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# Germany, Blockade and Strategic Raw Materials in the Era of the Two World Wars

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## ABSTRACT

The concrete lessons that the Nazi regime drew from the Allied sea blockade of the First World War have only been studied in fragments. Our knowledge of the effects of blockade and the effectiveness of German countermeasures during the Great War is vague, contradictory and, above all, incomplete, mainly for a lack of data. Based on hitherto unused secret surveys and statistics commissioned by the Nazi government to examine Great War lessons, this article shows that imports of raw materials were drastically reduced early in the war, and that this reduction was largely due to blockade. Despite this massive decline and low pre-war stocks, substitution and conservation measures made Imperial Germany surprisingly resilient in the case of many essential raw materials. Based on these quantifications and the conclusions drawn, explicitly or implicitly, in interwar studies, this article presents the general lessons the Nazi government drew from the Great War blockade. As the post-1933 measures show, the Nazi regime did learn the lessons, at least in this respect. This had important implications for the Second World War: as Nazi planners became convinced that, with proper preparation, Germany could withstand a raw materials blockade, they became more willing to gamble on war.

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## I. Introduction

Adolf Hitler, along with most of his political comrades-in-arms and the leading figures of the Nazi regime and the Wehrmacht, were born in the years around the turn of the century. This generation experienced not only combat in the First World War, but also the Allied naval blockade, which was primarily directed against Germany. It is widely recognised that this experience, and the expectation of economic warfare in future conflicts, had a profound effect on the actions of the Nazi regime.<sup>1</sup> It was reflected in the Nazis' desire to become self-sufficient, to create a larger economic space, and ultimately to create an autarkic *Lebensraum* for the German people.

However, despite the blockade's clear influence on the actions of the Nazi regime, the specific lessons of the First World War blockade have not been systematically studied. This is because our larger understanding of the blockade's impact on Imperial Germany's war economy is fragmentary, vague, and contradictory. The measures taken by the Entente and Germany's counter-measures are fairly well known, but we lack clarity about the blockade's effectiveness. While some historians, such as recently Nicholas Mulder, regard the blockade rather as a failure<sup>2</sup>, others, such as Eric Osborne, emphasize its

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importance,<sup>3</sup> especially from 1917, when the USA as the most important neutral sided with Germany's adversaries. They disagree, however, over whether the raw materials blockade, as Alan Kramer emphasizes, or the food blockade – which dominates existing scholarship<sup>4</sup> – was more important, as for example Paul Vincent suggests.<sup>5</sup> Moreover, scholars also do not know precisely how important the different supply sources and measures were that Germany adopted to overcome shortages (such as German pre-war stocks, recycling, and substitution).<sup>6</sup> The fact that the effects of the blockade and the counter-measures are still unclear also makes it difficult to ascertain the exact lessons Nazi planners drew from blockade – beyond the realization that one had to prepare for another one and that Nazi Germany implemented a policy of autarky.<sup>7</sup> In other words, without a better understanding of the effects of the blockade of the First World War, we cannot know which lessons were learned, and what continuity there was between the blockades of both world wars.

The incomplete understanding of the effects of the First World War blockade on the war economy of Imperial Germany is largely due to the lack of data.<sup>8</sup> Essential files on the German war economy were destroyed in the bombing of the Second World War, and little data was published in the inter-war period. The statistics of the German Statistical Office on crucial areas of the Imperial Germany's war economy, such as the consumption and production of raw materials and foreign trade, are very incomplete. We also know far too little about German pre-war stocks of strategic raw materials, an issue of particular concern to inter-war authors from the former Entente powers, who believed that these stocks had contributed decisively to Germany's ability to sustain the war until 1918.<sup>9</sup> By strategic raw materials we mean materials essential for the production of war goods, such as nonferrous metals and their ores, rubber, and cotton; foodstuffs are generally not counted as strategic raw materials. In the case of trade, which is essential for assessing the effectiveness of the blockade, only total trade figures were published, both in current prices and in goldmark terms (i.e. adjusted for the wartime devaluation of the German currency).<sup>10</sup> However, neither for the total volume of trade nor for individual sectors, such as raw materials, semi-finished goods and foodstuffs, do we have data, making it impossible to assess which sectors were especially affected by decreasing imports.

This lack of quantitative information can be (partly) compensated by several secret inter-war surveys written by the military history department of the German National Archive (Reichsarchiv) and its successor institutions. These surveys, which have been largely neglected by scholars, were commissioned by the German government, especially from 1933 onwards, to examine the lessons of the First World War in the field of war economy, focusing on key raw materials and sectors vital to the war effort, such as metals, rubber, leather, textiles, iron, glycerine, technical oils and fats.<sup>11</sup> Some of these studies, or fragments of them, are extant in archival files. The files contain not only the surveys, but also transcripts or original documents of the wartime economic administration of Imperial Germany, including crucial statistics on production, consumption, imports, and exports of many raw materials as well as semi-finished products. As these studies were highly classified and were used by the Nazis to learn the lessons of the Great War, their findings, data and information can be considered trustworthy. Furthermore, the general findings of these studies and sources provide some insight into the minds of Nazi war planners.

Based primarily on these sources, this article makes three major contributions. First, it quantifies the extent of German wartime imports of strategic raw materials, challenging the prevailing narrative that import reductions occurred mainly in the second half of the war. The data show that imports of raw materials were drastically reduced early on, and that this reduction was to a large extent due to the blockade. Second, the article outlines the measures Germany took to cope with the shortage of key raw materials and assesses their effectiveness. It shows that Imperial Germany's resilience in the face of dwindling imports of many raw materials was impressive, largely due to substitution and conservation efforts, although supplies of certain raw materials became scarce in the final year of the war. Third, based on these quantifications and the conclusions drawn – explicitly or implicitly – in the inter-war studies, this article summarises the more general lessons that the Nazi government drew from the First World War blockade. The measures introduced in Germany from 1933 onwards show that the Nazi regime did learn

the lessons of the First World War, at least in this respect. The article suggests that Nazi planners must have been under the impression that a raw materials blockade was manageable for many years, provided that appropriate counter-measures were prepared. During the Second World War, it was primarily the lessons learned – substitution, conservation, recycling and stockpiling – that produced a supply situation that was superior than that of the previous war.

## II. Blockade and trade reduction during the First World War

In 1913, 52.2% of the value of German merchandise imports were raw materials such as copper ores and semi-finished goods such as copper, while 38.2% were foodstuffs and the rest were finished goods.<sup>12</sup> Pre-war merchandise exports consisted mainly of finished goods (63.9%), which meant that imports of raw materials and semi-finished goods often exceeded basic domestic needs.<sup>13</sup> The top five categories of raw materials and semi-finished goods in terms of value were textile fibres and yarns (1913 million marks accounting for 34% of all imported raw materials and semi-finished goods), non-ferrous metals and their ores (769 million marks), hides and skins (667 million marks), wood (347 million marks), and iron ore (227 million marks). Other essential raw materials for a war economy were coal (205 million marks), mineral oil products (174 million marks), Chilean saltpetre (172 million marks) and rubber (126 million marks). With the exception of iron ore, coal and timber, all these raw materials were mainly imported from overseas. Also important for the war effort were raw materials whose pre-war import value was not very high, but for which Germany was heavily dependent on imports, especially from later adversaries and often from overseas. These included tanning agents for the leather industry (47 million marks), and sulphur pyrites (25 million marks), imported mainly from Spain, needed to produce sulphuric acid, which in turn was a raw material for the chemical industry and explosives.

The inter-war surveys provide annual imports of raw materials and semi-finished goods crucial to the war economy. Table 1 shows some of these commodities as a percentage of German imports in 1913, highlighting the extent of pre-war import dependency. The data suggest that war and blockade had an immediate and significant impact on imports of many strategic commodities for which Germany relied heavily on foreign supplies: imports fell particularly sharply in 1915 or 1916, not later.

Germany relied on a variety of sources for its wartime imports, depending on the raw material or product in question. In the case of rubber, for example, in addition to accessing stocks in occupied territories, especially in 1914, blockade runners were crucial and made up more than

**Table 1.** Import volume (1913=100) and pre-war import dependency of some selected strategic raw materials and semi-finished products.

	Pre-war import dependency <sup>a</sup>	Import volume 1915-8 (1913=100) <sup>b</sup>			
		1915	1916	1917	1918
Cotton	100	59	6	6	5
Chile saltpetre	100	2	<1	<1	0
Rubber	100	5	3	<1	1
Bauxite	100	232	751	838	608
Mineral oil	c. 95	32	63	62	51
Copper and copper ores	89	16	14	14	12
Wool	79	30	25	25	22
Hides	56	19	11	22	13
Iron ore	55	49	44	64	56

<sup>a</sup>Pre-war import dependency is expressed in percent of German consumption in 1913. For data, see 'Die Lederbewirtschaftung während des Krieges', 17. BArch RH 61/1096; 'Die Vorkriegslage der deutschen Metallwirtschaft'. BArch RH 61/324; 'Überblick über die Rohstoffbewirtschaftung in den Jahren 1917 und 1918', fol. 178-96. BArch RH 61/854; Otto Goebel, *Deutsche Rohstoffwirtschaft im Weltkrieg einschließlich des Hindenburgprogramms* (Stuttgart: DVA, 1930), 34. Figures of copper ores and iron ores are expressed in metal content.

<sup>b</sup>Wartime import figures include, where available, data on war loot and confiscations in the occupied territories. For data on import figures in metric tons, see table 2, note a.

2/3 of total wartime imports. Access to stocks in occupied territories played a crucial role in the imports of textile fibres and yarns.<sup>14</sup> Occupied territories also were an important source of iron ore (France), iron scrap and some non-ferrous metals, either in the form of ore, scrap, or metal, or chrome and copper ores from Serbia.<sup>15</sup> In other cases, neutral countries played a significant role in supplying Germany with key raw materials, particularly nickel, tin, iron ore, and aluminum. Austria-Hungary was an important supplier of key raw materials, particularly bauxite for aluminum production and steel alloys like vanadium, tungsten, and molybdenum.<sup>16</sup> Austria-Hungary began mining bauxite soon after the outbreak of the war to replace French bauxite, making it possible for Germany to build up an aluminium industry. Mineral oil was imported from Romania and Austria-Hungary.

The picture conveyed by the newly-discovered import data offers a mixed picture. Imports of many raw materials and semi-finished goods fell dramatically, some only moderately, and a few, not at all. To get a more accurate picture, I have calculated an annual import index for all raw materials for which data is available.<sup>17</sup> It should be noted that this index does not include all goods in this category, as the sources only provide data for goods which the authorities considered important for the German war economy. In total, the index covers about two-thirds of the pre-war import value of all raw materials and semi-finished goods.

However, this index does not only reveal how the wartime import volume performed compared to the prewar period. It is also a precondition for answering the question how much of the wartime change in imports was due to the blockade in the broader sense, i.e. the naval blockade, diplomatic pressure on neutral countries, and the financial blockade, or to wider wartime conditions—since in wartime the belligerents' ability to finance imports tends to decline (as terms of trade deteriorate, resources are diverted from export sectors and, as Alan Kramer has pointed out, former customers become enemies).<sup>18</sup> The answer to this question depends on what one assumes would have been the level of German merchandise imports in the absence of the blockade, which in turn depends among other things on assumptions about German demand and Germany's ability to finance additional imports. In order to assess the counterfactual level of German imports, it is useful to look at the development of the merchandise trade of those belligerent countries which were not subject to a blockade (or at least to an effective blockade for the entire war period<sup>19</sup>) and which were comparable to Germany in terms of pre-war trade patterns, such as Great Britain and France, which, like Germany, were mainly importers of raw materials and foodstuffs, and also had a pre-war merchandise trade deficit.<sup>20</sup> While average annual German merchandise imports during the war amounted to only 43% of pre-war imports, British merchandise imports declined much less, averaging about 80%.<sup>21</sup> France was even able to increase its merchandise imports considerably. France and Britain financed these imports partly through their merchandise exports, which fell much less (by 49% and 40% respectively) than Germany's (by about 75%), and partly through other sources. With the help of these other sources, Britain and France financed wartime trade deficits that were considerably larger than Germany's in terms of both pre-war and war measures of national income and output.<sup>22</sup>

France and especially Britain were moreover in a much better position to finance such high imports. First, even in the counterfactual scenario, i.e. without a blockade, Germany's merchandise exports would not have been significantly higher than they actually were. This is due to Germany's pre-war geographical export structure: those neutral markets that de facto were inaccessible to Germany due to the naval blockade accounted on annual average during the war for only about 12% of the level of German exports in 1913. The corresponding share going to later enemy countries was much higher at about 50% (and also much higher than that of France at about 33% and Great Britain at about 20%).<sup>23</sup> However, it cannot be assumed that in the counterfactual situation Germany, especially as an exporter of manufactured goods, would have been able to compensate in the short term for the loss of its wartime adversaries as customers, at least as long as it wanted to achieve acceptable prices for its exports. After all, the volume of profitable export business is likely to be smaller the fewer potential trading partners one has to choose

from. At best, it could be assumed that Germany would have been able to generate additional export revenues of the same magnitude as in 1913 from those neutral countries that were no longer accessible as export markets during the war due to the naval blockade. However, it can be assumed that due to other factors hampering exports - such as labour shortages due to conscription or unfavourable prices - Germany would have realised only part of its total pre-war revenues in these markets, just as with the other countries that remained trading partners under the conditions of the blockade: expressed in goldmarks, the latter only generated an annual average of around 2/3 of the pre-war export revenues.<sup>24</sup>

The most important of the countries that could no longer be reached was the United States, which had been by far Germany's largest non-European export market before the war and with which trade had been practically impossible since the spring of 1915.<sup>25</sup> On the basis of the considerations I have made so far, the USA would have had to leave the circle of potential trading partners in our counterfactual scenario from the moment it declared war on Germany. However, the declaration of unrestricted submarine warfare, which was the reason for the US entry in the war, may have been at least in part a German response to the British blockade, as German policymakers believed that the longer the war dragged on, the more likely German defeat would be, due to limited economic resources and economic strangulation.<sup>26</sup> Thus, I assume two variants for the period after the USA entered the war: one in which I assume that the USA would not have entered the war without the blockade, and one in which they would have done so even without unrestricted submarine warfare. Accordingly, in the first variant I assume that without the blockade there would have been income from exports to the US until the end of the war, while in the second variant this income is excluded after March 1917. Taking this into account, and assuming the same rate of realisation compared to the 1913-exports as with the other countries that remained trading partners under the blockade, the additional export revenues would have amounted to a maximum of some 6.6–8.1 billion marks in current prices, i.e. between 22–27% of the amount in current prices that Germany actually spent on wartime imports.<sup>27</sup>

Second, the Western powers were also in a much better position to finance massive merchandise trade deficits and thereby keep their import volumes at high levels.<sup>28</sup> While Britain was able to achieve substantial net exports of services during the war, Germany was no longer able to compensate for its deficits in the merchandise trade balance with net exports of shipping, as it had done before the war, because the Royal Navy dominated the seas.<sup>29</sup> In addition, the confiscation of German assets in enemy countries massively reduced the inflow of capital income from abroad. To be sure, Germany had considerable foreign assets that could either be used for financing or serve as collateral for foreign debt. In terms of measures of national income and output, however, British and French foreign assets were considerably larger.<sup>30</sup> Moreover, while only a small proportion of British and French assets abroad were in enemy territory at the outbreak of war, around 50% of German assets were.<sup>31</sup> In addition, Britain and France had the largest gold reserves in Europe, and before 1917, especially because of the greater political sympathy they enjoyed in the US, were able to borrow on the US money market to a much greater extent than Germany.<sup>32</sup> Furthermore, German assets in the US were seized after April 1917. Finally, unlike Germany, Britain and France were able to borrow from the United States after April 1917.

If other factors, including certain dependencies on German supplies of some raw materials such as coal, old business relationships or the sale of German shares, also influenced the amount of foreign loans that Germany could obtain from neutral countries during the war, the amount of realisable German foreign assets (i.e. excluding those in Central Powers and those sequestered in enemy countries) and German gold holdings increasingly limited Germany's ability to obtain sizable loans as the war progressed.<sup>33</sup> However, this remaining margin was quite small: at the end of the war, the Reichsbank still had gold reserves of 2.5 billion goldmarks and still realisable foreign assets of around 2 billion goldmarks (as well as assets in the USA worth 1.6 billion goldmarks).<sup>34</sup> It can be assumed that in the counterfactual scenario some of these financing possibilities available at the end of the war would have been used for additional imports in the period up to



November 1918. First, there would have been greater buying opportunities. Second, the ability of the relatively small neutral markets in Europe to absorb gold and foreign assets at any given time at reasonable prices was more limited than if the rest of the neutral world had been available.<sup>35</sup>

However, these funds would not have been used before mid-1917. Even in the counterfactual scenario, the state would presumably only then have considered using the gold reserves of the Reichsbank to finance imports, as it actually did.<sup>36</sup> Between the outbreak of the war and mid-1917, in contrast, the Reichsbank had greatly increased its gold reserves, using part of the inflows from the voluntary mobilisation of gold coins in circulation<sup>37</sup>, in order to signal to the public that the German currency was stable, even though its gold peg had been abandoned shortly after the outbreak of the war and the money supply had been expanding ever since.<sup>38</sup> It would therefore have been from mid-1917 – in the counterfactual situation as in reality – that the German state would have confiscated and used privately held foreign assets to finance imports.<sup>39</sup> In the counterfactual situation, it does not seem plausible that the decision to use gold reserves or to confiscate foreign assets would have been taken at an earlier point in time, since greater financing possibilities would have been available as a result of a larger volume of exports, as mentioned above. At the same time, the fact that alternative deficit financing possibilities would have dried up since 1916, even in the counterfactual, suggests that the decisions would have been taken at a similar point in time.

In a counterfactual scenario, however, only part of the gold reserves and realisable foreign assets actually available in November 1918 would have been used up between mid-1917 and the end of the war. It can be assumed that the War Ministry, which played a decisive role in decisions on import and foreign exchange permits, especially since the comprehensive centralisation of foreign trade in mid-1917<sup>40</sup>, was guided by the same planning horizon in the use of these scarce financial reserves as in the allocation of scarce raw materials stocks: in 1917 it decided that the latter should be used up in such a way that the war could be waged until the end of 1919.<sup>41</sup> As with the financing of additional imports through additional exports, a lower and an upper limit are calculated for the additional financing possibilities from foreign assets in the counterfactual scenario, depending on whether the USA is assumed to have become a belligerent even without the unrestricted submarine war (therefore restricting German access to the securities held there) or not.

In sum, without the blockade, German potential for financing merchandise imports from exports and other sources would probably have allowed about an annual average of 56–59 % of the pre-war import volume at maximum.<sup>42</sup> Since Germany imported an annual average of 43% of the pre-war import volume during the war, this means that the blockade reduced *total* war-time imports by a maximum of 22–27%. However, to determine the extent to which the blockade affected imports of raw materials and semi-finished goods, we must first answer the question of what proportion Germany would have spent on these goods in the absence of the blockade. Since Germany imported almost exclusively food and raw materials in 1913, both of which were essential during the war, it is reasonable to assume that, had there been no blockade, the share of imports in these categories would have remained roughly the same. This assumption is also corroborated by the case of Britain, where the distribution of imports during the war remained largely unchanged from the pre-war period.<sup>43</sup>

Table 2 provides information on the decline in German imports of raw materials and semi-finished goods and the underlying factors for the goods included in our index. While row 1 shows that imports at constant 1913 prices fell massively as a percentage of their pre-war value at the start of the war, row 2, based on the above considerations, shows the counterfactual imports, whose decline is less dramatic. Row 3 shows that the blockade had a significant impact on German imports of raw materials and semi-finished goods early in the war, explaining half of the decline in 1915 and 1916 compared to pre-war levels. The decline in the blockade effect in 1917 and 1918 is mostly due to the fact that Germany's ability to finance imports in the counterfactual was increasingly restricted (which, in the case of the counterfactual lower limit, was also

**Table 2.** German import volume of raw materials and semi-finished goods and the effects of the blockade, 1915-8.

	1915	1916	1917	1918
(1) Imports of raw materials and semi-finished goods (1913 = 100) <sup>a</sup>	35	25	26	19
(2) Counterfactual imports of raw materials and semi-finished goods (1913 = 100) <sup>b</sup>	72	65	45–50	41–49
(3) Share of blockade on import reduction (%) <sup>c</sup>	57	53	26–32	27–37

Sources and notes:

<sup>a</sup>The index is constructed by multiplying the annual import quantities of each commodity (in metric tons) with its respective price in 1913, then aggregating these for the years in question, and expressing the annual import values as a percentage of the 1913 value. 1913-import prices are calculated based on the information of import values and quantities for the respective commodities in 1913 given in Statistisches Jahrbuch für das Deutsche Reich 1914, 180-287. For import figures in metric tons, see *ibid.*, 180-287; 'Aussehenhandel nach Klein (t)', 16 Nov. 1940, BArch RH 61/860; 'Anlage 89'; 'Anlage 160'; 'Anlage 162'; 'Anlage 169'; BArch RH 61/886; 'Zu Blatt 7'; BArch RH 61/866; 'Kriegsgeschichtliche Forschungsanstalt des Heeres, Außenhandelsstatistiken für Chemikalien 1913 – 1918'; BArch RH 61/837; 'Anlage 4'; BArch RH 61/869; 'Anlage 43'; 'Anlage 44'; BArch RH 61/835; 'Rückblick auf die Kriegsrohstoffwirtschaft 1914 bis 1918'; BArch RH 61/854; 'Anlage Nr. 4, Einfuhr von Metallerzen und Metallen 1913 bis 1918'; BArch RH 61/869; 'Zusammensetzung der aus besetzten Gebieten zurückgeführten Metalle bis 31. August 1916 in Tonnen'; BArch RH 61/248; Alfred Müller, *Die Kriegsrohstoffbewirtschaftung 1914–1918 im Dienste des deutschen Monopolkapitals* (Berlin: Akademie Verlag, 1955), 54. For the import of wool and cotton from the occupied countries, only a total amount is given for the entire war period. (Goebel, *Kriegsbewirtschaftung*, 19). This amount is allocated in equal shares to the respective years.

<sup>b</sup>See Appendix A and Appendix B.

<sup>c</sup>Computed for each year as the ratio of the difference between line 2 and line 1 and the difference between line 1 and 100.

reinforced by the fact that the USA entered the war). Note that the blockade effect is slightly underestimated in 1915. This is because the counterfactual model assumes that only neutral countries and Imperial Germany's allies could be considered as countries of origin for German imports, but in fact, and this received considerable public attention in Britain at the time, goods from Entente powers, especially the British Empire, were being shipped to Germany *via* neutral countries, the extent of which had previously been unclear.<sup>44</sup> However, as an estimate based on the newly discovered data shows, these transshipments were not particularly significant.<sup>45</sup> While in 1915 they accounted for 3.1–4.8% of the actual value of imports in our sample, after 1915, i.e. after both the imposition of the unrestricted blockade in the spring of 1915 and the introduction of a rationing system for imports from neutral countries at the end of that year<sup>46</sup>, transshipments played virtually no role at all, as they were measured in thousandths of total imports in our sample.

### III. Coping with trade reduction

In certain cases, as we have seen, wartime imports of raw materials were massively affected by the blockade and often amounted to only a fraction of pre-war imports. This raises the question of whether the supply situation in Germany also deteriorated, or if Germany was able to meet this challenge, and if so, how. To begin answering this question, I will examine the case of non-ferrous metals, which were second only to textile fibres and yarns in terms of import value, and for which the source situation is particularly good. Moreover, metals were considered essential for armament production. Britain therefore declared them almost from the beginning of the blockade to be 'unconditional contraband'<sup>47</sup>, and the German war economy administration labelled them 'war raw materials' (*Kriegsrohstoffe*), i.e. raw materials that were considered both particularly important and scarce.<sup>48</sup> Subsequently, I will discuss some other strategic raw materials.

For the questions relating to metals, I utilized data from the economic plans discovered in the files of Nazi-era surveys. These plans were drafted by the German war economic administration between 1915 and 1918, and aimed to provide an overview of stocks, supply, and consumption for a given period.<sup>49</sup> Supply data was extrapolated from the previous six months, and the same principle was applied to the expected consumption, accounting for an anticipated increase in munitions output. The plans also predicted how long consumption needs could be met in the



future, and, based on this information, decisions were made regarding further substitution or other measures to reduce consumption or increase supply.

An analysis of this data reveals that while the blockade was successful in disrupting German imports of raw materials, it did not bring the German war economy to a standstill. In fact, despite the tightening of the blockade and the increase in armaments production, Germany's resilience in the field of non-ferrous metals grew significantly over time. The economic plans reveal that the point at which Germany was expected to run out of certain metals was repeatedly pushed further into the future. For example, the plan of August 1915 predicted that German consumption needs for copper and tin would be met up to October 1916 and November 1917 respectively.<sup>50</sup> However, the April 1918 plan indicated that the supply of both metals would be met until January 1920. Similar shifts can be observed for other metals.

Which factors explain German resilience? The first is the sources of supply. Besides imports, sources consisted of domestic pre-war stocks, German mining, and recycled metals. After 1918, foreign observers believed that pre-war domestic stocks in particular played an important role in Germany's surprising resilience during the war, given its pre-war dependence on imports.<sup>51</sup> Such interpretations dovetailed with the assumption that Berlin had willed and planned for a war in 1914. However, the newly discovered data shows that only eight months of German wartime consumption had to be met by drawing on domestic copper stocks.<sup>52</sup> Similar figures can be calculated for several other metals. We can thus conclude that stocks in general made only a small contribution to Imperial Germany's resilience in the case of non-ferrous metals.

What about other sources of domestic production? Beginning in 1915, state subsidies were utilized to stimulate the mining industry.<sup>53</sup> This effort involved reopening old mines, refining mine heaps, and conducting comprehensive explorations with varying degrees of success. As a result of these endeavours, the production of certain metals, such as nickel, tin, and tungsten, experienced a significant increase compared to the pre-war period. Moreover, recycling played a crucial role as a major source of copper and tin, as well as nickel and lead to a lesser extent. However, despite the combined efforts of mining and recycling, the consumption of most metals still experienced a considerable decline during the war. For instance, by 1918, monthly copper consumption had dwindled to only one-third of its 1913 level, and tin consumption had plummeted to a mere 16% of its pre-war amount.<sup>54</sup>

How do these newly-uncovered consumption figures align with the fact that armaments production, which is typically highly metal-dependent, peaked in 1918? This apparent contradiction is resolved by the considerable role played by substitution and conservation measures in bolstering the resilience of the German war economy with respect to non-ferrous metals. Prohibitions on using scarce metals and the introduction of substitutes were enacted soon after the outbreak of war.<sup>55</sup> In the latter half of the war, close collaboration between technical universities and army procurement offices further increased substitution efforts. Consumption per output unit was assessed quarterly to evaluate the effectiveness of substitution measures. In the case of copper, which represented approximately 50% of total imports of metals and metal ores by value in 1913, consumption per output unit of armaments plummeted by a staggering 87.5% during the war.<sup>56</sup> This figure provided in postwar publications without referring to sources is corroborated by a cross-check that also estimates a lower limit of the amount of copper saved during the war through substitution: wartime consumption would have been about four times greater without substitution.<sup>57</sup>

Although we cannot generalize the quantitative impact of substitution in the case of copper, there is an abundance of evidence indicating that it played a significant role in the case of other metals as well. In the case of high-grade steels, which are critical for almost all armaments, the use of scarce steel alloys such as tungsten and nickel was reduced by well over 50% without affecting quality.<sup>58</sup> Therefore, Germany's expertise in metallurgy was the single most important resource at its disposal. It was primarily the consumption reduction induced by substitution that was responsible for Germany's remarkable resilience in the realm of metals.

Despite the resounding success of substitution and conservation measures, total substitution was never achieved. There were always areas where scarce metals could not be replaced, and even the military's inflated demand for metals was only partially met by the rationing policy.<sup>59</sup> In some cases, armament programs were even put on hold to ensure that there was enough of the necessary metal for other programs.<sup>60</sup> In short, the blockade had an impact on the scale of Imperial Germany's armament plans. Furthermore, as highlighted by internal surveys, the need to conserve metals also hindered the substitution of labour with capital, i.e. machinery, in industry, exacerbating Germany's manpower problem.<sup>61</sup>

Similar strategies to those employed for non-ferrous metals, including recycling, substitution, and conservation, were also utilized for other critical raw materials, though their relative importance varied. Pre-war stocks of these materials were also relatively low, generally covering only about three to six months of Germany's annual pre-war consumption.<sup>62</sup> These strategic raw materials can be categorized into two groups. The first group comprises those materials where successful substitution or the activation of domestic sources ensured that supply remained comparatively satisfying. This group includes raw materials such as iron ore, manganese, and those necessary to produce explosives and powder.

The use of scrap metal from Germany and battlefields played a crucial role in steel production.<sup>63</sup> Shortages of manganese were effectively tackled through substitution, through a increase of domestic mining and especially the recycling of slag from earlier decades.<sup>64</sup> Imported raw materials, which were essential to produce explosives and powder, such as sulphur, fat (for glycerine), linters (short fibres produced from cotton seed), and saltpetre, were substantially and successfully substituted. This was achieved through the expansion of German pyrites mining, the costly sulphur gypsum process, the fermentation of glycerine based on sugar, and the partial replacement of glycerine with trinitrotoluene (TNT), which could be produced from coal tar.<sup>65</sup> Additionally, linters were substituted with pulp derived from wood cellulose. Finally, in order to replace imports of Chilean saltpetre, essential for the manufacture of explosives, as well as fertilizer, a technology was used that was to become established in the long term: the Haber-Bosch process made it possible to produce ammonia from which saltpetre could be extracted.<sup>66</sup> This was an area where substitution even led to a reduction of costs.<sup>67</sup>

In contrast to these raw materials, there was a second group, for which there were few or no substitutes. Here, the supply situation became increasingly precarious. Notably, this group included petroleum products, rubber, and raw materials necessary for producing essential consumer goods, especially shoes, textiles and soap. The decline in rubber imports could only be compensated to a small extent by the collection and import of reclaimed rubber and, especially in the last year of the war, by the production of synthetic rubber, the quality of which (like that of other rubber substitutes) was very low.<sup>68</sup> In total, the very small natural rubber and synthetic rubber allocation in 1918 provided tyres for no more than for 250 military trucks per month. As a result, trucks increasingly had tyres made of iron reducing their speed to twelve km/hour at maximum. The supply situation for petroleum products was also increasingly precarious, despite access to oil fields in Galicia and Romania, as well as substitutes such as benzene and lubricants from low-temperature tars.<sup>69</sup> Compared to the pre-war period, German oil production declined by more than 15%, partly due to the lack of drilling equipment. During the spring 1918 offensive, the shortage of fuel limited the mobility of the German army.<sup>70</sup> Moreover, the allocation of lamp oil in the winter of 1918 was only 5% of its pre-war use.<sup>71</sup> Consequently, many Germans had to wake up in the dark and spend their evenings in unlit homes.

The decline in private consumption of textiles and shoes was significant, too, and in 1918, the German chancellor and the German military considered it worse than the shortage of food.<sup>72</sup> One contemporary observer remarked that in 1918 it was probably more striking how tattered Germans looked than how emaciated and pale.<sup>73</sup> Despite efforts to increase recycling of rags and expand the production of so called spinning paper, i.e. paper webs twisted in paper yarns,<sup>74</sup> the

decline in imports of textile fibres could not be remotely offset.<sup>75</sup> With the few available natural fibres reserved for military textile production, civilian per capita consumption dropped significantly, leading to a massive increase in real prices for textiles and clothing. The same can be said for shoe supply. The greatly reduced quantity of hides compared with the pre-war period could not even be fully processed because the scarcity factor was the almost exclusively imported tanning agents, for which there were only completely inadequate substitutes in terms of quantity and quality.<sup>76</sup> With military supply taking priority, and with leather substitutes from shredded leather waste and adhesives being unsatisfactory in both quantity and quality, real shoe prices were many times the pre-war level.<sup>77</sup> The supply of soap was also massively reduced, as only 8% of the pre-war amount of fat could be allocated to the soap industry from 1915 on due to the shortage of fat caused by the decline in imports of oilseeds and fodder.<sup>78</sup>

#### IV. Learning the lessons

For anyone reading these surveys in the 1930s the most important lesson would probably have been that Imperial Germany – despite a lack of preparation for war, despite low pre-war raw material stocks, and despite imports, which decreased massively early in the war – had been able to meet the essential demands of the army for many years, even for raw materials for which it had heavily relied on imports before the war. Consequently, the authors of the secret surveys as well as contemporary publications drew several conclusions when contemplating a future blockade.<sup>79</sup> The first lesson was that better preparation, particularly regarding stocks and substitutes, could have helped avoid some of the supply difficulties caused by the blockade during World War I.<sup>80</sup> Additionally, the authors recognized that a time-lag of several years existed between the start of substitution research and development (R&D) and the implementation of new measures.<sup>81</sup> Therefore, they recommended that substitution efforts should begin several years before the next war. Moreover, introducing substitutes could be delayed by the resistance of producers, and misapplication could result from a lack of processing experience, which would waste resources. Thus, education of producers, such as through exhibitions or advisors, was crucial. The Nazi regime recognized these lessons early on as part of its autarky policy. It invested considerable resources in substitution research and made significant efforts to educate companies about proper usage, leading to several new applications of substitutes.<sup>82</sup> Furthermore, state-induced investments were responsible for a significant pre-war expansion of import substitution industries, particularly in areas where substitutes had played a minor role in the Great War, such as textile fibres, fuel, leather substitutes, and rubber, but where significant technological progress had been made since 1918.<sup>83</sup>

In addition, the Nazi war planners recognized that while substitution could significantly reduce import dependence, some uses would still require foreign supply, as was evident in the case of certain metals. Therefore, stockpiling and imports from a large economic area dominated by Germany were deemed necessary. From a geostrategic standpoint, this meant a pre-war policy focus on south-eastern Europe and the wartime exploitation of occupied territories.<sup>84</sup> Such considerations contributed to a reorientation of German foreign trade towards countries that were geographically accessible in the case of a naval blockade and were not expected to be Germany's opponents. Many authors of the studies on the First World War believed that occupied territories had been spared too much in the last war.<sup>85</sup> While the exploitation of occupied territories violated international law, it was seen as a measure of self-defence against the imposition of a blockade.

Furthermore, the importance of accurate statistical data in rationing, efficient distribution of scarce raw materials, and planning of substitute production was a crucial lesson learned from the war.<sup>86</sup> The acquisition of this statistical overview during the war was a painstaking

process, with data on metals not available on the period before spring 1915, and data on textiles not available until 1916.<sup>87</sup> This delay in data gathering led to initial inefficiencies in the allocation and use of scarce raw materials in the war economy. In response, significant efforts were made in the 1930s to improve the statistical basis for a future war, exemplified by the 1936 industrial census which aimed to record the flow of raw materials in the German economy.<sup>88</sup>

In addition, the First World War provided an important lesson about supplies for the civilian population. Although the blockade was not believed to be directly responsible for the German defeat in terms of a material collapse of the German army, many contemporaries, including Hitler, were convinced that the blockade had ultimately decided the outcome of the war. They believed that private households' precarious consumption levels, especially with regard to foodstuffs and essential consumer goods, ultimately caused by the blockade and by the priority of military needs, had weakened the morale of the population.<sup>89</sup> It was thus recognized that the resources that would have to be available in a future war – in the areas of textile fibres and food, for example – would have to be considerably greater than in the First World War. Therefore, substitution research and the development of substitute industries for essential consumer goods were not to be neglected in favour of goods intended for the military. In fact, one of the first important substitute industries to be massively expanded during the Nazi period was the semi-synthetic fibre industry, while considerable capacity was also built up in leather substitutes and synthetic tanning materials.

## V. Strategic raw materials during the Second World War

How did blockade-induced measures affect German consumption of essential raw materials during the Second World War? To answer this question, it is important to distinguish between measures aimed at the domestic economy (such as autarky policies and stockpiling) and those resulting from the exploitation of occupied territories and imports more broadly. This distinction is helpful because, prior to the war, the Nazi authorities did not have a clear understanding of which territories would be occupied and therefore could not determine the extent of inflows from them. By differentiating between the effects from domestic measures and those from abroad, we can better assess the extent to which the improved supply was the result of conscious preparation for a future blockade or simply favoured by the course of the war. This is particularly important because the improved supply during the Second World War is often attributed primarily to the greater exploitation of occupied territories through imports and foreign labour inflows.<sup>90</sup>

However, the contribution of occupied territories to Nazi Germany's wartime supply of raw materials for the armaments industry and the Wehrmacht during World War II was mainly rather small, especially if we consider that German consumption exceeded that of the First World War by far.<sup>91</sup> German supply (including that of substitutes) was often primarily or almost exclusively the result of domestic measures implemented in the 1930s to reduce consumption and/or increase of domestic production. This was particularly true for the supply of fuels, rubber, and non-ferrous metals.<sup>92</sup> However, the situation differed for iron ore: significantly larger domestic supply could have been achieved, but cost considerations prevented the mining of German ores, which had a low iron content, to the maximum extent.<sup>93</sup>

With regard to civilian consumption during the Second World War it is important to note that Germans did not enjoy a high standard of living during the war, particularly when compared to the British or Americans.<sup>94</sup> Additionally, as in the First World War, the military always took priority over civilian needs. Yet, despite the bombing war, black markets did not become a significant factor in Germany until the final phase of Second World War, and even then, they did not reach

the same scale as during the First World War. This can be attributed to the fact that private consumption of essential consumer goods during the Second World War was much higher than during the previous war. For example, while civilian textile consumption in the second half of the First World War was based almost entirely on low-quality spinning paper<sup>95</sup>, this played no part in civilian consumption in the Second World War. Overall, total fibre consumption (excluding spinning paper) was more than three times higher in the Second World War than in the First World War, and in 1942 civilian consumption of these fibres alone was higher than *total* consumption had been in 1917.<sup>96</sup> A similar trend can be observed in the shoe supply for civilians. While raw materials available for the manufacture and repair of civilian shoes decreased by 54% in 1943 compared to the pre-war period and amounted to 76,000 tons<sup>97</sup>, the annual average civilian leather consumption during the First World War was only 23,000 tons, or about 23% of domestic pre-war consumption.<sup>98</sup> As a result, shoe production for civilians during the Second World War surpassed that of the previous conflict by a significant margin.<sup>99</sup> The supply of soap was also much better during the Second World War, as the fat allocation to the soap industry was five times greater than during the First World War.<sup>100</sup>

As in the case of raw materials for armaments, the comparatively high level of civilian consumption during the Second World War was primarily due to domestic measures taken as a lesson learned from the blockade of the First World War, rather than to the direct effects of the exploitation of occupied countries for German supplies. Very early on – in fact, a few days before the war started – soap, textiles, and shoes, i.e. consumer goods which had proved to be essential during the First World War for the mood of the population, were rationed<sup>101</sup>, thus defusing one major problem of morale. Prices of goods were controlled so that goods remained affordable.<sup>102</sup> Net imports of textiles and clothing played only a small role for German supply and did not exceed 10%.<sup>103</sup> Also fibre imports made up less than 10% of German fibre supply.<sup>104</sup> Thanks to the massive expansion of the semi-synthetic fibre industry during the 1930s as a part of Nazi autarky policy, German fibre consumption during the war was almost maintained at pre-war levels, rather than falling to the extreme low of the First World War.<sup>105</sup> Finally, the share of foreigners in the workforce in the German textile and clothing industry (including shoe production) was below 10%, too.<sup>106</sup> The massive drop in the import of hides was almost fully compensated by the expansion of artificial leather.<sup>107</sup> The production of these substitutes increased sixfold between 1936 and 1943/44. These leather substitutes – such as rubber soles – the quality of which was far better than the ones used during the First World War, and which were to become competitive after 1945, had been developed during the 1930s and their wartime expansion was facilitated by massive investment in processing machines.

The increasing use of leather substitutes massively diminished the demand for tanning agents which before the war were mainly imported.<sup>108</sup> At the same time domestically produced synthetic agents became increasingly important, accounting for 37% of German consumption by 1944. Again, autarky policy stimulated the research and development of synthetic tanning materials, as well as the establishment of production sites during the 1930s.<sup>109</sup> Finally, the improved supply of soap during the Second World War compared to the First was also the result of autarky policy. At the outset of the war, Germany had stockpiled a significant amount of industrial fats that covered nearly a year's peacetime consumption.<sup>110</sup> Moreover, the Four-Year Plan incentivized the development of raw materials for synthetic detergents and the production of synthetic fats, resulting in the build-up of production capacities.<sup>111</sup> By 1943, these capacities sufficed for roughly half of industrial fat consumption.<sup>112</sup>

It was not a lack of raw materials or a shortage of labour but the bombing war that led to a noticeable deterioration in the supply of some essential consumer goods for large parts of the population from late 1943 onwards.<sup>113</sup> During this period, most of these goods were supplied to the increasing number of people who had lost their homes. Meanwhile, the clothing and shoe industry, primarily situated in major cities, became a primary target of aerial warfare, leading to substantial output reductions.

## VI. Conclusion

The prospect of an adversary imposing a sea blockade or economic sanctions can serve as a form of deterrence against starting a war.<sup>114</sup> However, this deterrence only holds if the potential consequences for the targeted country appear unbearable or likely to result in its defeat. In the case of Germany during the Second World War, Nazi war planners studied the effects of the First World War blockade and concluded that, with careful preparation, Germany could manage the effects of a blockade for an extended period. This conclusion was based on the observation that, despite early and significant reductions in imports and low stocks of strategic raw materials, Imperial Germany was sustained in the war for over four years primarily through domestic measures.

The Nazi wartime economy faced bottlenecks, but in many ways, the supply situation was better than during the First World War. This was largely since the lessons of the previous war had been taken to heart, and extensive preparatory measures were put in place during the 1930s. Admittedly, the Nazi regime benefited from the technological advances of the 1920s, particularly in the realm of substitution. However, the quantitative challenges faced during the Second World War were far greater than those of the previous conflict, not least because civilian consumption was not reduced as drastically as it had been in the First World War.

Despite these lessons, despite the relatively good supply situation, and despite the fact that the blockade was not an effective deterrent, it would be misleading to attribute no significance to the blockade for the outcome of the Second World War. The blockade had a secondary function: it put a strain on the enemy's economy and its moral resources by reducing consumption and massively lowering its quality through inadequate substitution. It diverted substantial resources and labour into investment for and the production of substitutes. The Nazis undoubtedly succeeded in avoiding a noticeable overall deterioration in morale (at least in the sense that the population did not rebel against the government), partly through terror and a more sophisticated analysis of public opinion, and partly because of the lessons learned from the First World War. They stockpiled, built up autarky industries for consumer goods, and funded research and development in these sectors. Many of the substitutes for the war economy and for the civilian consumption soon became competitive in terms of their unit costs and quality, meaning that import substitution in these cases was only a minor burden on the economy, as in the case of semi-synthetic fibres, leather substitutes, rubber, synthetic tanning materials, plastics, and recycled metals.<sup>115</sup> Nevertheless, there were also areas that placed an enormous burden on the resource that ultimately proved to be the decisive bottleneck of the German war economy: labor. Foremost among these was the most important substitute industry in terms of investment volume, the synthetic fuel industry, whose production along the value chain employed half a million workers in the middle of the war, i.e. 5% of the total German industrial workforce, and ten times as many as the US oil industry needed to produce the same quantity.<sup>116</sup> In addition, for many years an annual average of 200,000 workers were employed to build up this industry. Planning and preparation were therefore able to neutralize many of the effects of the blockade, but they sometimes came at a significant cost. Because labour was already the critical bottleneck to the German war effort during the First World War, Nazi war planners ultimately solved one problem by exacerbating another. In other words, their learning remained selective. Ultimately, they could not escape the constraints of the economic resources available to them.

## Notes

1. See for example recently Nicholas Mulder, *The Economic Weapon. The Rise of Sanctions as a Tool of Modern Warfare* (New Haven/London: Yale University Press, 2022), 227–47; Lizzie Collingham, *The Taste of War: World War II and the Battle for Food* (London: Allen Lane, 2011).



2. See for example Gerd Hardach, *The First World War, 1914–1918* (Berkeley/Los Angeles: University of California Press, 1977), 34; Lance Davis/St Stanley Engerman, *Naval Blockades in Peace and War: An Economic History since 1750* (Cambridge: Cambridge University Press, 2006), e.g. 230, 246; Mulder, *Economic Weapon*, 80.
3. Eric W. Osborne, *Britain's Economic Blockade of Germany, 1914–1919* (London: Taylor and Francis, 2004), 4; 182–83. See also Archibald C. Bell, *A History of the Blockade of Germany and of the Countries Associated with her in the Great War: Austria-Hungary, Bulgaria, and Turkey, 1914–1918* (London: HMSO, 1937); C. Paul Vincent: *The Politics of Hunger: The Allied Blockade of Germany, 1915–1919* (Athens: Ohio University Press, 1985); Belinda J. Davis, *Home Fires Burning: Food, Politics, and Everyday Life in World War I Berlin* (Chapel Hill: University of North Carolina Press, 2000).
4. See also Avner Offer, *The First World War: An Agrarian Interpretation* (Oxford: Clarendon Press, 1989); Mary E. Cox, *Hunger in War and Peace. Women and Children in Germany 1914–1924* (Oxford: Oxford University Press, 2019); Marcel Boldorf, 'Außenhandel und Blockade' in Marcel Boldorf (ed), *Deutsche Wirtschaft im Ersten Weltkrieg* (Berlin: De Gruyter Oldenbourg, 2020), 479–520.
5. See for example Alan Kramer, 'Blockade and Economic Warfare', in Jay Winter (ed), *The Cambridge History of the First World War*, vol. 2 (New York: Cambridge University Press, 2014), 460–89, here 489; Alan Kramer, 'Naval Blockade (of Germany)', [https://encyclopedia.1914-1918-online.net/pdf/1914-1918-Online-naval\\_blockade\\_of\\_germany-2020-01-22.pdf](https://encyclopedia.1914-1918-online.net/pdf/1914-1918-Online-naval_blockade_of_germany-2020-01-22.pdf); Vincent, *Politics of Hunger*, 44, 49.
6. See for example, Kramer, 'Naval Blockade'.
7. On Nazi autarky policy, see for example Dietmar Petzina, *Autarkiepolitik im Dritten Reich: Der nationalsozialistische Vierjahresplan* (Stuttgart: DVA, 1968).
8. See for example Albrecht Ritschl, 'The Pity of Peace. The German Economy at War, 1914–1918 and Beyond', in Stephen Broadberry/Mark Harrison (eds), *The Economics of World War I* (Cambridge: Cambridge University Press, 2005), 41–76; here 41.
9. For this heavily politicized question during the war and afterwards, see for example Lothar Burchardt, *Friedenswirtschaft und Kriegsvorsorge: Deutschlands wirtschaftliche Rüstungsbestrebungen vor 1914* (Boppard: Boldt, 1968), 248.
10. Heinrich Kleine-Natrop, *Devisenpolitik (Valutapolitik) in Deutschland vor dem Kriege und in der Kriegs- und Nachkriegszeit* (Berlin: H. Preiss, 1922), 11; Ritschl, 'German Economy', 50–2.
11. For an overview, see 'Im Auftrag der 7. Abteilung (bzw. ihrer Vorgängerinnen) angefertigte Denkschriften', [Bundesarchiv] BArch RH 61/860. For examples, see Jonas Scherner, 'Preparing for the next blockade. Non-ferrous metals and the strategic economic policy of the Third Reich', *English Historical Review* 137 (2022), 475–512.
12. For data see *Statistisches Jahrbuch für das Deutsche Reich, 1914*, 180–287. I follow the German trade taxonomy in force at the time of the Nazi surveys, which differs from its predecessor mainly in that tobacco, fodder and oilseeds are counted as foodstuffs rather than raw materials. This is probably also the reason why for these no import data are reported in the surveys. *Statistisches Jahrbuch für das Deutsche Reich, 1924/25*, 141–4; *Statistisches Jahrbuch für das Deutsche Reich, 1939/40*, 321–4; Länderrat des Amerikanischen Besatzungsgebiets (ed), *Statistisches Handbuch von Deutschland 1928–1944* (Munich: Ehrenwirth, 1949), 392. By changing the taxonomy during the 1930s, statisticians attempted to make import dependency in the food sector more visible. For details, see 'Erläuterungen zur Übersicht: Der deutsche Außenhandel in wichtigen Warengruppen und Waren, wertmäßig, 19. Juni 1937', fos. 75–89; BArch R 2501/6610.
13. For example, the leather industry exported more than 40% and the textile industry almost a quarter of the output. 'Die Lederbewirtschaftung während des Krieges', 38–9, BArch RH 61/1096; 'Statistik der Bewirtschaftung der Spinnstoffe', 1937; 5, BArch RH 61/828.
14. Otto Goebel, *Kriegsbewirtschaftung der Spinnstoffe (Die deutsche Kriegswirtschaft im Bereich der Heeresverwaltung 1914–1918, vol. 3)* (Berlin: De Gruyter Oldenbourg, 2016), 17–9.
15. For details and the following see Jonas Scherner, 'Metallbewirtschaftung', in Boldorf, *Wirtschaft*, 67–88; Alfred Stellwaag, *Die deutsche Eisenwirtschaft während des Krieges, (Die deutsche Kriegswirtschaft im Bereich der Heeresverwaltung 1914–1918, vol. 2)* (Berlin: De Gruyter Oldenbourg, 2016), 213.
16. Albrecht Czimatis, *Rohstoffprobleme der deutschen Aluminium-Industrie im Rahmen ihrer wirtschaftlichen Entwicklung* (Diss., Dresden, 1930), 50–64; 'Die Kriegsbewirtschaftung der Metalle, 1. August 1914 bis 31. August 1916', BArch RH 61/1125.
17. For details see table 2, note a.
18. Kramer, 'Blockade', 478; Kramer, 'Naval blockade'.
19. For the short-lived German counter-blockade, see for example Davis/Engerman, *Naval Blockades*, 187; Kramer, 'Blockade', 488.
20. Hardach, *First World War*, 5. The ratio of foreign trade to GDP was almost the same in Britain and Germany. Ronald Findlay/Kevin O'Rourke, *Power and Plenty: Trade, War and the World Economy in the Second Millennium* (Princeton: Princeton UP, 2007), 510 table 9.2.
21. Ritschl, 'German Economy', 50 table 2.7; Kleine-Natrop, *Devisenpolitik*, 11; Stephen Broadberry/Peter Howlett, 'The United Kingdom during World War I: business as usual?', in Broadberry/Harrison, *Economics of World War I*, 206–34; here 220–1; Pierre-Cyrille Hautcoeur, 'Was the Great War a watershed? The economics of World War I in France', in Broadberry/Harrison, *Economics of World War I*, 169–205; here 189 table 6.13; Alfred Sauvy, *Histoire économique de la France entre les deux guerres*, vol. II (Paris: Economica, 1984), 154; Brian R. Mitchell, *British Historical Statistics* (Cambridge: Cambridge University Press, 1988), 522. The German import value in constant prices during the war is obtained by assuming, following Albrecht Ritschl, that the import price increase for Germany would have been similar to that for Great Britain. Ritschl, 'German Economy', 50 table 2.7, 51. The British import price index is calculated on the basis of Mitchell, *British Historical Statistics*, 453, 522.
22. For measures of national income and output, see Albrecht Ritschl/Mark Spoerer, 'Das Bruttosozialprodukt in Deutschland nach den amtlichen Volkseinkommens- und Sozialproduktstatistiken 1901–1995', *Jahrbuch für*

- Wirtschaftsgeschichte*, 38 (1997), 27–54, here 38 Tabelle 1; Broadberry/Howlett, 'United Kingdom', 219; Hautcoeur, 'France', 189 table 6.13.
23. Hardach, *First World War*, 5; Hautcoeur, 'France', 181; Statistisches Bundesamt, *Bevölkerung und Wirtschaft 1872 - 1972. Zum 100jährigen Bestehen der zentralen amtlichen Statistik* (Stuttgart: Kohlhammer, 1972), 201. The respective German export shares are average values for the entire duration of the war in view of the expanding number of German adversaries.
  24. *Statistisches Jahrbuch für das Deutsche Reich 1914*, 258; Ritschl, 'German Economy', 50 table 2.7.
  25. Kleine-Natrop, *Devisenpolitik*, 10; Marc Frey, 'Deutsche Finanzinteressen an den Vereinigten Staaten und den Niederlanden im Ersten Weltkrieg', *Militärgeschichtliche Mitteilungen* 53 (1994), 327–53, here 332. See also Brian R. Mitchell, *International Historical Statistics. The Americas and Australasia* (London: Macmillan Reference Books, 1983), 578, 616. Transshipment of German exports through European neutrals to the US remained possible for some time, but very limited. Boldorf, 'Außenhandel', 498.
  26. Erich Ludendorff, *Meine Kriegserinnerungen, 1914–1918. Mit zahlreichen Skizzen und Plänen* (Berlin: Ernst Siegfried Mittler Verlagsbuchhandlung, 1919), 242–7; Offer, *First World War*, 76; David Stevenson, *1914–1918. Der Erste Weltkrieg* (Düsseldorf: Albatros, 2010), 303.
  27. For the data, see appendix table A1 and appendix table B1. Data refer to 1915–8.
  28. Martin Horn, *Britain, France and the Financing of the First World War* (Montreal: McGill-Queen's University Press, 2002); Hew Strachan, *Financing the First World War* (Oxford: Oxford University Press, 2004), 115–60; Patrice Baubeau, 'War Finance (France)' [https://encyclopedia.1914-1918-online.net/pdf/1914-1918-Online-war\\_finance\\_france-2014-10-08.pdf](https://encyclopedia.1914-1918-online.net/pdf/1914-1918-Online-war_finance_france-2014-10-08.pdf).
  29. Kleine-Natrop, *Devisenpolitik*, 11. For the composition of Germany's balance of payments in 1913, see Walther G. Hoffmann, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts* (Berlin: Springer, 1965), 817 Tabelle 241.
  30. Hardach, *First World War*, 6; Niall Ferguson, *The Pity of War, 1914–1918* (London: Penguin, 1999), 35–6; Hautcoeur, 'France', 190; Kleine-Natrop, *Devisenpolitik*, 11. For measures of national income and output, see above.
  31. Nicholas Mulder, 'War Finance', [https://encyclopedia.1914-1918-online.net/article/war\\_finance](https://encyclopedia.1914-1918-online.net/article/war_finance). However, a significant proportion of both Germany's and France's foreign assets were located in such allied countries where they could hardly be mobilised. Hardach, *First World War*, 145.
  32. Mulder, 'War Finance'; Strachan, *First World War*, 985.
  33. Kleine-Natrop, *Devisenpolitik*, 15; 'Die Finanzierung der deutschen Einfuhr im Kriege, 5 Aug. 1938', fos. 437–41, BArch R 2501 /6610; Frey, 'Finanzinteressen', 344–45; Marc Frey, *Der Erste Weltkrieg und die Niederlande. Ein neutrales Land im politischen und wirtschaftlichen Kalkül der Kriegsgegner* (Berlin: Akademie Verlag, 1998), 186, 297–305; Gerd Hardach, 'Die finanzielle Mobilmachung in Deutschland 1914–1918', *Jahrbuch für Wirtschaftsgeschichte*, 56 (2015), 359–87, here 380–2.
  34. For the data, see Statistisches Reichsamt, *Zahlen zur Geldentwertung in Deutschland 1914 bis 1923* (Berlin: Verlag von Reimar H. Hobbing, 1925), 49–51; 'Die Finanzierung der deutschen Einfuhr im Kriege, 5 Aug. 1938', fos. 437–41, BArch R 2501 /6610. For the total amount of foreign assets, see 'Gesamtergebnis der Wertpapierbestandsaufnahme', fo. 174, 'Deutscher Besitz an ausländischen Wertpapieren', fo. 179, BArch R 2501/6664.
  35. On the limited gold absorption capacity of the Scandinavian countries and Switzerland, see 'Richtlinien, betreffend die Aenderung der jetzigen Handels- und Devisenpolitik zur Hebung der Markwährung im Ausland, 1917', fos. 234–44, BArch R 8851/131. In addition, British measures had already made it increasingly difficult for Germany to sell foreign securities on the American market since 1916. 'Reichsbank Direktorium, 22 Feb. 1916', fo. 37, BArch R 8851/344. On this financial blockade, see Mulder, *Economic Weapon*, 49–54.
  36. Statistisches Reichsamt, *Geldentwertung*, 49–51; 'Warburg an Havenstein, 25 June 1917', fos. 2–10, BArch R 8851/344. The decline was then offset by Russian reparations in gold in the final months of the war. 'Arbeit von Dr. Kramer/Rbk.O.I. Parchmann über Währungs- und Finanzmaßnahmen während des Krieges', fos. 226–33, BArch R 2501/6432.
  37. Hardach, 'Mobilmachung', 377; Statistisches Reichsamt, *Geldentwertung*, 46, 49–51.
  38. Stephen Gross, 'Confidence and Gold: German War Finance 1914–1918', *Central European History*, 42 (2009), 223–52; 'Reichsbank-Direktorium an den stellvertretenden Kriegsminister, 27 April 1915', fos. 29–31; 'Reichsbankdirektorium an Staatssekretär des Innern, 14 Dec. 1915', fos. 147–57, BArch R 2/41699.
  39. See for example Kleine-Natrop, *Devisenpolitik*, 15–6; Konrad Roesler, *Die Finanzpolitik des Deutschen Reiches im Ersten Weltkrieg* (Berlin: Duncker & Humblot, 1967), 139.
  40. Kleine-Natrop, *Devisenpolitik*, 15–6; Roesler, *Finanzpolitik* 139. For more details see, 'Anlage 11 – Zeittafel'; 'Der deutsche Aussenhandel im Weltkriege unter Mitbenutzung der Akten des Reichsarchivs (Einleitung und 1. Hauptteil) Sachbearbeiter: Diplomvolkswirt Dr. Klein, Potsdam, 12 March 1936', 6, 32–5, BArch RH 61/826.
  41. 'Hildebrand, Betrifft: Band XIV, Kapitel VII. Die Rohstofflage Ende September/Anfang Oktober 1918, May 1942', fo. 333, BArch RH 61/854.
  42. Calculated on the basis of Appendix table B1, row III, and the actual import value in 1913. Data refer to 1915–8.
  43. Mitchell, *British Historical Statistics*, 457.
  44. On these transshipments, see Bell, *Blockade*, 246, 269; Hardach, *First World War*, 19.
  45. Appendix C. The estimate refers only to the volume of imports from the British Empire, as contemporaries attached particular importance to these, but not to those from France (and later Italy). It should be noted that transshipments of German exports to France and Britain, which were also of concern in Germany, were insignificant. 'Einfuhr und Ausfuhr bis Ende August 1916, Aug. 1937', BArch RH 61/824.
  46. Hardach, *First World War*, 19, 26.
  47. See Bell, *Blockade*, 722–9.
  48. Paul Irrgang, *Deutschlands Kupferversorgung seit 1914* (Diss., Marburg, 1931), 16.
  49. 'Koeth zu Kriegsminister, 9 Nov. 1915'; 'Christian Hildebrand, Wirtschaftsplan, Sep. 1937', 10, BArch RH 61/679; Joseph Koeth, 'Rohstoffbewirtschaftung', in Gerhard Anschütz(eds), *Handbuch der Politik*, 3rd ed., vol. 2 (Berlin/Leipzig: Walther Rothschild, 1920), 224–35, here 228, 232.

50. 'Koeth to Kriegsminister, 9 Nov. 1915'. BArch RH 61/679; 'Anlage 8c, Wirtschaftsplan für Metalle (bis 1.1.1920)', RH 61/679.
51. See for example Louis Guichard, *The Naval Blockade, 1914–1918* (London: Philip Allan & Co, 1930), 274. For further examples, see Burchardt, *Friedenswirtschaft*, 248.
52. Pre-war copper stocks amounted to 150,000 tons of which around 60,000 tons were still available at the end of the war. Scherner, 'Preparing', 497; 'Anlage, Metalle bei Kriegsende in Tonnen', BArch RH 61/871.
53. For the following, see Scherner, 'Metallbewirtschaftung'.
54. For the data, see 'Aus den Handakten von Professor Tröger, Metallverbrauch Deutschlands 1913–1918', BArch RH 61/248.
55. Scherner, 'Metallbewirtschaftung'; Helmut Maier, *Forschung als Waffe. Rüstungsforschung in der Kaiser-Wilhelm-Gesellschaft und das Kaiser-Wilhelm-Institut für Metallforschung 1900 bis 1945/48* (Göttingen: Wallstein, 2007).
56. Richard Tröger, 'Technik in der Metallwirtschaft', in: Max Schwarte (ed), *Die Technik im Weltkrieg* (Berlin: Ernst Siegfried Mittler Verlagsbuchhandlung, 1920), 514–25, here 522–24.
57. The lower limit of copper saving is estimated from the cumulative difference between the annual counterfactual copper consumption based on the raw material input August/December 1914 per unit of powder (as a proxy for armament production) and actual copper consumption. For data see Robert Weyrauch, *Waffen- und Munitionswesen (Die deutsche Kriegswirtschaft im Bereich der Heeresverwaltung 1914–1918, vol. 1)* (Berlin: De Gruyter Oldenbourg, 2016), 251; 'Abgänge für Kriegslieferungen, („Zuweisung“) 1916', BArch RH 61/1118; 'Zusammenstellung über die monatlichen Sparmetallkontingente für das I. Halbjahr 1918'; 'Zusammenstellung über die monatlichen Sparmetallkontingente für das II. Halbjahr 1918', BArch RH 61/869; 'Anlage 2, Metallmengen: Bedarf für Rüstung an Kupfer', BArch RH 61/248.
58. Tröger, 'Technik', 522–24. Substitution was not always successful. In addition, it could make a product more expensive. For examples, see Weyrauch, *Waffen- und Munitionswesen*, 57–8, 229.
59. See for example 'Kontingentierung des Zinnverbrauchs, 12 Jan. 1917', BArch R 8752/8.
60. Scherner, 'Metallbewirtschaftung'.
61. 'Die Kriegsbewirtschaftung der Metalle, 1. August 1914 bis 31. August 1916', 44, 49, BArch RH 61/1125.
62. For data see 'Die Lederbewirtschaftung während des Krieges', 49–51, BArch RH 61/1096; 'Statistik der Bewirtschaftung der Spinnstoffe, 1937', 11, BArch R 61/828; Goebel, *Kriegsbewirtschaftung*, 15–6; Ferdinand Friedensburg, *Das Erdöl im Weltkrieg* (Stuttgart: Enke, 1939), 68; 'Anlage 2, Gummiversorgung 1914–1918 in Tonnen', BArch RH 61/248; Wilhelm Vaas, *Die Kautschukwarenindustrie Deutschlands* (Berlin: Union Deutsche Verlagsgesellschaft, 1921), 19, 233–4.
63. Christian Marx, 'Eisen- und Stahlindustrie', in Boldorf, *Wirtschaft*, 157–192, here 174–5; Stellwaag, *Eisenwirtschaft*, 210–3.
64. Ibid, 230; 'Rückblick auf die Kriegsrohstoffwirtschaft 1914 bis 1918', fo. 190, BArch RH 61/854; Andreas Zilt, 'Die Mangannot verlangt ganze Arbeit!'. Manganersatzverfahren und Sparstrategien der deutschen Stahlindustrie', in Elisabeth Vaupel (ed), *Ersatzstoffe im Zeitalter der Weltkriege. Geschichte, Bedeutung, Perspektiven* (Munich: Deutsches Museum Verlag, 2021), 135–66, here 153.
65. Verein Deutscher Ingenieure (VDI), *Technische Kriegserfahrungen für die Friedenswirtschaft, im Rahmen der volkswirtschaftlichen Untersuchungen der ehemaligen Mitglieder der Wissenschaftlichen Kommission des Preussischen Kriegsministeriums*, Berlin, 1923, (unpub.), 110–1, 122–23, 132; Ludwig Wurtzbacher, 'Die Versorgung des Heeres mit Waffen und Munition', in: Max Schwarte (ed), *Der grosse Krieg 1914 - 1918, vol. 9, Die Organisation der Kriegsführung, 1. Teil: Die für den Kampf unmittelbar arbeitenden Organisationen* (Leipzig: Barth, 1921), 69–146, here 79–80; Elisabeth Vaupel, 'Einführung', in: Vaupel, *Ersatzstoffe*, 9–82, here 66, Strachan, *First World War*, 1025–7.
66. For a recent publication on this subject, see Christine Strotmann, 'Nitrogenous Fertilisers in Germany – Paths of Distribution from Chile Saltpetre to Haber-Bosch-Ammonia and Cyanamide (ca 1914–1930)', *Jahrbuch für Wirtschaftsgeschichte*, 62 (2021), 159–89.
67. 'Wiedenfeld, Deutschlands Rohstofflage und Rohstoffaufgaben, Oct. 1917', 14–6, BArch RH 61/838.
68. VDI, *Technische Kriegserfahrungen*, 157–61; 'Stellungnahme zu den Fragen', Feb. 1941, fo. 558, BArch RH 61/854.
69. 'Die Öle in der Kriegswirtschaft', fos. 437–436, BArch RH 61/854; Friedensburg, *Erdöl*, 67–79; Rainer Karlsch/Ray G. Stokes, *"Faktor Öl": die Mineralölwirtschaft in Deutschland 1859 – 1974* (Munich: C.H. Beck, 2003), 98–111.
70. See for example, Holger Afflerbach, *Auf Messers Schneide: wie das Deutsche Reich den Ersten Weltkrieg verlor* (Munich: C.H. Beck, 2018), 412, 432, 444.
71. Friedensburg, *Erdöl*, 122.
72. Guichard, *Blockade*, 270; 'Monatsberichte der stellv. Generalkommandos vom 3.8.1918', BArch RH 61/690.
73. Rudold Meerwarth/Adolf Günther/Waldemar Zimmermann, *Die Einwirkung des Krieges auf Bevölkerungsbewegung, Einkommen und Lebenshaltung in Deutschland* (Stuttgart: DVA, 1932), 421–25.
74. For details, see Wilhelm Heinke, *Das Spinnpapier, seine Rohstoffe, Herstellung und Prüfung; ein kurzgefasstes Lehr- und Handbuch für alle Gebiete der Papiergarn- und Textilindustrie sowie für die Schüler der Spinn- und Webschulen* (Dresden: Selbstverlag, 1917), 39–63.
75. Goebel, *Kriegsbewirtschaftung*, 15, 19.
76. VDI, *Technische Kriegserfahrungen*, 75–81; Guichard, *Blockade*, 283. 88% of German pre-war consumption of tanning agents had been imported. 'Die Lederbewirtschaftung während des Krieges', 19, BArch RH 61/1096.
77. Meerwarth/Günther/Zimmermann, *Einwirkung des Krieges*, 421–25.
78. Erwin R. Luhn, *Die jüngste Entwicklung der deutschen Seifenindustrie* (Barmen: Walter Odendahl, 1922), 12, 23.
79. For a comprehensive review of many published inter-war studies and their perceptions of avoidable errors in German economic policy before and during the First World War, see Heinz Henning, *Die Situation der deutschen Kriegswirtschaft im Sommer 1918 und ihre Beurteilung durch Heeresleitung, Reichsführung und Bevölkerung* (Diss., Hamburg, 1957).
80. See for example VDI, *Technische Kriegserfahrungen*, 3; Hans Garcke, 'Unterlassungssünden in der militärischen Rüstung Deutschlands vor dem Kriege', in Walter Jost/Friedrich Felger (eds), *Was wir vom Weltkrieg nicht wissen* (Leipzig: H. Fikentscher Verlag, 1936), 72–88, here 85–8.

81. See for example VDI, *Kriegserfahrungen*, 33–6; 80–1; Goebel, *Rohstoffwirtschaft*, 122–25.
82. See, for example, Sören Flachowsky, 'Das Reichsamt für Wirtschaftsausbau als Forschungsbehörde im NS-System: Überlegungen zur neuen Staatlichkeit des Nationalsozialismus', *Technikgeschichte*, lxxxii (2015), 185–224; Helmut Maier, 'Autarkie- und Rüstungsforschung und die Technischen Hochschulen im "Dritten Reich"', in Wolfgang A. Herrmann/Winfried Nerding (eds), *Die Technische Hochschule München im Nationalsozialismus* (Munich: TUM.University Press, 2018), 34–49; Scherner, 'Preparing'; Manfred Knauer, *Hundert Jahre Aluminiumindustrie in Deutschland (1886 - 1986): die Geschichte einer dynamischen Branche* (Munich: De Gruyter Oldenbourg, 2014), 242.
83. See for example, Petzina, *Autarkiepolitik*.
84. On the increasing orientation of German trade towards south-eastern Europe because of these reasons, see for example Mulder, *Economic Weapon*, 246–7. On the necessity of access to the Polish and Romanian oil fields as lesson from the First World War, see for example Friedensburg, *Erdöl*, 126.
85. See for example Goebel, *Kriegsbewirtschaftung*, 19; Wurtzbacher, 'Versorgung', 76–7.
86. See for example, VDI, *Technische Kriegserfahrungen*, 3–4, 11.
87. Goebel, *Kriegsbewirtschaftung*, 70–1; Scherner, 'Metallbewirtschaftung'.
88. Generally, see J. Adam Tooze, *Statistics and the German State 1900–1945: The Making of Modern Economic Knowledge* (Cambridge: Cambridge University Press, 2001). For the industrial census, see for example Rainer Fremdling, 'The German Industrial Census of 1936. Statistics as Preparation for the War', *Jahrbuch für Wirtschaftsgeschichte*, 46 (2005), 155–65; J. Adam Tooze, 'The Rosetta Stone of German Industry: The Reich's Census of Industrial Production 1936', in: Christoph Buchheim (ed), *German Industry in the Nazi Period* (Stuttgart: Franz Steiner Verlag, 2008), 97–116.
89. For inter-war voices, see for example VDI, *Technische Kriegserfahrungen*, 15; Ernst von Wrisberg, *Heer und Heimat 1914–1918. Erinnerungen an die Kriegsjahre im Königlich Preußischen Kriegsministerium*, vol. 2 (Leipzig: Koehler, 1921), 94. For the significance of these lessons for the Nazi regime, see for example Tim Schanetzky, "Kanonen statt Butter": *Wirtschaft und Konsum im Dritten Reich* (Munich: Beck, 2015), 195–8.
90. See for example Lothar Burchardt, 'Die Auswirkungen der Kriegswirtschaft auf die deutsche Zivilbevölkerung im Ersten und im Zweiten Weltkrieg', *Militärgeschichtliche Mitteilungen*, 15 (1974), 65–97, here 80–1, 86; 94; Alan Milward, *Die deutsche Kriegswirtschaft 1939–1945* (Stuttgart: DVA, 1966), 46–7; Werner Abelshäuser, 'Germany: guns, butter, and economic miracles', in Mark Harrison (ed), *Economics of World War II. Six Great Powers in International Comparison* (Cambridge: Cambridge University Press, 1998), 122–76, here 170.
91. German mineral oil consumption was during the first 4 years of the Second World War about 5 times that of World War I, steel consumption almost 2 times, aluminium about 10 times and consumption of synthetic rubber alone was 30 times of total rubber consumption during World War I. Friedensburg, *Erdöl*, 73; 'Überblick über die Rohstoffbewirtschaftung in den Jahren 1917 und 1918', fos. 178–96, BArch RH 61/854. 'Statistische Schnellberichte zur Kriegsproduktion', fos. 8, 9, 12, 21, BArch R 3102/3147.
92. Ibid; BArch RW 19/3383; Scherner, 'Preparing'. Foreign labour used in the domestic production of these goods made up 10–15% of the respective labour force on an annual average during the war. Rolf Wagenführ, *Die deutsche Industrie im Kriege 1939 bis 1945* (Berlin: Duncker & Humblot, 1954), 149, 155. For synthetic rubber, employment data for the chemical industry is employed.
93. See Alexander Donges, 'Import Dependence and Strategic War Planning – The German Iron and Steel Industry, 1933–1945', *International History Review* (forthcoming).
94. Christoph Buchheim, 'Der Mythos vom Wohleben. Der Lebensstandard der deutschen Zivilbevölkerung im Zweiten Weltkrieg', *Vierteljahrshefte für Zeitgeschichte*, 58 (2010), 299–328; Richard J. Overy, "Blitzkriegswirtschaft"? Finanzpolitik, Lebensstandard und Arbeitseinsatz in Deutschland 1939–1942', *Vierteljahrshefte für Zeitgeschichte*, 36 (1988), 379–435, here 409; Burchardt, 'Auswirkungen', 76–7.
95. 'Anlage 79', BArch RH 61/835.
96. See for 1942 and 1943, 'Aufstellung der für das Auflagenprogramm eingesetzten Rohstoffe I/42-III/43 und der damit gefertigten hauptsächlichsten Spinnstoffwaren für den zivilen Verbrauch', BArch R 3/579; 'Ausnutzung der Bedarfsträgerkontingente 1943'; 'Ausnutzung der Bedarfsträgerkontingente 1.1.1942-31.12.1942', BArch R 8/1 316. For the First World War see, Goebel, *Rohstoffwirtschaft*, 74.
97. 'United States Strategic Bombing Survey (USSBS), *The Effects of Strategic Bombing on the German War Economy Overall Economic Effects Division, October 31, 1945* (Washington 1945), 135 Table 79.
98. 'Anlage 2, Lederversorgung 1915–1918 in Tonnen', BArch RH 61/248; 'Die Lederbewirtschaftung während des Krieges', 33, 38–9, BArch RH 61/1096.
99. Whereas in 1917 only 12 million boots (10% of the pre-war production) were produced in Germany (Guichard, *Blockade*, 283), civilian shoe production in 1943 (without slippers and gym shoes) amounted to 113 million. Jonas Scherner, 'Bericht zur deutschen Wirtschaftslage 1943/44. Eine Bilanz des Reichsministeriums für Rüstung und Kriegsproduktion über die Entwicklung der deutschen Kriegswirtschaft bis Sommer 1944', *Vierteljahrshefte für Zeitgeschichte*, 55 (2007), 499–546, here 530.
100. For data see, Kurt Riebel, *Die Versorgung Deutschlands mit tierischen Ölen und Fetten. Ein Vergleich mit der Vorkriegszeit* (Diss, Heidelberg, 1926), 35; *Statistisches Handbuch von Deutschland*, 329; 'Reichsstelle Industrielle Fette und Waschmittel, Zusammengefasste Rohstoff-Bilanz Kalenderjahr 1943', BArch R 3/349.
101. Buchheim, 'Wohleben', 304.
102. On prices, see Scherner, 'Bericht', 541.
103. For data see *Statistisches Handbuch*, 402–9; 'Special Paper No 8, Industrial Sales, Output, and Productivity, Prewar Area of Germany'. National Archives and Records Administration (NARA), RG 243; 'Reichsstelle für Textilwirtschaft, Deutschlands Textilausfuhr 1939–1943', BArch R 8/1 306.
104. 'Reichsstelle für Textilwirtschaft, Eigen- und Fremdversorgung der deutschen Textilindustrie, Zeichnung Nr. 213', BArch R 8/1 316.



105. *Statistisches Handbuch*, 321. For the expansion of the cellulose fibre industry, see Jonas Scherner, *Die Logik der Industriepolitik im Dritten Reich. Die Investitionen in die Autarkie- und Rüstungsindustrie und ihre staatliche Förderung* (Stuttgart: Steiner Verlag, 2008), 163–223.
106. For data see Wagenführ, *Industrie*, 149, 155. Figures for the textile industry include the cellulose fibre industry.
107. Anne Sudrow, *Der Schuh im Nationalsozialismus. Eine Produktgeschichte im deutsch-britisch-amerikanischen Vergleich* (Göttingen: Wallstein, 2010), 258, USSBS, *Effects*, 135 Table 79. On the bad quality of leather substitutes during World War I, see VDI, *Technische Kriegserfahrungen*, 76. On investments, see Jonas Scherner, 'Industrielle Entwicklung und Investitionen', in: Boldorf/Scherner, *Wirtschaft*, 145–67, here 162–3.
108. 'Reichsstelle für Lederwirtschaft, Hauptstatistik Tabelle 44, Tabelle 45', BArch R 8/MI 51.
109. 'Hilfsmittel für die Lederindustrie', BASF Archiv Pertinenzbestand P8.5/2.
110. 'Note, 3 Jan. 1943', BArch R 3/347.
111. Egbert Gritz, *Mersol: Entwicklung und Einsatz von Ersatzwaschrohstoffen aus Kohle 1936–1945. Ein Beitrag zur nationalsozialistischen Autarkiepolitik* (Stuttgart: Steiner, 2013).
112. 'Reichsstelle Industrielle Fette und Waschmittel, Zusammengefasste Rohstoff-Bilanz Kalenderjahr 1943', BArch R 3/349.
113. USSBS, *Effects*, 134; Wagenführ, *Industrie*, 111–2; Scherner, 'Bericht', 538; Mark Spoerer, 'Textilproduktion und -versorgung', in: Boldorf/Scherner, *Wirtschaft*, 349–372. On raw material supply see 'Statistische Schnellberichte zur Kriegsproduktion', fo. 26, BArch R 3102/3147.
114. Mulder, *The Economic Weapon*.
115. See for example for leather substitutes, cellulose fibers and synthetic rubber, Sudrow, *Schuh*; Scherner, *Industriepolitik*, 88–92, 190–99.
116. For the data see David Edgerton, 'Controlling resources: coal, iron ore and oil in the Second World War', Michael Geyer/Adam Tooze (eds): *Cambridge History of the Second World War, vol. III* (Cambridge: Cambridge University Press, 2015), 122–148, here 141; 'Beantwortung der an Prof. Krauch gestellten Fragen'. NARA, RG 243 Box 780, folder 110b, 67.

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## Notes on contributor

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## Appendix A: Determination of the additional import finance potential in the counterfactual

In order to calculate the counterfactual imports, it is first necessary to determine the value of the annual loss in exports due to the blockade and the annual amount of the potential for financing imports through the additional use of the Reichsbank's gold reserves and the additional realisation of foreign assets. As mentioned in the text, it is assumed that the additional exports to the countries that could no longer be reached due to the blockade would have developed in the same annual ratio to pre-war exports as was the case for the countries with which Germany was still able to trade. Therefore, to determine the counterfactual additional exports (in current prices), the value of exports in 1913 to former countries is multiplied by the annual ratios between actual war exports (in current prices) and the 1913-exports to countries with which trade was possible during the war. For the determination of country shares and export values in 1913, see *Statistisches Jahrbuch für das Deutsche Reich 1914*, 258; for actual war exports, see Ritschl, 'German Economy', 50 table 2.7. Since the additional import finance from additional exports would have accrued continuously, it is assumed that it would also have been used regularly to finance further imports in the year in question. A lower and an upper limit are calculated according to the considerations in the text. For the lower limit, only a quarter of the counterfactual value of exports to the USA calculated as above is used for 1917, and no exports to the USA are assumed for 1918 (see Appendix table 1, row I).

## Appendix Table A1: Additional import finance potential in the counterfactual in current prices (million marks)

	1915	1916	1917	1918
(I) Additional exports	1,680	2,055	1,327-1,894	1,525-2,538
(II) Additional use of gold and foreign assets	0	0	1,188-1,729	1,979-2,880
(III) Sum of (I) and (II)	1,680	2,055	2,515-3,623	3,504-5,418

To determine the annual amount of the additional potential import finance through the additional use of the Reichsbank's gold reserves and the additional realisation of foreign assets, it is assumed, in accordance with the considerations made (see text), that these two financing reserves could only have been used from mid-1917 onwards, as they were in reality. The first step is to determine the maximum amount that could have been used between mid-1917 and the end of 1919, i.e. in accordance with the assumed time horizon (see text). For this purpose, the gold reserves of the Reichsbank still available at the end of the war (2.5 billion goldmarks) and the realisable foreign assets (2 billion goldmarks, see text) are added to the sum of the gold and the foreign assets (in goldmarks) used to finance imports between mid-1917 and the end of the war. I do not include the gold coins in circulation at the end of the war (the amount of which was very small) as a possible source of financing for imports, since contemporary observers believed that it would not have been possible to mobilise them to any significant extent. In order to determine the amount of foreign assets used to finance imports between mid-1917 and the end of the war, it is assumed that the known amount of foreign assets of 1 billion goldmarks used to finance imports between September 1916 and the end of 1918 was distributed evenly over the months. For the foreign assets actually used, see 'Die Finanzierung der deutschen Einfuhr im Kriege, 5 Aug, 1938', fos. 437-441, BArch R 2501/6610. Again, as in the case of the additional import finance potential stemming from additional exports, an upper and a lower limit have been calculated in accordance with the considerations in the text as far as the USA is concerned (German-owned sequestered foreign assets in the USA totaled 1.6 billion goldmarks, see text). To determine the amount of gold actually used to finance imports between mid-1917 and the end of the war, the amounts of the decline in circulation of gold coins and the decline in the Reichsbank's gold reserves after mid 1917 are added together. For the data, see Statistisches Reichsamt, *Geldentwertung*, 45-6, 51. Note that the end point is the end of June 1918, not the end of October 1918, as due to Russian reparations in gold, both gold reserves of the Reichsbank and gold coins in circulation slightly increased during the last months of the war. See 'Arbeit von Dr. Kramer/Rbk.O.I. Parchmann über Währungs- und Finanzmaßnahmen während des Krieges', fos. 226-33, BArch R 2501/6432. The sources do not provide information on whether and to what extent Russian reparations were also used to finance imports.

In a second step, this total amount of gold and foreign assets available between mid-1917 and the end of 1919 is now allocated pro rata to the period until the end of the war, i.e. multiplied by the number of months between mid-1917 and the end of the war divided by the number of months between mid-1917 and the end of 1919. In a third step, the sum of the Reichsbank's gold reserves and the value of the foreign assets that were actually used to finance imports between mid-1917 and the end of the war are deducted from the result of this calculation. In a fourth step, this difference is allocated to 1917 and 1918 according to the number of months in each period. In a final step, these amounts are converted into current prices (Appendix table A1, row II) by dividing them by the implicit import price index provided by Ritschl, 'German Economy', 50 Table 2.7.

## Appendix B: Calculation of the counterfactual import index numbers

To calculate the counterfactual import index numbers, the first step is to calculate the counterfactual import value in current prices (Appendix table B1, row I) by adding the additional annual import financing possibilities (in current prices) (Appendix Table A1, row III) to the respective actual annual import value in current prices (Appendix Table B1, row II). For the actual import value in current prices, see Ritschl, 'German Economy', 50 table 2.7. In a second step (Appendix Table B1, row III), these import values are deflated, following Albrecht Ritschl, with the British import price index, which is calculated based on Mitchell, *British Historical Statistics*, 453, 522. In a third step, these import values are converted into a 1913-based index at constant 1913 prices. Again, an upper and a lower limit have been calculated in accordance with the considerations in the text as far as the United States is concerned. Note that the index numbers are the same for the counterfactual *total* imports and the counterfactual *raw material* imports (shown in Table 2) due to the assumption that the share of raw materials imports in total imports would have been the same as in 1913.



### Appendix Table B1: Counterfactual total imports and actual total imports in both current prices (million marks) and in 1913-prices

	1915	1916	1917	1918
(I) Total counterfactual imports in current prices	8,780	10,455	9,615-10,723	10,604-12,518
(II) Total actual imports in current prices	7,100	8,400	7,100	7,100
(III) Total counterfactual imports in 1913-prices	7,702	7,017	4,832-5,388	4,437-5,238
(IV) Total actual imports in 1913-prices	6,228	5,638	3,568	2,971

### Appendix C: Estimating British transshipments to Germany

As a first step, I estimate the quantities of transshipments from the British Empire for those raw materials that the British believed (see Bell, *Blockade*, 246, 269) were re-exported from the neutrals to Germany, i.e. tin, aluminum, cotton, wool, lubricants and rubber, which are part of our sample. In a second step, these quantities are weighted by the respective import prices in 1913, added up and related to the total import value of our sample in 1913 prices. While for cotton the quantities of imports from British India and Egypt is given directly in German sources, an upper limit can be determined for the other goods mentioned by subtracting from the German imports those that can be shown to have come from other sources, such as blockade runners, production in neutral countries or stocks in occupied territories. Thus, only cotton and (presumably) tin were demonstrably important in terms of value, while imports of other goods to Germany were low or even zero. For rubber see, 'Rückblick auf die Kriegsrohstoffwirtschaft 1914 bis 1918'; BArch RH 61/854; for wool and cotton see Goebel, *Kriegsbewirtschaftung*, 19; 'Eingänge der Kriegs-Wollbedarf A.G. an Wolle in 1000 kg'; 'Anlage Nr.25, Die besetzten Gebiete'; 'Anlage Nr. 26, Die Kriegswoll-Bedarfs-A.G (KWB.)'; 'Anlage Nr. 44, Die Einfuhr an Rohbaumwolle und Linters in 1000 t'; BArch RH 61/835; for aluminium and tin see Table 2, footnote a as well as 'Rückblick auf die Kriegsrohstoffwirtschaft 1914 bis 1918'; BArch RH 61/854; for lubricants, see 'Kristallisationskern für die Darstellung der Rohstofflage 1917/18'; BArch RH 61/866; 'Anlage 2'; BArch RH 61/860.

In the case of the lower limit, I assume that the proportions of countries of origin of tin imports in 1915 were the same as in 1913, i.e. that considerably more came from the Dutch Indies than from the British Empire. For these proportions, see *Statistisches Jahrbuch für das Deutsche Reich 1914*, 235.