediterranean, and beyond. As a result, Britain was less able to resist the

U-boat offensive in the Atlantic, German and Italian aggression in Greece and North Africa, and Japanese aggression in the Far East, and less capable of offensive operations.

Another diversion of resources arose from the immobilization of Britain's east coast ports after the fall of France (Hancock and Gowing 1949: 253, 260). The western ports became congested, forcing ships to lie idle at the docks and so reducing their effective carrying capacity. Once unloaded, the supplies arriving on the west coast had to be rerouted to their destinations, so that the railways also suffered congestion, slowdown, and reduced capacity.

The German bomber offensive diverted British economic fighting power in 1940 and 1941, but this falls short of strategic success. On the contrary, 1940 and 1941 were years in which war production climbed and the workforce was comprehensively mobilized into uniform and war work. Indirect evidence of German success might have been signalled by crumbling civilian morale (the "will to make war," as defined by USSBS (1945: 95)) or by indicators of declining health and work capacity of civilians. But there is little to no evidence of either (McKay 2003: 248-265; Overy 2014: 169-196; Todman 2016: vol. 1, 515-524; 2020: vol. 2, 7-16,).

To summarize, the German air offensive imposed serious costs on the British economy but did not put at risk either Britain's military defence or social stability. If the aim was to undermine or destroy Britain's economic fighting power, the outcome was a clear failure.

Food and the submarine blockade

Before World War II, Britain imported more than three quarters of wheat and flour, oils and fats, butter, cheese, and sugar (Hammond 1951: 394). The Battle of the Atlantic was hard fought and costly to both sides. By 1942, as Table 6.2 shows, Britain's quarterly food imports were running at just half the rate of the first nine months (October 1939 to June 1940). The loss of imports was only partly mitigated by a substantial increase in home production. Yet, after a dip at the end of 1939, British food stocks never fell below the pre-war level.

Table 6.2 here

The war saw sweeping changes in the composition of the British diet, which became much more vegetarian and considerably more monotonous. The sharpest declines were in the consumption of sugar, fruit, fish and poultry, and tea and coffee, all of which were rationed. The

largest increases were in the consumption of grains and potatoes, which were the most important sources of energy. These were never rationed, which speaks to the adequacy of the food supply, if not its variety (Hammond 1951). The result, also shown in Table 6.2, was that the calories consumed per person remained essentially constant throughout the war, while their distribution was probably somewhat equalized by rationing.

A series of interventions brought this about. Shipping space was rationed. Bulky and perishable foods were to be produced at home. Luxury foods were rationed. Food was subsidized and farmers were paid to plough up grassland and focus on arable crops.

While food supplies remained adequate, the same cannot be said of other consumer products. Civilian supplies of cloth and clothing, fuel and access to transport services, and consumer durables of all kinds were severely restricted (Table 6.3).

Table 6.3 here.

As for health and longevity, adult death rates, which had trended down through the interwar years, rose in 1939 and rose again in 1940. The spike was temporary, however. By 1942 adult mortality was once again below the prewar level and thereafter continued downward along the pre-war trend (Figure 6.5). Infant mortality followed a similar pattern, spiking in 1940 and thereafter declining. By contrast, the prewar downward trend of stillbirths was barely disturbed by the outbreak of war (Figure 6.6).

Figure 6.5 here.

Figure 6.6 here.

It would be rash to conclude that public health posed no issues for the British civilian authorities in wartime. On the contrary, air raids, evacuations, and the unprecedented wartime mixing of the civil population presented stiff tests. Among these (Table 6.4) were upticks of notifiable infections. Dysentery, pulmonary tuberculosis, and scarlet fever were persistent; typhoid fever spiked in 1941, then died away. Infectious diseases did not, however, develop into a serious threat.

Table 6.4 here.

Living with food rationing, like living under bombardment, occasioned grumbling in queues and in shelters, but did not undermine morale in the form of expectations of victory and willingness to work.

To summarize, Britain survived blockade despite substantial dependence on food imports. Adaptation to blockade, like adaptation to bombing, was costly. In Britain's case, however, the price of survival did not bear heavily on the war effort. Much grassland was ploughed up for arable cultivation. While the agricultural workforce grew by more than 10 percent, the increase was entirely made up of people drawn out of inactivity. Growing use of agricultural machinery also helped: domestic tractor production increased by 250 percent from 1938 to 1943 (CSO 1995: 46, 67, 176). The turn to home production and the growing consumption of bread and potatoes reduced import requirements (Table 6.2), saving 50 million tons of shipping capacity, or nearly two years of peacetime non-oil imports (Olson 1963: 128).

Other countries that entered the war nearly or entirely self-sufficient struggled and sometimes failed to feed their populations. They failed because they were poorer at the outset, and so began the war with fewer inessential uses of food; or because their economies were insufficiently integrated, so that wartime shortages could not be mitigated by efficient substitutions; or both.

Adaptation and its limits: Germany

Neutralizing blockade

Scarred by the experience of blockade in the previous war, German leaders prepared for the same in the next one. As already discussed, they planned to feed Germans at war at the expense of the territories conquered in the East.

Table 6.5 here

Conquest yielded major resources for the Germany economy, for which the figures given in Table 6.5 represent a lower bound. Klemann and Kudryashov (2012: 99) estimate the net wartime contribution of occupied and "dependent" Europe to the German war economy at RM93.6 billion, close to a full year of prewar German GDP. But, of that sum, only RM9.3 billion, or one tenth, came from the occupied East, with another RM8.9

billion from northern and eastern Europe.[5] Measured at prewar prices, the annual volume of net imports reached at least 20 billion in 1942 and 1943, representing 15 per cent of Germany's GNP in those years. In 1943, 70 percent of German revenues from the major channel of exploitation, the "occupation costs" that Germany levied on its occupied territories, came from Western Europe. More than 40 percent came from France alone (Abelshauser 1998: 143). France overall contributed resources equal to 9 percent of German GDP (Milward 1977: 140).

The Eastern territories made a larger contribution in the form of labourers. By 1944, one in five German civilian workers in industry, transport, and agriculture, was a foreigner (Abelshauser 1998: 161). A war designed to subjugate or kill Europe's undesirable foreigners brought more than 7 million of them into the heart of Germany.

Despite additional resources from conquest, German civilians were increasingly exposed to war mobilization, blockade, and bombing. By 1943 real civilian consumption in Germany was already 20 percent down on its 1939 peak. In early 1943, Germany's colonial sphere reached its maximum extent, after which it began to shrink. At the same time, as shown below, Allied bombing was starting to drive Germany's aggregate production below its full potential, shifting pressure into the civilian sphere.

The ultimate failure of German plans to pre-empt the Allied blockade by war prompted the official historian (Medlicott 1959: 646) to conclude:

> Fear of the consequences of the blockade played a part in drawing Germany into the Russian adventure and the two-front war which ultimately proved so disastrous for her; perhaps one could say that in this sense the fear of blockade may have been more important than the blockade itself in bringing her to ultimate defeat.

War production and bombing

The salient fact of the German war economy was the growth of war production despite the suffocating pressure of relentless blockade and bombing. The index of war production compiled by Rolf Wagenführ showed a threefold increase from the first months of 1941 to the summer of 1944. The "production miracle" made a mockery of efforts to find a close link from Allied bombing to the German war effort.

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[5] The figure of RM8.9 billion is based on summing the subtotals for Albania, Bulgaria, Croatia, Finland, Hungary, Romania, and Slovakia.

The success of German war production should not be taken entirely at face value. There were elements of “mirage” in the “miracle” (Scherner and Streb 2016). The index was designed to promote the image of minister of munitions Albert Speer. It concealed occupied Europe's contribution and emphasized the growing supply of "big ticket" items while quality and reliability declined. Still, the achievement was real to a considerable extent.

The Allied air offensive did not prevent the production miracle. Its contribution was to force Germany to defend against the bombers and adapt to continuous bombing. The costs of defence alone were many and heavy. Of the 93,000 military aircraft that Germany produced after 1941, more than half were fighters. From 1942 more fighter aircraft were deployed in the West and over Germany than in the East (O'Brien 2015: 290-291).

Both sides lost around 40,000 aircraft. Plane for plane, the Allies lost more aircrews and more valuable machinery. In 1943, for this reason, German air commanders calculated they could win the war of attrition in the air (O’Brien 2015: 337). But they did not reckon with the Allies' greater economic capacity to replace losses.

From the summer of 1943 German air power was in decline. German fighters were concentrated over the homeland and were used up in air defence. While Allied bomber streams attacked airframe and aeroengine plants, the long-range fighters that escorted them were also given free rein to attack German fighters and airfields. As the turnover of pilots accelerated, replacements were insufficiently trained for their own survival. Accident rates rose with non-combat losses. The Luftwaffe went into a tailspin from which it did not recover. By 1944, 30 per cent of German fighter pilots were dying each month, while replacements were insufficiently trained for their own survival (O’Brien 2015: 293-297, 336-339). Such losses, being unsustainable, marked the beginning of the end. The simultaneous no-shows of German air power over the Normandy landings (June 1944) and the Bagration operational area (which annihilated Army Group Centre Operation in the East in June and July 1944) were directly attributable to the Allied bomber offensive. Without air support, the combined arms approach that had underpinned early German victories was gone.

Allied air raids also drew German labour resources and armament into air defence and bomb repair. More German troops served in air defence from 1943 onwards than in Stalingrad. 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).

On top of the costs of defence, Germany also had to adapt economically and pay the costs of adaptation. 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).

Mançur Olson (1962) later showed how Germany's war effort adapted quickly to the blow: by a ripple of economizing and substitution. Before the Schweinfurt raids, Germany's ball-bearing supplies were already more than adequate. In the face of sudden shortage, it was not difficult to concentrate remaining supplies on war production where they were most needed. The German war economy retained considerable slack until 1944, facilitating adaptation to the combined impact of blockade and bombardment.

While taking up slack helped with adaptation in the short term, there was also the creation of new capacity. Allied bombing is thought to have destroyed one sixth of the industrial fixed capital stock in the future zone of British-American occupation. But damaged capacities could be quickly rebuilt and augmented on a surprising scale. By 1945 the gross value of fixed industrial assets in West Germany 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 new capital created in wartime Germany was costly. The 4,100 factories that were relocated in the twelve months up to November 1944 absorbed more 70 per cent of available construction materials. This was one of the two great wartime projects of industrial dispersal, the other being the Soviet evacuation and relocation of industrial assets out of the path of the invading German armies in1941 and 1942. The heavy costs of new industrial construction had to be taken from somewhere. At first, they came from the remaining reserves of civilian consumption. As the war progressed and the scope for civilian adaptation dwindled, the risk would arise that more new facilities could be built only at the expense of new war production.

The new industrial facilities were also not as productive as those they replaced. To reduce their vulnerability to repeated raids, they were

dispersed away from existing industrial centres, and external economies were lost in the process (Overy 1994: 373-374). Dispersal also undermined efforts 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). Moreover, the dispersed facilities were more exposed to disruption of railway transportation (USSBS 1945b: 158-159), so they had to carry larger stocks, reducing efficiency further.

War production suffered not only from the dispersal of capital. It waw also impeded by the scattering of the workforce following Allied air raids. By the end of the war, two fifths of the urban housing stock of Western Germany and West Berlin had been destroyed. At the same time, residential investment came to a standstill. At the war's end, the shortage of urban dwelling units stood at 4.3 million. Because of this, German towns were depopulated, losing 2.3 million inhabitants by 1946 (compared to 1939). As Vonyo (2012) has shown, the housing shortage became a major drag on industrial recovery that persisted for years after the war.

How did German war production and fighting power respond to Allied bombing as the war progressed? The sources fall into two categories: insider estimates found after May 1945 in contemporaneous German documents or reported afterwards by German officials to Allied interrogators; and independent estimates constructed afterwards by the Allied bombing surveys (USSBS 1945a; BBSU 1998).

An advantage of the insider accounts is that they are rich in narrative. On the other side, it is hard to identify any German source with a clear commitment or other reason to tell the truth. The explicit mission of both Allied postwar survey teams was to reach unbiased conclusions. The US team was large and relatively independent. The smaller British team was led by Sir Solly Zuckerman, a respected scientific adviser, though not a disinterested party: in wartime he was Tedder's ally in advocating the bombing of German transportation.

Both Allied reports presented and deployed much data. For causal inference they relied considerably on narrative and judgement. However, they introduced two methods that offered a firmer basis for identifying causation: differences-in-differences and the construction of counterfactual series.

Both Allied teams exploited variations in the intensity of bombing across German towns to estimate the effects of town raids (shown in Table 6.6). The Americans estimated losses of total ("Reich") production year by year from a sample of ten cities. Based on the known destruction of these towns and their contributions to industrial production, the loss of production was found to have reached 2.5 percent in 1942, 9 percent in 1943, and 17 per cent in 1944. This did not show the effect on war production, however.

Table 6.6 here

The British team compared 21 towns that were heavily bombed to 14 that were largely untouched. Monthly data by town and by industrial branch from April 1943 to June 1944 showed that total output rose everywhere, but the bombed towns fell short of the control group by 13.7 percent. The war production lost through bombing was much less, however—only 6 per cent, and the loss diminished over time. This indicated 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 6.4 again).

These studies were limited to the effects of area raids, which became a much smaller proportion of the total effort in 1944. The effects might be understated, however, because the method of differences-in-differences necessarily excluded spillover effects on the economy as a whole.

A more comprehensive picture emerges from the efforts of the British team to construct a counterfactual index of potential war production. They estimated the capacities of every plant in every branch of German war industry quarter by quarter through the war and added them up on the same basis as Wagenführ's index of war production.

Figure 6.7 here

Comparison of actual and potential war production (Figure 6.7) shows two turning points. One is marked in the second quarter of 1943, when German war production first slowed and began to fall short of potential. Another is marked in the third quarter of 1944, when German war production peaked, turned down, and began to fall absolutely.

The idea that Allied bombing first forced German war production below its potential in spring 1943 is consistent with the BBSU differences-in-differences estimate of town raid effects (Table 6.6) and narrative accounts of the Ruhr campaign from March to July 1943 (Tooze 2007:

596-598; USSBS 1945b: 146; Biddle 2015: 501-503). O'Brien (2015a: 298) tells another story, different in substance but consistent in timing.

The collapse of German war production began around the time Allied forces approached Germany's frontiers. To control for territorial losses, they were counted separately in the potential war production series. Figure 6.7 shows that potential output on German-controlled territory began to turn down in early 1945; in contrast, the collapse of war production began earlier and proceeded more rapidly than territorial losses could explain.

Figure 6.9 here

The BBSU found a consistent explanation of the final collapse in the transportation campaign in the attack on German transport (railways, canals, and bridges). The attack began in the early months of 1944, intensified in September as Allied control of France was consolidated, and eventually absorbed more than a quarter of the overall Allied bombing effort (Mierzejewski 1984: 102-161). Using differences-in-differences, the British team showed a causal effect of bombing on German railway shipments. Monthly data for 31 railway districts through 1944 showed a precipitate decline of railway shipments that began in August (Figure 6.8). The decline was fully explained by the 23 districts that were attacked from the air. Districts that were not attacked showed no loss of performance. Thus, the attack on the railways was effective.

Finally, the disruption of the railways could be linked to the decline of war production. Over the ten months up to the end of the war, the decay of German war production appeared to respond to the decline of railway shipments with a lag of one or two months (Figure 6.9). By implication. the transportation campaign had at last pushed Germany’s war industries up to and over a cliff edge.

Figure 6.8 here

Table 6.7 here

Table 6.7 summarizes a conjecture. The bombing war can be separated into three phases. In the first phase of the bombing campaign, Allied bombing of German economic targets ran at 7 thousand tons per quarter, of which one thousand were dropped on transport facilities. War production was unaffected, because Germany's civilian economy was fully capable of adapting and protecting the war effort. In the second phase, the intensity of Allied bombing rose to 81 thousand tons per quarter, of which transport accounted for 27 thousand. Now adaptation became

insufficient, so there were observable effects: German war production paused its growth and fell short of potential for the first time. Growth resumed with small but persistent losses of 16 index points per quarter. In the final phase, Allied bombing increased again, averaging 285 thousand tons per quarter and 113 thousand tons on transportation. With the German economy pushed beyond its limit, adaptation stopped. Quarterly losses of war production rose to 123 index points per quarter, signifying an irretrievable collapse.

Why was the attack on German transportation effective when all else seemed to fail? On this interpretation, when every railway interchange, canal, and bridge had been destroyed, every supply chain was broken. When nothing could move, production stopped, and military resistance also came to an end (O'Brien 2015: 349-357).

The exhaustion of civilian reserves

The intention of economic warfare was to make the costs of adaptation and countermeasures so heavy that Germany could no longer sustain them. Did this happen? The evidence can be found in available measures of nutrition, morbidity, mortality, and morale of the German civilian population.

Nutritional standards were already problematic for the mass of German people before the war. Under prewar rearmament, according to Baten and Wagner (2002), mortality failed to improve in Germany at rates observed elsewhere in Europe in the interwar years. The immediate reason was the greater prevalence in Germany of infectious and parasitic diseases associated with poor nutrition of the urban population. Behind the poor quality of food supplies to towns and cities lay the pressures of military mobilization, price controls, and the disintegration of the German food market. Even before the war, German consumers were already making a down-payment on the price of their leaders' war ambitions.

On the eve of war, the German authorities introduced food rationing. The arrangements were both more and less comprehensive than those made in the United Kingdom. In Germany, rationing was not applied to the agricultural population, because farmers and farm workers were expected to be "self-sufficient." For others, the German system covered a wider range of foodstuffs, including bread (from the start) and potatoes (eventually); these were never rationed in the UK.

As Table 6.8 suggests, the energy and protein content of rations for a German working family was adequate at first, judged by the rather poor

standards of the prewar years. It then declined in steps that were particularly marked in April 1942, May 1943, and October 1944, ending at a level that was altogether inadequate.

Table 6.8 here.

Table 6.9 offers a more granular picture that distinguishes between energy and proteins. In wartime, workers performing heavy labour and children were given priority. Those performing heavy work received more calories and more proteins than regular workers.. In proportion to their body weight, older children were assigned more calories and younger children were given more proteins. The result was that the entitlements of those employed in heavy work declined at half the rate of others. By the end of 1944, those engaged in “normal” work had lost up to 15 percent of their calories and almost one-quarter of their protein intake – more, if we allow for unobserved quality deterioration.

Table 6.9 here.

These entitlements applied to non-agricultural households. In farming communities, "self-sufficient" households retained a substantial advantage (Buchheim 2010: 315). For urban dwellers, the significance of nutritional deficits was cumulative. An SS report of 1943 on intellectual workers, who lacked access to ration supplements for "heavy" work, referred to "severe fatigue, lack of concentration and greater irritability," associated with significant weight loss since the war began (Buchheim 2010: 322).

Urban residents often traded illegally for farmers’ food surpluses. The black market increased the farmers' incentive to hide produce from government procurement officials. It increased food availability in towns but disrupted the supply of rationed food. The growing shortfall of rations was both debilitating and demoralizing. Ration cuts tended to follow military setbacks, undermining the regime's propaganda of inevitable victory. The regime's attitude to the black market vacillated between tightening rules and easing enforcement (Buchheim 2010: 311, 314).

There was a physical toll on health. Table 6.10 compares the incidence of notifiable diseases in wartime Germany to other places and times. German civilians experienced waves of diphtheria, pulmonary tuberculosis, and scarlet fever. For diphtheria and scarlet fever, the burden was heavier than in World War I. Germany also suffered more widespread infections than the United Kingdom in World War II for these

illnesses, though British authorities struggled to contain TB and dysentery to some extent (Table 6.4).

Table 6.10 here

Eventually, German civilians began to die. Until 1943 (as Figure 6.10 indicates), they had died no more frequently than in England and Wales. After 1943, there are no more statistics for Germany as a whole. But the Bavarian authorities' records through the remaining war years have been kept. They show that mortality rose sharply in 1944, and again in 1945 (but most of that year fell after the German surrender). In the Bavarian countryside in 1944, the crude death rate rose from 127 to 145 per 10,000. In Bavarian towns, the increase was far greater, from 122 to 191—and 1945 saw further increases. Infant mortality rose in Bavaria in 1944 and 1945, and also in Germany's major cities (Figure 6.11). Heightened morbidity and mortality in the last year of the war point to a critical deterioration of the conditions of civilian life.

Figure 6.10 here

Figure 6.11 here

Finally, we address civilian morale. Allied bombing and food shortages weakened civilian support for National Socialist leadership and war aims. Official records, secret Gestapo reports, captured correspondence, and interrogations suggest several conclusions. Bombing directly affected more than 25 million German civilians, or one third of the population. It increased the desire for an end to the war, willingness to surrender, and distrust in leaders, exacerbated by inadequate air raid precautions and poor shelter access.

Nazi officials were intensely concerned about civilian morale and bombing's impact on citizens' perception of leaders and war aims (USSBS 1945a: 97-98). Bitter jokes circulated, contrasting Nazi boasts with the devastation of German cities. After the Hamburg raid in 1942, party officials were confronted by outraged citizens. Many hid their party insignia, and citizens stopped using "Heil Hitler." Speer feared a few more attacks like Hamburg would finish Germany. Support for bombed-out civilians became a priority, with special staffs created to repair buildings and increased production of furniture and textiles.

The American bombing survey found "diminishing returns": bombing was bad for morale, but those survived heavy bombing were not more demoralized than others who experienced "lighter" bombing (USSBS 1945a: 96).

Did morale matter? As the American survey notes, government documents of the time "consistently assert that air attacks were undermining morale and producing defeatism, but they usually claim that no matter how the civilians thought and felt, their behaviour showed no active opposition to the war . . . depressed and discouraged workers were not necessarily unproductive workers" (USSBS 1945a: 97). If so, morale was irrelevant to the war's progress.

Such scepticism is undermined by recent research using new data and modern methods. Contrary to USSBS findings, Adena et al. (2021) show that bombing stimulated civilians to resist the regime and damaged military productivity. They measure civilian morale by the frequency of treason trials for anti-Nazi activity, and military morale by the victory rates of ace fighter pilots. Anti-Nazi resisters and ace fighter pilots exemplify the extraordinary efforts that can make a difference in war.

The study of civilian morale is based on a sample of 911 cities, of which almost half were bombed at least once (Table 6.11). The bombed cities accounted for nearly all (86 per cent) of resistance episodes; thus, resistance was 6.9 times more likely in bombed cities than in those spared. Considering only the cities that were bombed at least once, the timing of resistance tells a similar story. In a month without bombing, the likelihood of a resistance group starting to operate was just 7.6 per cent. The risk more than doubled, reaching 17.6 per cent, in the month such a city was bombed.

Table 6.11 here.

The catastrophe engulfing Germany's towns had indirect military effects. Fighting men were kept informed through home visits, letters, and emergency postcards from those made homeless. Many came back from home leave in distinctly low spirits (Hastings 2000: 27). The bombing of an ace fighter pilot's hometown promptly reduced their subsequent aerial victory rate, and repeated bombing magnified the effect.

The same research finds that bombing was not the only way to lower German civilian morale. Access to BBC radio news complemented Allied bombing, each augmenting the other's effect in stimulating resistance. BBC broadcasting was far cheaper in lives and resources than Allied bombing.

The morale dimension of bombing led Germany into its most ambitious and costly technology project. The V weapons programme was intended to terrify Allied populations and shore up German domestic morale. It

cost Germany a share of national resources equivalent to the Manhattan Project but had few economic or military effects (O'Brien 2015: 335).

In summary, when the supply of war was attacked, the civilian economy acted as a shock absorber. Civilians were forced to adapt by making do with inferior substitutes and by making do with less; the effect was to free resources to fill gaps in war supplies. By 1944, the German household sector approached the limit of its adaptability. Nazi fears for morale restricted further resource transfers from the civilian sector. Germany ran out of capacity to absorb the hammer blows of economic warfare. The collapse of the war economy proceeded slowly at first, then rapidly over the war's last six months.

Conclusion

> There will come a time . . . when the effects of economic war will begin to multiply themselves . . . failure accumulates, battles are lost, wars are lost; and in that ultimate breakdown the effects of economic war will be completely merged with the phenomena of defeat (Vickers 1943: 21-22).

Economic warfare was a central process of the war. Britain and Germany tried to strangle each economically and to pre-empt the other's attempt to do the same. Both had prepared for a repetition of World War I at sea – Germany through an extensive autarky programme before 1939; Britain by maintaining a large navy to ensure dominance on the seas. Neither was ready for the air war that came after 1939.

Germany and Britain were tough targets for economic warfare. Neither country was brought low by economic warfare alone. Economic warfare took time to implement and more time for its effects to ripple through the adversary's economy and for the adversary to run out of resources. The attrition arising from economic warfare was felt only in combination with attrition on the battlefield. Britain, with support from its American ally, was too tough a nut to crack. Germany lacked time (and its leaders lacked patience) for economic warfare against Britain to succeed; and it faced a wealthier adversary.

By contrast, British and Allied economic warfare against Germany largely succeeded. It succeeded only after much more time elapsed than was originally hoped and after the expenditure of extraordinary and unanticipated efforts to build a bomber force of thousands and to replace tens of thousands of planes and more than a hundred thousand aircrew lost. Precision bombing and the idea that, with the destruction of a few critical industries, war production would come to a halt turned out to be

wish dreams. Air attack had important military effects by diverting fighter strength, shell output, artillery, and manpower to the defence of the Reich – and by grinding down the German air force even before the Normandy landings, but it succeeded in economic terms only when combined with the pressures brought about by the Allied blockade and the Allied victories on the Eastern front, in the Mediterranean, and in France.

Allied economic warfare against Germany aimed to weaken its war effort through the denial of resources – by destroying production or the means of production. The results of the air offensive, measured by the undermining of the German war effort, were imperceptible until the spring of 1943. They still disappointed through the summer of 1944, reducing German war production by no more than a few percentage points. They became fully effective only late in 1944 with the intensifying attacks on oil plants and on railway, bridges, and canals.

Allied economic warfare succeeded by forcing Germany to divert resources, economic and military, before the war and during it. Before the war, the fear of blockade drove Germany to bid for autarky, undertaking costly investments in domestic iron ores for steel and in synthetic oil, and rubber. Once the war began, the same fear spurred German ambitions to seize the food-surplus regions to the East. But, instead of freeing Germany from the fear of blockade, the Eastern front became a sink for German military power. Meanwhile the Combined Bomber Offensive forced Germany into a dispersal of war factories that was costly in labour and building materials and reduced the effectiveness of capital investments. At the same time air defence of the homeland acquired higher priority than the pursuit of victory in the East.

To protect its war effort from the effects of economic warfare, German leaders shifted the costs of defence and adaptation onto the civilian sphere. While the German war effort thereby expanded for much longer than Allied planners hoped, civilian resources and reserves were depleted. German leaders understood that there was a limit to this process. The long shadows of 1918 limited the hardships that the Nazi regime felt it could impose on civilians. Civilian production stayed higher for longer to stave off the morale effects of Allied bombing. But eventually the point came where the losses, not only from economic warfare but from attacks on every front, could no longer be made good by civilian sacrifice. Now the damage rebounded back onto the war effort, which suddenly weakened and began to collapse.

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Tables

Table 6.1. Bomb tonnage on the UK and on occupied Europe, 1940 to 1945

	German bomb tonnage on UK	Allied bomb tonnage on occupied Europe	Allied/German ratio
1940	36,844	14,631	0.397
1941	21,858	35,509	1.62
1942	3,260	53,755	16.5
1943	2,298	226,531	98.6
1944	9,151	1,188,577	130
1945	761	477,051	627
Total	74,172	1,996,054	26.9

Notes: The German figure includes V-weapons (used from June 1944 to March 1945). For Allied bombing, the figures used here are those most nearly comparable to the German figures: the total tonnage dropped by the long-range bombers of RAF Bomber Command and the 8th and 15th US Army Air Forces, making 2.0 million tons of high explosives. A larger figure, 2.7 million tons, is the total of bombs dropped by all Allied air forces on all targets in the European theatre (USSBS 1945a: 1).

Source: Figures in tons are from Overy (1980: 120). Ratios are calculated from the figures given in the source.

Table 6.2. Food availability in the UK, 1939-1945

	Prewar	1939	1940	1941	1942	1943	1944	1945
Imports under Ministry of Food (mn tons and quarterly rate)	…	*5.5	**3.8	3.7	2.7	3.0	2.8	
Home production, crops (mn tons):								
--Wheat	1.7	1.6	1.6	2.0	2.6	3.4	3.1	2.2
--Potatoes	4.9	5.2	6.4	8.0	9.4	9.8	9.1	9.8
--Sugar beet	2.7	3.5	3.2	3.2	3.9	3.8	3.3	3.9
--Vegetables	2.4	2.4	2.6	2.9	3.7	3.1	3.4	3.2
Home livestock (mn head and mid-year)								
--Cattle		8.9	9.1	8.9	9.1	9.3	9.5	9.6
--Sheep and lambs		26.9	26.3	22.3	21.5	20.4	20.1	20.2
--Pigs		4.4	4.1	2.6	2.1	1.8	1.9	2.2
--Poultry		74.4	71.2	62.1	57.8	50.7	55.1	62.1
Food stocks at end-of year (mn tons)	10.5	7.5	10.6	13.4	13.7	15.8	15.0	…
Energy consumed (thou. calories per person, average)	3.0	…	2.8	2.8	2.9	2.8	…	…

Key: *October 1939 to June 1940. ** July to December 1940

Sources. Imports taken or calculated from Hancock and Gowing (1949: 206, 357). Home production from Hammond (1951: 393). Food stocks from Hancock and Gowing (1949: 207, 358). Energy consumed from Hammond (1951: 387), the figures given there being rounded to the nearest 100 calories in accordance with discussion in the accompanying text.

Table 6.3. Real civilian outlays on consumer goods in Germany and the UK, 1938 to 1944 (per cent of 1938)

	United Kingdom	Germany	
	per cent of 1939	Per cent of 1940	Rebased to 1939
1939	100	108	100
1940	87	100	93
1941	81	97	90
1942	79	88	81
1943	76	87	81
1944	77	79	73

Source: Columns 1 and 2 from BBSU (1998: 76). Column 3 is calculated from the source.

Table 6.4. Notifiable infectious diseases per 10,000 residents the United Kingdom, 1939-1945

	Dysentery	Diphtheria	Pulmonary tuberculosis	Scarlet fever	Typhoid fever
1939	0.6	12.1	11.2	19.6	0.4
1940	1.0	13.1	11.4	15.9	0.8
1941	1.9	13.4	12.4	14.4	1.2
1942	2.0	10.8	12.9	20.8	0.2
1943	2.2	9.1	13.3	27.5	0.2
1944	3.6	6.4	13.3	22.1	0.2
1945	4.3	5.1	12.7	17.8	0.1

Sources. Calculated from total notifications in CSO (1995: 00), normalized by the mid-year resident population (1939) and civil population (1940 to 1945) from LCES (1970: 8).

Table 6.5. Germany's gross national product and resources available, 1938-1943 (billions of Reichsmarks and 1939 prices) according to Burton H. Klein

	1938	1939	1940	1941	1942	1943
Government expenditures	33	45	62	77	93	109
Consumer expenditures	70	71	66	62	57	57
Gross domestic investment	13	14	10	7	6	5
Net exports	1	–1	–9	–15	–20	–21
GNP, total	117	129	129	131	136	150
Resources available, total	116	*130	138	146	156	171

Source: Klein (1959: 257). The total of resources available is either the sum of government and consumer expenditures and gross domestic investment, or GNP plus net imports (net exports with opposite sign). For 1944, Klein provides only a figure for real consumer expenditures – RM53 billion, 7 per cent less than in 1943.

Notes: * Corrected from 126 in the source.

The reader should treat all the figures in this table with circumspection. They provide only a rough guide to general trends and orders of magnitude. Real consumer expenditures may be overstated. Gross domestic fixed investment is certainly understated (although inventory investment may also be overstated), and some investment costs may be hidden in the figures for government expenditure. Finally, the contribution of the occupied territories to wartime resources available is certainly understated. In more detail:

(a) The level of household consumption may be overstated. A recent benchmark estimate of Germany's GNP for 1936, based on input-output data from the 1936 industrial census, yields RM53.2 billion of private consumption in 1936 (Fremdling and Staeglin 2014: 377), around 5 percent less than Klein's (1959: 252) 55.8 billion in the same year.
(b) The level of domestic investment may be understated. The Fremdling-Staeglin benchmark for Germany's GNP in 1936 shows RM11.4 billion of gross fixed capital formation, nearly twice the 6.2 billion found by Klein in the same year. (For inventory investment, however, the discrepancy, although smaller, runs the other way: RM3.0 billion according to Klein, 1.4 billion according to Fremdling and Staeglin.) Independently, Scherner (2010, 2013) has identified

various large and consequential omissions from the investment series available to Klein. Consistently, he finds industrial fixed investment of RM2.65 billion in 1936 (Scherner 2010: 438) compared with the previously accepted figure of 2.16 billion. Of greater significance is the discrepancy Scherner finds for the war years. Summing over the three years from 1941 to 1943, Klein (1959: 256) valued gross domestic investment at current prices at RM19 billion. But this sum is equalled or even exceeded by the RM19.1 billion that Scherner was able to find over the same period for *industrial fixed investment alone*.

(c) Net imports are underestimated, potentially by billions of Reichsmarks. Germany was able to exploit its occupied territories through many channels, not all of which were accounted for at the time. The figures omit, for example, foreign goods purchased and consumed by the German armed forces abroad without entering the country. They also omit the value of foreign goods seized and consumed without payment. Various estimates are available (Klemann and Kudryashov 2012: 75-117; Scherner 2012), but have not been compiled for national accounting purposes.

Table 6.6. German production, 1942-1945: Allied estimates of reduction attributed to Allied area bombing (per cent of estimated potential)

	USSBS estimates of loss of Reich production	BBSU estimates	
		Loss of all industrial production	Loss of 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 6.7. Germany's war production shortfall and Allied bomb tonnage on economic targets in three periods, 1941-1945

Period	Germany's shortfall of war production, index units per quarter		Allied bomb tonnage, thousands per quarter: Total	Allied bomb tonnage, thousands per quarter: Of which, on transport
1. Apr/41-Mar/43	0	(complete adaptation)	7	1
2. Apr/43-Jun/44	–16	(partial adaptation)	81	27
3. Jul/44-Mar/45	–123	(collapse)	285	113

Notes and sources: Germany's war production shortfall is actual war production less potential war production allowing for territorial losses, as shown in Figure 6.7. Index units are percentages of the January-February 1942 monthly average level of production. Allied bombing tonnages are as shown in Figure 6.3. Period 1 starts with the Allied bombing of economic targets. Period 2 begins when German war production first fell below potential (although not yet at its peak). Period 3 starts when German war production began to fall.

Table 6.8. Energy content of food rations for a German worker family member, 1939/40-1945/46

	kCalories per day
1939/40	2,435
1940/41	2,445
1941/42	1,928
1942/43	2,078
1943/44	1,981
1944/45	1,671
1945/46	1,412

Source: Abelshauser (1998: 155).

Table 6.9. Feeding worker households in Germany in World War II: rationed energy and proteins from six food groups, by main breadwinner's type of work and age of children, per cent of average consumption in 1937

Type of work:	Heavy		Normal	
Age of children:	Older	Younger	Older	Younger
Energy:				
End-1939	100	100	91	91
Mid-1942	93	92	85	84
End-1944	96	94	87	85
Proteins:				
End-1939	98	100	86	88
Mid-1942	83	82	73	73
End-1944	87	87	76	77

Notes: The six food groups covered in this table are bread and flour, meat, fats, whole milk, eggs, and sugar and jam; fruit and vegetables (especially potatoes, rationed from April 1942) are not counted. The baseline is average consumption of a family of five (two adults and three children) with an annual income of 2,500 to 3,000 Reichsmarks in 1937. In wartime, rations were differentiated by class of employment (heavy labour attracted more energy and proteins) and age (older children were given more calories while younger children were given more proteins). In all cases the energy and protein content of rations is shown for a family of five. Older children in the table were 14, 10 to 13, and 3 to 6 years of age; younger children were 12, 7, and 1½ years.

Sources: Family rations are from Buchheim (2010: 317). Energy and proteins are converted on the basis of Gebhardt and Thomas (2002) as follows: bread and flour (#419 bread, whole wheat); meat (#764 fresh pork chop, lean and fat); fats (#154 butter, unsalted), whole milk (#118); eggs (#140 one medium size, raw); sugar and jam (#1024 white granulated sugar). These conversions likely overstate the absolute quality of German wartime foodstuffs, but they suffice to give relative weights for the index numbers reported in the table. No allowance is made for the deterioration of food quality from 1937 to the war years, described by Buchheim (2020: 319).

Table 6.10. Notifiable infectious diseases per 10,000 residents in Germany in the two World Wars

	Dysentery	Diphtheria	Pulmonary TB	Scarlet fever	Typhoid fever	Typhus (spotted fever)
World War II						
1938	0.8	21.8	8.9	16.1	0.9	0.0
1939	0.9	20.6	10.5	18.5	0.8	0.0
1940	1.8	19.6	13.3	19.2	1	<0.1
1941	1.2	24.1	13.4	34.3	1.9	0.1
1942	1.7	33.4	16.1	48.7	1.8	0.3
1943	0.8	33.5	17.4	48.4	1.9	0.4
1944	0.8	33.6	17.1	32.2	1.3	1.8
World War I						
1914	0.9	19.2	..	15.8	2.6	0
1915	1.2	26.1	..	22.7	3.2	1
1916	1.5	29.9	..	14.3	2.2	<0.1
1917	10.5	26.7	..	7.4	4.6	<0.1
1918	4.8	24.8	..	6	3.7	<0.1

Source. Süss (2003: 442).

Table 6.11. Bombing frequency and risk of resistance, Germany, 1943-1944

(A) Resistance in towns that were bombed once or more versus towns never bombed

	Total	Never bombed	Bombed once or more
Towns	911	457	398
Any resistance?	56	8	48
Resistance risk	6.1%	1.8%	12.1%
Odds ratio	..	..	6.9

(B) In towns that were bombed once or more, resistance starts in town/months when bombing took place versus town/months without bombing

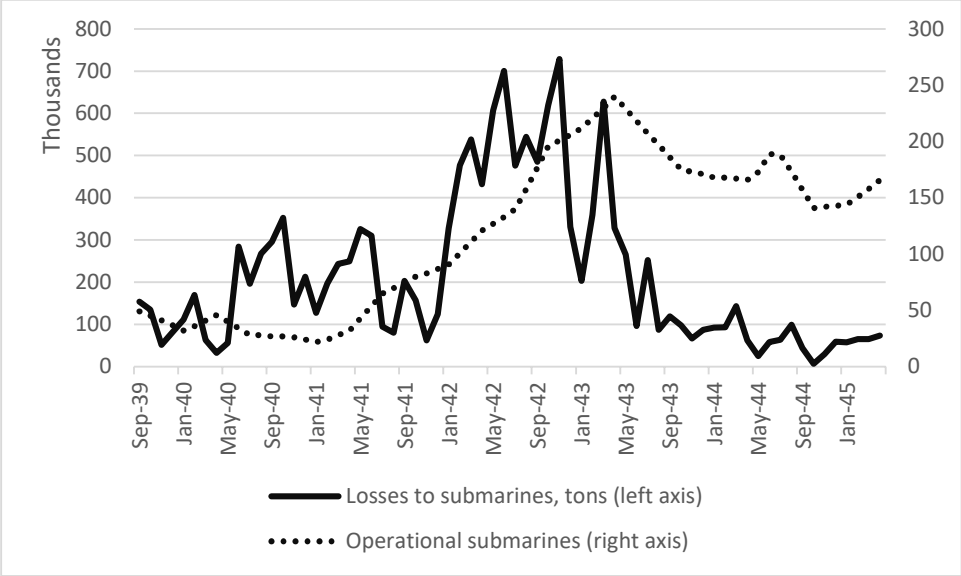
	Total	Without bombing	Bombed once or more
Town-months	10,704	9,150	1,554
Resistance starts?	972	698	274
Resistance risk	9.1%	7.6%	17.6%
Odds ratio	..	..	2.3

Source: Adena et al. (2020) – author's communication.

Note: Cases of resistance are counted in the month of instigation based on court records. The odds ratio is the risk of instigation of resistance in a town (town/month) where (in which) bombing took place as a multiple of the risk in the absence of bombing.

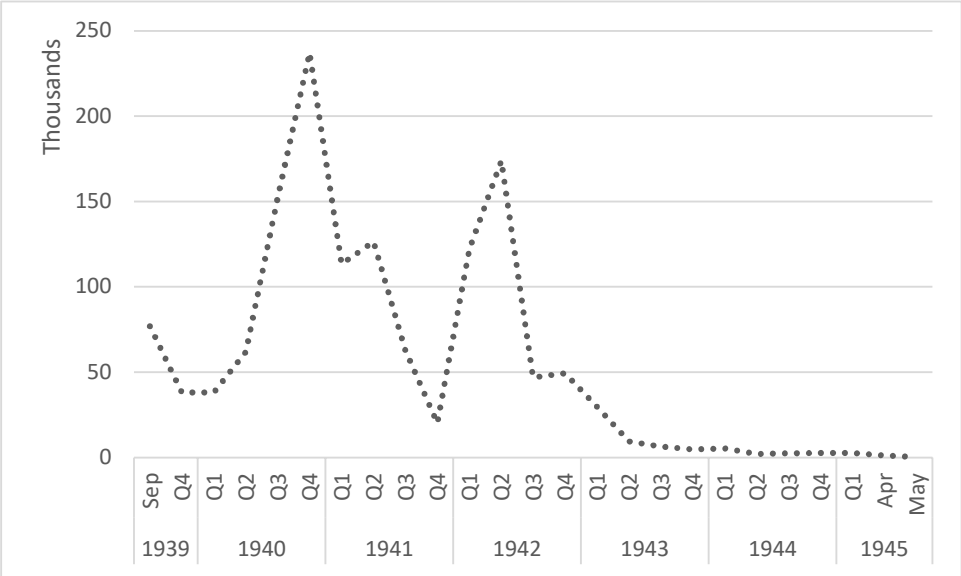
Figures

Figure 6.1. Germany's operational submarines and the sinking of Allied and neutral shipping, 1939-1944



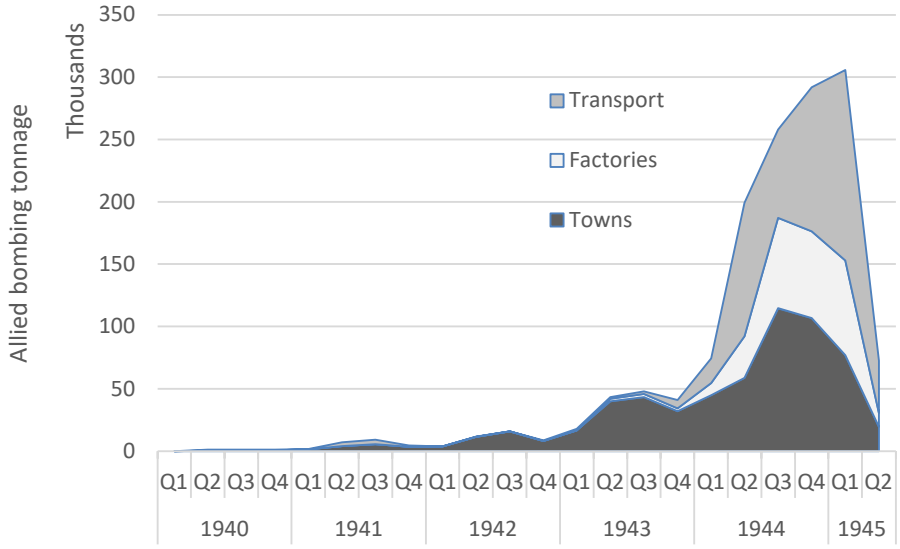
Source. Monthly data from Davis and Engerman (2006: 298-300). Shipping losses are those attributed to submarine warfare (around three quarters of all losses.

Figure 6.2. Allied and neutral shipping tonnage sunk per U-boat lost, September 1939 to May 1945



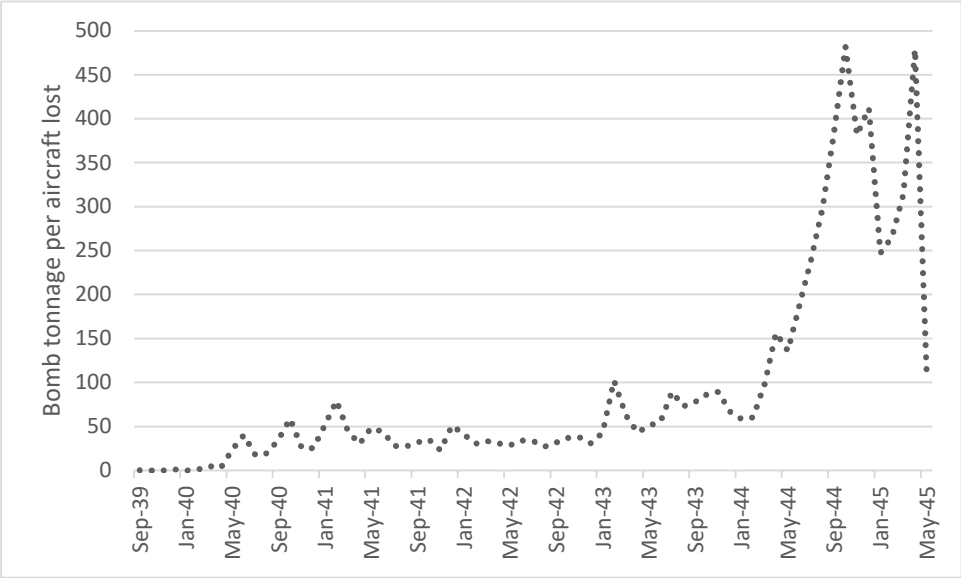
Source: As Figure 6.1. Monthly data are reported here on a quarterly basis because, in some months, no submarines were sunk.

Figure 6.3. Allied bombing of economic targets, 1940 to 1945 (thousand tons)



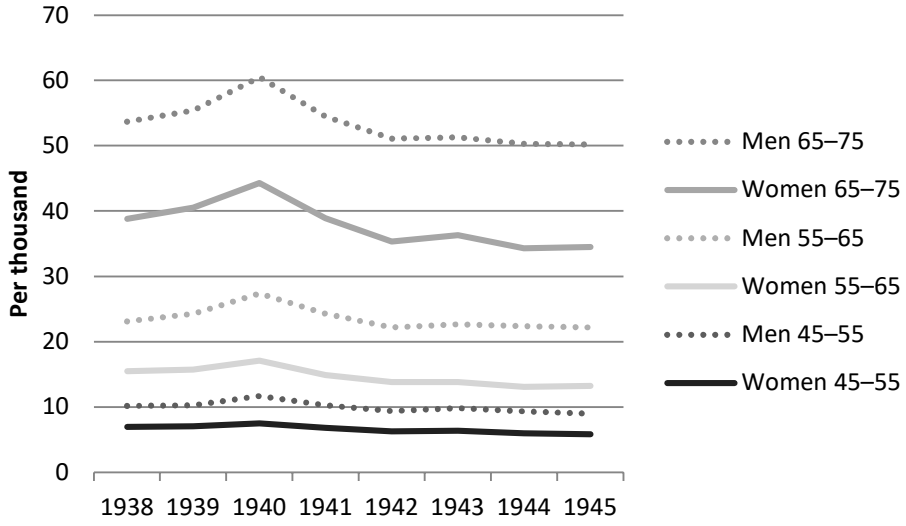
Source. Quarterly data from USSBS (1945b: 2-5). These figures cover approximately three-quarters (1.425 million) of the 2 million tons of Allied bombs dropped by RAF Bomber Command and the U.S. 8th and 15th Air Forces and listed in Table 6.1. Economic targets included towns (43 per cent), industrial facilities (20 per cent), and transport facilities (37 per cent). The remaining 575 thousand tons were dropped on "other targets," including submarine pens and airfields, in support of military operations.

Figure 6.4. Bomb tonnage dropped by RAF Bomber Command per airplane lost, 1939 to 1945



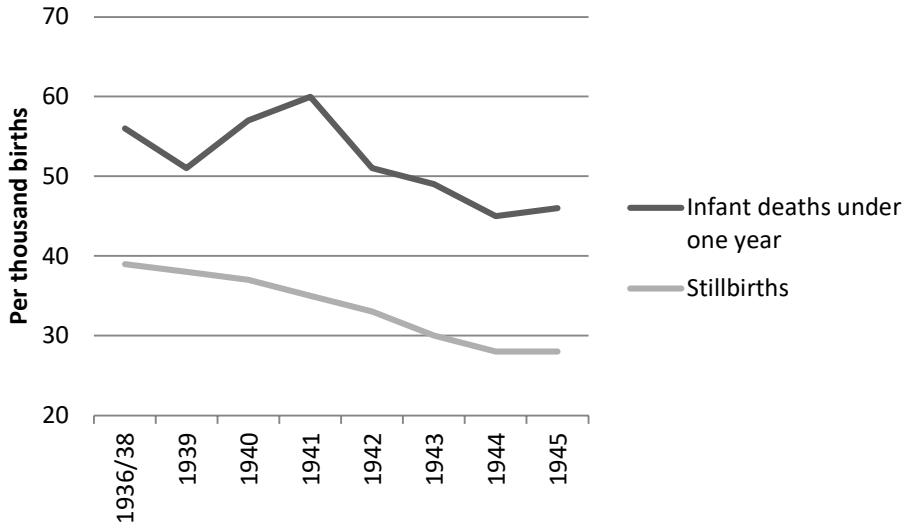
Source: Monthly data from Webster and Frankland, vol. 4 (1961): 431-436, 455-457. Figures cover all Bomber Command operations, not just those directed against economic targets.

Figure 6.5. Adult civilian male and female death rates at ages 45 to 75 years in the UK, 1938-1945



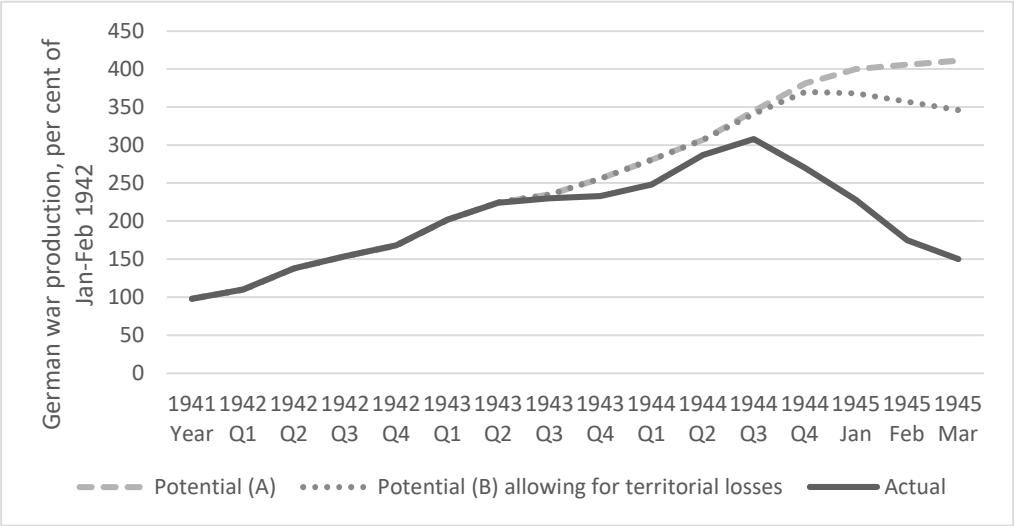
Source. Annual data from Titmuss (1950: 521). Causes of death exclude operations of war.

Figure 6.6. Infant deaths and stillbirths in the UK, 1936/38 (average)-1945



Source. Annual data from Titmuss (1950: 524).

Figure 6.7. German war production, potential and actual, 1941-1944 (percent of January-February 1942), according to Rolf Wagenführ and the BBSU



Source: Quarterly data from BBSU (1998: Figure 20, facing page 90). Actual production is the Wagenführ index; potential production is the same adjusted by the BBSU.

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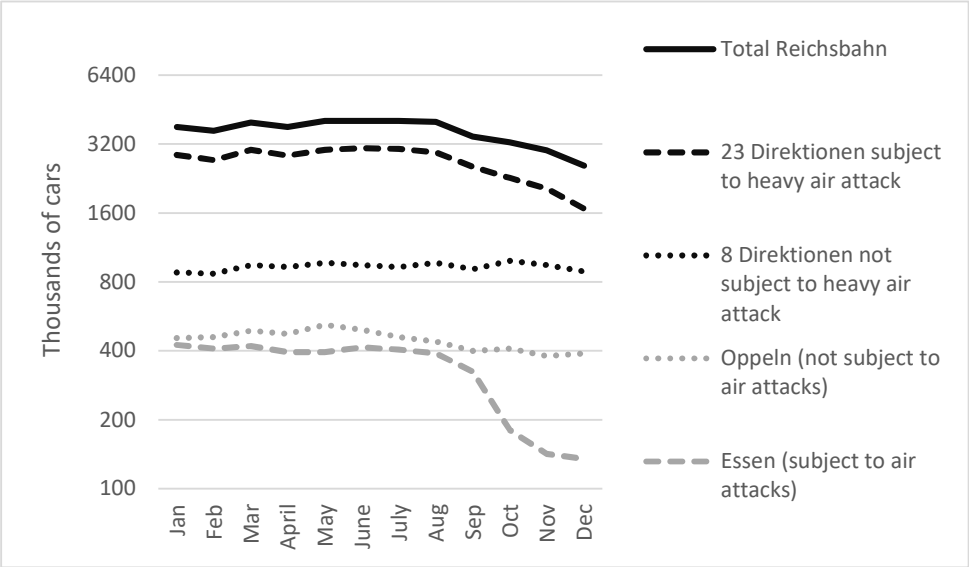
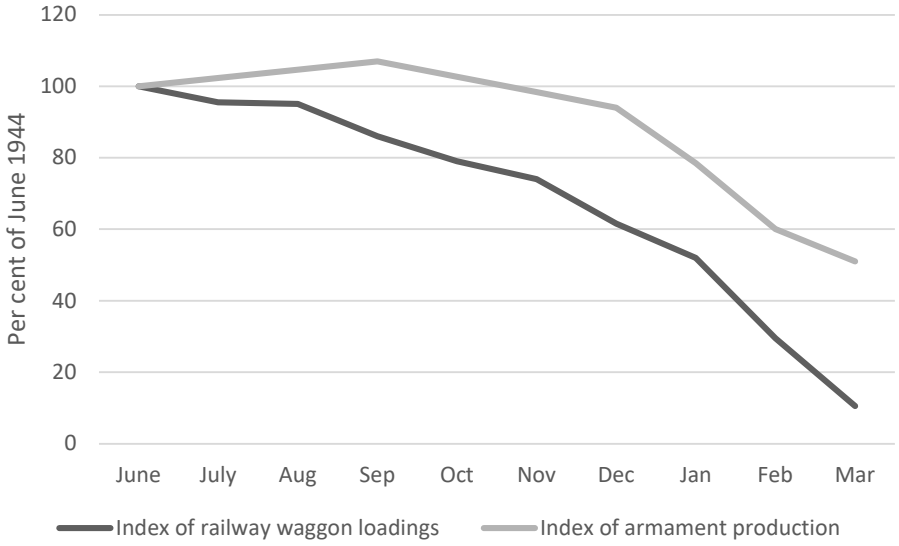
Figure 6.8. Effects of Allied bombing on German railway wagon loadings across Reichsbahn Direktionen, January to December 1944



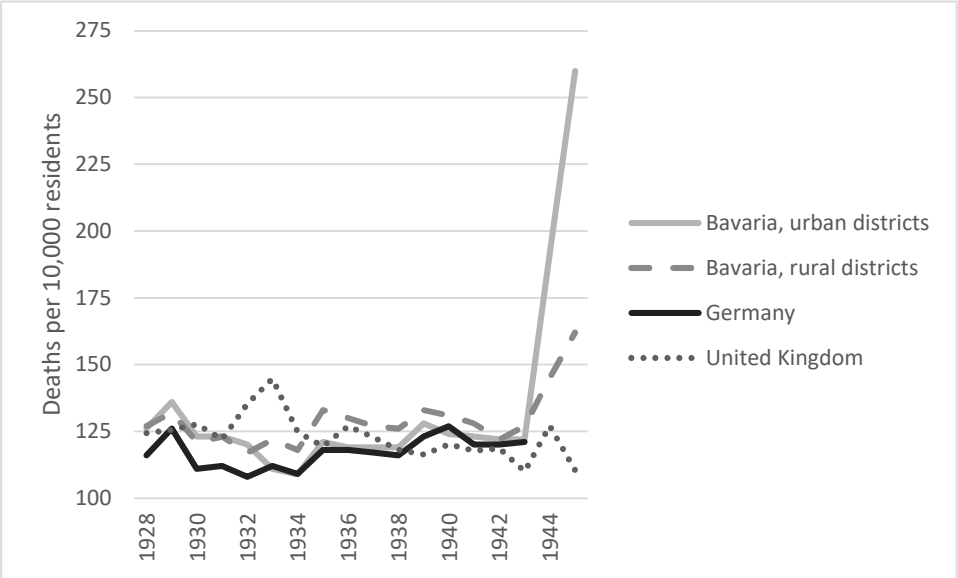
Source: Monthly data from BBSU (1998: Figure 47, facing page 129).

Figure 6.9. War production and railway loadings, June 1944 to March 1945 (per cent of June 1944)



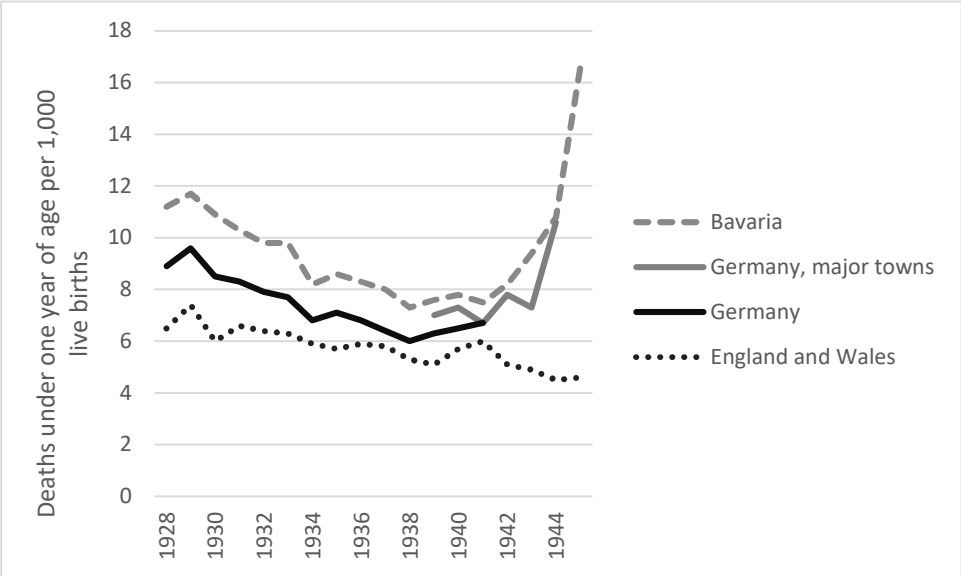
Source: Monthly data from BBSU (1998: Figure 42, facing page 134). Mierzejewski (1984: 198) gives a similar chart, comparing German monthly war production with monthly railway loadings in total and of hard coal, covering a longer period, January 1943 to March 1945.

Figure 6.10. Mortality in Germany (including Bavaria by urban and rural districts), 1928-1945, compared to the United Kingdom



Source: Annual data from Süss (2003: 447).

Figure 6.11. Infant mortality in Germany (including Bavaria), 1928-1945, compared to England and Wales



Source: Annual data from Süss (2003: 447).